



TECHNICAL REFERENCE BOOK

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HYDERABAD

**TRANSMISSION CORPORATION OF
ANDHRA PRADESH LIMITED**

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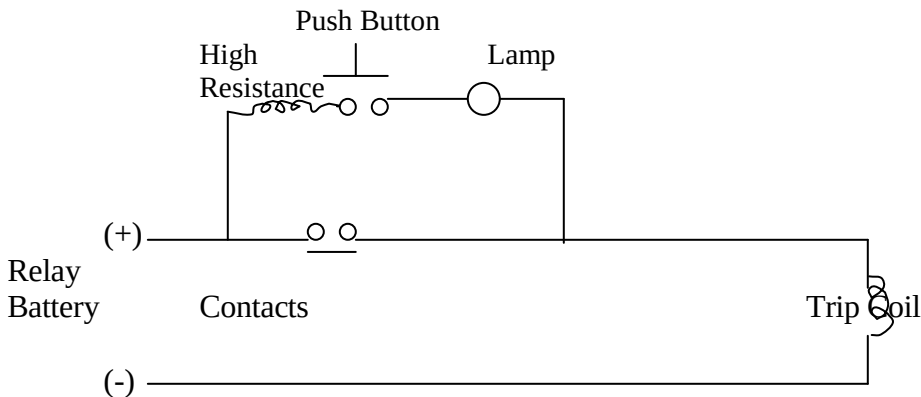
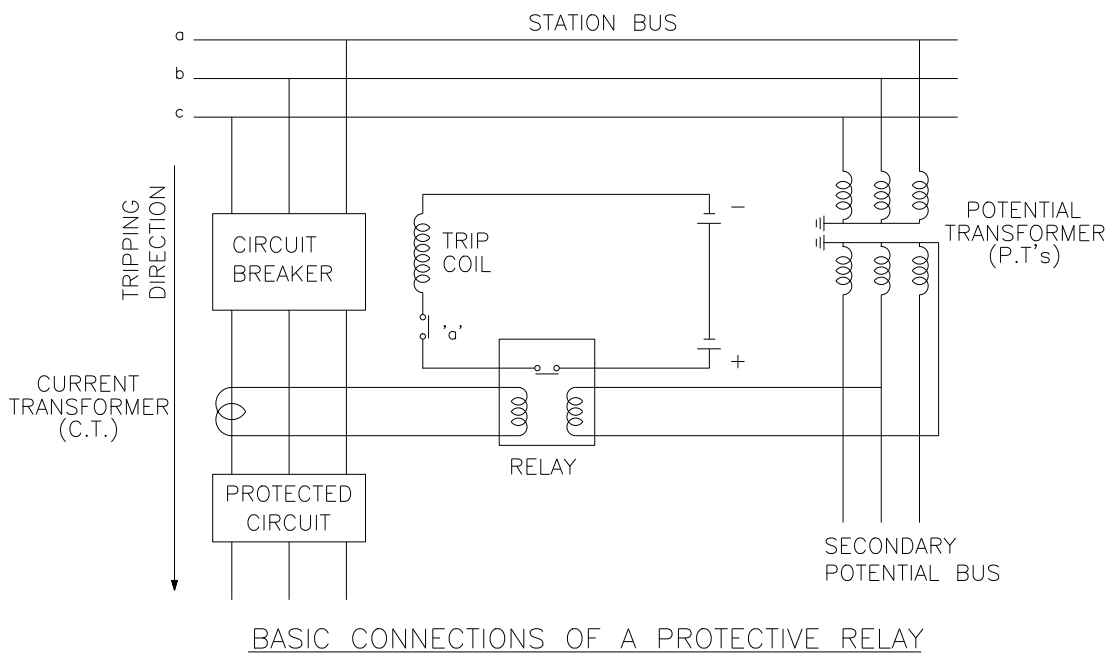
PROTECTIVE RELAYING

1.1 PHILOSOPHY OF PROTECTIVE RELAYING

1.1.1 Function of Protective Relaying

It is to cause a prompt removal from service of any element of a power system when it suffers a short circuit or when it starts to operate in any abnormal manner that might cause damage or otherwise interfere with the effective operation of the rest of the system. The relaying equipment is aided in this task by circuit breakers that are capable of disconnecting the faulty element when they are called upon to do by the relaying equipment.

The basic connections of a protective relay and healthy trip circuit are indicated below:



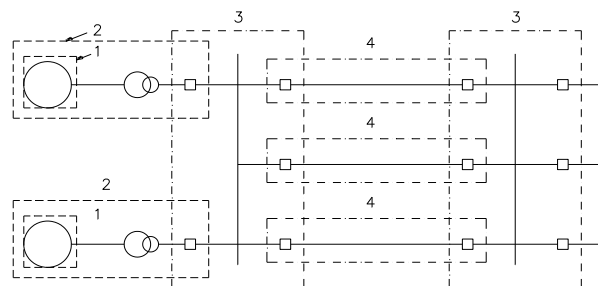
1.1.2 The functional requirement of the relay:-

- i) Reliability:** The most important requisite of protective relay is reliability since they supervise the circuit for a long time before a fault occurs; if a fault then occurs, the relays must respond instantly and correctly.
- ii) Selectivity:** The relay must be able to discriminate (select) between those conditions for which prompt operation is required and those for which no operation, or time delayed operation is required.
- iii) Sensitivity:** The relaying equipment must be sufficiently sensitive so that it operates reliably when required under the actual conditions that produces least operating tendency.
- iv) Speed :** The relay must operate at the required speed. It should neither be too slow which may result in damage to the equipment nor should it be too fast which may result in undesired operation.

1.1.3 Different Types of panels in use

1 Control Panels	12 Marshalling Boxes
2 Relay Panels	13 MG Panels
3 Control & Relay Panels	14 Machine Panels
4 Synchronising Panels	15 Duplex(HV,LV) combined Panels
5 Communication Panels	16 Bus Zone Protection Panels
6 Annunciation Panels	17 OLTC/RTC Panels (Master Follower)
7 D.C. Distribution Boards	18 RTI Panel
8 A.C Distribution Boards	19 Indoor Panels
9 Charger Panels	20 Outdoor Panels
10 Relay Galleries	21 Panels with mimics & Semaphore indicators for circuit breaker and isolator status
11 Auxiliary Control Panels	

The general arrangement of protective zones

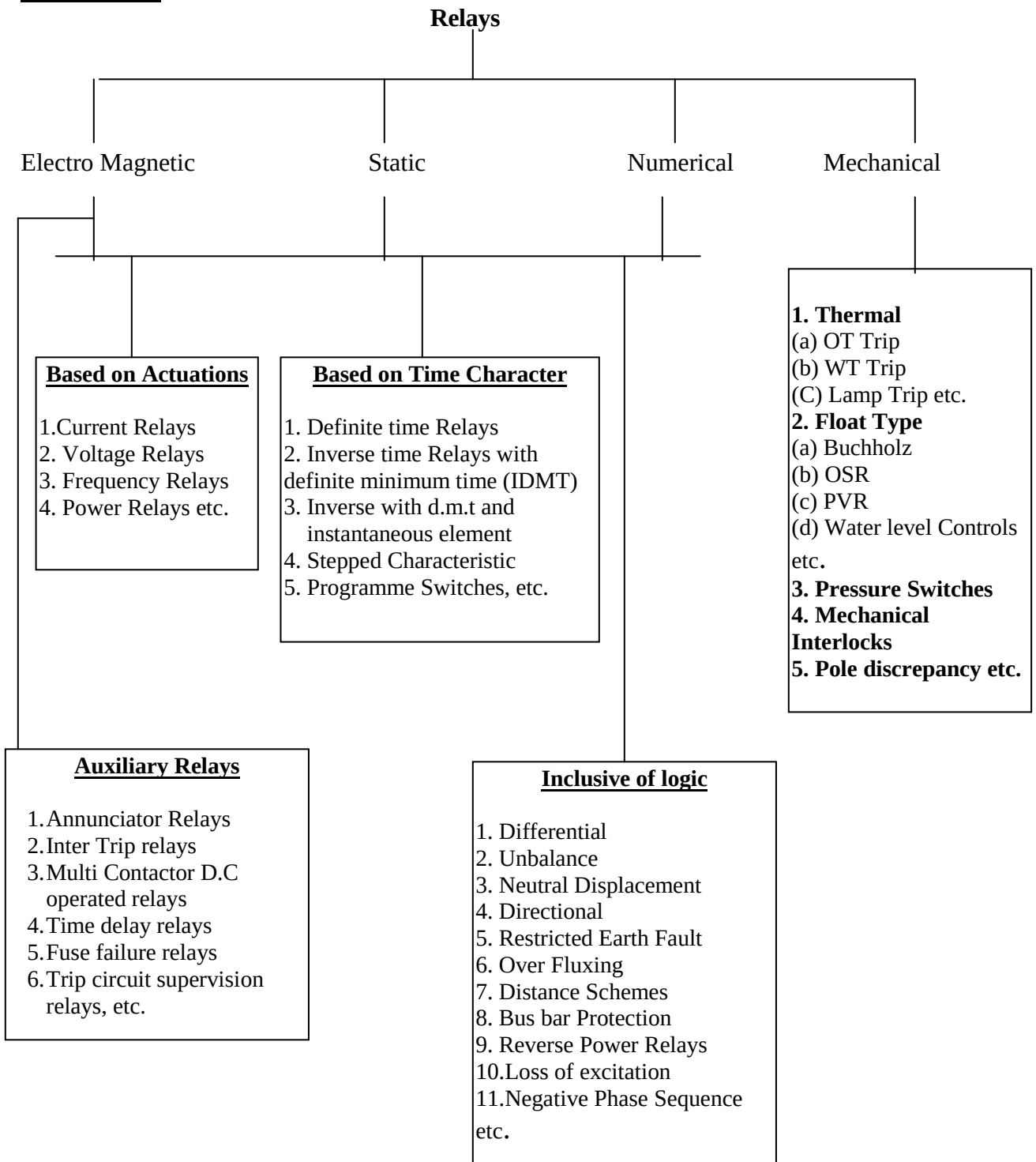


- 1. GENERATOR PROTECTIVE ZONE
- 2. GENERATOR TRANSFORMER UNIT PROTECTIVE ZONE
- 3. BUSBAR PROTECTIVE ZONE
- 4. TRANSMISSION LINE PROTECTIVE ZONE

PROTECTIVE ZONES

1.1.4 The types of Relays based on various sensing mechanism are indicated below:

Relay Family



1.1.5 DEVICE NUMBERS AND THEIR UNIVERSAL NOMENCLATURE

2	Time delay relay
3	Interlocking relay
21	Distance relay
25	Check synchronizing relay
27	Undervoltage relay
30	Annunciator relay
32	Directional power (Reverse power) relay
37	Low forward power relay
40	Field failure (loss of excitation) relay
46	Negative phase sequence relay
49	Machine or Transformer Thermal relay
50	Instantaneous Overcurrent relay
51	A.C IDMT overcurrent relay
52	Circuit breaker
52a	Circuit breaker Auxiliary switch "Normally open" („a" contact)
52b	Circuit breaker Auxiliary switch "Normally closed" („b" contact)
55	Power Factor relay
56	Field Application relay
59	Overvoltage relay
60	Voltage or current balance relay
64	Earth fault relay
67	Directional relay
68	Locking relay
74	Alarm relay
76	D.C Overcurrent relay
78	Phase angle measuring or out of step relay
79	AC Auto reclose relay
81	Frequency relay
81U	Underfrequency relay
81O	Overfrequency relay
83	Automatic selective control or transfer relay
85	Carrier or pilot wire receive relay
86	Tripping Relay
87	Differential relay
87G	Generator differential relay
87GT	Overall differential relay
87U	UAT differential relay
87NT	Restricted earth fault relay (provided on HV side of Generator transformer)
95	Trip circuit supervision relay
99	Overflux relay
186A	Auto reclose lockout relay
186B	Auto reclose lockout relay

1.2 NORMS OF PROTECTION BEING FOLLOWED IN APTRANSCO / APSEB

1.2.1 For Transmission & Distribution Lines

S. No.	Voltage	Protection Scheme
1.	400 KV Line	Main-I: Non switched or Numerical Distance Scheme Main-II: Non switched or Numerical Distance Scheme
2.	220 KV Line	Main-I : Non switched distance scheme (Fed from Bus PTs) Main-II: Switched distance scheme (Fed from line CVTs) With a changeover facility from bus PT to line CVT and vice-versa.
3.	132 KV lines	<u>Main Protection</u> : Switched distance scheme (fed from bus PT) <u>Backup Protection</u> : 3 Nos. directional IDMT O/L Relays and 1 No. directional IDMT E/L relay.
4.	33 KV lines	Non-directional IDMT 3 O/L and 1 E/L relays.
5.	11 KV lines	Non-directional IDMT 2 O/L and 1 E/L relays.

Notes

- On some of the old 220KV lines one distance scheme with backup directional IDMT 3 O/L & E/L relays were provided.
- On some of the 132KV grid lines, only distance scheme is available
- Very few 66KV lines are in service (which are also being phased out) with distance / OL / EL relays

1.2.2 Busbars: All 220 KV busbars will have busbar protection scheme with main and check zone

1.2.3 Breaker failure protection: The LBB protection scheme will be provided for all 220KV stations (along with busbar protection scheme)

1.2.4 Transformers

- No Buchholz relay for transformers below 500 KVA capacity
- Transformers upto 1500 KVA shall have only Horn gap protection
- Transformers above 1500 KVA and upto 8000 KVA of 33/11KV ratio shall have one group control breaker on HV side and individual LV breakers if there is more than one transformer. When there is only one transformer HV CB is necessary if the transformer is 3 MVA or above.
- Transformers above 8000 KVA shall have individual HV and LV circuit breakers.
- The following relays shall be provided on HV and LV
- LAs to be provided on HV & LV for transformers of all capacities and voltage class.
- OLTC out of step protection is to be provided where Master follower scheme is in operation
- Fans failure and pumps failure alarms to be connected.
- Alarms for O.T., W.T., Buchholz (Main tank & OLTC) should be connected.

NORMS OF PROTECTION FOR EHV CLASS POWER TRANSFORMERS

Voltage ratio & capacity	HV Side	LV Side	Common relays
i. 132/33/11KV upto 8 MVA	3 O/L relays + 1 E/L relay	2 O/L relays + 1 E/L relay	Buchholz, OLTC Buchholz, OT, WT
ii. 132/33/11KV above 8 MVA and below 31.5 MVA	3 O/L relays + 1 dir. E/L relay	3 O/L relays + 1 E/L relay	Differential, Buchholz, OLTC Buchholz, OT, WT
iii. 132/33KV, 31.5 MVA & above	3 O/L relays + 1 dir. E/L relay	3 O/L relays + 1 E/L relay	Differential, Overflux, Buchholz, OLTC PRV, OT, WT
iv. 220/33 KV, 31.5MVA & 50MVA 220/132KV, 100 MVA	3 O/L relays + 1 dir. E/L relay	3 O/L relays + 1 dir. relay	Differential, Overflux, Buchholz, OLTC PRV, OT, WT
v. 400/220KV 315MVA	3 directional O/L relays (with dir.highset) +1 directional E/L relays. Restricted E/F relay + 3 Directional O/L relays for action	3 directional O/L relays (with dir.highset)+1 directional E/L relays. Restricted E/F relay	Differential, Overflux, Buchholz, OLTC PRV, OT, WT and overload (alarm) relay

1.3 TRANSMISSION LINE PROTECTION

1.3.1 Distance Relays Principles

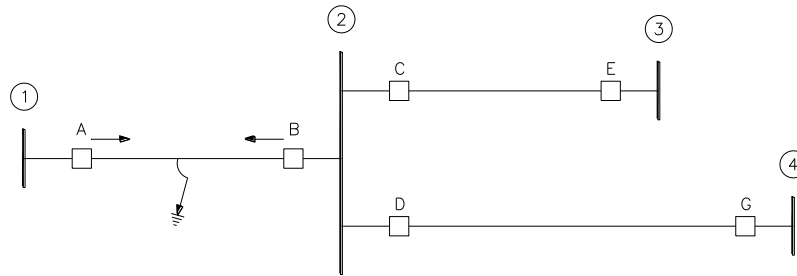
Introduction:

Generating Stations, transmission and receiving substations are interconnected to form a power system network. In such a system, it become impossible to co-ordinate overcurrent or directional overcurrent relays to provide protection for the transmission lines, since for a given fault location, the current seen by the relay varies over a wide range depending upon the system operating conditions.

The impedance relays provides method of protecting transmission lines connected in a network. Though the ideal form of protection for feeders is the “Unit” protection. It is also established that “Unit” protection for feeders is not economical when long lines are involved. A Non-Unit form of protection like distance relay, offers considerable economic and technical advantage. They are comparatively simple to apply, operate with extremely high speed, and both primary and backup protection features are inherent in them. Moreover, they can be easily modified to work as unit schemes by coordinating them with power line carrier facilities and are suitable for high speed reclosing. The impedance relay is made to respond to the impedance between the relay location and the fault point. The

impedance is proportional to the distance to the fault, (hence the name „distance relay“) and is therefore independent of the fault current levels.

Ex: Consider the following system to be a section of a larger system:



For the fault at X, the relays at A & B will operate in the forward direction (i.e for currents flowing from the bus onto the line)

Distance Relaying Principle:

A distance relay compares the currents and voltages at the relaying point with Current providing the operating torque and the voltage provides the restraining torque. In other words an impedance relay is a voltage restrained overcurrent relay.

The equation at the balance point in a simple impedance relay is $K_1 V^2 = K_2 I^2$ or $V/I = K_3$ where K_1 , K_2 and K_3 are constants. In other words, the relay is on the verge of operation at a constant value of V/I ratio, which may be expressed as an impedance.

For a fault at the far end of the line, the local voltages, is the IZ drop in the line and therefore the voltage to current ratio for such a fault will be „ Z “, where Z is the impedance of the line. For a fault internal to the protected section, $V/I < Z$ and for a fault beyond the protection section, $V/I > Z$. The V/I ratio at the relay can be termed as the “impedance” seen by the relay. The relay will operate if the impedance seen by the relay is less than „ Z “. Since the impedance seen is directly proportional to the length of the line between the relay and the fault, it is also a measure of distance to the fault from the relay and hence such relays which compare the voltage and currents are called “distance relays”.

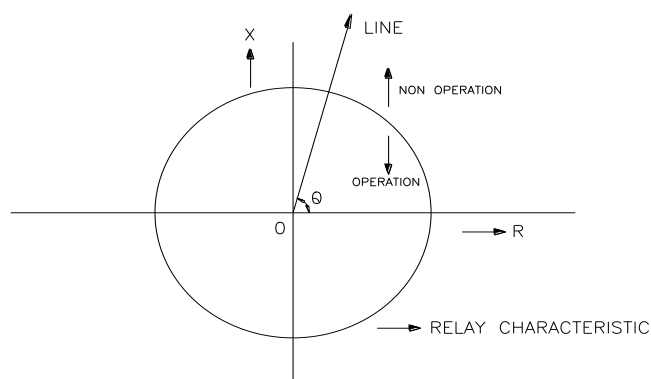
Since the operating characteristics of the relay depend upon the ratio of voltage and current and the phase angle between them, their characteristics can be best represented on an R-X diagram where both V/I ratio and the phase angle can be plotted in terms of an impedance $R+jX$. Further, the power system impedance like fault impedance, power swings, loads etc. can also be plotted on the same R-X diagram. Therefore response of a particular relay during power swing, faults and other system disturbances can easily be assessed.

Types of Distance Relays:

- (1) Impedance relay
- (2) Reactance relay
- (3) Mho relay
- (4) Modified impedance relay

(1) Impedance relay:

Characteristics of an impedance relay on R-X diagram is shown in fig



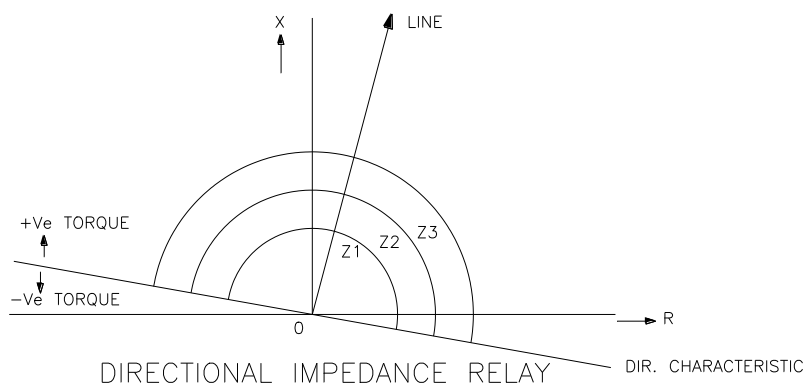
IMPEDANCE RELAY

The numerical value of the ratio of V to I is shown as the length of the radius vector, such as Z and the phase angle between V and I determines the position of the vector, as shown.

Operation of the impedance relay is practical or actually independent of the phase angle between V and I. The operating characteristic is a circle with its center at the origin, and hence the relay is non-directional.

Characteristic of Directional Impedance Relay:

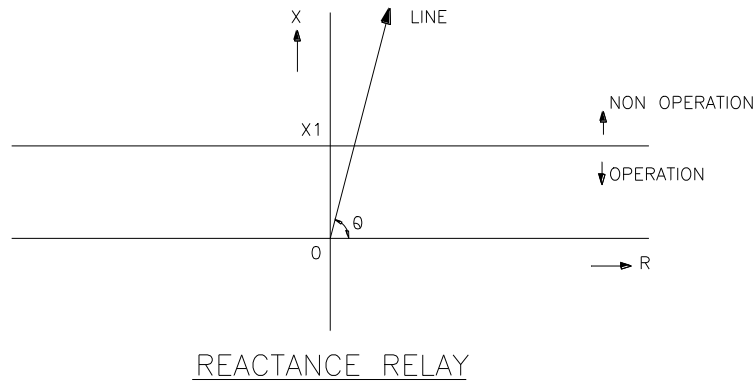
Characteristic of a directional impedance relay in the complex R-X phase is shown in fig.



Along the line impedance locus line, the positive sequence impedance of the protected line as seen by the relay between its location and different points along the protected line can be plotted. The directional unit of the relay causes separation of the regions of the relay characteristic shown in the figure by a line drawn perpendicular to the line impedance locus. The net result is that tripping will occur only for points that are both within the circles and above the directional unit characteristic.

The Reactance-type Distance Relay:

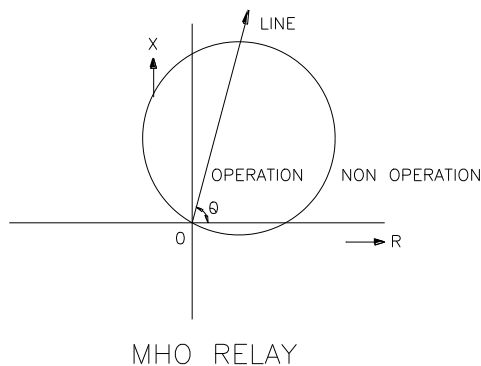
Reactance relay measures $V/I \sin \phi$ (i.e. $Z \sin \phi$). Whenever the reactance measured by the relay is less than the set value, the relay operates. The operating characteristic on R-X diagram is indicated below:



The resistance component of impedance has no effect on the operation of reactance relay, the relay responds solely to reactance component of impedance. This relay is inherently non-directional. The relay is most suitable to detect earth faults where the effect of arc resistance may render other types of relays to detect faults with difficulty.

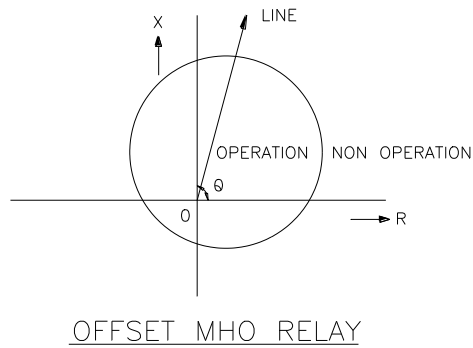
Mho relay:

This is a directional impedance relay, also known as admittance relay. Its characteristic on R-X diagram is a circle whose circumference passes through the origin as illustrated in figure showing that the relay is inherently directional and it only operates for faults in the forward direction.



Modified impedance relay:

Also known as offset Mho relay whose characteristic encloses the origin on R-X diagram as indicated below:



This offset mho relay has three main applications: -

- i) Busbar zone backup
- ii) Carrier starting unit in distance/carrier blocking schemes.
- iii) Power Swing blocking.

Other Operating characteristics :

During the days of electromagnetic relays, the characteristics involving straight lines and / or circles on R-X diagram were only possible. With the advent of static relays, microprocessor based relays and presently of numerical relays, and desired / required operating characteristic is possible giving wider choice for selection of relays, These will be discussion in more detail in subsequent paras.

1.3.2 DISTANCE RELAYS APPLICATION

1.3.2.1 Relay Setting

Since the distance relays are fed from the secondaries of line CTs and bus PTs/line CVTs, the line parameters are to be converted into secondary values to set the relay as per requirements.

$$Z_{\text{secy}} = Z_{\text{pri}} / \text{Impedance ratio}$$

(where Impedance ratio = P.T.Ratio/C.T.Ratio)

It is to be noted that C.T Ratios (and P.T Ratios) and relay settings are inter-related. Hence any changes in C.T .ratio has to be effected along with revision of relay settings only.

For the lines, the impedance in Ohms per KM is approximately as under:

KV	Z1 (=Z2)	Line Angle
132 KV	0.4	60 to 70 Deg
220 KV	0.4	70 to 80 Deg
400 KV	0.3	80 to 85 Deg

A distance relay is either 3 zones or 4 zones to provide protection.

To ensure proper coordination between distance relays in power system, it is customary to choose relay ohmic setting as follows: -

S.No.	Zones	Reactance	Time
1.	Zone-1	80% of ZL	Instantaneous (no intentional time delay)
2.	Zone-2	100% of ZL + 40-50% of ZSL	0.3 to 0.4 seconds
3.	Zone-3	100% of ZL + 120% of ZSL	0.6 to 0.8 seconds
4.	Zone-4	100% of ZL + 120% of ZLL	0.9 to 1.5 seconds

where ZL = Positive sequence impedance of line to be protected.

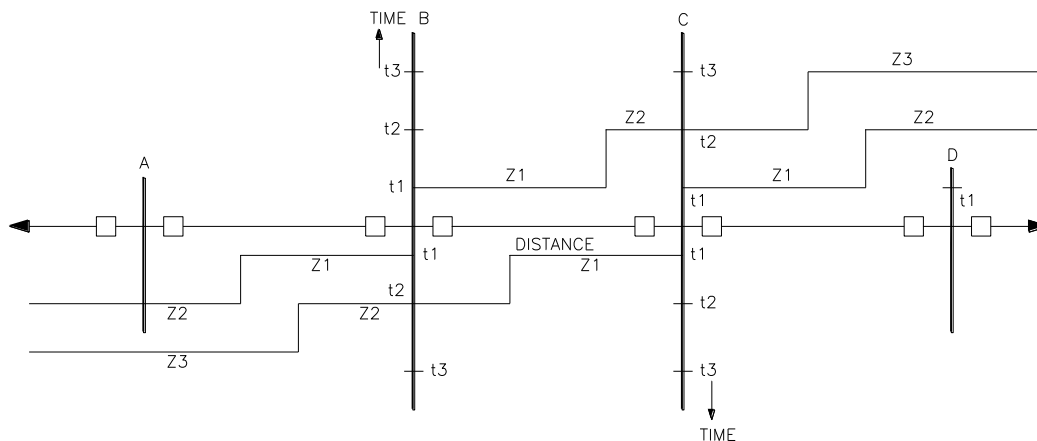
ZSL = Positive sequence impedance of adjacent shortest line.

ZLL = Positive sequence impedance of adjacent longest line.

Note:

- Where a three zone relay only is available, the zone 3 will be set to cover the adjacent longest line.
- The zonal timings will be carefully selected to properly grade with the relays on adjoining sections.

A. Typical 3 zone time distance characteristic of distance relay is shown in sketch below:



THREE ZONE TIME-DISTANCE CHARACTERISTICS

The zone-1 reach is limited to 80% of ZL to provide a reasonable margin against a possible overreach due to errors in CTs, PTs, relay measurement, line parameters, etc.

The zone-2 reach is set to cover upto 40-50% of adjoining line so that this will definitely cover the balance 20% of main line (after zone-1 reach) and provides backup to adjoining line relay. Zone-2 setting shall be not less than 120% of ZL in order to ensure definite coverage of 100% of main line.

The zone-3 & zone-4 reaches will be suitably set to provide backup for relays on adjacent lines with proper time gradation.

1.3.2.2 Distance Scheme consists of the following major components

- i) Starters.
- ii) Measuring units.
- iii) Timers
- iv) Auxiliary relays

i) Starters: -

The starting relay (or starter) initiates the distance scheme in the event of a fault within the required reach (more than zone-3).

Other functions of the starter are: -

- a) Starting of timer relays for second and third zones.
- b) Switching of the respective faulty phase currents and voltage to the measuring unit in a Switched Scheme.

The starters are generally of Mho or impedance type.

With Mho type starters: -

Measuring units for phase and earth faults can be either directional or non-directional as Mho starter is inherently directional.

With impedance type starters: -

Measuring units have to be directional as impedance starters are non – directional.

The under impedance relay can be used in conjunction with the directional relay as starter which will then function similar to the Mho starter.

ii) Measuring units: -

They are generally of a mho or reactance or a combination of mho, reactance and resistance types.

Phase Fault Units:-

These measuring units are fed with line to line voltages (such as V_a , V_b) and difference between line currents (I_a - I_b). They measure the positive sequence impedance from the relay location to the fault point. Three such relays respond correctly to all possible single line to ground faults line to line faults, double line to ground faults and 3-phase faults. They however do not respond correctly to earth faults.

Earth Fault Units: -

These measuring units utilize line to neutral voltage (V_{an} , V_{bn} , V_{cn}) and phase currents (I_a , I_b , I_c). In order to make these units measure the positive sequence impedance correctly, a zero sequence current compensation is to be provided which is obtained by:

$KN = (Z_0 - Z_1) / 3 * Z_1$ (where Z_1 = positive sequence impedance of line.

Z_0 = Zero sequence impedance of line)

In the current circuit $(1+KN) I_a$ will be fed for the above measurement.

iii)Timers: -

Timer relays when initiated by starters provide the time lag required for zones. They also will be used for zone extension purpose whenever required.

iv)Auxiliary relays: -

Distance scheme comprises of several auxiliary relays, which perform functions such as flag indications, trippings, signaling, alarm etc.

Additional Features in distance schemes: -

i) Power Swing blocking relay

ii) VT fuse failure relay.

iii)Switch onto fault relay

iv)Fault locator

v) Auto-reclosing scheme.

vi)Carrier communication scheme.

i) Power Swing blocking: -

Distance relay which respond to balanced 3-phase changes in the impedance will be affected by power swings. These swings or oscillations occur following a system disturbance such as major load change or a dip in voltage due to delayed fault clearance.

As generators in the system strive to find a stable operating angle relative to each other, the enroute distance relays on the line may see these conditions as three phase fault and falsely operate to trip their breakers. To avoid such operation, power swing blocking relays is used.

In case of fault, the transition from period of impedance locations (25 to 33% of starter impedance) to fault impedance (starter impedance) is sudden whereas during power swings, the transition to swing impedance is slow, the PSB relays use this difference to block the tripping during swings.

While the old schemes have blocking in all three zones whereas new static / numerical schemes have the feature of blocking any particular zone of our choice.

ii) VT fuse failure relay: -

The distance relays being voltage restraint O/C relays, loss of voltage due to main PT fuse failure or inadvertent removal of fuse in one or more phases will cause the relay operation. The fuse failure relay will sense such condition by the presence of residual voltage without residual current and blocks the relay.

iii) Switch onto fault: -

Under normal service conditions, a close-up 3-phase fault will be seen by the relays in zone-1 and clear the fault instantaneously. But when the line is switched on to a close by fault (say after line clear with earth switch closed), the voltage at the relaying point will be zero. Faults of this type will normally be cleared by backup zones.

The voltage applied to the relay is low and this condition occurring simultaneously with the operation of starter will cause instantaneous trip by SOTF relay. This SOTF feature will be effective only for about 1-2 seconds after the line is charged. Faults occurring after this time will be measured in the normal way.

iv) Fault locator: -

It measures the distance between the relay location and fault location in terms of Z in Ohms, or length in KM or percentage of line length.

This relay gets same inputs as the distance relay (connected in series with one of the main relays). The measurement is initiated by trip signal from distance relays.

While the distance relay provides general idea where a fault has occurred, the fault locator gives the exact location of the fault, thereby reducing the time of restoration.

v) Auto Reclosing Schemes:-

Types of faults:-

i) Transient Faults:-

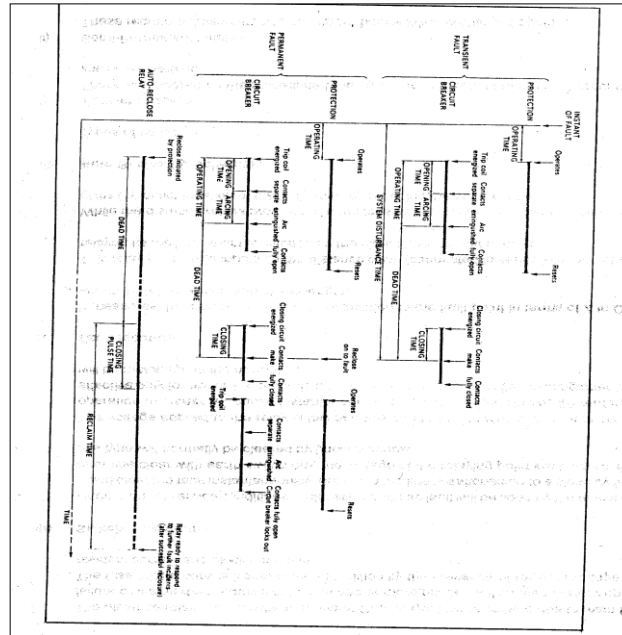
These are cleared by the immediate tripping of circuit breakers and do not recur when the line is re-energised

ii) Semi-Permanent Faults:-

These require a time interval to disappear before a line is charged again.

iii) Permanent Faults:-

These are to be located and repaired before the line is re-energised



About 80-90% of the faults occurring are transient in nature. Hence the automatic reclosure of breaker (after tripping on fault) will result in the line being successfully re-energised, thereby

- a) Decreasing outage time
- b) Improving reliability
- c) Improving system stability
- d) Reduces fault damage and maintenance time

Dead Time:-

The time between the Auto-reclosing scheme being energized and the operation of the contacts which energise the circuit breaker closing circuit.

Reclaim Time:-

The time following a successfully closing operation measured from the instant auto-reclosing relay closing contacts make which must elapse before the auto-reclosing relay initiates another reclosing attempt. In other words, it may be said to be the time between 1st and 2nd auto-reclosure.

Types of Auto-reclosing schemes (based on phase):

a) Three Phase Auto-reclosing:-

This type of auto-reclosing causes an immediate drift apart of the two systems and hence no interchange of synchronizing power can take place during the dead time.

b) Single Phase Auto-reclosing:-

In this, only the faulty phase (which already has tripped on SLG fault) is reclosed without causing interruption in interchange of synchronizing power between two systems through other two healthy phases.

Types of Auto-reclosing schemes (base on attempts of reclosure)

a) Single shot Auto-reclosing:-

In this scheme, breaker is reclosed only once a given fault before lockout of circuit breaker occurs. High speed auto-reclosing for EHV system is invariably single shot.

b) Multi-shot Auto-reclosing:-

In this scheme, more than once reclosing attempt is made for a given fault before lockout of the circuit breaker occurs. Repeated closure attempts with high fault level would seriously affect the circuit breaker, equipment and system stability. The factors that must be taken into account:-

i) Circuit Breaker Limitations:

Ability of circuit breaker to perform several trip close operations in quick succession.

ii) System conditions

In the percentage of the semi-permanent faults (which could be burnt out) is moderate, for example on the lines through the forest, multishot auto-reclosing is followed.

Types of Auto-reclosing (depending on speed)

i) High speed Auto-reclosing

This aids in fast restoration of supply but should be done by taking into account the following factors:-

- i) System disturbance time can be tolerated without loss of system stability
- ii) Characteristics of protection schemes and circuit breaker.

ii) Low speed or Delayed Auto-reclosing:-

This is suitable for highly interconnected systems where the loss of a single line is unlikely to cause two sections of the system to drift apart and lose synchronism.

For EHV Systems

a) Choice of Dead time:-

Lower limit is decided by deionising time of circuit breaker.

Upper limit is decided by transient stability and synchronism

Long transmission lines require longer dead time for single phase faults.

The dead time for high speed auto-reclosing scheme with EHV system is 0.3-0.8 Sec.

b) Choice for reclaim time:-

This should not be set to such a low value that the operating cycle of breaker is exceeded when two fault incidents occur close together. The reclaim time will be in the range of 10-30 Sec., depending on the breaker opening and closing mechanisms.

These relays are provided in all the 132 KV and 200 KV feeder relay panels, they are not being commissioned so far.

vi) Carrier Communication Schemes

The main disadvantage of conventional time-stepped distance protection is that the instantaneous zone-1 of the protective scheme at each end of the protected line is set to cover 80% of the line and hence faults in the balance 20% of the line (at each end) are cleared in zone-2 time, which is undesirable.

The desirable scheme is the one wherein the relays clear the faults on the 100% of the protected line instantaneously and also provide backup for uncleared faults on adjacent lines. This can be achieved by interconnecting the distance relays at each end of the line by a signaling channel (which can be either pilots, a powerline carrier communication channel, a radio link or a microwave channel).

The purpose of the signaling channel is to transmit the information about the system conditions at one end of the protected line to the other end and initiate or prevent tripping of the remote circuit breaker. The former arrangement is referred to as a "Transfer trip scheme" while the latter is known as a "blocking scheme".

a) Transfer trip scheme

In this scheme, the distance relay at one end of the protected lines sends a carrier signal to the relay at other end of the line for inter-tripping, thereby clearing the faults on entire line instantaneously.

Transfer trip of two types:-**i) Under-reaching scheme:-**

The scheme in which the zone-1 relay (set to cover about 80% of ZL) is used to send a signal to the remote end of the feeder for inter-tripping is termed as transfer trip under-reaching scheme. To avoid mal-operation due to receipt of false signal, the receiving end relay operation is inter-locked with its Zone3 / starter operation i.e., the scheme operates either by its own Zone-1 relay operation or by receipt of carried and its Zone-3 / Starter operation.

ii) Over-reaching scheme:-

This scheme is suitable for short lines where an under-reaching zone-1 would be too short to be of any practical use. In this scheme the relay set to reach beyond 100% of the line, is used to send an inter-tripping signal to the remote end of the line. It is essential that the received relay contact be monitored by a directional relay to ensure that tripping does not take place unless the fault is within the protected section. The disadvantage of this scheme is that there is no independent Zone-1 tripping. The fast tripping therefore realizes entirely on signaling channel.

The disadvantage of these schemes is that the signal is transmitted over the faulty line section. Distortion of the signal may occur due to attenuation introduced into the line by the fault.

b) Blocking schemes:-

In this scheme, a blocking signal is sent by the reverse looking directional unit ZR to prevent instantaneous tripping for Zone-2 & Zone-3 faults, external to the protected line. Here ZR must operate faster than forward looking Zone-3 units and the signaling channel must also be extremely fast in operation.

Though all the distance schemes with carrier inter-tripping / carrier blocking facility are procured, the same are yet to be commissioned.

1.3.2.4 Factors affecting distance relay operation:-

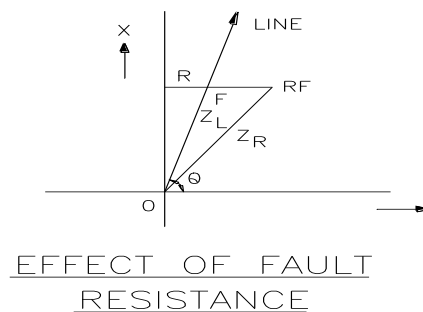
- i) Fault resistance.**
- ii) Infeed effect.**
- iii) Branching-off effect.**
- iv) Load encroachment.**

i) Fault resistance:-

Fault resistance has two components:-

- a) Arc resistance.
- b) Ground resistance.

In a fault between phases, only arc resistance is involved.



For a fault at F, the actual line impedance
 $= R + jX = Z_L$

Due to the presence of fault resistance, the impedance measured by the relay

$$= R + jX + RF = Z_R \text{ (where } Z_R > Z_L \text{)}$$

Fault arc resistance is given by Warrington's formula:

$$R_{\text{arc}} = 8750 \times l / I^{1.4}$$

where l = length of arc in ft

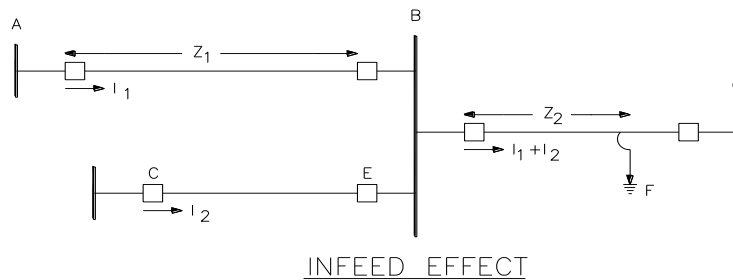
I = fault current in Amps

The arc resistance has little effect on accuracy of zone-1 unit as it operates instantaneously before the arc can stretch appreciably except in case of short lines. Reactance relays are therefore used for short lines where the fault resistance may be comparable with that of the protected lines and also for ground faults where the ground resistance is high.

The arc resistance will have greater impact on accuracy of backup zones (time delayed) as the arc stretches appreciably.

ii) Infeed effect:-

The effect of intermediate current source between relay location and fault point is termed as infeed effect. Consider the following example:-



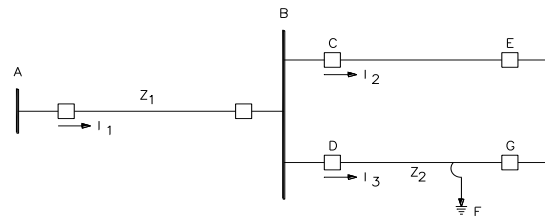
A fault at F on the line BC is at a distance of $Z1 + Z2$ for the relay at station A. But when current $I2$ flows from bus D, the impedance to the fault as seen by the relay at A is $Z1 + Z2 + Z2 \times (I2/I1)$.

Thus the fault is seen by the relay as farther than what it really is, i.e. distance relay under reaches due to the infeed effect.

The effect of infeed becomes more pronounced with more interconnections at station-B.

iii) Branching-off effect: -

Consider the following example:



BRANCHING OFF EFFECT

A fault at F is at the distance of $Z_1 + Z_2$ for the relay at station A. But when current I_1 gets distributed as I_2 & I_3 at station B, the impedance to fault seen by the relay at station A will be $(Z_1 + I_3/I_1 * Z_2)$ which is less than $(Z_1 + Z_2)$.

Then the fault is seen by the relay as nearer than what it really is i.e. distance relay overreaches due to branching-off effect. This overreaching tendency will cause the relay to loose its selectivity.

iv) Load encroachment: -

While protecting long lines the necessary reach may be so large that the minimum service impedance (or load impedance) falls within the region of the starter. This would result in tripping without there being any fault. The two conditions i.e. operation at heavy load and short circuit differ by virtue of phase angle between voltage and current. For the load impedance, the phase angle will be within $+30$ to -30 Deg. While during short circuits, the fault impedance has a phase angle of 60 to 80 deg. (i.e. line angle).

Load encroachment problem is more pronounced in case of under impedance starters and gets lessened in case of mho, elliptical, lens etc, type of starters. Relays with suitable characteristic on R-X diagram have to be carefully chosen to protect long and heavily loaded lines, and this becomes easily possible with microprocessor based numerical relays.

1.3.2.5 Non-switched scheme vs switched scheme: -

In an ideal Non-switched scheme, there will be 6 starters, 3 for phase faults and 3 for ground faults. There will be independent measuring units for both phase faults and earth fault for each phase, for all three zones, totaling to 18 units. This scheme is faster and more accurate but is costly.

In the switched scheme, only one measuring unit will be used for all types of faults. This single measuring unit is switched to the correct fault loop impedance by switching-in the respective voltages and currents by the starter.

The reach of the measuring element gets extended to zone-2 and zone-3 after the elapse of corresponding timings through zone extension process. Switched scheme is relatively slow in operation and has the risk of total scheme failure in the event of failure of the only one measuring unit available.

Zone extension schemes: -

As a via media between non-switched and switched schemes, there are schemes with zone extension facility (such as EE make MM3V & MR3V relays). These schemes consists of 3 measuring units for phase faults and 3 measuring units for earth faults (apart from 3 starters).

The reach of the measuring unit gets extended to zone-2 and zone-3 after elapse of corresponding timings through a zone extension process.

13.3 DISTANCE RELAYS IN A.P SYSTEM & THEIR CHARACTERISTICS

13.3.1 Distance relays in service in A.P.System:

S.No.	Make	Main-I distance relay	Main-II relay
1.	GEC Alstom/ EE • RR3V	MM3V - SHPM OPTIMHO	MR3V SSRR3V (MHO/UI starter) PYTS
2.	ABB/ASEA	RELZ-100 RAZFE RYZFC RADSL	RAZOA RAZOA RAZOG RELZ-100
3.	BBC/HBB	LZ96 L3wyas+L6ft L3wys+L6ft	LIZ6 L3wyas+L6ft L3wys+L6ft
4.	SEIMENS • RIZ24a	7SA511	7SA511
5.	ER	THR4PE24	THR4PE1
6.	UE	MDT45B	MDTB101

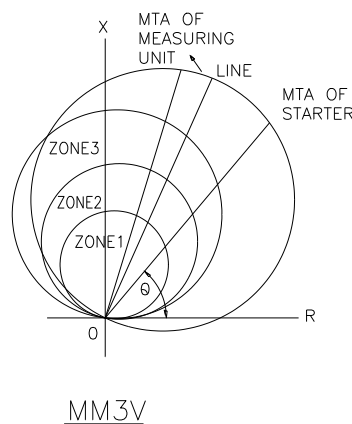
On 220 KV lines, the above combination of distance relay is provided. On 132 KV lines, the relay indicated under “Main-II distance relay” column are provided along with directional IDMT 30 / L& 1E/L relays, on few lines MM3T, LZ32 type relays are available.

Details of distance relays:-

1.3.3.2

- 1) Make: - GEC Alstom Ltd.
- i) MM3V: - It is an electromagnetic type distance relay with:
- 3-mho measuring units for phase to phase faults.
 - 3-mho measuring units for phase to earth faults.
 - 3-mho starting units, each starter being associated with one phase and operating for all faults associated with that phase and one offset mho unit for power swing blocking.

R-X diagram is indicated below



Setting range in ohms for Zone-1

- 0.834 to 30
- 1.335 to 48
- 1.668 to 60
- Z2 = 1 to 3.5 times Z1
- Z3 = 1 to 5 times Z1

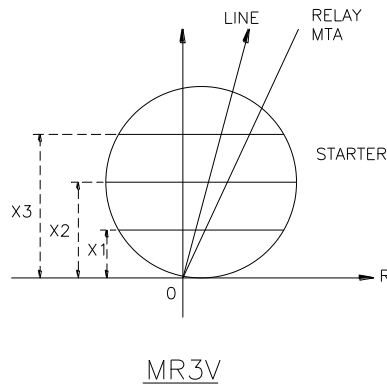
Some of the schemes are provided with a Zone-4 timer to make the scheme works as a 4 zone relay, the starter itself being the 4th zone.

ii) MR3V: -

It is an electromagnetic relays with 3 mho units for phase faults, 3 reactance units for earth faults. 3 mho starters, each being associated with one phase for all types of faults and one offset mho unit for power swing blocking.

Setting ranges same as in MM3V.

R-X diagram for phase faults is same as that for MM3V relay and for earth faults it is indicated in figure



iii) RR3V: -

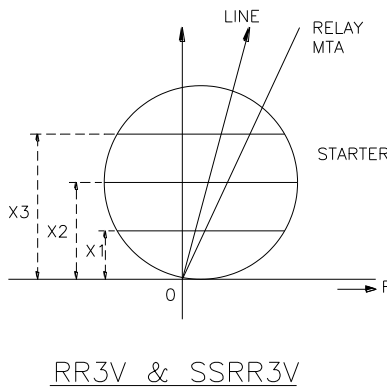
It is an electromagnetic relay with 3 Nos. reactance units for phase faults, 3 reactance units for earth faults, and 3 mho starters per phase for all types of faults and one offset mho unit for PSB. R-X diagram is indicated in figure

iv) SSRR3V: -

It is an electromagnetic switched scheme with two version i.e. with mho or under impedance starter and available in low and high range.

SSR3V (Mho)

3 Mho starters for all types of faults. One reactance measuring unit for phase and earth faults.



SSRR3V (U/I)

3 under impedance starters directionalised by mho element or 3 mho element starters and for all types of fault, one reactance-measuring unit for phase and earth faults.

Low range relay: $Z1 = 0.5 \text{ to } 7.7 \text{ Ohms}$
(k1 of zone1: 7.7, 3.0, 1.22)

High range relay: $Z1 = 1.3 \text{ to } 20 \text{ Ohms}$
(k1 of zone-1: 20, 7.8, 3.16)
 $Z2 = (1 \text{ to } 3.5) \text{ times } Z1$
 $Z3 = (1 \text{ to } 5) \text{ times } Z1$

R-X diagram is same as that for RR3V relay.

Few versions do not have separate zone-4 timer. In such relays, zone-4 time = zone-3 time + 150 msec (fixed built-in delay).

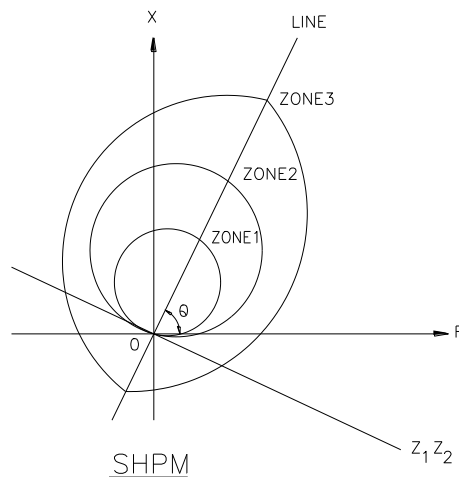
v) SHPM (Quadra mho): -

It is a non-switched static scheme with 18 measuring mho units. The zone-3 measuring elements will act as starters, which have either mho or a lenticular characteristic. The operating characteristic on R-X diagram is indicated in figure

The lenticular characteristics allows healthy overloads and hence prevents tripping on load encroachment.

Setting range: - 0.2 to 240 Ohms.

It has built-in feature of continuous self monitoring (on demand and periodic self testing).

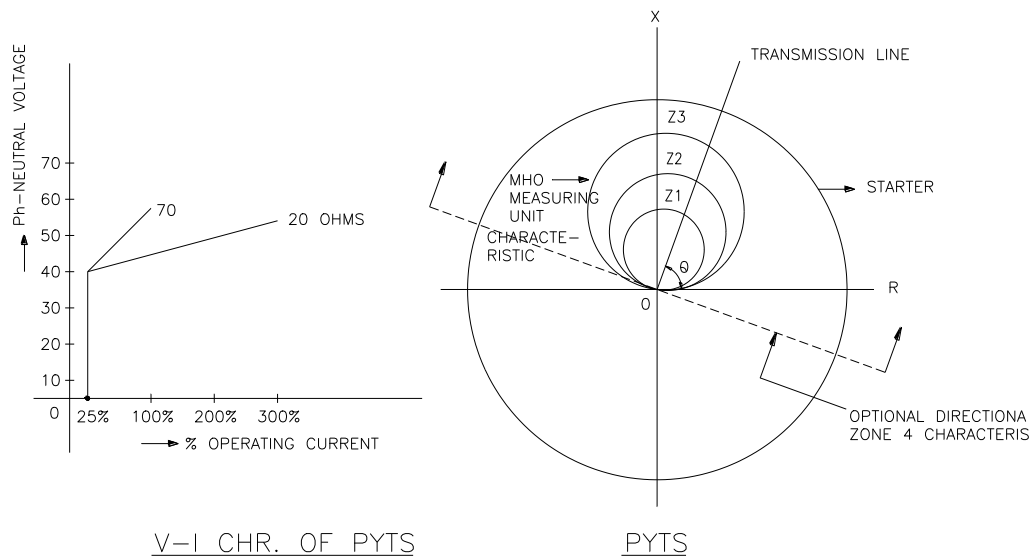


All the additional features provided by relay can be enabled or disabled with the help of switches provided for them.

vi) PYTS: -

It is a static switched scheme with modular plug-in construction (with built in test points).

It has 3 under impedance starters and a single mho measuring unit. One U/I unit for power swing blocking. R-X diagram is indicated below.



Setting range: 0.05 to 40 Ohms, with starter having range of 20 to 70 Ohms.

It has an uncompensated U/I starter, which has become a problem due to load encroachment for long lines.

The V-I characteristic of the starter is indicated in above figure.

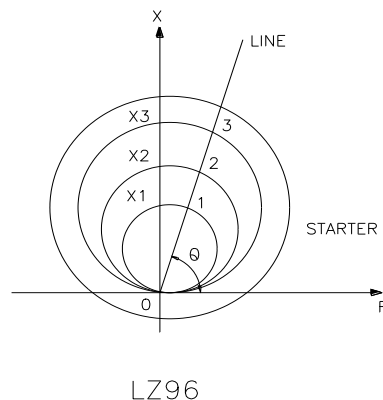
When the voltage is less than 65% rated, the starter operates at a current greater than 0.25 In. With low voltages at some of the stations, this feature has caused relay to operate unnecessarily. The same can be avoided by making the zone-4 trip inoperative (by making L IN K 6 of module 5 „OUT“ position).

1.3.3.3 Make: - BBC/HBB

i)LZ96:

It is a non-switched scheme with 3 underimpedance measuring units common for ground and 3-phase faults.

3 Nos. under impedance (offset mho) starters, one under-impedance unit for all possible phase to phase faults. R-X diagram is indicated below:

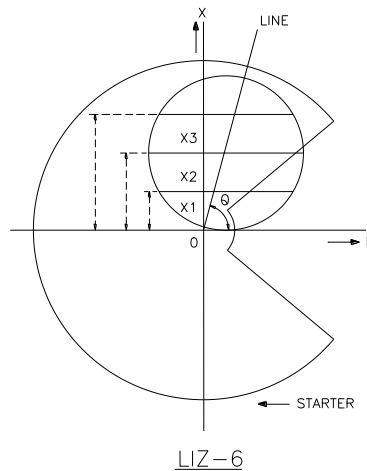


Forward and reverse reach can be selected independently in starters (with zone-4 time setting).

Setting range: 0.1 to 100 Ohms.

ii) LIZ6: -

It is a switched scheme with 3 under-impedance starters, 3 overcurrent starters and one neutral current starter. It has one reactance measuring unit for all faults. With the provision of angle replica unit the relay has special operating characteristic on R-X diagram indicated in figure, which permits high loading on long lines. This being the initial versions of static relays there have been number of component failure and are being phased out.

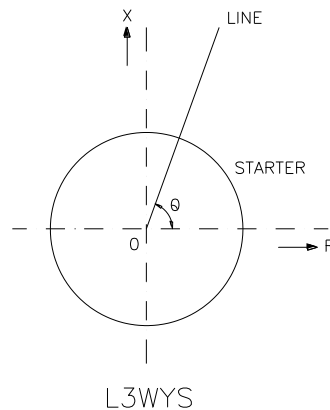


iii) L3 relays: -

a) L3WYS:

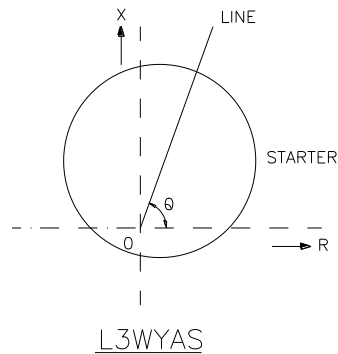
This relay consists of 3 under impedance starters and a single directional reactance measuring unit (CM relay).

It is four zone relay, the zone-4, starter step being non-directional. Time settings for all the four zones (including Zone-1) can be varied from 0.1 to 5 seconds. R-X diagram is indicated in figure.



b) L3wyas: -

This is similar to L3WYS relay except that the U/I starters are provided with compounding chokes thereby shifting the circle, making it an offset mho as indicated in figures.



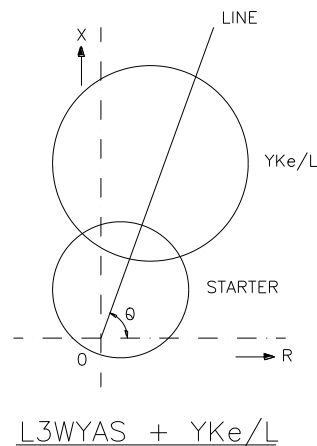
It is also supplemented by Yi/L - power swing blocking unit.

iv) L6ft: -

It is high speed, single step distance relay usually supplemented to L3wyas or L3wys. It is set to protect 80% of line and without any time delay.

v) Yke/l relay: -

This consists of three under impedance starters, used in conjunction with L3wyas relays. By provision of compounding chokes, the operating region of the Yke/l relay is shifted much above the origin of the R-X diagram. The operating characteristic of the combination of L3wyas and Yke/l relay is indicated in figure.



It may be seen from the diagram that this combination permits much higher loading and protects longer lines, without any problem of load encroachment. These relays are one of the oldest relays in system procured in late 50's and early 60's and still working reasonably well.

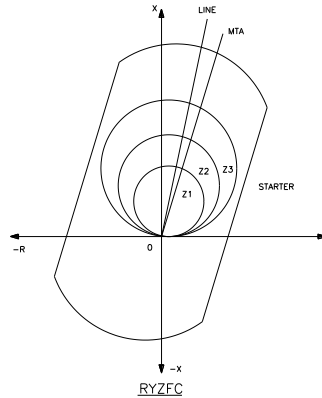
1.3.3.4. Make: ABB: -

i) RYZFC: -

It has come into service in the initial stage of the advent of static relays, has 3 mho measuring units for earth faults, one mho unit for phase faults and 3 under impedance starters.

In addition, this relay has negative sequence current starter with a fixed setting of 20% of I_n , which causes the relay to trip in Zone-4. The starter can be made to operate either as a circle or as oval.

R-X diagram is indicated below.



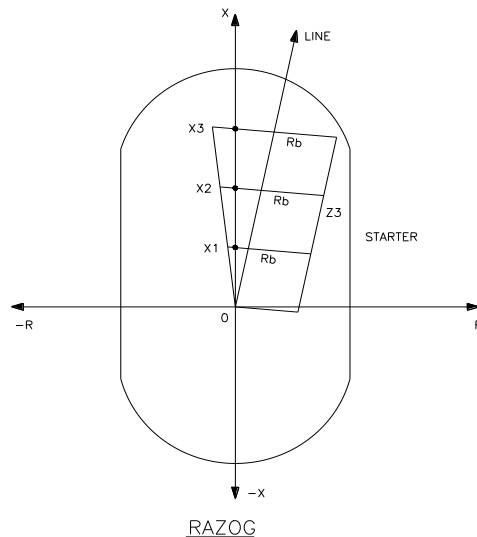
Setting range: - 1.8 to 200 Ohms.

- a) This relay is found to lose its directional sensitivity for closeby reverse faults and hence not recommended for use on feeders emanating from generating stations.
- b) Also the negative phase sequence starter is found to respond to very far end faults.

ii) RAZOG: -

It is a switched scheme with 3 under impedance starters and one reactance measuring unit. It has quadrilateral characteristic.

R-X diagram is indicated below.



Setting range: 0.25 to 64 Ohms.

The starter can be made to operate either as a circle or oval.

iii) RAZFE:

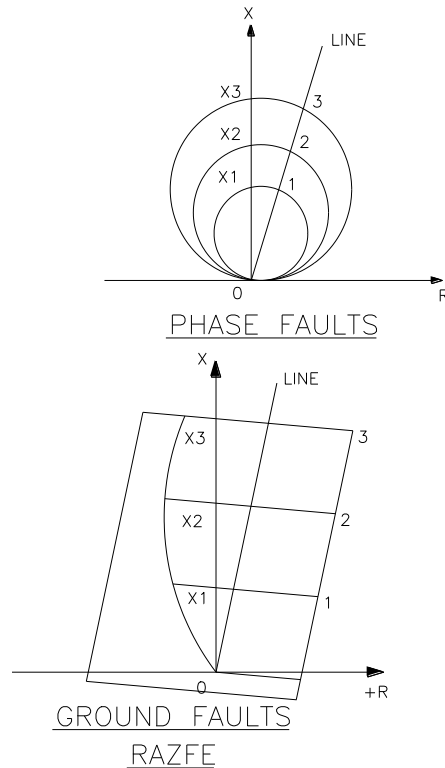
It is static three zone non-switched scheme.

For ground and 3-phase faults, the distance relay has a reactance like operating characteristic, the reactance line being inclined by a few degrees towards resistance axis on R-X diagram, which provides excellent margin for high resistance faults and minimises effects of load current and remote ends infeed on distance measurement. R-X diagram is indicated below.

To avoid load encroachment problem, the relay is provided with blinder, which has independent settings in resistive and reactive directions.

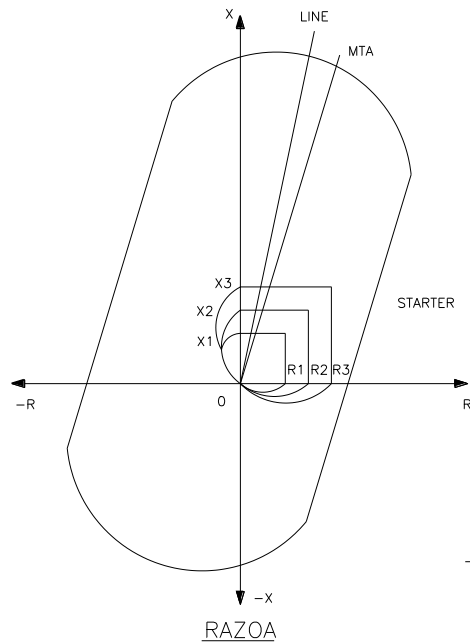
For phase to phase faults, mho units are used.

Setting range: 0.25 to 64 Ohms.



iv) RAZOA: -

It is a static scheme having 3 zone impedance starters and one measuring unit. The directional measuring unit has got quadrilateral characteristic with independent settings in resistive and reactive directions. R-X diagram is as indicated below.



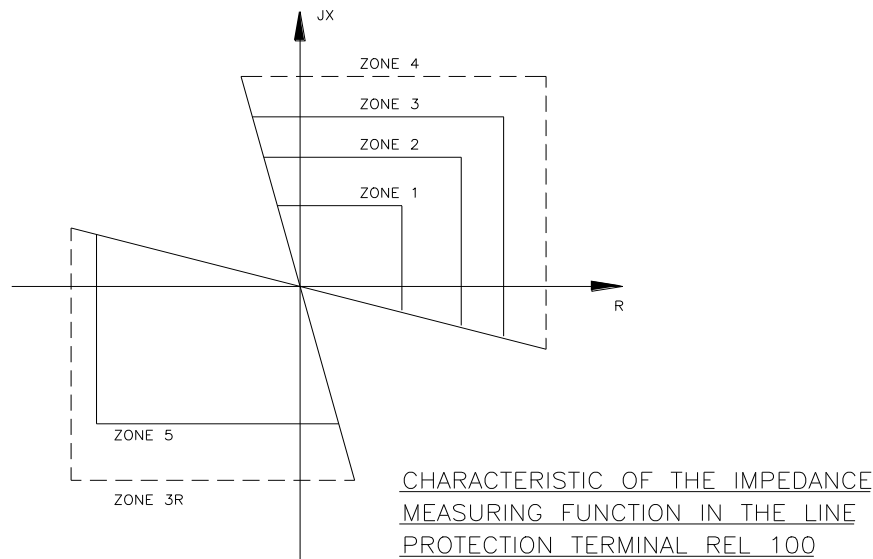
The U/I starter can be made to operate with a circle or oval characteristic with a selectable switch (S3: 1 ON for circle OFF for oval in RGZB module).

RGSB Module:

Directional	: S1: 1 - OFF
Non-directional	: S1: 1 - ON
Setting range	: 0.16 to 64 Ohms.

(v)RELZ-100:

It is a numerical relay with quadrilateral impedance units for phase and earth faults. Each measuring unit has individual and independent setting of the reach in resistive and reactive directions, as well as for the zero sequence compensation factor, KN. Entire Zone-3 reach (in forward direction) is available in reverse direction with a separate timer T3R. R-X diagram is as indicated



Four groups of setting parameters are possible to suit different system conditions. Only one of the groups will be in service by choice. It has continuous self monitoring and self testing feature and indicate the same by extinguishing "Relay A available" LED on the relay. Through MMI, one can enter; edit the settings, read the mean service values of line voltage, current, real, reactive power and frequency. It stores data of latest 3 disturbances occurred. (The settings are not password protected).

Setting range: 0.1 to 150 Ohms.

Timers: 0 to 10 Secs.

It has a feature which does overload supervision and unsymmetrical load condition, which can be used for alarm or trip.

vi) RADSL: -

This pilot wire protection scheme used for protection of short lines. It is very fast operating relay, clearing the faults in 100% of line without any time delay. This is commissioned on 220 KV KTS „C“ Station - KTS V Stage tie lines 1 & 2 at both ends as Main-1 protection scheme (Main-II being RELZ-100 relay).

Likewise GEC make FAC34 pilot wire differential relays are provided on 220 KV NTPC - RAMAGUNDAM tie lines 1 & 2 with backup O/L, E/L relays.

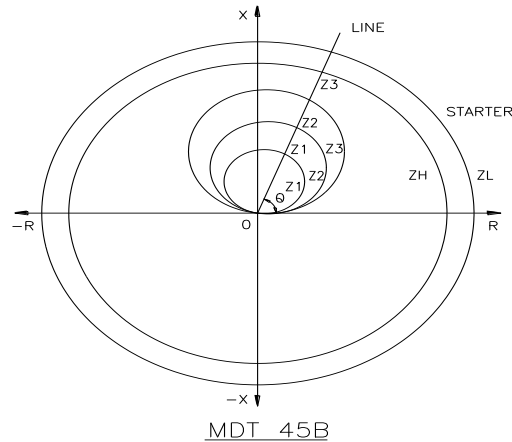
1.3.3.5 Make: - Universal Electric

i) MDT45B:

It is a non-switched 3-zone distance scheme with 18 measuring units, 3 Nos. low set starters ZL and 3 Nos. high set starters ZH. It is available in two ranges low and high.

R-X diagram is indicated in figure.

- a) **For Low range:**
Reactance Measuring units for Zone-1 & Zone-2.
- b) **For High range:**
Mho measuring units for Zone-1 & Zone-2.



ii) MDTB101:

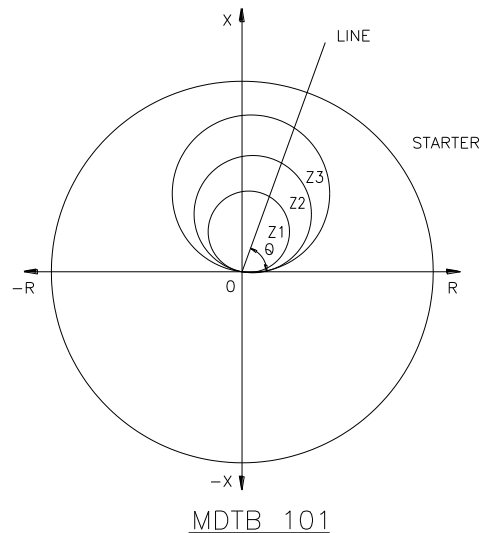
It is switched scheme, with 3 impedance starters, one neutral overcurrent starter and one mho measuring unit.

R-X diagram is indicated in figure.

This relay has a V-I characteristic similar to that of PYTS relay. When the voltage is less than 65% rated, the starter operates at a current greater than $0.25 I_n$.

For 220 KV lines, the settings on Main-I distance relay must be on par with that of Main-II relay and vice-versa.

For 132 KV lines, distance relay along with directional O/L, E/L relays are used. The operating time of O/L, E/L relays for adjacent bus faults are set equal to or more than zone-2 time of distance relay.



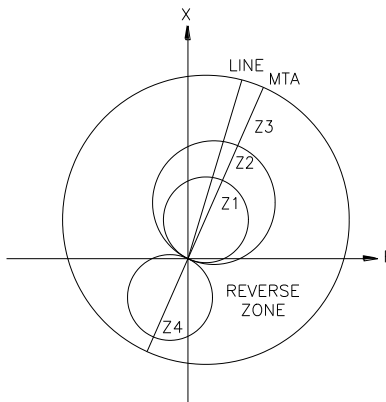
1.3.3.6 Make: - Easun Reyrolle: -

i) THR4PE24: -

It is static non-switched scheme with 3 forward zones and 1 reverse zone consists of a total of 24 measuring units. 12 Nos. mho units for zone-1 & zone-2 for phase and earth faults. 6 Nos. offset mho units for zone-3, 6 Nos. Mho units for reverse reach.

R-X diagram is indicated in figure.

It has reverse reach set to $(c \times \text{zone-1})$ for phase faults and $(c \times \text{zone-1}) (1+KN)$ for earth faults, KN being compensation factor. Generally c is set equal to „1“.



THR4PE24

ii) THR4PE1: -

It is static switched scheme with 3 offset mho starters and one mho measuring unit.

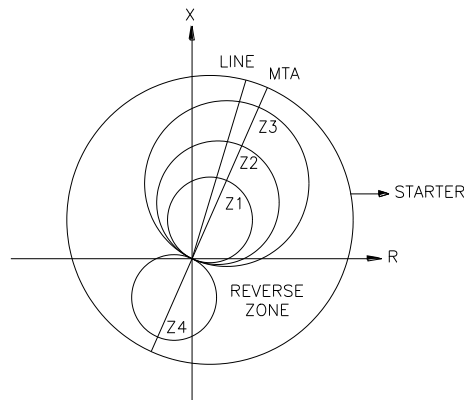
R-X diagram is indicated in the figure.

It is available in low and high ranges: -

Setting range: -

Low range: - 0.08 to 9.5 Ohms (with A:0.8 to 9.6)

High range: - 0.4 to 47.5 Ohms (with A: 4 to 48)



THR4PE1

The starter has a built in reverse reach, equal to 50% of forward reach for phase faults and 50% of forward reach $(1+KN)$ for earth faults, KN being compensation factor.

Make: - Seimens Ltd.

7SA511 relay:

It is a numerical protection scheme with 16 bit microprocessor. With three version of detectors.

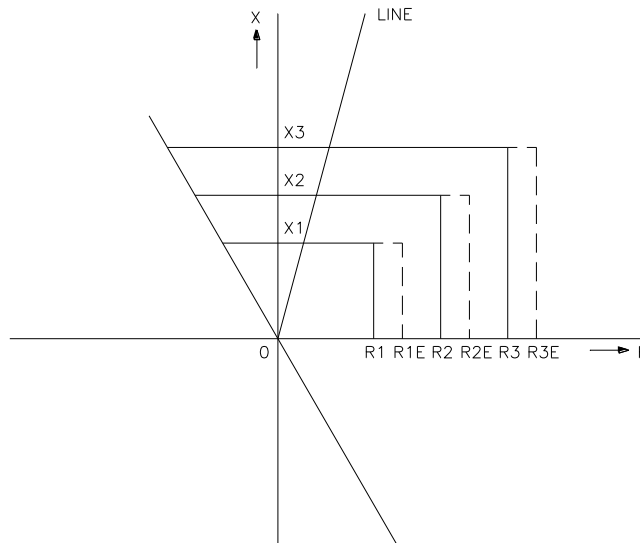
- i) Phase selective overcurrent fault detector.
- ii) Voltage controlled (under-impedance) fault detector (with independent R & X reaches) and
- iii) Polygonally shaped angle-dependent impedance fault detector.

It has five zones (two of which can be used for communication schemes).

R-X diagram is indicated below.

Apart from common features, it provides Emergency overcurrent function, which comes into picture when main distance scheme is blocked due to VT fuse failure conditions.

It provides two user defined logic functions. It has continuous self monitoring and self testing feature. It stores data of latest three faults and measures values of load current, operating voltage, power and frequency continuously.



7SA511

Setting range: 0.1 to 200 Ohms with 0.0 to 32 sec (in step of 0.01 sec) timers.

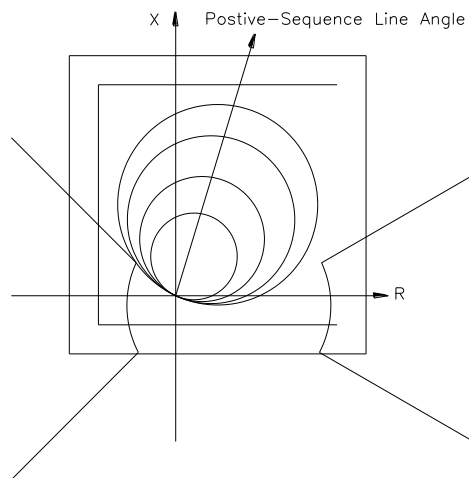
Four groups of settings are possible to suit different system conditions. Only one of the groups will be in service by choice.

SEL – 321: - It is numerical relay with

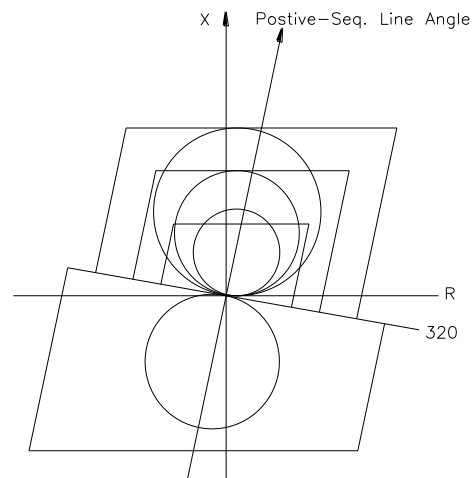
- a) Four Mho zones for phase faults with independent phase to phase overcurrent supervision.
- b) Four ground faults for Mho and Quadrilateral zones with independent phase and residual overcurrent supervision and zero sequence compensation.
- c) Two Quadrilateral zones for power swing blocking.
- d) Load-encroachment characteristics.
- e) Instantaneous, Definite time and IDMT overcurrent characteristics.
- f) Six (6) setting groups are available in the scheme.

Setting ranges:-

For Mho zones	:	0.25 to 320 Ohms (Secondary)
For Quadrilateral Zones	:	
Reactance	:	0.25 to 320 Ohms (Secondary)
Resistance	:	0.25 to 250 Ohms (Secondary)
Timers	:	0-2000 Cycles



Three-Phase and Phase-Phase Distance Characteristics



Ground Distance Characteristics

SEL321

1.3.3.8 Relay indications: purpose and meaning: -

The relay indications are a guide to identify the type and broad location of fault. They are the means to assess the relay performance by tallying with the actual faults occurred. They help in review and analysis of the trippings occurred. Different manufacturers used different symbols/flags of signaling different types of faults.

Whenever the relays operate, their indications should be noted before they are reset

Relay indications with their meanings on various types and makes of relays are indicated in the following table.

CHART SHOWING RELAY INDICATIONS FOR VARIOUS RELAYS

S.No	Make & Type of Relay	Distance protection operated Trip.	Type of Fault with Indications				Zone Indication				Switch On-to Fault Trip	Power Swing Blocking	Carrier Relay Operated	V.T Fuse Failure
			<u>Type</u> Phase to phase	Indica-tions	<u>Type</u> Phase to Earth	Indica-tions	Z1	Z2	Z3	Z4				
1.	EE/GEC MM3V		R-Y	30(A-B)	R-E	30A		30G	30G	2/21			85X	Tripping Blocked
			Y-B	30(B-C)	Y-E	30B	30G	30H	30H					
			B-R	30(C-A)	B-E	30C			30J					
2.	MM3T		R-Y	AB	R-E	AN	Z1	Z2	Z3					Tripping Blocked
			Y-B	BC	Y-E	BN								
			B-R	CA	B-E	CN								
			R-Y-B	AB,BC,C A										
3.	RR3V		R-Y	30(A-B)	R-E	30A	30G	30G	30G					Tripping Blocked
			Y-B	30(B-C)	Y-E	30B		30H	30H	2/21				
			B-R	30(C-A)	B-E	30C			30J					
4.	MR3V		R-Y	30(A-B)	R-E	30A	30G	30G	30G					
			Y-B	30(B-C)	Y-E	30B		30H	30H	2/21				
			B-R	30(C-A)	B-E	30C			30J					
5.	MR3V		R-Y	30A	R-E	30D	30G	30G	30G					Tripping Blocked
			Y-B	30B	Y-E	30E		30H	30H					
			B-R	30C	B-E	30F			30J					
6.	SSRR3V		R-Y	A,B	R-E	A	Z1	Z1,Z2	Z1,Z 3					
			Y-B	B,C	Y-E	B				2/21				
			B-R	C,A	B-E	C								
			R-Y-B	A,B,C										

CHART SHOWING RELAY INDICATIONS FOR VARIOUS RELAYS

S.No	Make & Type of Relay	Distance protection operated Trip.	Type of Fault with Indications				Zone Indication				Switch On-to Fault Trip	Power Swing Blocking	Carrier Relay Operated	V.T Fuse Failure
			Type Phase to phase	Indica-tions	Type Phase to Earth	Indica-tions	Z1	Z2	Z3	Z4				
7.	EE/GEC PYTS		R-Y	A,B	R-E	A		Z2	Z3	Z4	SOTF	PSB		
			Y-B	B,C	Y-E	B								
			B-R	C,A	B-E	C								
			R-Y-B	A,B,C										
8.	SHPM "QUADROMHO"		R-Y	A,B	R-E	A		Z2	Z3		SOTF		AIDED TRIP	V-FAIL
			Y-B	B,C	Y-E	B								
			B-R	C,A	B-E	C								
			R-Y-B	A,B,C										
9.	LZ-96	D	R-Y	R,S	R-E	R								
			Y-B	S,T	Y-E	S								
			B-R	T,R	B-E	T		2	3	4			HF (Yellow)	
			R-Y-B	R,S,T										
10.	LIZ-6		R-Y	R,S	R-E	R,E		T2	T2, T3	T2,T3T4				
			Y-B	S,T	Y-E	S,E								
			B-R	T,R	B-E	T,E								
			R-Y-B	R,S,T										

CHART SHOWING RELAY INDICATIONS FOR VARIOUS RELAYS

S.No	Make & Type of Relay	Distance protection operated Trip.	Type of Fault with Indications				Zone Indication				Switch On-to Fault Trip	Power Swing Blocking	Carrier Relay Operated	V.T Fuse Failure
			Type Phase to phase	Indications	Type Phase to Earth	Indications	Z1	Z2	Z3	Z4				
11.	L3wyas / L3wys/ Lz3s (signal Block)	PD (D)	R-Y	PAR®, PAS(S)	R-E	PAR®P E(E)		PSII (2)	PSII PS-III (2) (3)	PSII PS-III (2) (3)	PTa		PtrH	
			Y-B	PAS(S) PAT(T)	Y-E	PAS(S) PE(E)								
			B-R	PAT(T) PAR®	B-E	PAT(T) PE(E)								
12.	L6FT	PD3										PTa5		
13.	ASEA / ABB :- RYZF C	UD												
			R-Y	R,S	R-E	R		2	2,3	2,3,4		P	CS/C R	
			Y-B	S,T	Y-E	S								
			B-R	T,R	B-E	T								
			R-Y-B	R,S,T										
14.	RAZOG	UD	R-Y	R,S	R-E	R		2	2,3	-		P		
			Y-B	S,T	Y-E	S								
			B-R	T,R	B-E	T								
			R-Y-B	R,S,T										
15.	RAZFE	U	R-Y }	2-phase	R-E	RN	Z1	Z2,	TK2,			P		
			Y-B }		Y-E	SN	Z2	TK 2	TK3					
			B-R }		B-E	TN								
			R-Y-B	3-Phase										

CHART SHOWING RELAY INDICATIONS FOR VARIOUS RELAYS

S.No	Make & Type of Relay	Distance protection operated Trip.	Type of Fault with Indications				Zone Indication				Switch On-to Fault Trip	Power Swing Blocking	Carrier Relay Operated	V.T Fuse Failure
			Type Phase to phase	Indica-tions	Type Phase to Earth	Indica-tions	Z1	Z2	Z3	Z4				
16.	ASEA/ ABB RAZOA	Trip												
			R-Y	R,S	R-E	R,N		2	2,3	2,3,4		P		
			Y-B	S,T	Y-E	S,N								
			B-R	T,R	B-E	T,N								
			R-Y-B	R,S,T										
17.	REL-100	Trip Z	R-Y	PSR,PSS	R-E	PSR,PSN	TRZ1	TRZ2	TRZ3	TRZ3R	TREF	PSB	CRZ/CBZ	VTF / VTS
			Y-B	PSS,PST	Y-E	(Trip-R)	Zm1,	Zm2,	Zm3	Zm3R	SOTF			
			B-R	PST,PSR	B-E	PSS,PSN (Trip-S)	Zm2,	Zm3		(Reverse)				
			R-Y-B	PSR,PSSP ST		PST,PSN (Trip-T)	Zm3							
18.	UE MDT-45B		R-Y	AB,ZIS	R-E	A	Z1	Z2	Z3	Z4	SOFT	PSB	RR/CS	SV
			Y-B	BC,ZIS	Y-E	B								
			B-R	CA,ZIS	B-E	C								
			R-Y-B	ABC,ZIS										
19	UE MDTB-101		R-Y	AB	R-E	A		Z2	Z3	Z4	SOFT		CAT	VTF
			Y-B	BC	Y-E	B								
			B-R	CA	B-E	C								
			R-Y-B	ABC										
20.	ER THR4PE24	PO	R-Y	r, y	R-E	r							Pt	
			Y-B	y, b	Y-E	y		1	2	3				
			B-R	b, r	B-E	b								
			R-Y-B	r, y, b										

CHART SHOWING RELAY INDICATIONS FOR VARIOUS RELAYS

S. No	Make & Type of Relay	Distance protection operated Trip.	Type of Fault with Indications				Zone Indication				Switch On-to Fault Trip	Power Swing Blocking	Carrier Relay Operated	V.T Fuse Failure
			Type Phase to phase	Indications	Type Phase to Earth	Indications	Z1	Z2	Z3	Z4				
21.	THR4PE1	PO	R-Y	r, y	R-E	r, Earth		2	3	2&3				
			Y-B	y, b	Y-E	y, Earth								
			B-R	b, r	B-E	b, Earth								
			R-Y-B	r, y, b										
22.	SIEMENS RIZ-24a		R-Y	JR,JS,R,S	R-E	JR,TM, R,M		T2	T3	T4		P		
			Y-B	JS,JT,S,T	Y-E	JS,JM,S,M								
			B-R	JT,JR,T,R	B-E	JT,JM,T,M								
			R-Y-B	JR,JS,JT, R,S,T										
23.	75A511		R-Y	LED 2,3, 12,13	R-E	LED 2,5,12	LED 7	LED 8	LED 9	LED 10			AR	
			Y-B	LED 3,4, 13,14	Y-E	LED 3,5,13								
			B-R	LED 4,2, 14,12	B-E	LED 4,5,14								
			R-Y-B	LED 2,3, 4,12,13,14										
24	IGE:- a) GCY-51A b) GCX-51A													
			R-Y	R,Y										
			Y-B	Y,B			I	II	III					
			B-R	B,R										
					R-E	R								
					Y-E	Y								
					B-E	B								

1.3.4 : DISTANCE RELAY TESTING

In testing high speed distance relays, it is important to apply simulated fault conditions suddenly, otherwise the behavior of the relay in service may be different from its behavior in test. Checking the relay characteristic by reduction the voltage or increasing the current until the relay operates is not realistic, as the voltage and current change Instantaneously in magnitude and phase angle when a fault occur in service. This causes transient mechanical, electrical and magnetic conditions in the relay which may cause it to over-reach unless its operating time exceeds 4 cycles, during which time the conditions will have disappeared.

One of the popular makes of distance relay testing equipment (EE make type ZEB) is described below in order to understand the various components in the testing equipment and procedure that should be followed for testing the distance relays.

Warning :- Wherever Main-II relays are being tested, the LBB relay for that breaker should be disenabled lest it should operated the busbar protection.

Description :

The testing equipment comprises four units.

- a) supply unit.
- b) Control unit
- c) Current transformer
- d) Fault impedance unit

Figure (2) shows the internal and external connections of the equipment.

(a) **Supply Unit** : This unit comprises the following major components.

Three single phase transformer (T1, T2 and T3) ratio 420, 400, 380/110, 63.5 volts connected delta/star to form a three phase transformer bank.

Transformer 1 is used to supply the control unit at 110 volts or 63.5 volts as desired, and is continuously rated at 12 amperes secondary output. This transformer also has a further volts secondary winding rated at 300 mA to give an auxiliary supply to the fault contractor in the control unit. Transformers 2 and 3 are used merely to supply quadrature or polarizing voltage to relays that require such voltage in addition to the normal fault voltage. These transformers are continuously rated at 1 ampere secondary output.

A fast operating electrical reset, trip relay suitable for DC supplies of 30, 110 or 220 volts. The relay is provided with indicating lamps and push buttons. The indicating lamps show the position of the trip relay and also indicate that the main AC supply is healthy. The trip relay is included so that it is operated from the distance scheme under test while the master trip relay on the relay panel is left in service with the backup protection still connected contracts of the trip relay are koved out to terminals (as to stop the external ti ming, device when timing the operation of the scheme and (b) to remove the DC negative of any auxiliary deenergised when the scheme trips.

A relay selector switch is included to quick selection of relays in the scheme. Having once connected the three voltage and current leads to the relay scheme; any one of the „measuring“ or human error when changing in connections from one relay in the scheme to another. The selector switch Connections are arranged such that when injecting into a phase to connected „measuring“ relay the fault voltage and current are supplied from transformer T1 of the main supply bank while transformers T2 and T3 supply the necessary quadrature voltage for the „starting“ relays in the scheme.

When injection into a phase to phase connected relay, the fault voltage and current are again supplied from transformer T1, while additional voltage connection for the starting relay is taken from transformer T3. This arrangement is not ideal but is sufficient to cause operation of the „starting“ relays under the fault condition which is all that is necessary.

Control Unit:-

This unit comprises the following major components :-

The source impedance (L2) tap provides a range of 0.5 to 24 Ohms. This impedance is issued to control the relay current and vary the source to line (fault) impedance ratio in confirmation with the fault impedance (L1) and (R1).

The voltage anti-transformer (T4) which is connected across the line impedance via the fault contractor, is tapped in 10% and 1% steps from 0-110%. This permits a precise setting of voltage to be applied to the relay and alarms the fault impedance to be matched to the relay impedance setting.

The load resistance which is connected in series with the line impedance via the load push button, permits the load current to be passed through the relay coils prior to a fault being applied.

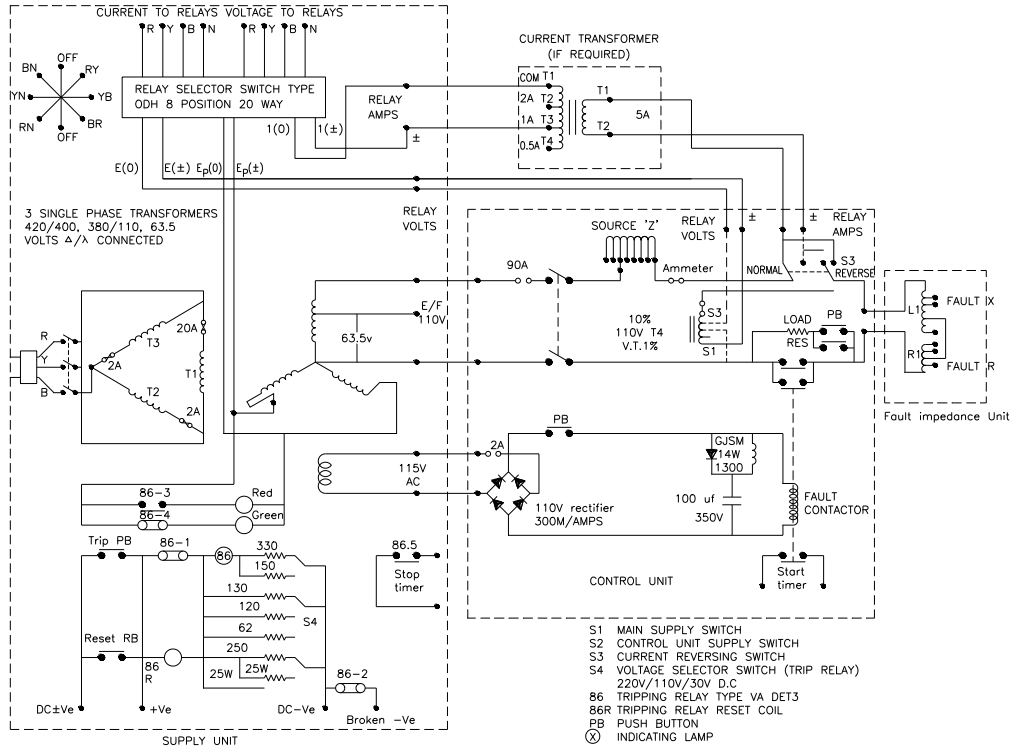
The load resistance is fixed to give a current of approximately 3.5 amperes for phase to phase faults and 2.0 amperes for phase to earth faults.

The fault contactor is energized from the 115 volts AC supply from the supply unit via bridge rectifier and push button. The contactor is fitted with an economy resistance and the coil is thus continuously started operation of the fault contactor causes current to flow from the supply unit transformer T1 via the source impedance (L2) the relay current coil and the fault impedance (L1 and R1). A normally open contact of the fault contractor is brought out to terminals to start an external timing device when required.

The current reversing switch S3 is included to enable the current supplied to the relays to be reversed and so check that the relays are measuring in the current direction.

Fault impedance unit :-

This unit represents the line impedance as seen by the relays under the fault condition. The impedance is made up from a tapped choke (L2) and tapped impedance (R1). The choke is the same type as used for the source impedance (L2) and has an Ohmic range of approx. 0.5 Ohms to 24 Ohms in 8 steps. The angle of the choke varies between approx. 72 Deg. And 82 Deg. Depending on the Ohmic tap the resistance has 15 taps are calibrated within 1% accuracy and all the data, including all the possible combinations of tappings, are tabulated in the lid of the fault impedance unit.



SCHEMATIC DIAGRAM 3 PHASE PROTABLE DISTANCE TEST SET MK11 (EE ZFB)

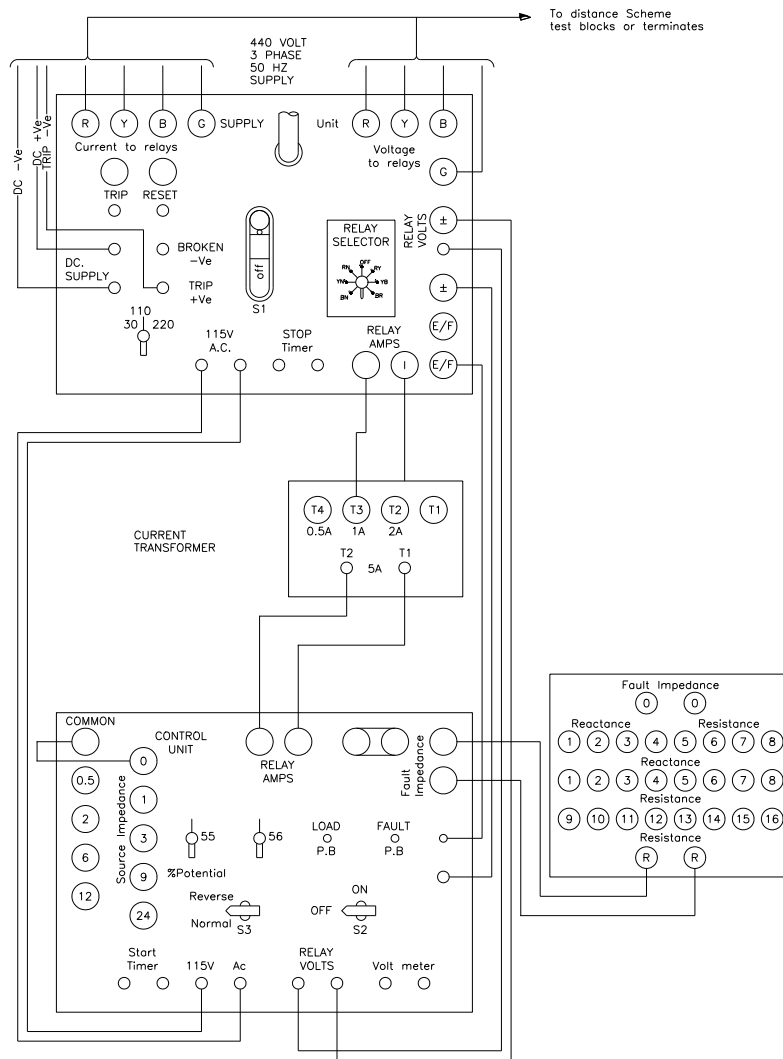


FIGURE 3

1.4 TRANSFORMER PROTECTION

1.4.1: Type of Faults

The type of faults that the Power Transformers are subjected to are classified as:

- 1) Through Faults
- 2) Internal Faults

Through Faults:-

These are due to overload conditions and external short circuits.

The Transformers must be disconnected when such faults only after allowing a predetermined time during which other protective gear would have operated. A sustained overload conditions can be detected by a thermal relay which gives an alarm so that the situation can be attended to or the supply disconnected, if necessary. For the external short circuit conditions, time graded O/C relays are generally employed. Fuses are provided for low capacity Transformers (Distribution Transformers).

Internal Faults:-

The primary protection of a transformer is intended for conditions which arise as a result of faults insider the protected zone. Internal faults are very serious and there is always the risk of fire. These internal faults can be classified into two groups.

- a) **Electrical Faults** which cause immediate serious damage but are generally detectable by unbalance of voltage or current such as phase to earth or phase to phase faults, short circuit between turns of high voltage and low voltage windings, etc.
- b) **Incipient faults** : Which are initially minor faults, causing slowly developing damage. They include:
 - i) A poor electrical connection of conductors or a core fault due to breakdown of the insulation of lamination bolts or clamping rings.
 - ii) Coolant failure which will cause a rise of temperature even below full load operation.
 - iii) Possibility of low oil content or clogged oil flow, which can readily cause local hot spots on windings.
 - iv) Bad load-sharing between transformers in parallel, which can cause overheating due to circulating currents

Generally for group (a) it is important that the faulted transformer should be isolated as quickly as possible after the fault has occurred to limit the damage to the equipment. The faults of group (b) though not serious in their incipient stage may cause major faults in the course of time and should thus be cleared as soon as possible. It should be emphasized that the means adopted for protections against faults of group (a) are not capable of detecting faults of group (b), whereas the mean applicable to detect the faults of group (b) may detect some faults in group (a) but are not quick enough. These ideas are basic to transformer protection and the means for protection against groups (a) and (b) should not be treated as alternatives but as supplements to each other.

In A.P System, the rating of Power Transformers at EHV substations in general are as follows:-

220/132 KV 100 MVA Auto Transformers.
 220/33 KV 50 KVA and 31.5 MVA Transformers
 132/66 KV 40 KVA and 27.5 MVA Transformers
 132/33 KV 50 MVA, 31.5 MVA, 25, 16, 15 & 7.5 MVA Transformers
 132/11 KV 16, 15 & 7.5 MVA Transformers

Most of the Power Transformers are of star-star type with neutral solidly earthed. There are a few Transformers with Delta-Star windings (Delta on HV side)

Norms of Transformer Protection generally followed in A.P System are indicated below.

Voltage ratio & capacity	HV Side	LV Side	Common relays
i. 132/33/11KV upto 8 MVA	3 O/L relays + 1 E/L relay	2 O/L relays + 1 E/L relay	Buchholz, OLTC Buchholz, OT, WT
ii. 132/33/11KV above 8 MVA and below 31.5 MVA	3 O/L relays + 1 dir. E/L relay	3 O/L relays + 1 E/L relay	Differential, Buchholz, OLTC Buchholz, OT, WT
iii. 132/33KV, 31.5 MVA & above	3 O/L relays + 1 dir. E/L relay	3 O/L relays + 1 E/L relay	Differential Overflux, Buchholz, OLTC Buchholz PRV, OT, WT
iv. 220/33 KV, 31.5MVA & 220/132KV, 100 MVA	3 O/L relays + 1 dir. E/L relay	3 O/L relays + 1 dir. relay	Differential Overflux, Buchholz, OLTC Buchholz PRV, OT, WT
v. 400/220KV 315MVA	3 directional O/L relays (with dir.highest) +1 directional E/L relays. Restricted E/F relay	3 directional O/L relays (with dir.highest)+1 directional E/L relays. Restricted E/F relay	Differential, Overflux, Buchholz, OLTC PRV, OT, WT and overload (alarm) relay

1.4.2 Transformer Protection – Different types of relays

- i) Buchholz relays
- ii) Differential relays
- iii) O/C & E/F relays
- iv) REF relays.
- v) Overfluxing relays

1.4.2.1 Buchholz Relays:

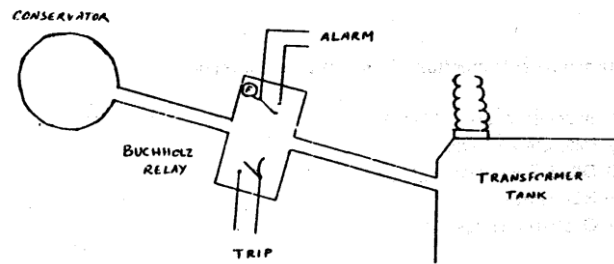
Whenever a fault in transformer develops slowly, heat is produced locally, which begins to decompose solid or liquid insulated materials and thus to produce inflammable gas and oil flow. This phenomenon has been used in the gas protection relay or popularly known as Buchholz relay. This relay is applicable only to the so called conservator type transformers

in which the transformer tank is completely filled with oil, and a pipe connects the transformer tank to an auxiliary tank or "Conservator" which acts as an expansion chamber. Figure shown as Buchholz relay connected into the pipes leading to the conservator tank and arrange to detect the gas produced in the transformer tank. As the gas accumulates or a minor fault the oil level falls and, with it a float "F" which operates a mercury switch sounding an alarm. When a more serious fault occurs within the transformer during which intense heating takes place, an intense liberation of gases results. These gases rush towards the conservator and create a rise in pressure in the transformer tank due to which the oil is forced through the connecting pipe to the conservator. The oil flow develops a force on the lower float shown as "V" in the figure and overtips it causing it contacts to complete the trip circuit of the transformers breaker. Operation of the upper float indicates an incipient fault and that of the lower float a serious fault.

Buchholz Relay Operation : Certain Precautions:

The Buchholz relay may become operative not only during faults within the transformer. For instance when oil is added to a transformer, air may get in together with oil, accumulate under the relay cover and thus cause a false operation of the gas relay. For this reason when the „Gas“ alarm signal is energised the operators must take a sample of the gas from the relay, for which purpose a special clock is provided. Gases due to faults always have colour and an odour and are inflammable.

The lower float may also falsely operate if the oil velocity in the connection pipe though not due to internal faults, is sufficient to tip over the float. This can occur in the vent of an external short circuit when overcurrents flowing through the windings over-heat the copper and the oil and cause the oil to expand. If mal-operation of Buchholz relay due to overloads or external short circuits is experienced it may be necessary that the lower float is adjusted for operation for still higher velocities.



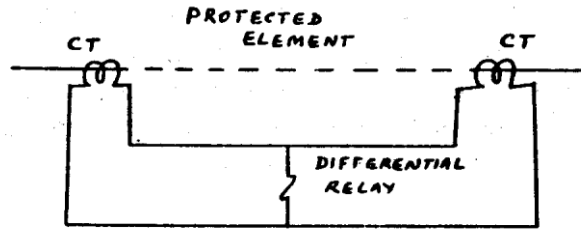
In installing these relays the following requirements should be fulfilled.

- a) The conductor connection the contacts to the terminal on the cover must have paper insulation, as rubber insulation may be damaged by the oil.
- b) The floats must be tested for air tightness by for example, submerging them in hot oil to create a surplus pressure in them.
- c) The relay cover and the connection pipe should have a slope of 1.5 to 3 percent and not have any protruding surface to ensure unrestricted passage of the gases into the conservator.

A large number of false gas protection operations may result from failure to fully observe the above precautions.

1.4.2.2 Differential relays

A simple differential relay compares the current at both ends of a protected element as indicated below:

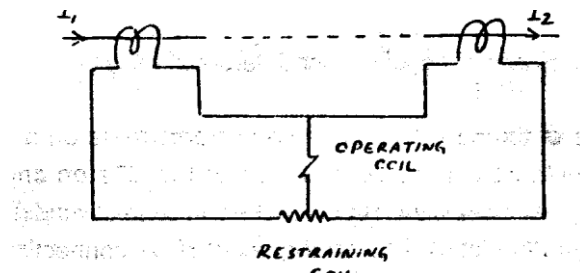


As long as there is no fault within the protected equipment the current circulates between the two CTs and no current flows through the differential element. But for internal faults the sum of the CTs secondary currents will flow through the differential relay making it to operate

Percentage Differential Relays :

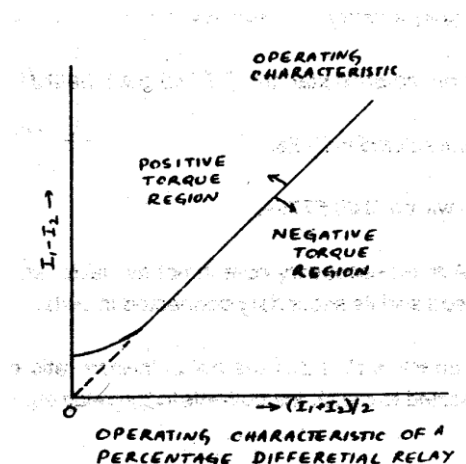
Two basis requirements that the differential relay connections are to be satisfied:

- i) It must not operated for load or external faults
- ii) It must operate for internal faults



As on-load tap change facilities are invariably provided in the grid transformers, any departure from the nominal tap position will result in spill currents in the relay circuits. Further, the CTs are often of different types and have dissimilar magnetization characteristics, again resulting in spill current during heavy through fault conditions. To avoid unwanted relays operation under the above two conditions a "Percentage bias" differential relays is uses.

The operating characteristic of percentage bias differential relay is shown in following figures



In general the transformer primary currents do not equal their secondary current and the connections of the secondary winding do not correspond to those of the primary. In order that the current flowing through the relay should nearly equal zero during normal operating conditions and when external short circuit appear, it is necessary to do everything to have secondary current of the current transformers on the transformer primary and secondary sides of equal order and coincide in phase. This is achieved by accordingly selecting the current transformer ratios, having the method of connection CTs made in conformity with the vector group of the 3-phase power transformer and by the use of additional auxiliary CTs in the scheme.

Current Transformer ratios and connections for differential relays:

A simple rule of thumb is that the current transformers on any Wye (Star) winding of a Power Transformer should be connected in delta and the CTs on any delta winding should be connected in Wye (Star). Very rarely this rule is broken. In case of winding connected in zig-zag the CTs will be connected in Wye (Star). This arrangement of CT connections will compensate for the phase shift due to power transformer vector group connection.

The significant point is that, when ground current can flow in the Wye windings for an external fault, we must use the delta connection (or resort to a “Zero-phase-sequence-current shunt” that will be discussed later). The delta CT connection circulates the Zero-phase-sequence components of the currents inside the delta and thereby keeps them out of the external connection to the relay. This is necessary because there are no Zero-phase-sequence components of current on the delta side of the power transformer for a ground fault on the wye side: therefore, there is no possibility of the Zero-phase-sequence currents simply circulating between the sets of CTs and, if the CTs on the Wye side were no delta connected, the Zero-phase-sequence components would flow in the operating coils and cause the relay to operate undesirably for external ground faults.

Transformer full load current:

$$I_n = \text{Transformer Capacity in MVA} / \sqrt{3} \times \text{Rated KV}$$

If the CTs are to be connected in Star, the C.T ratio will be $I_n/1 \text{ A}$

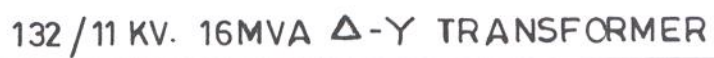
If the CTs are to be connected in Delta

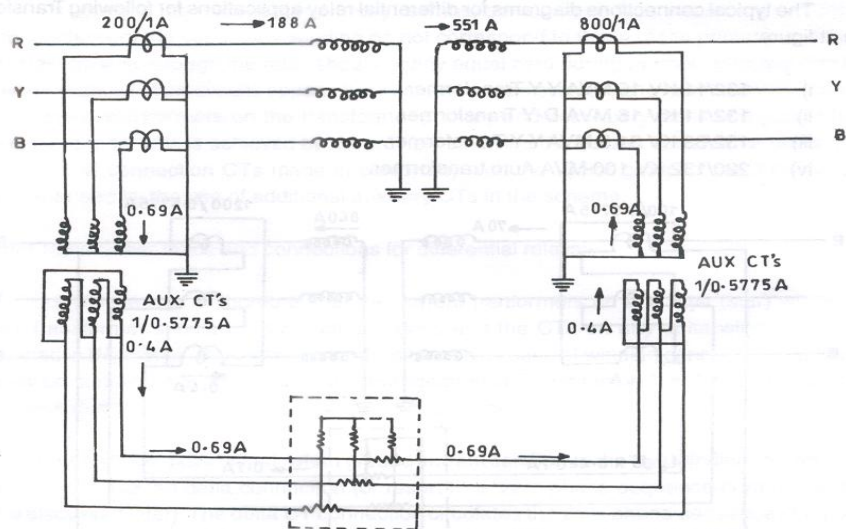
- i) The C.T Ratio will be $I_n / 0.5775 \text{ A}$
- ii) If the 0.5775 A rated secondary core is not available, an auxiliary CT of 1/0.5775 A ratio can be used and its secondary connected in delta.

If the available CTs on HV & LV sides are not in inverse ratio of voltage, auxiliary CTs of suitable ratio have to be selected to match the currents to the relay equal from both HV & LV sides.

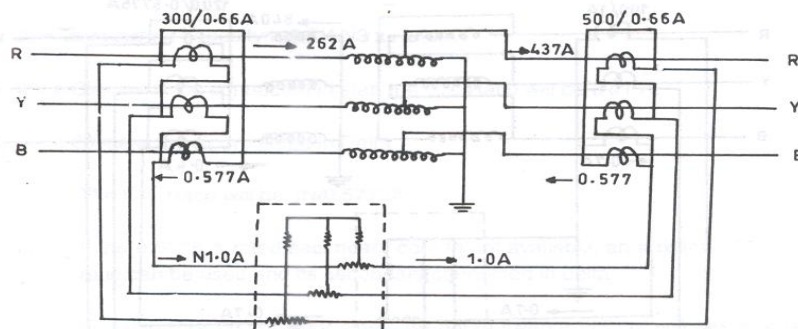
The typical connections diagrams for differential relay applications for following Transformers are at figure:

- i) 132/11 KV 16 MVA Y-Y Transformer
- ii) 132/11 KV 16 MVA D-Y Transformer
- iii) 132/33 KV 31.5 MVA Y-Y Transformer
- iv) 220/132 KV 100 MVA Auto-transformer





132/33 KV. 31.5 MVA Y-Y TRANSFORMER WITH AUX. CT's



220/132 KV. 100 MVA AUTO TRANSFORMER

Magnetizing Inrush Current:

When a power Transformer with its secondary circuit open, is switched on, it acts as a simple inductance and a magnetizing inrush current which will be several times, transformer full load current will flow. As the inrush current flows in the primary of the Transformer only, it appears to the differential relay as an internal fault.

This relay is able to distinguish the difference between the magnetizing inrush current and short circuit current by the difference in wave shape. Magnetising inrush current is characterized by large harmonic components and that are not noticeably present in the short circuit current. A harmonic analysis of a typical magnetizing inrush current wave is shown in table below:

Harmonic Component	Amplitude in percentage of fundamental
2 nd	63.0
3 rd	26.8
4 th	5.1
5 th	4.1
6 th	3.7
7 th	2.4

As seen from the above, the second harmonic component is predominant in the magnetizing inrush current.

A differential relay which extracts the 2nd harmonic current and fed to the restraining coil to make the relay inoperative due to magnetizing inrush current.

1.4.2.3 Backup O/L & E/L relays

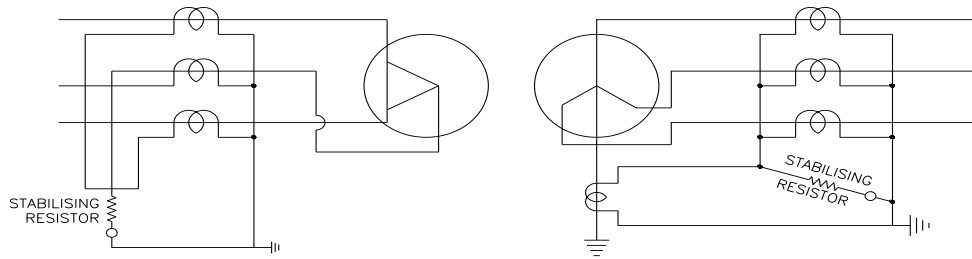
The following O/L & E/L relays are provided on Transformers in A.P System

Make of relay	HV O/L & E/L (Type)	LV O/L & E/L (Type)
EE / GEC	CDG (with highest) + CDD	CDG (without highest) + CDG (CDD for 100 MVA transformers)
ABB	ICM 21P (with highest)	ICM21 NP + ICM21 NP
ER ALIND	TJM1 (highest) + TJM12 TMAS311a + TMAS101a + TMWD (Directional element)	TJM10 + TJM10 TMAS301a + TMAS 101a

1.4.2.4 Restricted Earth Fault Protection (REF):

An earth fault in the winding is the most common type of transformer fault and is best detected by using a „restricted“ form of earth fault protection. In this way time and current setting can be made independent of other protection systems, thus low settings and fast operating times can be achieved.

The restricted scheme is a balanced system of protection and can be applied to either Star or Delta windings. The scheme connections of either types of winding are shown in figure.



RESTRICTED EARTH FAULT PROTECTION OF TRANSFORMER

For the star winding, three line current transformers are balanced against a current transformer in the neutral connection; while on the delta side, the three line current transformers are connected in parallel.

An external fault on the star side will result in current flowing in the line current transformer of the affected phase and a balancing current in the neutral current transformer, the resultant current in the relay is therefore zero. During an internal fault, the neutral current transformer only carries current and operation results.

The arrangement of residually connected CTs on the delta side of a transformer is only sensitive to earth faults on the delta side because zero sequence currents are blocked by the delta winding. For example, on earth fault on the star side transferred through the transformer appears on the delta as a phase fault. Therefore the arrangement is an inherently restricted earth fault scheme in this application.

Modern practice is to employ a voltage operated (high-impedance principle) relay for the application. The relay is set to operate with a certain minimum voltage across its terminals. The value of this operating voltage is chosen to be slightly higher than the maximum voltage which can possibly appear across the relay terminals during external fault conditions.

1.4.2.5 Overfluxing Protection : Principles & Relays in A.P System:

The fundamental equation for generation of e.m.f in a Transformer to give flux.

$$\Phi = K (E/F)$$

The Overfluxing condition in a transformer can occur during system over voltage and/or under frequency conditions (V/F). This will cause an increase in the iron loss and disproportionately great increase in the iron loss and disproportionately great increase in magnetizing current. In addition flux is diverted from the laminated core structure into the steel structural parts. In particular under condition of over-excitation of core, the core bolts which normally carry little flux may be subjected to large component of flux diverted from highly saturated and constricted region of core along side. Under such condition, the bolts may be rapidly heated to a temperature which destroys their own insulation and will damage the coil insulation if the condition continues.

The Overfluxing condition does not call for high speed tripping. The tripping can be delayed for a minute or two by which time, the conditions may come to normalcy.

Of late the margins between the operating flux density and the designed flux density are coming down due to economic consideration for the manufacturer of the Transformer. Moreover with sustained low frequency operation, the Transformers are naturally subjected to more than the rated values.

These conditions prompted provision of overfluxing relays from 80's in the system .

For following overfluxing relays are used in A.P System.

i) EE make / GTT type relay

The setting is adjustable from 1.0 to 1.25 times the rated V/F

It has defined time delay adjustable from 12 to 120 Sec.

Normal Settings :-

V/F : 1.1875 rated V/F

Time delay : 30 Sec.

ii) GEC / GTTM type overfluxing relay :

The overfluxing withstand time of Transformer is generally found to be varying inversely with the working flux density in the core.

GTTM relay with inverse time characterizing measuring element is designed to detect the overfluxing conditions taking into account the overflyuxing withstand capability of the Transformer. The highest element provides protection against severe overfluxing condition (which can be blocked when not required)

Setting ranges :

V/F (inverse) K1 : 1 – 1.25 times rated V/F

V/F (highest) K2 : 1.0 to 1.5 times K1

Operating times:

Alarm : 0.5 Sec (Fixed)

Time delayed Unit:

If follows inverse time characteristic curve. Typical operating timers are a follows:

V/F	1.01	1.05	1.1	1.15	1.2	1.25	1.3
Time in Sec.	605	149	55	24.7	9.3	5.8	4.3

iii) ABB make RATUB type overfluxing relay:-

RATUB relay is similar to GTTm relay, with adjustable inverse time characteristic to suit overfluxint withstand capability of the Transformer

Setting range:-

Operating Value : 1.5 to 3.0 V/Hz., for both alarm and tripping

Operating times :-

For alarm : 0.1 to 3.5 Sec.
 For tripping (Inverse characteristic)
 Operating time $t = 0.8 + 0.18 \times K (M-1)^2$ Sec.

Where

M = actual excitation (V/F) divided by set starting value

K = the adjustable constant (1-63) for adapting the operating time of RATUB to the excitation characteristic of the power transformer.

iv) ALIND make TMB type overfluxing relay:-

The TMB relay gives a two-level protection from the same input value, named „low - threshold“ and „high-threshold“.

When „low -threshold“ value is reached, the detector operates the starting of T2 & T3 timers. When the „Short time (T2)“ is over, the alarm output relay is energized. When the „long time“ (T3) is over, the output relay actuates the release of the “high threshold” measuring circuit.

When the „high threshold“ value is reached, the detector operates the starting of the timer T1. When the short time T1 is over, the output relay energizes the tripping of the machine.

Setting ranges :-

Low threshold	:	1.4, 1.7, 2, 2.3, V/Hz.
High threshold	:	1.8, 2.1, 2.4, 2.7 V/Hz
Fine adjustment for both	:	0, 0.05, 0.1, 0.15, 0.25 V/Hz
T1 & T2	:	1 to 10 Sec. in seps of 1
T2	:	21, 64, 96, 128, 160, 192, 224, 256, 286, 320 Sec.

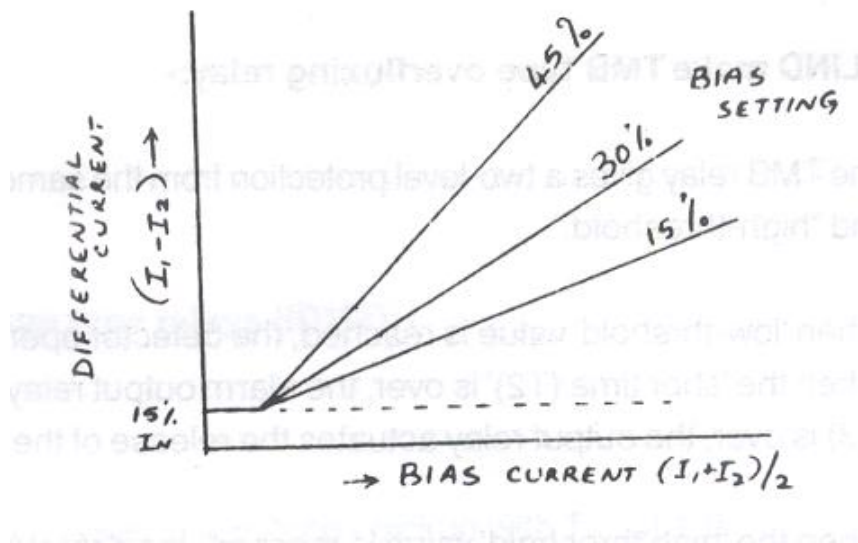
1.4.3 Differential relays IW AP System and their characteristics:**i) EE make DTH-31 relay:-**

The relay is a triple pole high speed biased differential relay, designed to protection Transformer against internal faults. This really is used for 2-winding Transformer.

Biased to provide stability during heavy through-faults. The relay utilities second harmonic restraint to prevent operation by normal magnetizing in-rush current produced when the Transformer is energized. Fifth harmonic bypass circuit is provided to avoid mal-operation under over-excited conditions.

An instantaneous highest circuit overrides the biased differential circuit to clear heavy internal faults in about one cycle.

The relay operates when differential currents exceeds 15% (fixed) relay rated current. Bias setting is adjustable to 15%, 30% or 45%. Highest circuit operates when differential current exceeds 10 times (fixed) the rated current.



ii) EE make DTH-32 relay:-

This relay used for a 3-winding Transformer is similar to DTH-31 in all aspects.

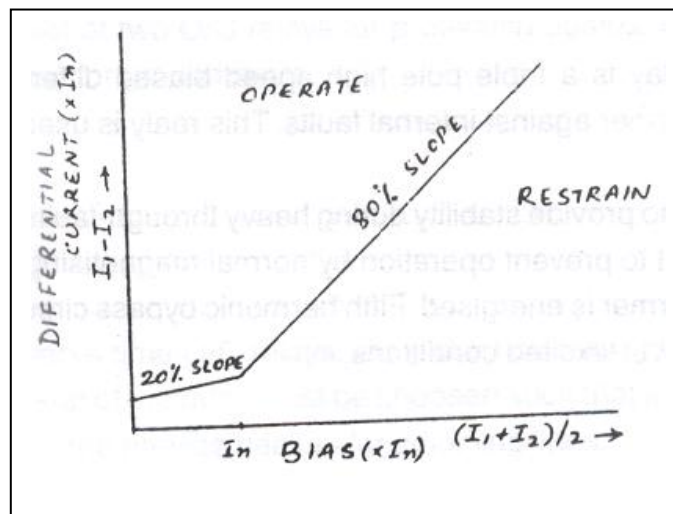
iii) GEC make MBCH-12:-

This is static relay with dual slope percentage bias restraint, having high stability during through faults even under conditions of C.T saturation and with upto 20% ratio unbalance resulting from effect of tap changing and C.T errors.

Differential current setting is adjustable between 10% and 50% of rated current in steps of 10%.

The initial bias slope is 20% from zero to rated current, which ensures sensitivity to faults while allowing a 15% ratio mismatch due to tap range, plus 5% for C.T ratio errors. Above rated current, extra mirror may be introduced due to C.T saturation and bias slope is increased to 80%.

At the inception of a through fault the transient bias is increased to more than 100% ensuring stability. During internal faults this transient bias is suppressed to ensure faster operation of the relay.



iv) ABB make RADS B type relay:-

This is having all the features of DTH relay, with non-linear percentage restraint characteristic which provided stability for external faults.

This relay has an unrestrained instantaneous module which responds to total differential current and will provide redundant operation for severe internal faults.

The two operate value of the differential relay:

The restraint operate value:

ISR – 0.20, 0.25, 0.35 & 0.5 times rated current

The unrestrained value:

ISU – 8, 13 & 20 times rated current

v) ALIND make , TMADT differential relay

In addition to the regular features, this relay is provided with multiple tap auxiliary transformers to enable current matching.

vi) E.R make 4C21 type differential relay

Biased high speed differential protection, with 2nd harmonic restraint feature.

Differential current setting (Operation)	=	20% in (fixed)
Bias setting	=	20%, 30% & 40%

The above relay is equipped with separate high-set unbiased element type „M C A A “, to operate on heavy internal fault, having a setting range of 400% to 1600%.

vii) UE make HUB type differential relay

HUB differential relay has the following features:-

- i. Second harmonic restraint to prevent operation against magnetizing in-rush current.
- ii. Fifth harmonic restraint to avoid spurious trippings on over excitation of Transformer.
- iii. Variable ratio differential characteristic to give better stability during through-fault conditions.
- iv. Mismatch tap settings of 0.58-0.65-0.72, 0.08-0.90-1.00-1.74 A are provided (both on high voltage and low voltage sides)
- v. Minimum pick-up of differential measuring unit is set to 30% (fixed)
- vi. The operating value of instantaneous highest element is fixed to 1000% of the tap value current.
- vii. Inverse bias characteristic.

1.5 : O/L & E/L RELAYS

1.5.1. Types of O/L relays:-

1) Inverse definite minimum type relays (IDMT)

a) Normal Inverse:-

- i) 3.0 sec relays – i.e., 3.0 Sec., at ten times pick-up with T.L of 1.0
- ii) 1.3 sec. relay – i.e., 1.3 sec at 10 times pick-up

b) Very inverse relays

c) Extremely inverse relays

2) Definite time relays

Instantaneous highest O/L relay supplementing the above O/c relays.

The O/L, E/L relays are used for line protection (for 11 KV to 132 KV) and for Transformer Protection.

O/C relaying is very well suited to distribution system protection for the following reasons:-

- 1) It is basically simple and inexpensive
- 2) Very often the relays do not need to be directional and hence no PT supply is required
- 3) It is possible to use a set of two O/C relays for protection against inter-phase faults and a separate O/C relay for ground faults.

1.5.2: Relay settings:

i) Pick-up settings:-

For coordination of the inverse time O/C relays, the pick-up current and time dial setting are to be chosen. The pick-up of the relay must be chosen such that it will operate for all short circuits in its own line and provide back-up for adjoining lines.

In choosing the pick-up of the O/C relay, we must also consider that under minimum fault current conditions, the multiple of pick-up (ratio of actual current to pick-up value) is not less than 1.5 so that the relay will operate reliably under such conditions. The pick-up of the phase O/C relay is selected as:

$$I_p = K_{sf} \times I_L (\text{Max}) / K_d$$

Where I_p = Pick-up current

$I_L (\text{Max})$ = Maximum load current anticipated

K_{sf} = Safety factor (1.15 to 1.3)

K_d = Drop out to pick-up ratio of the relay (0.9 to 0.95)

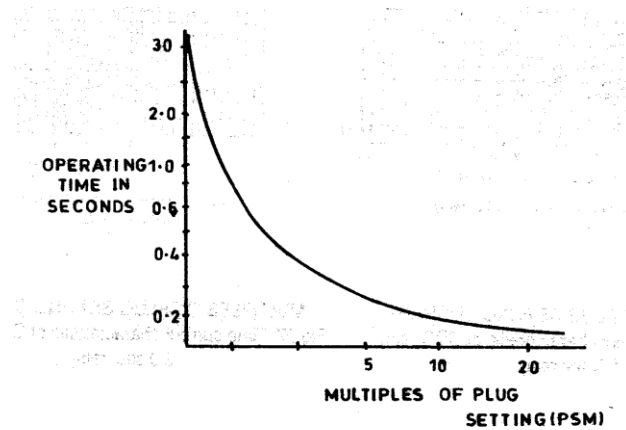
For the E/F relay, the load current is not a factor in the selection of pickup settings (for the Transformers and EHV lines), and is normally set at 20% of rated current. For distribution lines it is preferably to have higher setting since there will be a ground current normally because of unbalance load.

ii) Time Setting :-

The actual operating time of the O/C relay can be varied by proper selection of the "Time Dial Setting" which is selectable from 0.1 to 1.0.

1.5.3. Time Characteristics :-

A typical time characteristics to an IDMT relay shown below :



A family of inverse time curves for an IDMT relay with the different time dial settings is indicated below:

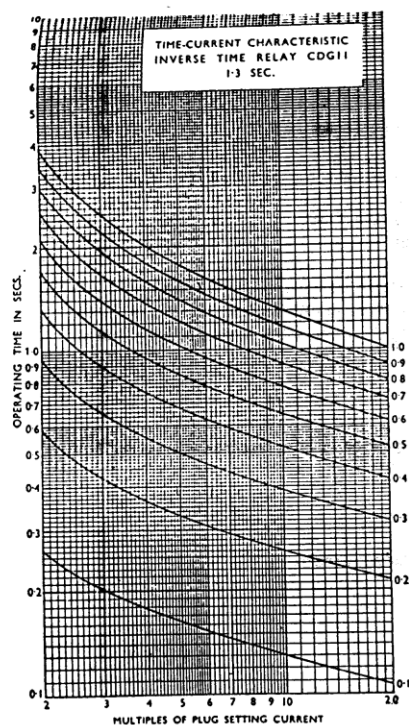


Fig. 28. Time current characteristic of CDG relay—1.3 sec. relay

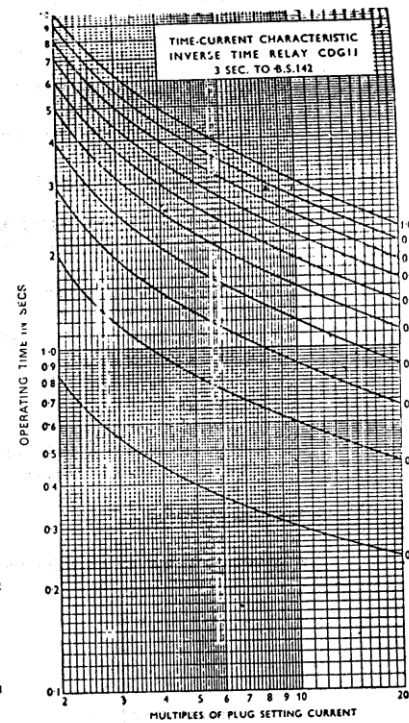


Fig. 27. Time current characteristic of CDG 11 relay 3.0 sec. relay

It may be noted that both the figures are plotted in terms of multiple of pickup (PSM) so that the same curves can be used for an value of pickup.

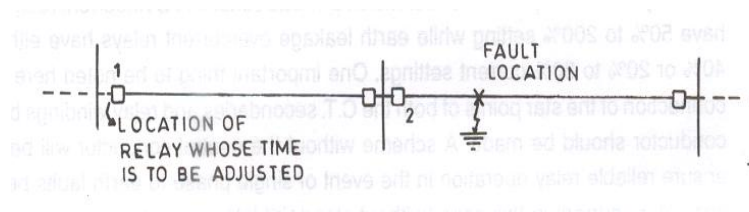
$$\text{PSM} = I_f (\text{Fault current}) / I_p (\text{Pickup current})$$

Where PSM is plug setting multiplier.

1.5.4: Selective time interval:-

The time interval between two successive breakers to provide the required selectivity is termed as selective time interval.

Consider the following:



The operating time of the relay at 1

$$\text{i.e., } t_1 = t_2 + b_2 + 0.1 + 1$$

Where t_2 = operating time of relay at 2

b_2 = breaker operating time at 2

F = factor of safety time

0.1 = overtravel time of relay at 1

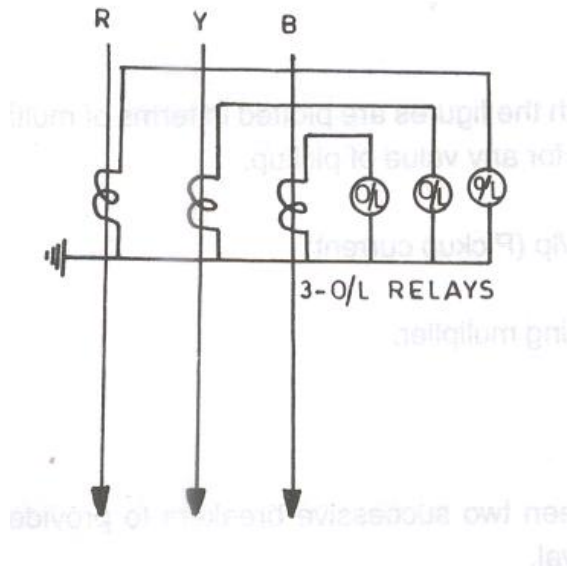
The selective time interval

$$S = b_2 + 0.1 + 1 = 0.3 \text{ to } 0.4 \text{ Sec.}$$

1.5.5: Current Transformers and Relay Connections :-

- i) Three overcurrent relays for affording protection against both phase and earth faults:-

For 3-phase faults the overcurrent relays in all the 3-phases act. For phase to phase faults the relays in only the affected phases operate. For single line to ground faults only the relay in the faulty phase gets the fault current and operates. Even then with 3-O/L relays, the sensitivity desired and obtainable with earth leakage overcurrent relays cannot be obtained in as much as the high current setting will have to be necessarily adopted for the



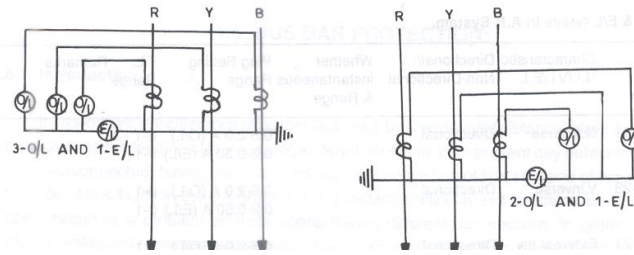
O/L relays to avoid operation under maximum load condition. Overcurrent relays generally have 50% to 200% setting while earth leakage overcurrent relays have either 10% to 40% or 20% to 80% current settings. One important thing to be noted here is that the connection of the star points of both the C.T. secondaries and relay windings by a neutral conductor should be made. A scheme without the neutral conductor will be unable to ensure reliable relay operation in the event of single phase to earth faults because the secondary current in this case (without star-point interconnection) completes its circuit through relay and C.T. windings which present large impedance. This may lead to failure of protection and sharp decrease in reduction of secondary currents by CTs. It is not sufficient if the neutral of the CTs and neutral of the relays are separately earthed. A conductor should be run as stated earlier.

ii) Three overcurrent relays and one earth fault overcurrent relays (3-O/L & 1-E/L):-

The scheme of connection for 3-O/L and 1 = E/L relays is shown in figure. Under normal operating conditions and three phase fault conditions the current in the 3-phase are equal and symmetrically displaced by 120 Deg. Hence the sum of these three currents is zero. No current flow through the earth fault relay. In case of phase to phase faults (say a short between R and Y phases) the current flows from R-phase upto the point of fault and return back through „Y “phase. Thus only 0 /L relays in R and Y phases get the fault and operate. Only earth faults cause currents to flow through E/L relay. A note of caution is necessary here. Only either C.T secondary star point of relay winding star point should be earthed. Earthing of both will short circuit the E/L relay and make it inoperative for faults.

iii) Two overcurrent relays and one earth fault relay:-

The two overcurrent relays in R&B phases will respond to phase faults. Atleast one relay will operate for fault involving two phase. For fault involving ground reliance is placed on earth fault relay. This is an economical version of 3-O/L and 1-E/L type of protection as one overcurrent relay is saved. With the protection scheme as shown in Figure complete protection against phase and ground fault is afforded



iv) Directional O/L & E/L relays:-

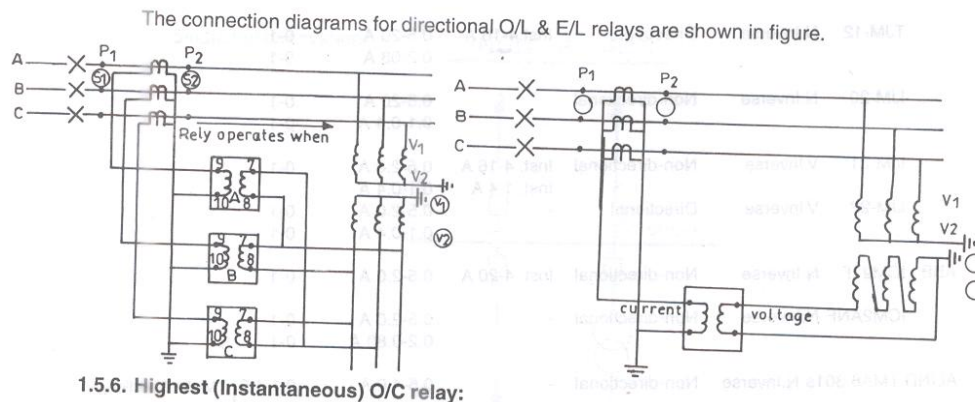
Except at locations where fault power can flow in only one direction O/C relays must be supplemented by directional elements. They have to be used to discriminate between faults for which a relay should trip and those for which it should not trip according to direction of fault. The tripping direction of the relay is away from the bus, looking into the equipment to be protected.

The directional O/L, E/L relays have to be supplied with both current and voltage.

Directional O/L & E/L relays are used for all 132 KV lines as a backup protection. Directional E/L relays are used on HV side of 132/33/11 KV Transformers and on both HV & LV side of 220/132 KV 100 MVA transformers. On 400/220 KV 315 MVA Transformers directional O/L & E/L relays are used on both HV & LV sides.

For all 33 & 11 KV feeders and lower capacity transformers non-directional O/L & E/L relays are used.

The connection diagrams for directional O/L & E/L relays are shown in figure.



1.5.6 Highest (Instantaneous) O/C relay

A highest instantaneous relay is provided in addition to the IDMT relays for the Transformer Protection.

Recently highest elements in conjunction with IDMT relays are being used on the 11 KV feeders for faster clearance of faults.

1.5.7 O/C & E/L relays in A.P System

Make	Type	Characteristic N.I / V.I / E.I	Directional / Non- Directional	Whether instantaneous & Range	Plug setting Range	T.L Range	Remarks
EE /GEC	CDD-21	N.Inverse	Directional	-	0.5-2.0A (O/L) 0.2-0.80A (E/L)	0-1 0-1	
	CDD-23	V.Inverse	Directional	-	0.5-2.0A (O/L) 0.2-0.80A (E/L)	0-1 0-1	
	CDD-24	External Inv.	Directional	-	0.5-2.0A (O/L) 0.2-0.80A (E/L)	0-1 0-1	
	CDG-11	N.Inverse	Non- Directional	-	0.5-4.0A (O/L) 0.2-0.80A (E/L)	0-1 0-1	
	CDG-13	V.Inverse	Non- Directional	-	0.5-4.0A (O/L) 0.2-0.80A (E/L)	0-1 0-1	
	CDG-14	Extremely	Non- Directional	-	0.5-4.0A (O/L) 0.2-0.80A (E/L)	0-1	
	CAG-17	-	-	Inst.5-20 A	-	-	This will be used CDD 41 & CDG21 for Transformer Protection
ER	TJM-10	N.Inverse	Non- Directional	-	0.5-200A 0.2-0.80A	0-1 0-1	
	TJM-11	N.Inverse	Non- Directional	Inst. 4-16 A	0.5-20A 0.2-0.80A	0-1 0-1	
	TJM-12	N.Inverse	Directional	Inst. 4-16 A	0.5-20A 0.2-0.80A	0-1 0-1	
	IJM-20	N.Inverse	Non- Directional	-	0.5-20 A 0.1-0.4 A	0-1 0-1	
	IJM-21	V.Inverse	Non- Directional	Inst. 4-16 A Inst. 1-4 A	0.5-2.0 A 0.1-0.4 A	0-1	
	IJM-22	V.Inverse	Directional	-	0.5-2.0 A 0.1-0.4 A	0-1 0-1	
ABB	ICM21F	N.Inverse	Non- Directional	Inst. 4-20 A	0.5-2.0 A	0-1	
	ICM2ANF	N.Inverse	Non- Directional	-	0.5-2.0 A 0.2-0.80 A	0-1 0-1	
ALIND	TMA8 301a	N.Inverse	Non- Directional	-	0.5-4.0 A	0.1- 1.0	TMWD Directional elements used for directionalising these relays
	TMA8 311b	N.Inverse	Non- Directional	Inst. 4-20 A	0.5-4.0 A	0.1- 1.0	
	TMA8 101a	N.Inverse	Non- Directional	Inst. 4-20 A	0.125-1 A	0.1- 1.0	

1.6. BUS BAR PROTECTION

1.6.1 Introduction

In olden days, the clearance of busbar faults was by time delayed distance relays or overcurrent relays, causing the feeding of fault for longer duration of time. With present day networks, which are highly interconnected, having numerous infeeds and consisting of line sections of varying lengths clearance of bus faults in zone-2 or zone-3 of a distance relay cannot be tolerated. Also selective tripping becomes a problem on installations having different bus sections. In order to maintain system stability and minimize fault damage due to high fault levels, time delayed tripping for busbar faults is not longer acceptable. It is therefore necessary to detect busbar faults selectively with a unit form of protection scheme.

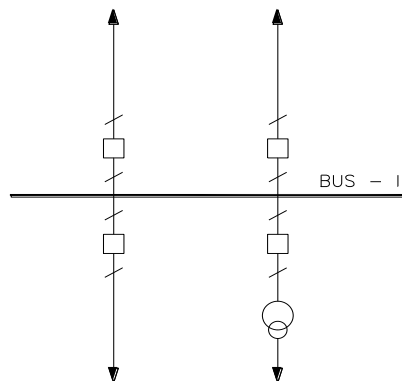
Busbar protection scheme should possess following things:-

- i) It should be completely reliable
- ii) It should be absolutely stable under all types of severe through fault conditions.
- iii) It should provide discrimination between sections of the busbars to ensure that circuits connected to fault busbar alone are isolated
- iv) It should be high speed protection so as to minimize damage and maintain system stability

1.6.2 General Busbar Arrangements

i) Single Busbar Arrangement

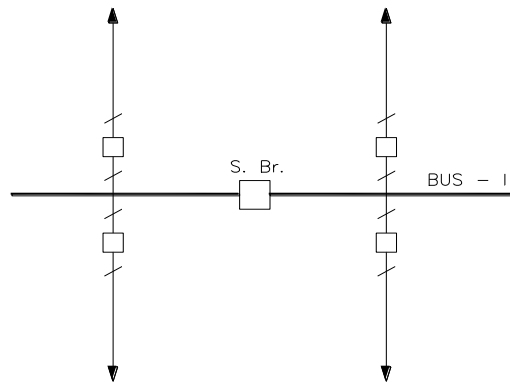
This scheme has only single busbar to which all lines/Transformers/Generators, etc. are connected. In the event of the fault or breaker failure, the entire bus has to be de-energised and a major outage occurs. It lacks operational flexibility



SINGLE BUSBAR

ii) Single Sectionalised Busbar Scheme

In this, main bus is divided into two sections with a circuit breaker. One complete section can be taken out for maintenance or for breakdown works without distribution continuity of other section.

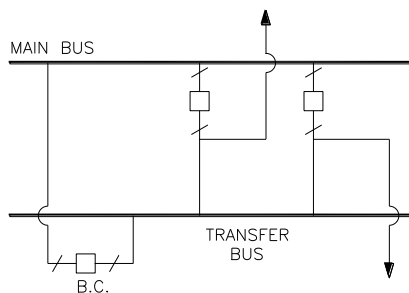


SINGLE SECTIONALIZED BUSBAR

In this, main bus is divided into two sections with a circuit breaker and isolators in between the adjoining sections. One complete section can be taken out for maintenance without disturbing the continuity of other section. Even if a fault occurs on one section of the bus, that faulty section along will be isolated while the other section continues to be in service.

iii) Main & transfer busbar scheme: -

With this arrangement, all the feeders are normally on the main bus. If at any time, a line breaker maintenance is required, that particular feeder, can be transferred on to the transfer bus. The feeder protection thus gets transferred to trip bus couple breaker. On fault occurrence or maintenance, entire bus becomes de-energised.

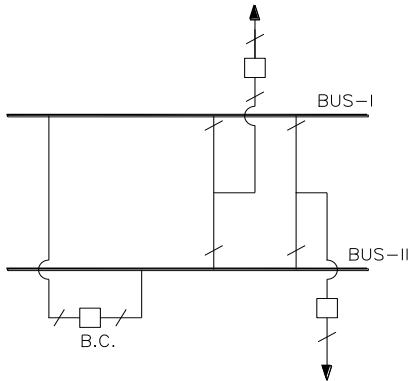


MAIN AND TRANSFER BUSBAR

Salient features:-

- a) Only one line at a time can be transferred on the transfer bus
- b) For maintenance or on fault occurrence, total bus becomes dead.

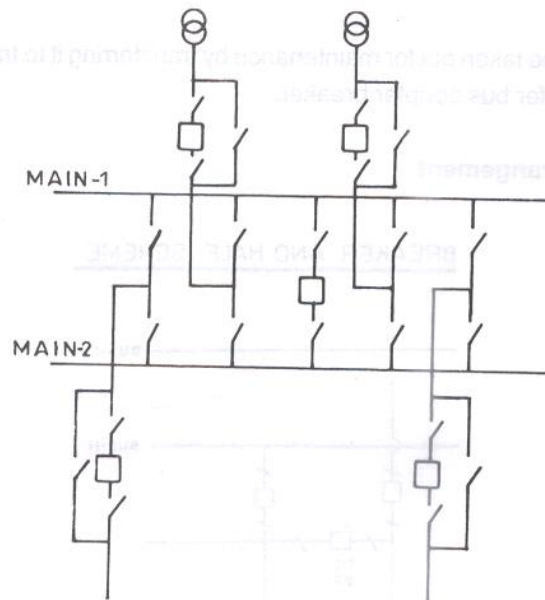
iv) Double Bus arrangement: -



DOUBLE BUSBAR

Salient features:-

- a) This has got flexibility of transferring any line to any of the buses
- b) For maintenance or on fault occurrence only one bus becomes dead while the other bus remains in service
- c) For maintenance of a breaker, that particular line has to be taken out of service. To overcome this, an additional bypass isolator is provided as indicated in figure below



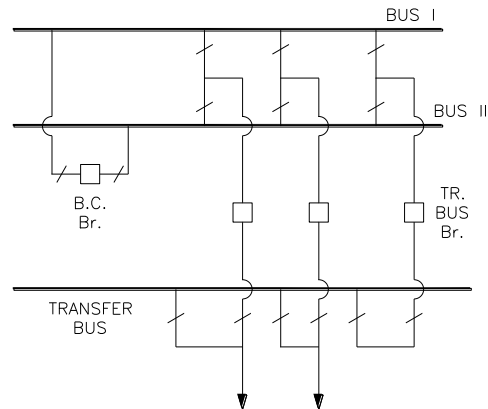
6.1.1-3

DUPLICATE BUS BAR
ARRANGEMENT

In this scheme, all other lines have to be transferred to one bus and this line breaker is bypassed by using the bypass isolator, transferring line protection to bus coupler breaker.

v) Double bus and transfer bus arrangement:-

This is combination of main and transfer bus and double bus arrangement.

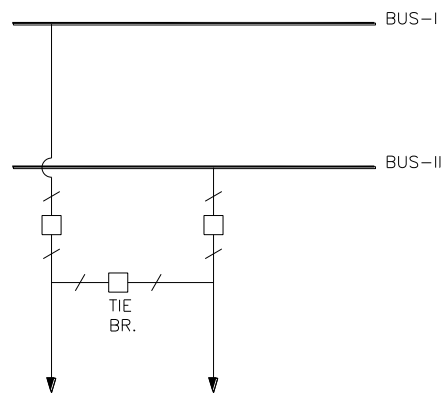


DOUBLE AND TRANSFER BUSBAR

Salient features:-

- a) This has got flexibility of transferring any line to any of the main buses
- b) For maintenance or any fault occurrence, only one bus becomes dead while other bus continues to be in service
- c) Any line breaker can be taken out for maintenance by transferring it to transfer bus, transferring its protection to transfer bus coupler breaker.

vi) Breaker and half arrangement:



BREAKER AND HALF SCHEME

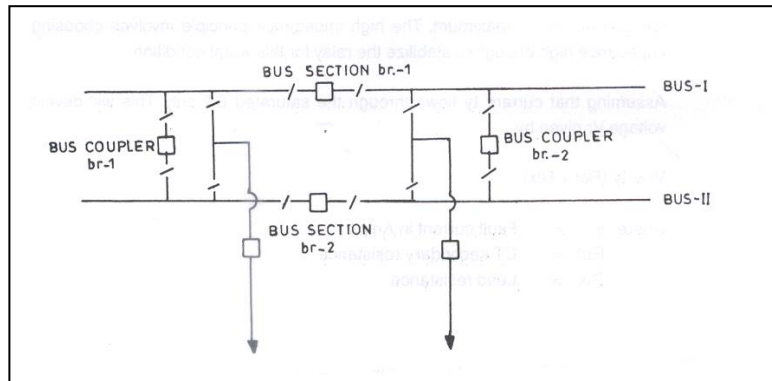
Salient features:-

- a) It has 3 breakers for two circuits.
- b) No changeover of line from one bus to the other is required.
- c) For breaker maintenance of any line, the load gets transferred to the other bus.

- d) For maintenance or an occurrence of a bus fault, all the interconnections will be on healthy bus.
- e) Even if both buses become dead, lines can still be in service through the tiebreaker.
- f) This has got many such advantages to maintain the system stability

vii) Double bus with sectional breakers:-

The 220 KV double bus at Kothagudem (A, B & C Stations) is provided with bus sectional breakers on the buses as indicated in figure below.]



This is an improvement over the double busbar arrangement. For maintenance or an occurrence of a fault, only one section of the faulty bus only becomes dead while the rest continues to be in service.

1.6.3 BUSBAR PROTECTION SCHEMES : Principles & Applications

- i) High impedance circulating current scheme
- ii) Biased differential or low impedance circulating scheme.

1.6.3.1: High Impedance circulating current protection – Principles

a) Operating Principles:-

This is a unit type of protective scheme in which the currents entering and leaving the busbar installations are compared continuously. The object is to provide fast operation at a low fault setting for internal faults and yet retain stability up to the highest possible value of short circuit current on through faults. Current transformers on each circuit of the busbar are connected in parallel (phase – segregated), which will provide a resultant current to operate a relay for faults internal to the busbars installations only. Theoretically, such a system is unaffected by through faults, but in practice, the associated current transformers may not behave ideally when the current exceeds a certain value. Errors in transformation due to saturation on the CT cores may be sufficient to cause maloperation if special precautions are not taken.

Consider the figures 1 (a) & 1 (b). Assuming that due to external fault on line X, CT X gets saturated (i.e.) produces no output. This is represented by short circuit as indicated in figure (b). This is the worst condition for the relay from stability point of view, since the spill current is maximum. The high impedance principle involves choosing an impedance high enough to stabilize the relay for this worst condition.

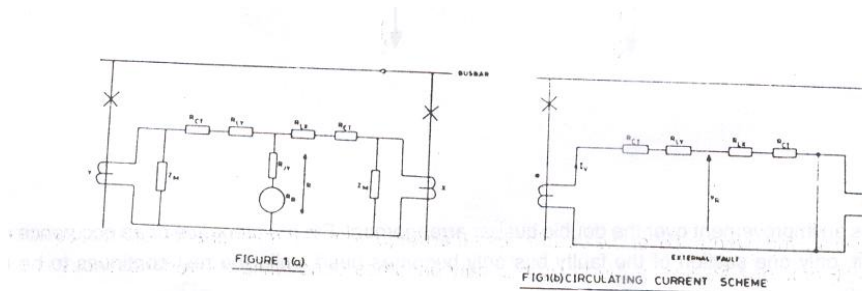
Assuming that current I_y flows through the saturated CT only. This will develop a voltage V_r given by

$$V_r = I_y (R_{ct} + R_{lx})$$

Where y = Fault current in Amps

R_{ct} = CT secondary resistance

R_{lx} = Lead resistance



The relay circuit impedance is then adjusted so that the necessary voltage to operate the relay is greater than the voltage V_R .

$$V_s = I_r * R$$

Where V_s = Setting voltage

I_r = Relay current setting

R = Relay branch impedance

To avoid relay operation for inter faults

$$V_s > V_r$$

For this, an additional resistor called stabilizing resistor R_{st} is used in series with relay coil resistance R_r

$$\text{Thus } R = R_{st} + R_r$$

During an internal fault (indicated in figure-2) the CTs will attempt to transform the full fault current and pass this through relay circuit. This will be many times the setting current and hence voltage output required from CTs will be of the order of many KVs. Practically this is not possible and CTs may get saturated. To enable faster operation of relay, this CTs should have a knee point voltage equal to atleast twice the relay setting voltage V_s .

b) Through Fault Stability

The stability limit of the scheme is based on the maximum throughfault current. As shown previously, the stability limit is governed by the relay setting voltage. Time must not be less than the stability voltage of the system, which is calculated by assuming that maximum through fault current flows through one CT and out through a second one, the latter being the most remote (and hence maximum lead resistance) from the relay associated with the Zone considered. It is further assumed that the DC component of the offset primary current completely saturates the second CT, while the first one continues to transform perfectly.

c) Check Feature

A second line of defence is considered good practice in most schemes of busbar protection, not to give security against mal-operation of the primary protection, but to prevent incorrect tripping due to damage to wiring and equipment from extraneous sources. A check feature is provided by duplication of the primary protection using a second set of current transformers on all circuits other than bus section and bus coupler units. The check system its arranged in a similar manner of the primary protection, but forms one zone only covering the whole of the busbars and does not discriminate between faults in various sections of the busbars.

d) Use of Non-linear Resistors

Under internal fault conditions the high impedance relays circuit constitutes an excessive burden to the CTs, leading to development of high voltage. The insulation of CT secondary winding and the relay will not be able to withstand these high voltages, hence it is limited to less than 3 KV peak by use of non-linear resistors called metrosils connected in parallel with the relay circuits as shown in figure-3

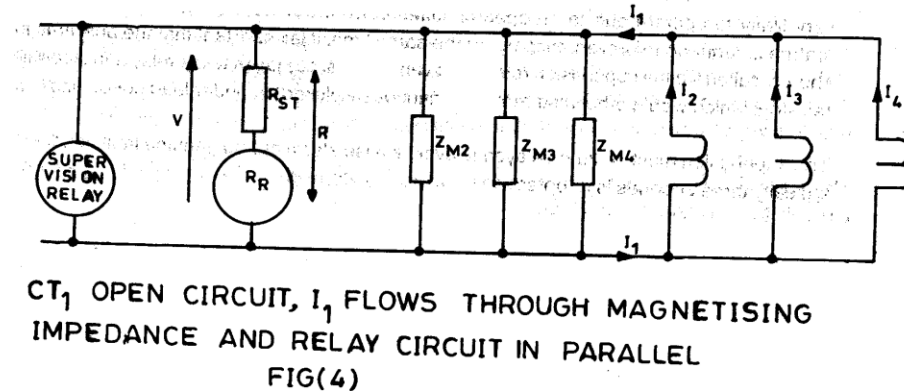
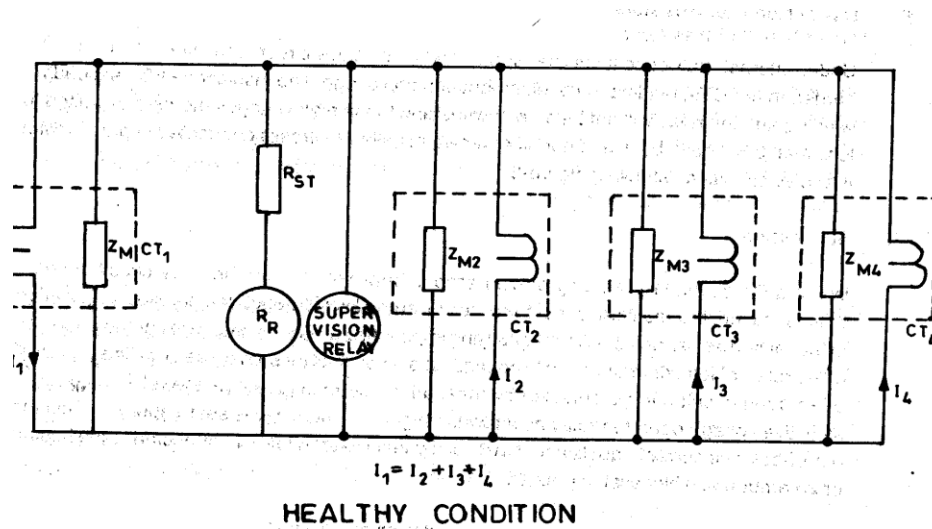
e) Supervision

When a CT secondary winding or connections between CT and the relay circuit become open circuited, the resultant out of balance current will flow through the parallel combination of the relay, metrosil and the CT magnetizing impedance. This may cause unwanted operation of the relay for load or through faults depending on the effective primary setting. This condition of an open circuit can be detected by measuring the voltage across the relay circuit by a sensitive voltage operated relay as shown in Figure.4. This relay is set to operate when the out-of-balance current equals about 10% of the least loaded feeder connected to the busbar or 25 amperes, whichever is greater.

Operation of the supervision relay is arranged to give an alarm that the busbar protection is faulty, and to short circuit the buswires if this is necessary to prevent damage to the protective relay and stabilizing resistors.

When the busbar protection has a fault setting below full load of the connected feeders, it is very likely to operate due to an open circuited current transformer. In this case, a check feature is required to prevent tripping. At the same time, it is important that the buswires are short circuited via the supervision relay to prevent thermal damages to the relay and stabilizing resistors which would otherwise remain continuously picked up under load conditions.

The supervision must be time delayed to avoid a false alarm during genuine fault conditions, typically three seconds is adopted.



1.6.3.2. High Impedance relays :-

a) GEC make CAG-34 type :-

This relay is designed for applications where sensitive settings with stability on heavy through faults is required.

It consists of Main and Check zone element.

During through faults, the voltage developed across the relay is

$$V = I_f (R_{ct} + 2R_1)$$

Where I_f = Fault current (in secondary)
 R_{ct} = Internal resistance of CT at 75°C
 R_1 = Cable resistance

EEC recommended that the operating current lop (primary) setting should be less than 30% of the minimum fault current and should be more than 130% of full load rating of heavily loaded circuit.

Once V is known, one can adjust the relay circuit and ensure that the relay operating voltage is slightly above this value. This is achieved by means of stabilising resistor SR in series with a current operated relays.

SR is computed by the formula.

$$SR = (V_{lop}) - [(VA \text{ burden of relay}) / I_{op}]$$

The range of current settings ; 10-40% of I_n .

Stabilising resistor : 0-200 Ohms.

The resistor setting may require change depending on fault level of the busbar.

It is provided with VTX31 type supervision relay which guards against faults and opening in CT secondary windings & bus wires and issues and alarm after time delay of 3 sec.

b) GEC make PBDCB relay :-

It is static scheme with main and check zone. It is five zones relay i.e. we can protect five different sections of busbar. Its operating time is 5 m Sec. It consists of

- (i) Static high impedance differential relay PVHN161 (both for main and check zone each)
- (ii) Static bus supervision relay PVHD 161.
- (iii) Bus shorting relay module RWH161.

Range for voltage setting 'Vs' : 100-348 in 32 equal steps

2	---	$V_s = (25 + V_s) \times 4 \text{ Volts}$
4	---	
8	---	
16	---	
32	---	

Supervision relay :-

Setting range :- 2-14 Volts continuously adjustable.

Trip relay is energized in operation of both the main and check zone relay.

Supervision relay PVHD161 supervises the CT open circuits and raises an alarm and shorts the differential relay.

PBDCC is same as PBDCB but provided with built-in Auto-test facility.

1.6.3.3: Low impedance biased differential relays :- Principle.

An alternative to the high impedance protection described above is the biased differential relay. This type of protection makes use of the fact that during system conditions that give rise to high spill current (namely, heavy through faults), there is high amount of circulating current as well between the in-feeding and out-feeding CT secondaries. The operating quantity in the scheme is the same as before – the secondary differential current. The total value of fault current is usually obtained by means of diodes which route all the secondary currents through the bias circuit. The resultant bias is proportional to the arithmetic sum of all the circuit current, whereas the operating circuit is energized by the vector sum of all the

circuit currents as shown in figure 5. In a biased differential relay, the operating current is arranged to increase proportionally to the load (circulating) current.

Many of the considerations application to high impedance schemes are applicable here as well. For example independent check zone in addition to the main zone and supervision element are provided in this scheme.

1.6.3.4.: Low impedance relays in A.P. System :-

i) ABB make RADSS relay :-

This is a percentage biased restraint bus differential relay. It come with factory setting.

This relay has only main zone. A separate check zone relay is not provided. A simple O/C starting relay SR is included as standard check feature in RADSS. This O/C relay is of the same high speed as that of main differential relay and has a fixed setting normally arranged to coincide with the largest line CT primary current rating.

An alarm (Supervising element) is included in the differential circuit to sense CT opening and disconnect the trip circuit after a present time delay of 5 Sec.

Relay's performance is unaffected by use of auxillary CTs.

ii) GEC make MBCZ relay :-

This is a percentage biased differential relay having main and check zones. Separate module is used each circuit breaker and also one for each zone of protection. In addition to these, there is a common alarm module (which supervises the CT secondary circuits), test unit and number of power supply units.

It has an O/C element in differential circuit to sense opening of CT secondary circuits. On CT open condition, it gives an alarm. This is time delayed of 3 Sec. So that the operation of alarm does not occur during faults either internal or external to the protected zone.

1.6.4: Some concluding Remarks :-

It must be clearly understood that the high impedance as well as low impedance schemes have their own advantages. Both are well-tried, proven methods of providing protection for the busbar.

The most obvious advantage of a high impedance scheme is the fact that it combines sensitivity to internal faults and stability during throughfaults. The scheme may be made stable to any throughfault level, and yet retain sufficient sensitivity for internal faults with weak infeeds. As it requires only very nominal current for operation, it can deal with internal faults that result in saturation of the CT. The scheme is simple and straightforward to apply.

A true low impedance scheme has the advantage that it can work with CTs of moderate output compared to a high impedance scheme. The scheme does not impose a high burden on the CT. Also, the scheme can work with CTs of unequal ratio, which is of use in some situations.

In most substations, two Class PS cores per feeder are allocated for busbar protection – one for the main zone and the other for the check zone. Whenever two cores are available, a protection scheme that utilized both the cores must be employed for busbar protection. Otherwise, one is compromising the security of the protection, as well as underutilizing available resources. A scheme that uses only one core has an inherent disadvantage - its setting must be such that no mal-operation occurs when there is an open circuitry of the CT secondary or the secondary leads.

Under this condition, the concerned zone will see an unbalance current equal to the load current flowing in the relevant feeder. To avoid unnecessary operation of the scheme, the zone settings or the setting of the check relay must be more than the maximum expected load current on any feeder in the substation. Thus, in the case of schemes that utilize only one CT core, the basic sensitivity is poorer than the load current.

When the scheme involves two CT cores, one feeding the main zone and the other feeding the check zone, the above problem does not arise. Open circuiting will affect only on the zones, and the tripping will not be through since the other zone remains stable. The chances of open circuitry occurring in two CT cores simultaneously is very remote. Hence in such a scheme, setting much lower than load current is possible.

In the same connection, it must be pointed out that schemes have check zone fed off independent CT cores are clearly superior to schemes that do not have check zones or those that cannot accommodate separate inputs for the main and check zones. First and foremost, a check zone contributes significantly to the security scheme.

1.7 : BREAKER FAILURE PROTECTION

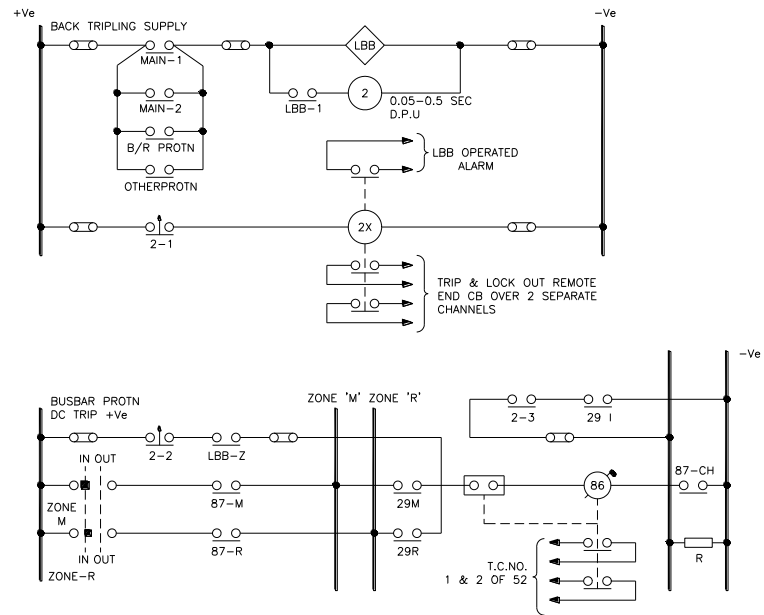
Main protective schemes provided for the line/transformer/generator are required to operate and clear the fault immediately, isolating the faulty section of the system. It is then important that the circuit breaker operates correctly, clearing the fault quickly by tripping. However, there is a risk that breaker may not trip (either due to mechanical sluggishness or due to inability to interrupt heavy fault current). Then the fault gets cleared by backup relays at remote stations.

Increasing power system complexity demands shorter fault clearing times. It is therefore necessary to provide breaker failure relay (also called “Local breaker backup relay” or “stuck breaker protection”). This scheme will isolate the bus to which the stuck breaker is connected, faster. It comprises of O/L & E/L relays with a timer. The LBB relay is energized by trip command of main protection schemes and thus initiate busbar protection scheme after elapsing of defined time. Then all the breaker connected to the bus get tripped, thus isolating faulty element.

In our system, ABB make RAICA, GEC make CTIG39 type breaker failure relays are commonly used. The general practice is to set the current setting = 20% of I_n and Time setting = 200 ms. The schematic diagrams for the application of the LBB relay (type CTIG) are indicated in the figure (a) enclosed.

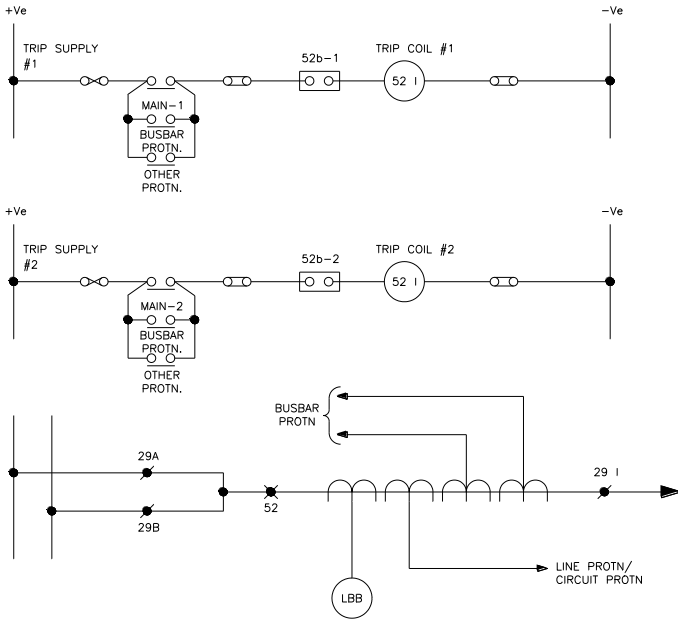
Even if the busbar protection scheme is not available, the LBB scheme can be made use of by providing special trip circuit and trip relays similar to that of bus protection trip circuits for each line. A schematic for such applications is indicated in figure (b) enclosed.

BACK TRIPPING LBB THROUGH BUSBAR PROTN, CKTS.

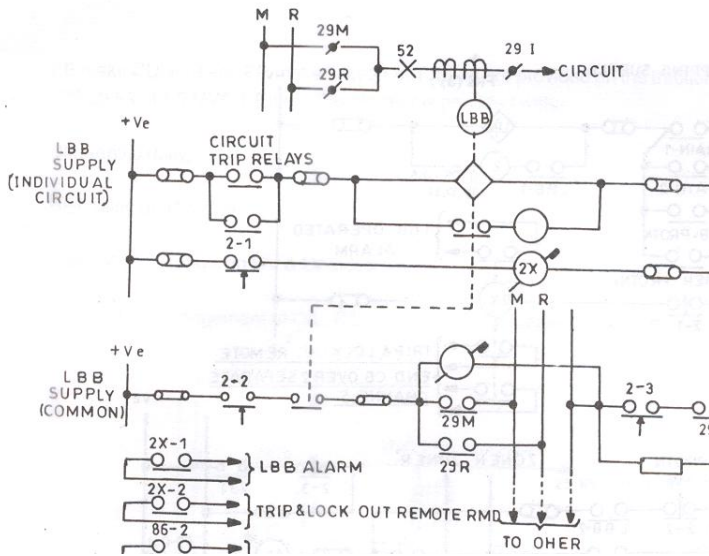


BUSBAR PROTN, CKTS.

C.B. TRIPPING



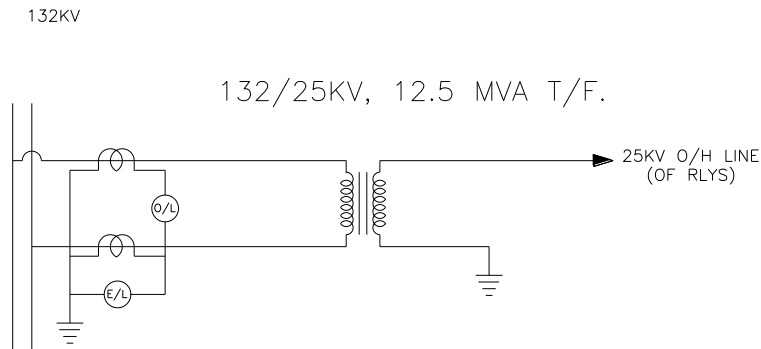
PRIMARY CIRCUITS



1.8: RAILWAY TRACTION SYSTEM

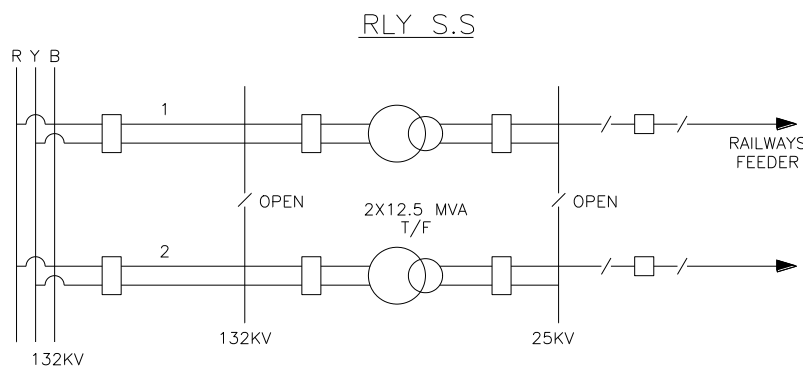
Railways avail 132 KV single phase supply (between phases R&Y or Y&B or B&R) from our 3-phase system to feed their 132/25 KV, 12.5 MVA single phase transformer whose one terminal on secondary side is earthed.

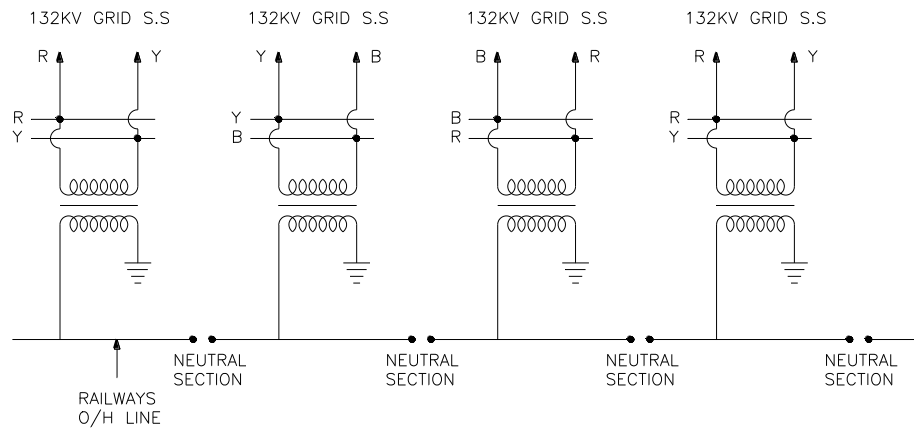
Schematic diagram of supply arrangement for AC traction system is shown below:



Railway traction avails supply through 2-phases. Double circuit line. Normally Railways avail supply on one line and one transformer. The other line is kept idle-charge from Board side and the other transformer is cent percent standby. On the transformer secondary side, one conductor is strung overhead (25 KV), while the other terminal is grounded. The railway track from the return path.

The 132KV supply between any two phases to railways will cause unbalanced loading on the system and creates some undesirable effects due to the presence of negative sequence currents. To reduce the unbalance on the 132 KV system, the feed for the adjoining railway substations are given from different phases in cyclical order (i.e.R-Y, Y-B, B-R) and hence not paralleled. A short dead section called „Neutral section“ will be created on the 25 KV overhead line of railways.





POWER SUPPLY TO RLY TRACTION

This concept of feeding adjoining Railway Substations from different phases in cyclic order was followed in Vijayawada – Madras section as well as in Waltair – Kirandul section (except in the case of similguda and Tyada substations which were fed from same station, because of ghat section and consequential difficulties to maintain the neutral section).

Protection Schemes provided:

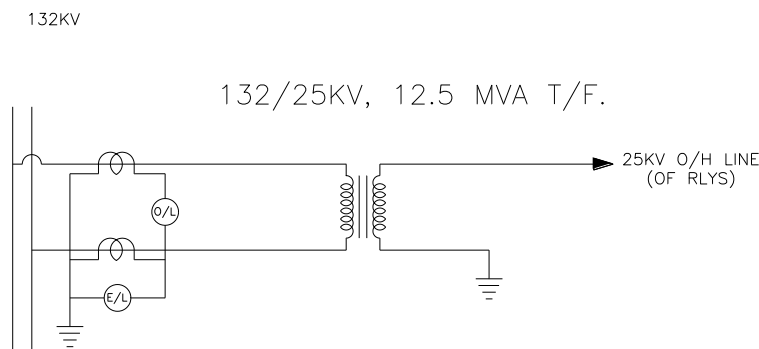
a) For 132 KV Traction feeders

Distance relay with IDMT O/L, E/L relays are provided. But most of the traction feeders are very short in length and hence are provide with very inverse O/L, E/L relays (with highest)

EE make CDG-13 and E.R make TJM-21 or TJM-22 are provided on the traction feeders. The 132/25 KV, 12.5 MVA 1-Phase Transformer is provided with:-

Differential relay,
REF relay on HV & LV
Side O/L, E/L relays on HV & LV sides.

The general arrangement of O/L, E/L relay on traction feeder is shown below:



The phase to earth fault on 25 KV side is seen as phase to phase fault on 132 KV side. Hence the E/L relay on 132 KV traction feeder need not be graded with Transformer relays and minimum plug setting and time lever settings can be adopted. Whereas the O/L relay has to be graded with Transformer HV O/L relays.

Supply to Railway traction is extended from the following substations

Sl. No.	N a m e of the B o a r d 's S u b s t a t i o n	Railway Traction station	Supply phase
1)	Vijayawada – Madras		
	Tadepalli	Krishna Canal Junction	R-Y
	Tenali	Tenali	B-R (*)
	Bapatla	Bapatla	Y-B
	220/132 KV Ongole SS	Ongole	B-R
	Kavali	Kavali	R-Y
	NTS	Padugupadu	Y-B
	Gudur	Gudur	B-R
	Sullurpet	Sullurpet	R-Y
	Renigunta	Renigunta	R-Y (*)
	Puttur	Puttur	R-Y (*)
2)	Vijayawada – Vizag		
	Eluru	Vatluru	R-Y
	Peddatadepalli	Tadepalligudem	Y-B
	Bommuru	Rajahmundry	B-R
	Peddapuram	Samalkot	R-Y
	Payakaraopeta	Tuni	Y-B
	Kasimkota	Anakapalli	B-R
3)	Vizag – Kirandul		
	Simhachalam	Simhachalam North	R-Y
	T.B Vara	S.kota	Y-B
	Araku	Tyada, Similiguda	B-R
4)	Sirpur Kagaznagar - Vijayawada		
	Sirpur Kagaznagar	Sirpur Kagaznagar	B-R
	Bellampalli	Bellampalli	Y-B (*)
	Ramagundam	Ramagundam	R-Y
	Jammikunta	Jammikunta	Y-B
	Nekkonda	Nekkonda	B-R
	Khammam	Domakal	R-Y
	Chillakallu	Bonakallu	Y-B
	Kondapalli	Kondapalli	B-R
5)	Kazipet – Hyderabad		
	Maddikonda	Kazipet	R-Y
	R.G.Palli	Ghanpur	Y-B
	Alair	Alair	B-R
	Ghanpur	Ghatkesar	R-Y
	Sanathnagar	Sanathnagar	Y-B

(*) Not contemplated earlier and commissioned later

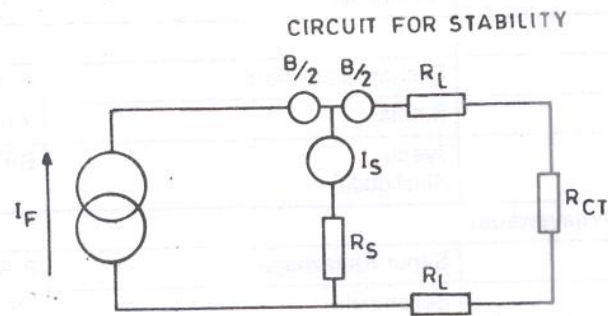
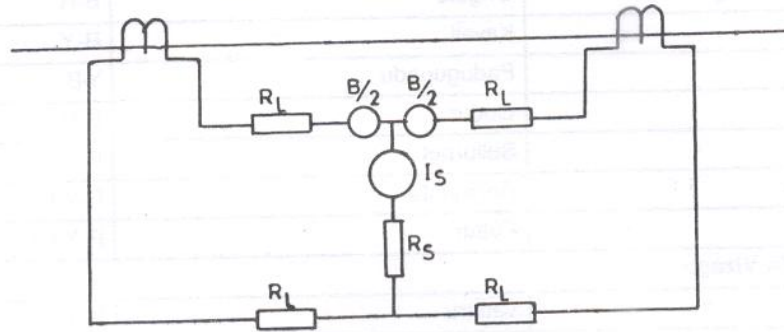


FIG-5 BASED DIFFERENTIAL CIRCUIT

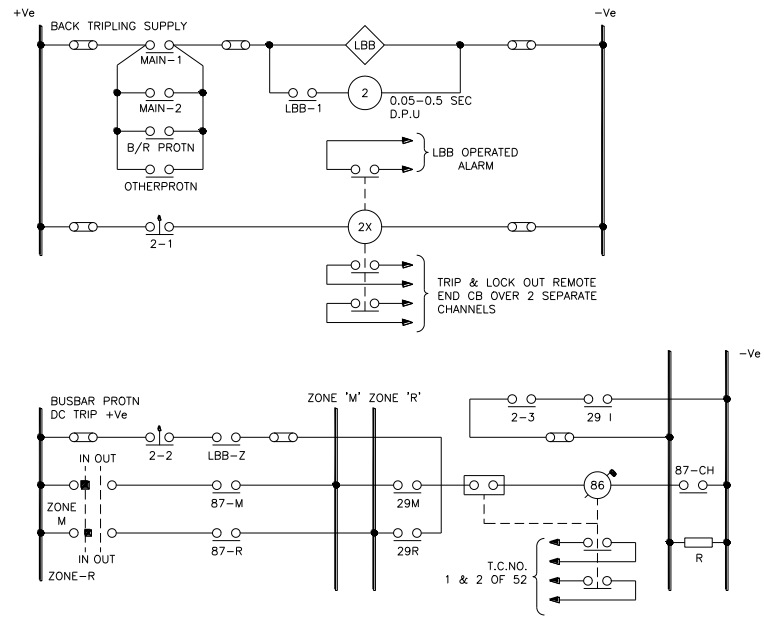
1.9: BULK LOAD FEEDER PROTECTION

For the consumers having CMD of more than 5 MVA, it is statutory to avail supply at 132 KV. These consumers avail the supply from nearest grid substation through a feeder.

As these consumers are linked to system, the consumer feeder protection is very important aspect. Most of the consumer feeders are very short in length (i.e., their substation is very close to A P T R A N S C O 's 132 KV substation)

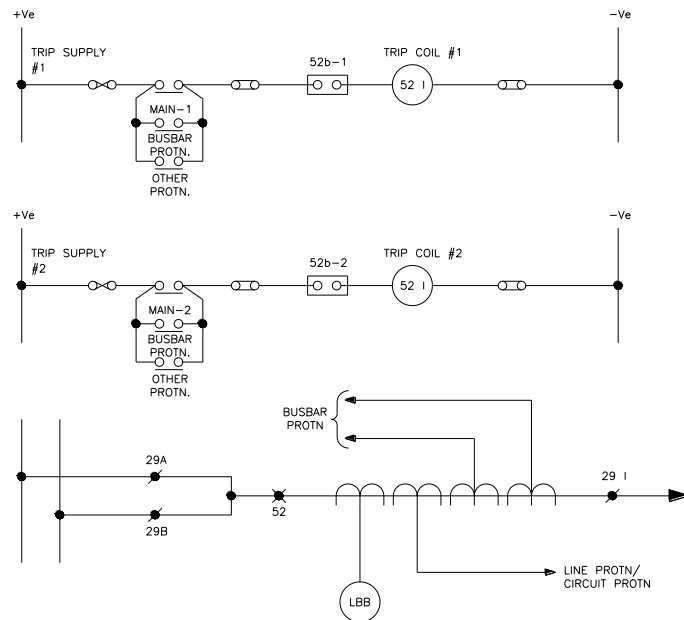
Very inverse O/L, E/L relays with highest (instantaneous) element are provided on consumer feeders. The highest element is set to cover 100% of the line and part of the consumer Transformer, to enable the relays clear the faults instantaneously for the entire line.

BACK TRIPPING LBB THROUGH BUSBAR PROTN, CKTS.



BUSBAR PROTN, CKTS.

C.B. TRIPPING



PRIMARY CIRCUITS

EXTRA HIGH TENSION TRANSMISSION LINES

EXTRA HIGH TENSION TRANSMISSION LINES

2.1 STATUTORY CLEARANCES

2.1.1 PLANNING AND CLEARANCE

The Extra High Tension Transmission Lines are covered by three categories (viz.) (i) Transmission & Distribution Scheme of Five Year Plans, (ii) Bulk Load Schemes and (iii) Special Transmission Schemes of Rural Electrification Projects. Plan lines are those proposed by the A.P. Transco for clearance by the Central Electricity Authority and Planning Commission of Government of India guided by Load Flow Studies and System Stability Conditions. The Central Electricity Authority scrutinizes the proposals of the A.P. Transco and recommends to the Planning Commission with necessary changes if any. The Planning Commission clears the E.H.T. Transmission Scheme guided by the budgetary considerations. There-upon, concerned Chief Engineer accords Technical Sanction which forms the starting point for execution of the lines. Normally the Plan lines have to be taken up for execution only after clearance by the Planning Commission. However, in case of delay in getting such statutory clearance, the lines can still be taken up for execution after obtaining administrative authorization from the A.P. Transco. The proposals for extension of supply to the prospective bulk consumers are cleared by the Electricity Board based on considerations of remuneration. The other category of EHT lines are linked up with the Rural Electrification Schemes. These lines are cleared and financed by the Rural Electrification Corporation of India under Special Transmission Schemes.

2.1.2. FIXING OF ROUTE ALIGNMENT

2.1.2.1 Reconnoiter surveys are made by the Transmission Line Construction Engineers and alignment of the power line will be finalized taking into consideration the site conditions. The route is to be got approved from the concerned Chief Engineer in Hqrs office.

2.1.3. ROUTE APPROVAL BY POWER TELECOMMUNICATION COORDINATION COMMITTEE (P.T.C.C.)

2.1.3.1 It is a statutory obligation of the Electricity Board to obtain approval of the Power Telecommunication Coordination Committee for the route of proposed E.H.T. line before its execution. The formation of this Coordination Committee is a result of recognition by the Government of the fact that a power line under fault conditions can cause L.F. inductions on the telecommunication lines, etc. in the vicinity. Also, the power lines under normal conditions cause interference currents in the single wire earth return circuits. The L.F. inductions produced in the telecommunication lines may cause fatal accidents to the personnel working on the telecommunication lines. The interference currents exceeding 10% limitation may make speech devoid of clarity. Based on the calculated values of induced voltages and interference currents, the P.T.C.C. decides the protective measures to be taken on the telecommunication lines and Railway Block Circuit etc. Approval for the route of the proposed power line will be given subject to carrying out the protective measures stipulated therein.

2.1.3.2 In order to facilitate quick clearance by the P.T.C.C. with lesser quantum of protective measures stipulated, it is necessary to judiciously choose the line alignment. It should be kept in mind that the Low Frequency induction depends on (i) Fault Level at the sending end if the proposed line is a radial one or at both ends if the line forms parallel one (ii) Soil resistances along the route of the proposed line (iii) The separation distance of telecommunication line from the power line (iv) The length of parallelism of the telecom line with the proposed power line, to the extent possible the power line may be taken away from the existing telecom lines. If the soil resistances in a particular region exceed 1,00,000 Ohm cms, it may be necessary to take alignment of the E.H.T. line away from the telecom line by a distance of 4 to 5 kms. If the region has soil resistances in the range of 5,000 to 20,000 Ohm cms., a separation distance of one to two K.M.s can still be adopted based on other site conditions. Judicious choice of the power line alignment may be made on the aforesaid conditions ensuring that the alignment so chosen shall not be longer than the „B ee“ line by 8% . To achieve this limitation, the Construction Engineer is at liberty to resort to Railway crossings and P & T line crossings, keeping in view however, the stipulated angles of crossing, electrical clearances and other design aspects.

2.1.3.3 Normally, the following protective measures are stipulated in the route approvals of the P.T.C.C.

- i) Re-Engineering of Telecommunication Lines has to be done if the L.F. induction on the telecom lines under single line to ground fault exceeds 2000 volts.
- ii) If the induction is more than 650 V but less than 2000 Volts, gas discharge tubes will be provided on the telecom lines at the cost of Power Supply undertaking.
- iii) For the induced voltages in the range between 430V and 650V, gas discharge tubes are to be provided at the cost of P & T Department.
- iv) If the interference current in the single wire earth return circuits is found to be more than 10% such S.W.E.R. circuits are to be converted to metallic return circuits.

2.1.3.4 It may be noted that clearance from Railways is necessary if it is found that their telecom lines and/or block circuits are likely to be affected due to low frequency induction. The Railway Authorities formulate the protective measures required for their telecom/block circuits which shall form part of the list of protective measures to be annexed to P.T.T.C. approval letter.

2.1.4. CLEARANCE FROM AVIATION AUTHORITIES

2.1.4.1 Clearance from the Aviation authorities is to be obtained if the towers are proposed to be erected within the Aviation Zone of one mile radius from the runway of the aerodrome. The limitations of tower height and coloured markings to be provided will be stipulated by the aviation Authorities for clearing the line.

2.1.5 P & T LINE CROSSINGS

2.1.5.1 Posts & Telegraphs Department has to give clearance for the crossing arrangement of power line with P & T lines. A detailed sketch showing profile of crossing span, angle of crossing and electrical clearance shall accompany the proposal along with the prescribed questionnaire duly answered. Clearance for the power lines will be given if the following conditions are fulfilled.

- (i) The angle of crossing of the power line with the P & T line is not less than 60°
- (ii) The nearest power conductor shall be away from the telecom line by not less than the distances tabulated below under maximum sag conditions.

For 132 KV Lines: 2.744 Mtr. (9feet).

For 220 KV Lines : 4.572 Mtr. (15 feet)

For 400 KV Lines : 4.881 Mtr. (16 feet)

2.1.6 RAIL CROSSINGS

2.1.6.1 Clearance is to be obtained from the Railway Authorities for the proposed power line crossing railway track. A sketch showing full particulars such as Vertical Clearance of the lowest power conductor over the railway track, angle of crossing and the shortest distance from the railway track from the nearest tower shall accompany the proposal for railway crossing. The prescribed questionnaire duly answered and Factor of Safety Calculations shall also be sent along with the proposals for railway crossing.

2.1.6.2 Clearance for the railway crossing will be accorded if the following conditions are fulfilled.

- i) The power line shall cross the railway track at an angle not less than 60° .
- ii) The crossing span shall not exceed 80% of the normal design span.
- iii) The minimum clearance of the lowest power conductor over the railway track shall be as per the statement 2-1 on page II-4.
- iv) The minimum distance between footing of the nearest tower and the railway track shall not be less than 1.5 times the height of the tower.
- v) The Railway crossing span shall be strung with double tension hardware fitted to the towers on either side of crossing span with dead end towers.
- vi) The foundations, structures and power conductors and earth-wire are all provided to have a minimum Factor of Safety of 2.00 under normal conditions and 1.50 under Broken Wire Conditions.
- vii) The towers shall be earthed by providing two earth pits on either side.

The clearance over the Railway Track and the bottom most conductor for different Transmission lines shall not be less than the distances below under max. sag conditions.

Statement 2-1.

For 132 KV Lines : 14.60 Metres.

For 220 KV Lines : 15.40 Metres

For 400 KV Lines : 17.90 Metres.

2.2 SURVEYS, TOWER SPOTTING AND FOUNDATIONS

2.2.1 RECONNOITRE SURVEY

2.2.1.1 Topo sheets to the scale 1" = 1 Mile or 1:50,000 covering the entire area through which proposed EHT line is likely to pass through are obtained from Geological Survey of India. The topo sheets may be joined together so that the entire line can be plotted on the combined topo sheets. Walk over survey has to be carried out touching all the salient land marks such as hillocks, tanks, railway stations/tracks, roads, rivers, etc. all along the probable alignment of the power line. Based on the findings during reconnoiter survey, the route of the proposed power line with Angle Points is marked on the topo sheets giving due consideration to the statutory requirements.

2.2.2. DETAILED SURVEYS

2.2.2.1 Detailed surveys include taking of levels in different sections of the line, each section being the portion between two angle points. The levels are taken on a graph sheet adopting the Scales 1 Cm. = 20 mtrs. Vertical. These profiles are again examined for lower spotting. After finalizing the tower schedules, check surveys are taken up.

2.2.3. TOWER SPOTTING REQUIREMENTS

2.2.3.1 For spotting of towers on the profiles (i) tower spotting requirements and (ii) sag template are needed. The tower spotting requirements are evaluated from the tower designs. These tower spotting requirements include (i) the maximum value of sum of adjacent spans, (ii) limitation of individual span on considerations of separation distance (iii) the maximum permissible weight spans for different deviation angles. (iv) whether or not vertical loads acting upward can be applied (v) normal values of wind span and weight span.

2.2.4. SAG TEMPLATE

2.2.4.1 Sag template is a tool to decide (i) tower location (ii) whether tower or tower fitted with bottom extensions to be used. A sag template is an acrylic sheet of requisite size on which sag template curves are inscribed. The sag template sheet being a white transparent one, a profile kept below it will be visible and hence facilitates to read the ground profile with reference to tower footing curve, ground clearance curve and conductor line of the sag template. The sag-template curves are virtually the span versus sag curves at maximum and minimum temperature. Three curves are drawn as per the above graph to represent (i) Tower Footing Curve. (ii) Ground clearance curve and (iii) Conductor Hot curve. There could be another tower footing line representing span versus sag curve at minimum temperature which is denoted as uplift curve, the scales to be adopted for vertical and horizontal axis shall be the same as those adopted in the profile.

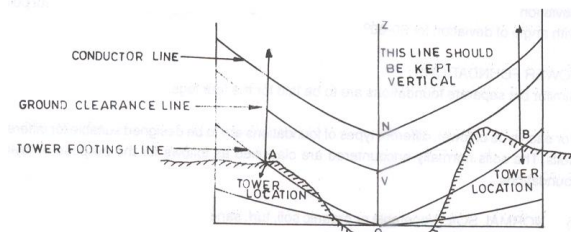


FIG. 2.1
SAG TEMPLATE APPLIED TO TOWER LINES

2.2.5 TOWER SPOTTING :

2.2.5.1 Refer to Figure 2-1 wherein application of sag template to ground profile for fixing tower locations is shown. The separation distances DN and OD shall be taken to be equal to maximum sag for normal span and ground clearance respectively as adopted in the design of towers. Having known an obligatory point „A “ on the profile it required to fix up another suitable support point „B “. For this purpose, the sag template shall be adjusted over the profile always keeping the central line „O Z “ perpendicular to the horizontal axis of the profile and at the same time ensuring that the point A on the profile touches tower footing line. It shall also be ensured that the ground profile does not cut the ground clearance line anywhere between the obligatory point „A “ and the subsequent support point „B “. If ground profile cuts the ground clearance line, it has to be checked if the normal tower fitted with 3 Metre or 6 Metre extensions can provide the required ground clearance. For this purpose, the tower footing line of the sag template shall be made to touch a point 3 mtr. Or 6 mtr. (10 ft. or 20 ft.) (reduced to scale) as the case may be vertically above the point „B “ on ground profile and it should be checked whether the ground profile is still cutting the ground clearance line. A judicious selection of the tower footing points if necessary with tower extensions can reduce the cost of project enormously while finalizing the tower schedules it is necessary to verify whether the tower locations so selected fulfil the tower spotting requirements. The profile rolls and the tower schedules so finalized and approved shall be communicated to erection agency to proceed with check survey along the proposed alignment of the power line.

2.2.6 TYPE OF TOWERS :

EHT Transmission towers are self supporting lattice structures.

2.2.6.1 There could be four types of normal towers (viz). (i) tangent towers designed as suspension tower with angle of deviation not exceeding 5° ii) 15° angle tower designed for cut point with angle of deviation for $0-15^\circ$, (iii) 30° angle tower designed for cut point with angle of deviation between $0 - 30^\circ$, (iv) Dead end tower designed for either terminal point or cut point with angle of deviation for $30-60^\circ$.

2.2.7 TOWER FOUNDATIONS :

Similar but separate foundations are to be laid for the four legs.

For each type of tower, different types of foundations are to be designed suitable for different soils. The soils normally encountered are classified as follows for the purpose of laying foundations.

- i) NORMAL SOIL : Vegetable or organic soil, turf, sand, ordinary gravel, clay, mud, black cotton soil, soft soil and loose morram.
- ii) HARD SOIL : Hard gravel, hard morram, kankar, lime stone and stone matrix.
- iii) SOFT ROCK : Decomposed rock, laterite or soft disintegrated rock which generally require chiseling, wedging and hammering, besides the use of pick axe or crowbar and spade.
- iv) HARD ROCK : The hard rock is the one which has to be excavated by drilling and blasting.

2.2.7.1 Under normal conditions the following types of foundations are adopted for the towers.

- i) Inverted frustrum with chimney and bottom concrete pad with or without reinforcement.
- ii) Stepped pads with chimney and with or without Steel reinforcement.
- iii) Mass concreting of excavated pits of designed dimensions for rocky locations.
- iv) Well foundations with anchor bolts laid in river bed locations.
- v) Pile foundations adopted in locations where soils of poor bearing capacity are met with.

The foundations to be adopted for different soils are detailed below :

- i. NORMAL DRY FOUNDATIONS : this foundation shall be adopted at locations where normal dry cohesive or non cohesive soils are met with.
- ii. WET FOUNDATIONS : This foundation shall be laid for soils wherein sub-soil water is met with at 1.5 metres more below ground level or surface water for a depth not more than 1.0 mtr. below ground level or where full depth dry black cotton soil is met with.
- iii. Partially submerged Type : This foundation is adopted at locations where subsoil water table is met at more than 0.75 metres below the ground level.
- iv. Fully submerged Type : This foundation is adopted at Locations where subsoil water is met with at less than 0.75 metres from the ground level.
- v. ROCKY FOUNDATIONS : This type of foundation shall be adopted for locations where hard rock is met with. (This foundation is designed for use in the hard rock having bearing strength not less than 66000 kgs/Sq. mtr. and for bond strength between stub angle and concrete not less than 6 kgs. Per sq. cm.) and where the bond strength between the rock and the concrete will be very high.

2.2.9. DESIGN CRITERIA FOR FOUNDATIONS

The design criteria for foundations is adopted from “Manual on Transmission Line Towers” chapter 10, Technical Report No. 9 of CBIP, December 1996 Issue and IS 456 – 1978.

2.2.9.1. The following Factor of Safety are to be adopted in the design of foundations.

132 KV and 220 KV and 400 KV LINES : 2.20 for normal Condition and 1.65 for Broken Wire Conditions.

2.2.9.2. The following loads are taken into account for designing foundations.

- i) Down thrust or compression for normal and broken wire condition.
- ii) Uplift for normal and broken wire condition.
- iii) Side thrust
 - a) Transverse for normal and Broken wire condition.
 - b) Longitudinal for normal and Broken wire condition.

2.2.9.3 The following characteristic values of different soils are adopted for the purpose of design of tower foundations

1. BEARING STRENGTH :-

- a) Normal dry soil - 27350 Kg / Sq.Mtr.
- b) Soil in wet location - 13675 Kg./Sq.Mtr.
- c) Soft Rock - 62500 Kgs/Sq.Mtr.
- d) Hard Rock - 1,25,000 Kgs. / Sq.Mtr.

2. WEIGHT OF SOIL :-

- a) Normal Dry soil - 1440 Kg. / Cu.Mtr.
- b) Soil in Wet Location - 940 Kg. / Cu.Mtr.
- c) Dry Black Cotton Soil - 1440 Kg. / Cu.Mtr.

3. ANGLE OF REPOSE :-

- a) Normal dry soil - 30°
- b) Wet Soils due to presence of soil water - 15°
- c) Black Cotton soil - 0°
- d) Soft Rock - 20°

4. LATERAL BEARING STRENGTH OF EARTH

$$\frac{1}{2} \times W \times h^2 \times B \times (1 + \sin \theta)$$

(1 - sin θ)

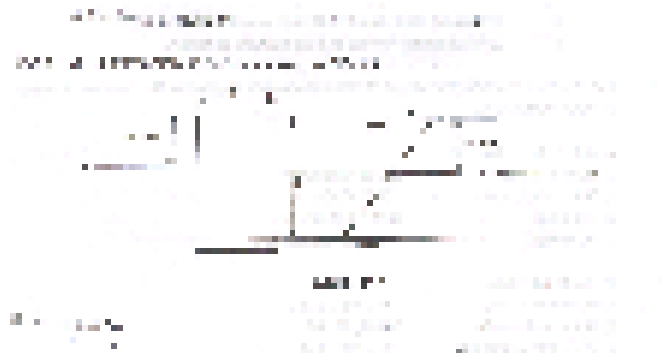
Side Thrust Force (F) = where

W = Weight of soil
 B = 0.65
 θ = Angle of earth frustrum

2.2.9.4 The following characteristic values of the concrete of 1:2:4 mix are adopted in the design of tower foundations.

1. Weight of dry concrete	= 2400 Kg. / Cu.Mtr.
2. Weight of concrete in wet and submergible location	= 1400 Kg. / Cu.Mtr.
3. The bond strength between stub angle and concrete	= 10 Kg / Cm ²
4. The maximum stress in concrete „C “	= 153 Kg. / Cm ²
5. Limit bond stress between concrete and reinforcement steel deformed Bars in Tension	= 16 Kg / Cm ²
6. The Modular Ratio „m “	= 19

Design of Reinforcement is done as shown in Fig.2.2



From the above,

$$\frac{C}{n} = \frac{t/m}{(d-n)} = \frac{t}{md(1-n)} \quad \text{OR} \quad \text{no} \quad \frac{mc}{t + mc} = 0.4286 = .43 \text{ say}$$

$$\text{Hence } n = .43 d$$

Total Cross section of reinforcement bars required is A_s

$$\text{Resistance Moment } RM = A_s \times t \times .857 d$$

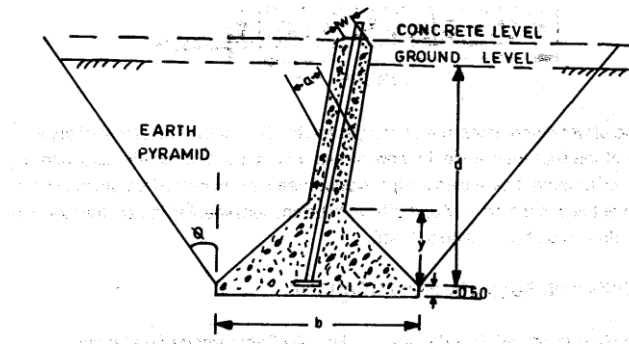
Taking into account the actual over hang provided in the reinforced bottom pad, the turning moment „M “ can be calculated .

The steel reinforcement (cross section A_s) is given by

$$A_s = \frac{M}{.857 d}$$

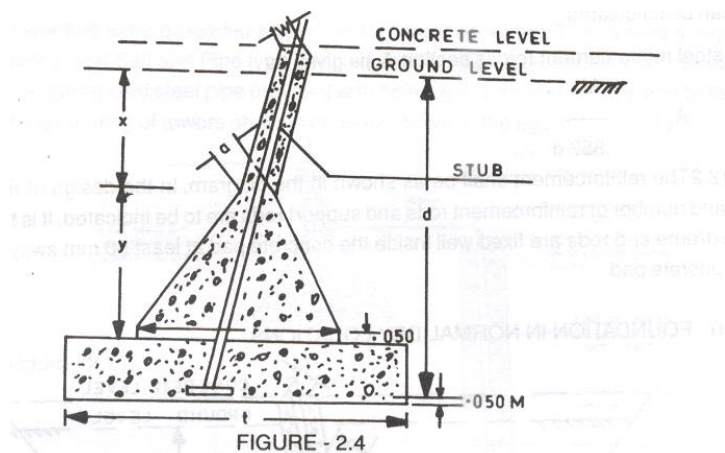
2.2.12.2 The reinforcement shall be as shown in the diagram. In the design of reinforcement, the size and number of reinforcement rods and support rods are to be indicated. It is to be ensured that the extreme end rods are fixed well inside the concrete pad at least 50 mm away from the edge of the concrete pad.

2.2.10. FOUNDATION IN NORMAL DRY LOCATIONS



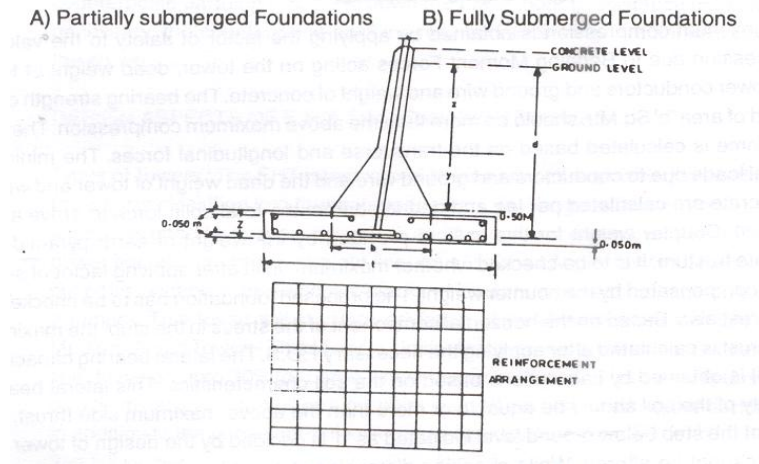
2.2.10.1 The maximum compression is obtained by applying the factor of safety to the value of compression due to Bending Moment Forces acting on the tower, dead weight of tower and power conductors and ground wire and weight of concrete. The bearing strength of the ground of area „b” Sq. M tr. should be more than the above maximum compression. The total uplift force is calculated based on the transverse and longitudinal forces. The minimum vertical loads due to conductors and ground wire and the dead weight of tower and weight of concrete are calculated per leg and deducted from the total uplift force to arrive at the net uplift. Counter weight for this uplift is provided by the weight of earth pyramid and concrete frustum. It is to be checked whether maximum uplift after applying factor of safety is fully compensated by the counter weight. The proposed foundation has to be checked for side thrust also. Based on the horizontal component of the stress in the stub, the maximum side thrust is calculated after applying the necessary F.O.S. The lateral bearing capacity of the soil is obtained by calculations based on the soil characteristics. This lateral bearing capacity of the soil should be equal to or more than the above maximum side thrust. The depth of the stub below ground level indicated as „d” is decided by the design of tower and hence cannot be altered. While choosing dimensions „a” and „w”, care must be taken to ensure that the thickness of concrete all around the stub is not less than 100 mm.

2.2.11 FOUNDATION IN WET LOCATIONS



2.2.11.1 In case of wet foundation, the bearing strength of the soil is half of dry soil and the angle of internal resistance. In view of this an additional concrete slab with or without steel reinforcement as shown in fig.2.4 underneath the inverted frustum may be provided. However, the dimension „x“, „y“ and „z“ have to be chosen, keeping in view the fixed dimension „d“ (depth of stub below ground level).

2.2.12 FOUNDATION IN SUBMERGIBLE LOCATIONS



2.2.12.1 In case of fully submergible location steel reinforcement has to be provided in view of a large bottom concrete pad and as the over-hang of bottom concrete pad is too long to be contained under compression. The dimensions t and z are determined based on the soil characteristics and the design values of compression and uplift.

2.2.13 FOUNDATIONS IN ROCKY LOCATION

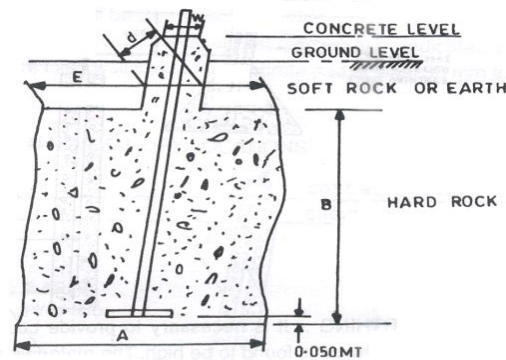


Fig. - 2.6

2.2.13.1 In view of tremendous bearing strength of rock and bond strength between stub angle and concrete, special type of foundation is to be designed providing for preparing a much smaller pit and mass concreting after stub setting. The dimension „A“ and „B“ have to be decided based on the design values of compression and uplift. The excavation in the hard limited to „A“ and „B“ within hard rock portion. After stub setting the pit in the hard rock and chimney shall be filled with concrete of 1:2:4 Mix as shown in the figure. Depending upon how deep below ground

level, the rock is met with, the stub angle may have to be cut to limit the depth of stub below ground level to (C-0.050) Mtr. It may be noted that necessary holes have to be provided at the bottom of the stub angle to fix the cleat. The remaining portion of the pit above the hard rock level shall be back filled with the excavated rock bits and earth properly rammed to form a homogenous earth pyramid. The dimension „E“ may be kept slightly less than the designed dimension „A“ to ensure rigidity of concrete block. The dimensions „d“ and „w“ of the chimney portion may normally be taken the same as those of wet foundations.

2.2.14 REVETMENT FOR FOUNDATIONS :

2.2.14.1 Revetment has to be provided for the foundations laid on sloping grounds to prevent loss of earth. The revetment or the retaining wall will protect the foundation from being exposed to running water during rains.

2.2.15 EARTHING OF TOWERS

2.2.15.1 Every tower has to be grounded as per the standard procedure. The materials required are Charcoal and Salt and Pipe type earthing set. The pipe type earthing set consists of 3 mtr. long galvanized steel pipe provided with holes, galvanised steel strip and bolts and nuts. The grounding of towers shall be done as shown in the figure.

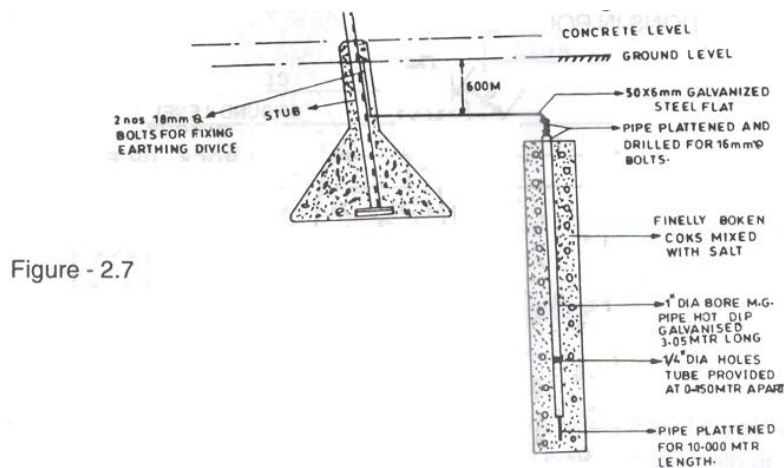


Figure - 2.7

2.2.15.2 COUNTERPOISE EARTHING :- It is necessary to provide counterpoise earthing at locations where soil resistance is found to be high. The materials required for providing counterpoise earthing are (a) 60 metres or more of 7/10 SWG G.I. Wire, (b) 4 Nos. Connecting lugs to tower legs and (c) 4 Nos. H.R.H. Bolts & Nuts. 15 Mtrs. of G.I. Wire shall be connected to each leg through the connecting lug. The four wires shall be taken radially to a distance of 15 Mtrs. duly buried in the ground. The purpose of providing the counterpoise earthing is to bring down the tower footing resistance to below 15 Ohms. If necessary, the counterpoise earthing may be run to longer radial distances to achieve the above.

2.3 DESIGN ASPECTS OF E.H.T. TRANSMISSION TOWERS

- 2.3.1. Types of Towers : The EHT transmission towers are self-supporting latticed towers. These towers are classified into four categories (viz.) (a) Tangent Tower:- This is a suspension tower designed to support the power conductors and ground wire (s) for extending the power line alignment in a straight line. (b) 15° Small Angle Tower: This tower is used at cut point location. Fitted with two stacjs of insulators per each phase duly connected by a jumper. This tower will facilitate deviation of power line alignment upto 15° (c) 30° Medium Angle Tower:- This tower is similar to the above angle tower but designed to take line deviation upto 30° (d) Large Angle Dead-end Tower :- This tower is designed for use as a terminal tower as well as a cut point support capable of taking the deviation upto 60°. In addition to the above normal towers, special structures may be used for river crossings and hill slopes.

Tower extensions to be fixed to the bottom of normal towers are also designed and fabricated for use on the lines wherever required. Normally 3 Mtr. and 6 Mtr. tower extensions are used for raising the normal tower to a vertical distance of 3 Mtr., and 6 Mtr., respectively. Special tower extensions for 9 Mtr., and 12 Mtr., elevation are also used. In addition to these, hill side tower extensions are also designed and fabricated to facilitate erection of the broad based towers in uneven hall ridges.

2.3.2 DESIGN PARAMETERS OF EHT TRANSMISSION TOWERS:-

The design of Transmission line towers is governed by the stipulations of IS 802 (Part-1 – Section 1 & 2) of 1995/92 use of structural steel in overhead transmission line towers was published in 1967 and subsequently revised in 1973, 1977 and 1995. Some of the major modifications made in revision 1995 are as follows:

- i) Concept of maximum working load multiplied by the factors of safety as per I.E rules has been replaced by the ultimate load concept.
- ii) For assuring the loads on tower, concept of Reliability, Security and Safety have been introduced on the basis of IEC 826-1991 “Technical report on loading and strength of overhead trans mission lines”.
- iii) Basis wind speeds based on peak guest velocity averaged over 3 seconds duration, as per the wind map of India given in IS 875-(Par-3) – 1987 “C ode of practice for design loads for buildings and structures (second revision)” are kept as the basis of calculating reference w ind speed. Terrain and Topography characteristics of the ground are taken into consideration in working out the design wind speeds.
- iv) Wind loads on towers and conductors have been revised. These are based on the modified wind map of the country. Reference wind speed averaged over 10 minutes duration has been used for the determination of wind loads on tower and conductor.
- v) Provisions for the temperature effects have been modified. In order to permit additional current carrying capacity in the conductor, the max., temperature in the ACSR conductor has now been permitted to be 75°C in any part of the country. For AAA Conductors, the corresponding max. temperature has been permitted to be 85°C.
- vi) Provisions for anti cascading checks have been included in the design of angle towers.

2.3.3 The towers to be used as supports for 132 KV, 220 KV and 400 KV Transmission lines are designed by adopting the following criteria.

Sl. No.	Description	132 KV lines	220 KV lines	400 KV lines
1.	Normal Span (Mtr.)	320	380 & 350	400
2.	Maximum weight span (Mtr.)	400/ 480	475, 525	600
3.	Minimum Weight span (Mtr.)	125	200	320
4.	a) Every day temperature	32 ^o c	32 ^o c	32 ^o c
	b) Maximum temperature for conductor (ACSR)	75 ^o c	75 ^o c	75 ^o c
	c) Maximum temperature for ground wire	53 ^o c	53 ^o c	53 ^o c
	d) Minimum temperature	10 ^o c	10 ^o c	10 ^o c
5.	Protection or shield angle	30 ^o	30 ^o	20 ^o
6.	Minimum midspan clearance between groundwire and top power conductor	6.1 Mtr.	8.5 Mtr.	9 Mtr.
7.	Minimum ground clearance of the bottom most conductor	6.10 Mtr.	7.0 Mtr.	8.84 Mtr.
8.	Minimum clearance of the live parts from the tower body			
	a) Suspension Insulator string when deflected	0 ^o 1.530 Mtr. 15 ^o 1.530 Mtr. 30 ^o 1.370 Mtr. 45 ^o 1.220 Mtr. 60 ^o 1.070 Mtr.	2.130 Mtr. 1.980 Mtr. 1.830 Mtr. 1.675 Mtr. ---	3.050 Mtr. (for deflection upto 22 ^o)
	b) Jumper connection on angle towers when deflected			3.050 Mtr. (for deflection upto 20 ^o)
	upto 10 ^o	1.530 Mtr.	2.130 Mtr.	1.86 Mtr. (for deflection upto 40 ^o)
	upto 20 ^o	1.070 Mtr.	1.675 Mtr.	
	upto 30 ^o	1.070 Mtr.	-	
9.	Factor of safety for design of members of tower.			
	a) Under normal conditions.	2.00	2.00	2.00
	b) Under broken wire conditions.	1.50	1.50	1.50
10.	Broken wire conditions:			
	a) For tangent towers.	Either groundwire or one of the power conductor broken.	Either groundwire or one of the power conductor broken.	Either groundwire or anyone bundled power conductor broken.

	b) For 15° and 30° angle towers	Ground wire and one of power conductor or any two power conductors broken.	Ground wire and one of the power conductor or any two power conductors broken.	Two ground wires and any one bundled conductor and one ground wire or any two bundled conductors broken.
	c) For 60° angle/ deadend towers.	Ground wire and any two power conductors or three power conductors broken.	Ground wire and any two power conductors or three power conductors broken.	Two ground wires and any one bundled conductor or one ground wire and two bundled conductors broken.

2.3.3.1 The various members of the tower can be classified into (i) main leg members including ground wire peak, (ii) Lattice member including transverse and longitudinal brackings, (iii) Horizontal and longitudinal belt members situated in the same horizontal plane as lower (compression) members of crossarms, (iv) Crossarm members and (v) redundant members and hip bracings.

The leg members are subjected to (i) Transverse forces due to (a) wind on conductors/groundwire (b) wind on tower (c) Force due to deviation in the alignment of power line at the tower location (d) Wind on insulators (ii) Vertical forces due to (a) weight of power conductors/groundwire (b) dead weight of tower (c) weight of man with kit and (d) weight of insulator strings, (iii) Longitudinal force due to tension in the broken conductor under broken wire condition only, and (iv) unbalanced vertical load under broken wire condition only.

The lattice members are to be designed for the stresses due to transverse loads, vertical loads, Longitudinal loads and torsional loads under broken wire conditions. The horizontal and longitudinal belts are to be checked for torsion due to longitudinal load. The purpose of redundant members is to reduce the unsupported length of design members thereby increasing the allowable maximum stress in that member. The crossarm members are to be checked for vertical and transverse loads.

2.3.3.2 UTLIMATE COMPRESSION STRENGTH

In respect of steel sections conforming to I.S 2062-1992 and having a minimum yield strength of 2600 KG/Sq.cm., the permissible stress on the gross section of axially loaded compression members is given by the following formulae.

a) $F = 2600 (KL/r^2) 12 \text{ Kgs/Sq.cm.}$, where KL/r is less than or equal to 120

b) $F = \frac{20,000,000}{(KL/r)^2} \text{ Kgs/Sq.cm.}$, where $KL/r > 120$

where

F = permission stress in the tower member.

KL/r = Slenderness ratio

Here again, K is fixity factor

L is unsupported length of the member

r is radius of gyration.

While " L " is decided by the design considerations, the radius of gyration " r " is obtained from the I.S.I Structural Hand Book. It is normal practice to take R_w for design calculations. The value of the fixity factor " K " depends on the physical status of the members within the tower. The value of " K " shall be taken as 1 in case of tower leg members and joint members bolted at connections in both faces and for members unrestrained against rotation at both ends of the unsupported panel for values of L/r from 120 to 200 and for members with concentric load at both ends of the unsupported panel for values of L/r upto and including 120.

For members with concentric loading at one end and normal eccentricities at the other end of the unsupported panel with values of L/r upto and including 120, the value of KL/r is taken as $30 + 0.75 L/r$.

It may be noted that the formulae 2.3.3.2 (a) and 2.3.3.2 (b) hold good for the largest width thickness ratio b/t not more than 13. Here again, " b " is defined as the distance between the edge of the root fillet and free edge of broader flange both appearing on the same flange. This dimension " b " is shown in figure - 3.9. " t " is the thickness of the section.

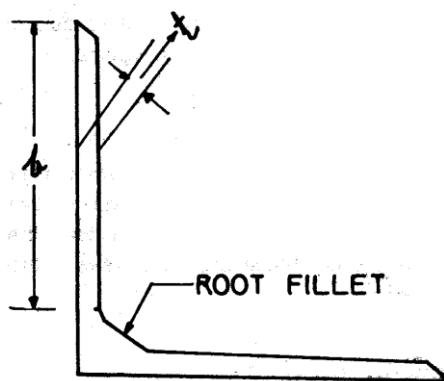


FIG. - 2.8

For values $\frac{b}{t}$ exceeding 13, the ultimate

Compression is given by the following formulae.

- (c) $F = 4680 - 160 (b/t) \text{ Kgf/Sq.cm.}$
Where $13 < b/t < 20$
- (d) $F = \frac{5,90,000}{(b/t)^2} \text{ Kgf/Sq.cm. where } \frac{b}{t} > 20$

2.3.3.3 ULTIMATE TENSILE STRENGTH :

For steel sections conforming to I.S 2062 the minimum yield strength is 2,600 KGs/ per sq.cm. This value multiplied by net sectional area of section of the member gives the permissible maximum tension in the member. The net sectional area is obtained after deducting the portions of the cross-section covered by the bolt holes.

2.3.3.4 BOLTS & NUTS :-

The number of bolts required for joining two or more members of a tower are worked out based on the maximum values of compression and tension ie., after applying factors of safety) obtaining in the member to be joined to the main member. Normally for E.H.T transmission line towers, the bolts of 16 mm dia are used. The bolts of different lengths will be required depending upon the thickness of the members to be joined. The dia of the bolt holes to be provided to the tower members shall be 17.5 mm. The centre of the bolt hole shall be away by not less than 20 mm from the rolled edge and 23 mm from the sheared edge. The bolts and nuts shall be hot dip galvanized and shall conform to IS 12427 of 1988. The bolts and nuts are to be used with galvanized spring washers of 3mm thickness. For design purpose, the maximum bearing strength of the bolts of property class 5.6 quality is taken as 6320 Kg/cm² and shear strength 3160/Kg/cm²

2.3.4 TOWER ACCESSORIES

2.3.4.1 BIRD GUARDS : These are fixed to the crossarms of tangent towers to prevent birds from perching over the insulator strings. If such provision is not made, the droplets may foul continuously with the insulator string resulting in breakdown of insulation. The bird guard is made of a 18 gauge M.S sheet. The arrangement of saw tooth type bird guard is shown in the Figure – 2.9 below.

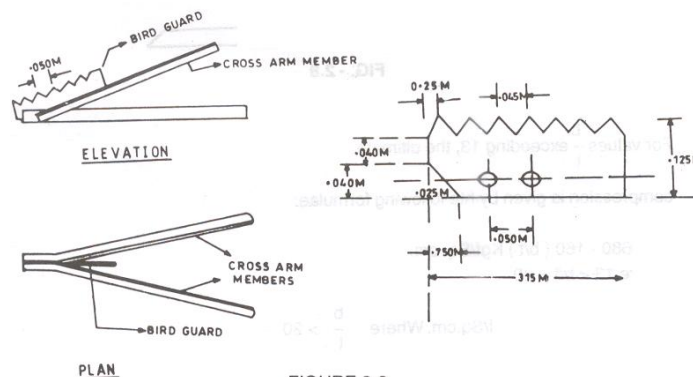
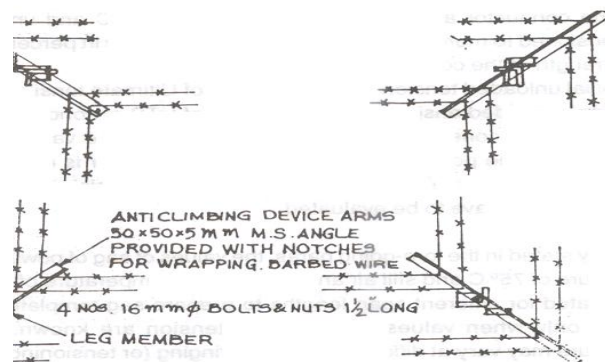


FIGURE 2-9
ARRANGEMENT OF BIRD GUARD

The dimensions indicated in the figure may be suitably altered depending upon the crossarm dimensions and arrangement.

2.3.4.2 ANTI-CLIMBING DEVICES :- These devices are provided to towers at a height of about 3.00 Mtrs. from ground at vulnerable places such as road crossings, near villages and other inhabited places. These anti climbing devices prevent persons from reaching the live power conductors or their vicinity. The anti climbing devices are made of M.S angle and barbed steel wire. The arrangement of anti climbing devices are fixed to the tower legs is shown in the Figure – 2.10.



Arrangement of Anticlimbing Devices as Fixed to Tower Legs.

2.3.4.3 DANGER PLATES :- 16 guage M.C sheet of size 200 x 325 Mtr. is used as Danger Plate. The word „DANGER“ in English and Local Language shall be inscribed on the Plate. Danger sign depicting of a skull above two bones is painted on the Danger Plate. The voltage at which the E.H.T line is charged is also indicated on the plate. Provision is made in the danger plate to fix it on the tower leg with 16mm bolts.

2.3.4.4 NUMBER PLATES :- Each tower in any transmission line is allotted a number in a serial order commencing from one terminal tower and ending with the terminal tower on the other end. The number plate is made of 16 guage sheet of 100 x 150 Mtr. Size. The number is enameled in Red on white enameled background. The number plate is fixed to the tower body at about 4 Mtrs ground level.

2.3.4.5 PHASE PLATES :- Each angle tower is provided with a set of three circular discs of 0.100 mtr. dia each enameled in Red, Yellow and Blue. These phase plates are fixed to the towers at a height of about 4 mtr., above ground.

2.4 STRINGING AND COMMISSIONING OF E.H.T LINES :-

2.4.1 Design Aspects of Tensioning of Power Conductors and Ground Wire (S)

2.4.1.1 The following shall be the basis for evaluating stringing data in respect of power conductor.

- (a) The minimum factor of safety for conductor at minimum temperature of 10°C and under full wind pressure shall be 2.00

- (b) The conductor at every day temperature of 32°C and under still air shall not be tensioned to more than the values indicated below in percentages of ultimate tensile strength of the conductor

Initial unloaded tension - 35% of Ultimate Tensile Strength of conductor

Final unloaded tension - 25% of UTS of conductor

- (c) Taking into consideration the above stipulation, the value of stress in Kgs per Sq.mm „f“ in the power conductor at 32°C and still air is decided while designing the towers. Hence the value of „f“ is fixed based on which the design aspects of power conductors have to be evaluated.

2.4.1.2 As already stated in the foregoing paras, the values of sag of power conductor at maximum temperature of 75 °C and still air and at minimum temperature of 10°C and still air have to be calculated for different span lengths to prepare sag-template. The values of sag are obtained only when values of conductor tension are known. Also, the atmospheric temperature may vary at different times of stringing (or tensioning) the conductor. In other words, the values of tension of power conductor at still air and at different temperatures ranging from 10°C to 60 °C have to be calculated. The tensions in the conductors and groundwire (s) have to be evaluated for full wind pressure at 32 °C and 2/3 full wind pressure at minimum temperature of 10 °C for arriving at the transverse and longitudinal forces acting on the tower. The following procedure shall be adopted for arriving at the tension in conductor or ground wire at a given temperature and wind pressure and for a given span length (equivalent span).

Let the stress in power conductor at every day temperature of 32°C and still air be „f“ kg per sq.mm for normal span „l“ mtrs. These values of „f“ and „l“ are decided for design of towers and shall form basic design criteria. It is now required to evaluate value of stress „f2“ in the power conductor at temperature T2 and wind pressure P2 for a span length of „l2“. The relationship between the values of „f“ and „f2“ in terms of other quantities is given by the following equation.

$$f_2 \left\{ \frac{f_2 - (f - E \alpha t - I^2 K^2 q^2 E)}{24 f^2} \right\} = \frac{I^2 K^2 Q_2^2 E}{24}$$

Where $K = W / A$

Where E = Final Modulus of Elasticity Kg/cm,

α = Co-efficient of linear expansion per °C

$t = T_2 - 32$

l = Normal span.

l_2 = Span for which stress „f2“ is to be calculated

k = Unit weight of conductor = W/A Kg/Mtr/Sq.mm

Here again, „W“ is weight of conductor/ground wire per metre length and „A“ is area of cross section in square millimeters. q and q_2 are loading factors.

$$q^2 = \frac{P^2 + W^2}{W^2} \quad \text{and} \quad q_2^2 = \frac{P_2^2 + W^2}{W^2}$$

Here P and P2 are wind pressures.

The value of „p“ is considered to be equal to zero as the stress „f“ pertains to still-air condition.

$$\text{Thus } q^2 = \frac{0 + W^2}{W^2} = 1 \text{ or } q = 1$$

$$\text{But } q_2 = \frac{\sqrt{P^2 + W^2}}{W}$$

As all the other values are known in the above equation, the values of f2 can be calculated for different span lengths at any given temperature or at different atmospheric temperatures for any given span at still air as well as at full wind.

2.4.1.3 STRINGING CHARTS : Also known as Sag-Tension Charts, these charts are required for deciding the value of tension to be applied to power conductor/ground wire at two consecutive angle points. A typical stringing chart is shown in Figure 2.11.

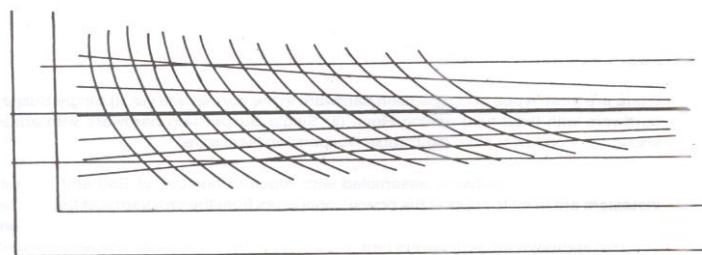


FIGURE - 2.11
SAG-TENSION CHART

The Sag-Tension chart consists of two sets of graphs (viz) (i) Span Vs. Tension for different atmospheric temperatures and (ii) Sag Vs. tension for different span lengths. It may be noted in this connection that the values of tensions for a given span may be taken from the tension statements pertaining to different temperatures. It is also to be noted that the value of span length in the span vs. tension curves is actually the equivalent span „l“ which is given by the following formula.

$$\text{Ruling span } l = \sqrt{l_1^3 + l_2^3 + l_3^3 + \dots} \div \ln$$

Where l₁, l₂, l₃, etc., are the individual spans between two consecutive tension points or in other words between two angle locations. The Sag Vs. Tension curves in the chart correspond to different values of individual spans.

HOW TO READ THE CHART :- It is required to know the quantum of tensioning to be made to the conductors/groundwire at angle towers on either side. The equivalent span shall be arrived at the site temperature is known. Choose the value of temperature indicated in the Chart nearest to the site temperature. Choose the Span Vs. Tension Curve corresponding to that nearest temperature. Read the value of tension in Kgs corresponding to the equivalent span. Note this point at „S“ the conductors/steel wire is to be tensioned to this value of tension at the two angle

towers. In between the two angle towers, there are individual spans. It is now required to know how much sag should be allowed in each individual span. Choose the tension vs. sag curve corresponding to the value of span length nearest to the individual span for which sag is to be computed. Draw a horizontal line from the above point S to cut the above chosen tension vs. sag curve. From the point at which the curve is cut, draw a vertical line and read the value of sag in respect of other individual spans between the two angle towers.

2.4.4 LINE MATERIALS FOR STRINGING POWER CONDUCTORS

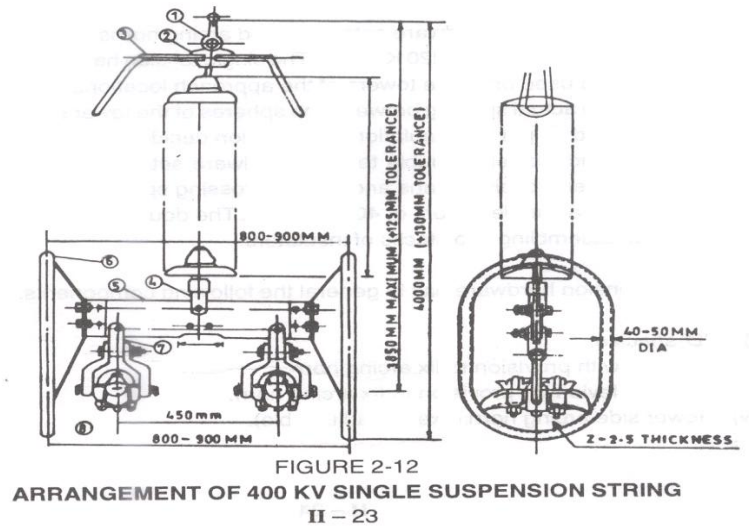
2.4.4.1 SUSPENSION HARDWARE

There are three types of Suspension hardware in the normal use viz., (i) Single Suspension hardware with fixed type arcing horn (ii) Single Suspension hardware with adjustable arcing horn on tower side (iii) Double Suspension Hardware

Single Suspension hardware assembled with required number of Ball and Socket type insulators are used to support the power conductors from the crossarms of tangent towers. The single suspension hardware provided with adjustable arcing horns on tower side are used on approach tangent towers near the substations. The double suspension hardware assembled with two stacks of insulators are used for the tangent towers on either side of river crossing spans, road crossing span etc.

The components of single suspension hardware are indicated below.

1. Ball hook with provision to fix adjustable or fixed arcing horn
2. Socket clevis to fix ball hook to yoke plate in case of double suspension hardware
3. Two yoke plates – one connecting two ball clevises to the two stacks of insulators and another connected to two socket clevises which are in turn connected to the bottom most insulators of the two insulators stacks. The bottom yoke is also connected to the suspension clamp through clevis-clevis or clevis link. Provision is made in the bottom yoke to fix line side arcing horns. All these components are required for double suspension hardware set.
4. In case of single suspension hardware the bottom most insulator is connected to the suspension clamp through socket clevis which has provision to fix line side arcing horns.
5. One set of line side arcing horns
6. One set of tower side arcing horns is provided in case of 132 KV, 220 KV and 400 KV hardware
7. One suspension clamp. In case of 400 KV suspension hardware, two suspension clamps are provided to support twin conductors
8. Corona Control Rings are to be fixed to the yoke plate which in turn connects the suspension clamps through clevis eyes in case of 400 KV single suspension hardware. A typical 400 KV single suspension hardware set is shown in Figure 2.12.



2.4.4.2 TECHNICAL REQUIREMENTS OF EHT SUSPENSION HARDWARE

The 132 KV and 220 KV suspension hardware shall be suitable for insulators of 16 mm ball designation and 400 KV hardware suitable for insulators of 20 mm., ball designation

The breaking/failing load of suspension hardware shall be 7000 kgs.

The slip strength of the suspension clamp shall be 25% of the ultimate tensile strength of conductor

In case of 400 KV suspension hardware, the magnetic power loss corresponding to 600 Amps per sub-conductor shall be not more than 7 watts.

In case of 400 KV suspension hardware, the maximum value of Radio Influence voltage for the complete string (i.e.,) including grading/corona rings, arcing horns, clamps etc. at 266 KV R.M.S shall be 500 Micro volts.

In case of 400 KV lines, the corona extinction voltage for the complete string is 320 KV (RMS).

2.4.4.3 TENSION HARDWARE

There are three types of tension hardware sets normally used (viz) (i) Single tension hardware (ii) Single Tension hardware with adjustable arcing horns and (iii) Double tension hardware. The tension hardware sets are used at angle locations. Two sets of hardware are required to clamp the conductor(s) for each phase connected in turn by a jumper. Thus, per each angle location of a single circuit line, six sets of tension hardware are required per each angle location for a single circuit line and twelve sets for a double circuit.

Normally, single tension hardware sets with fixed arcing horns on tower side are used for angle locations of 132 KV and 220 KV lines. The single tension hardware sets with adjustable arcing horns are used on angle towers of the approach locations of the connected E.H.T substations. The actual spacing between the spheres of the tower side and line side arcing horns is adjusted as per the insulation co-ordination decided for the connected substation near the approach towers. Double tension hardware sets are used for angle towers on either side of river crossing spans and railway crossing spans in case of 132 KV and 220 KV lines and for all angle towers of 400 KV lines. The double tension hardware sets have provision for assembling two stacks of insulators.

The single tension hardware has in general the following components .

- i) „D “ shackle.
- ii) Ball link with provision to fix arcing horn.
- iii) Socket clevis with provision to fix arcing horn.
- iv) Tower side arcing horn (fixed or adjustable).
- v) Line side arcing horn.
- vi) Compression type deadened cone.

The double tension hardware has in general the following components.

- i) Anchor shackle connected to the tower crossarm.
- ii) Link.
- iii) Anchor shackle connecting link and yoke plate.
- iv) Yoke plate on tower side.
- v) Tower side arcing horn connected to the yoke in between the two stacks of insulators.
- vi) Two ball clevises connecting two insulator stacks to the tower side yoke.
- vii) Two socket clevises connecting the bottom most discs of the two insulator stacks to the line side yoke plate.
- viii) Line side yoke plate with provision to fix line side arcing horn.
- ix) Line side arcing horn fixed to the line side yoke plate in case of 132 KV and 220 KV lines or Corona control ring in case of 400 KV lines.
- x) Clevis-Clevis to connect line side yoke plate to the compression type deadend tension clamp for 132 KV and 220 KV lines. Two clevis eyes in case of 400 KV lines.
- xi) Two sag adjusting plates connecting clevis eyes to the anchor shackles on line side for 400 KV double tension hardware.
- xii) Two anchor shackles connecting sag adjusting plates to the compression type deadend clamps, in case of 400 KV double tension hardware.
- xiii) One compression type deadend tension clamp for 132 KV and 220 KV double tension hardware and two numbers for 400 KV double tension hardware.

A typical 400 KV Double Tension hardware is shown in Figure- 2.13

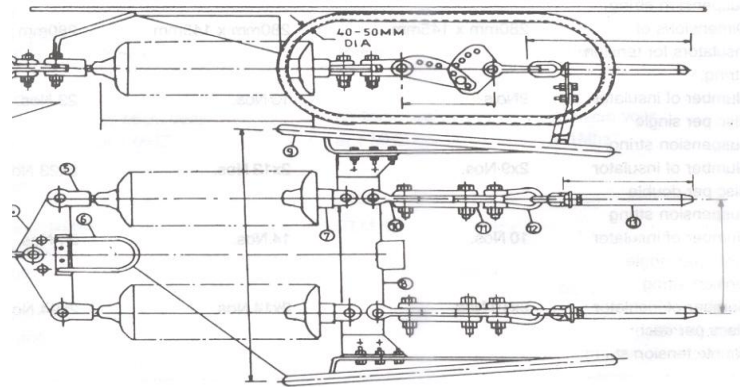


FIG - 2.13

II - 25

2.4.1.1 TECHNICAL REQUIREMENTS OF E.H.T. TENSION HARDWARE:

- The tension hardware shall be suitable for use with Ball and socket type disc insulators with designation/shank pin dia of 20 mm.
- The minimum failing load of the hardware set shall be 95% of the breaking load of conductor
- The compression type deadened cone shall be compressible with 100 ton hydraulic compressors to obtain requisite results after compression with reference to dimensions and bondage.
- In case of 400 KV lines, the R.I.V. for complete string (i.e.,) including grading/corona rings, arcing horns, clamps etc. at 256 KV (rms) shall not be more than 500 Micro volts
- The corona extinction voltage for complete string shall be 300 KV

2.4.4.5 INSULATORS:

Ball and socket type disc insulators are assembled to the 132 KV, 220 KV and 400 KV suspension and tension hardware, certain important design aspects and other details are indicated below :

Sl. No.	Description	132 KV lines	220 KV lines	400 KV lines
1.	Type of insulators	Ball and socket type disc insulator	Ball and socket type disc insulator	Ball and socket type disc insulator
2.	Dimensions of insulators of suspensions string	255mm x 145mm	280mm x 145mm	280mm x 145mm
3.	Dimensions of insulators for tension string	280mm x 145mm	280mm x 145mm	280mm x 170mm
4.	Number of insulator disc per single suspension string	9 nos.	13 nos.	23 nos.
5.	Number of insulator disc per double suspension string	2 x 9 nos.	2 x 13 nos.	2 x 23 nos.
6.	Number of insulator discs per single tension string	10 nos.	14 nos.	24 nos.
7.	Number of insulator discs per each double tension string	2 x 10 nos.	2 x 14 nos.	2 x 24 nos.

8.	Electro Mechanical strength for tension string insulator	7000 Kgs.	7000 Kgs.	11,500 Kgs.
9.	Electro Mechanical strength for suspension string insulator	11,500 Kgs.	11,500 Kgs.	16,500 Kgs.
10.	Total creepage distance of each disc insulator for suspension strings	280 mm	280 mm	315 mm
11.	Total creepage distance of each disc insulator for tension string	280 mm	280 mm	330 mm
12.	Minimum impulse dry withstand voltage (wave of 1 x 50 Micro second) for each disc insulator (I.E.C standard)	110 KV	110 KV	120 KV
13.	One minute power frequency withstand voltage for each disc insulator	70 KV (dry) 40 KV (wet)	70 KV (dry) 40 KV (wet)	70 KV (dry) 40 KV (wet)
14.	Power frequency puncture voltage per each disc insulator	110 KV (Suspension strings) 140 KV (Tension Strings)	110 KV (Suspension strings) 140 KV (Tension Strings)	140 KV (Suspension strings) 140 KV (Tension Strings)
15.	Size and designation of bal pin shank for suspension string discs	16 mm	16 mm	20 mm
16.	Size and designation of bal pin shank for tension string discs	20 mm	20 mm	20 mm
17.	Maximum Radio Influence Voltage at 10 KV (RMS) for each disc insulator	50 Micro Volts at 1 MHz	50 Micro Volts at 1 MHz	50 Micro Volts at 1 MHz
18.	Corona extinction voltage for complete (RMS) string both suspension and tension strings	-	- (RMS)	320 KV
19.	Maximum RIV for complete string both volts suspension and tension strings	-	-	500 Micro volts

A typical string insulator disc is shown in figure-2.14 with part-wise descriptions

A typical string insulator disc is shown in Figure - 3.15 with part-wise descri

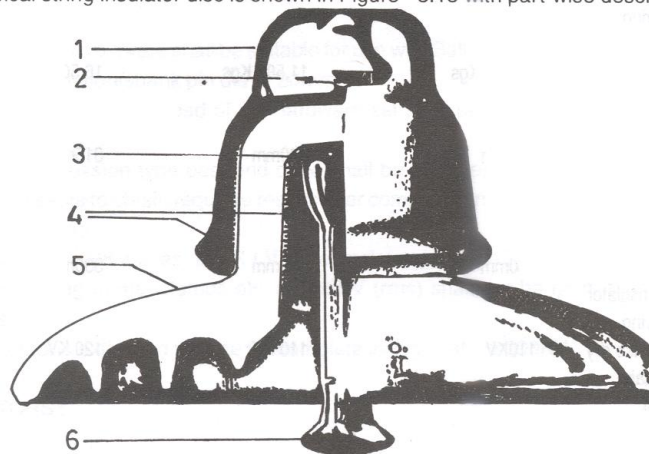


FIG. - 2.14

2.4.4.6 GROUNDWIRE CLAMPS AND ACCESSORIES

Normally for 132 KV and 220 KV lines, only one Groundwire is used, while for 400 KV lines two Groundwires are required. One groundwire suspension clamp is required for each groundwire for every tangent tower. Each suspension clamp is provided with tinned copper earth bond which is in turn connected to the tower body. Two ground wire tension clamps are required per groundwire per each angle tower. Each of these tension clamps is provided with tinned copper earth bond, which is to be connected to the tower body. Groundwire midspan joints are used for jointing two pieces of groundwire. After fixing the two end portions of the groundwires to be jointed, the midspan compressor with suitable die set.

2.4.4.7 POWER CONDUCTOR ACCESSORIES

- i) **PRE-FORMED ARMOUR RODS :-** The preformed armour rods are used at the tangent locations. The armour rods are wound over the portion of power conductor which is to be clipped in a suspension clamp of the suspension hardware. Each set of preformed armour rods generally consists of 11 nos. rods for 132 KV lines (PANTHER ACSR), 12 Rods for 220 Kv lines (ZEBRA ACSR) and 12 rods for 400 KV lines (MOOSE ACSR). The preformed armour rods are of helical shape and made of aluminium alloy which has a minimum tensile strength of 3500 Kg/ sq.cm. The armour rods can be fixed over conductor by hand. For 132 KV and 220 KV lines, either ball ended or parrot bill ended rods are accepted. For 400 KV lines, parrot ball ended rods are specified. The slip strength of suspension clamp over the conductor wound with armour rods shall be not less than 25% of the ultimate tensile strength of the conductor. For 400 KV lines, the RIV, at 266 KV (rms) phase to ground shall not be more than 500 Micro volts.
- ii) **MIDSPAN COMPRESSION JOINTS :-** The compression type joints are required for jointing two ends of two pieces of ACSR conductors. The compression joint consists of (a) outer sleeve made of Aluminium (extruded tube) and (b) inner sleeve made of Mild steel hot dip galvanized. After inserting the steel core portions of the conductors to be jointed into the steel sleeve, the same is compressed by means of 100 tonne hydraulic compressor fitted with suitable die set. The steel sleeve duly compressed with steel core portions of two conductors is fixed in the outer Aluminium sleeve alongwith the aluminium strands of both the conductors. Then the aluminium sleeve is compressed together with steel sleeve and aluminium strands by means of 100 tone Hydraulic Compressor fitted with suitable die set. Both the steel sleeve and the aluminium sleeves are compressed from round to hexagonal shape. The failing load of the compression joint shall be not less than 95 per cent of the breaking load of conductor. For 400 KV lines, the radio interference voltage at 260 KV rms, phase to ground shall not be more than 500 Micro volts
- iii) **REPAIR SLEEVES:-** The repair sleeve is of tubular shape with a sliding (removable) part known as a „keeper“. If a few strands (not more than three) of the conductor are found to be cut or damaged, the repair sleeve is to be fixed to the conductor over the damaged portion and compressed by means of 100 ton hydraulic compressor fitted with suitable die set. The repair sleeves are made out of aluminium extruded sections.

The compressor die used for repair sleeve is the same as that used for midspan compression joint. The repair sleeves are also compressed from round to hexagonal shape. The minimum failing load of repair sleeves used in 400 KV lines shall have RIV not more than 500 micro volts at 266 KV (rms), phase to ground

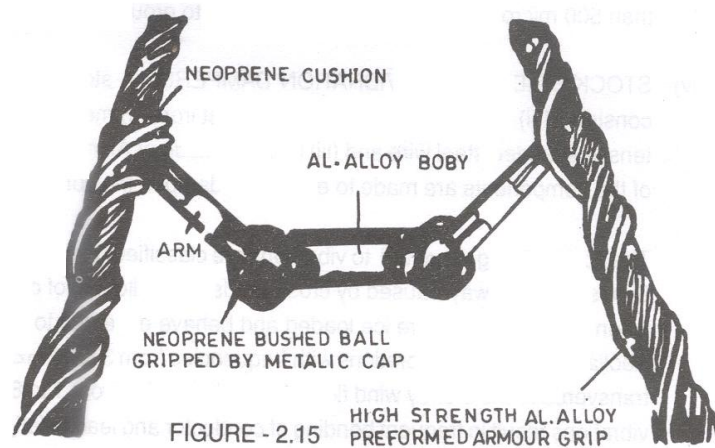
- iv) **STOCK BRIDGE TYPE VIBRATION DAMPERS :** A stock bridge vibration damper consists of (i) two dead weights made of cast iron (ii) messenger cable made of high tensile stranded steel wire and (iii) a clamp made of Aluminium alloy. The dimensions of the components are made to effectively dampen the conductor vibrations.

The conductors get excited to vibrations are classified under three categories (viz) (i) Side swing or „Sway“ caused by cross winds, (ii) Galloping of conductor which occurs when the conductors are ice loaded and behave eccentric to the wind force and (iii) Aeolian vibration; the vibrations with frequencies from 3 to 12 HZ occur in the direction transverse to the steady wind flow of speeds ranging from 1 to 8 mtr. per second. The vibrations result in frequent bending of conductor and lead to fatigue failure at the root. As the aeolian vibrations are known to be most detrimental, the prime objective is to effectively dampen (or substantially reduce the amplitude) the Aeolian vibrations.

As per the practice in vogue in this State, the vibration dampers are fixed to the power conductors at angle towers on either side. The vibration dampers may be used at tangent locations also to facilitate dampening of vibrations at suspension locations. The stock bridge type vibration damper is a vital conductor accessory to protect the power conductor from fatigue failure. The vibration damper has to be tested thoroughly for dynamic characteristics to assess its dampening capacity. The clamp shall have a slip strength not less than 250 Kgs. For 400 KV lines the RIV at 266 KV (rms) phase to ground shall be not more than 500 micro volts. Again among the stock bridge vibration dampers two types of dampers are in extensive use (viz) (i) two resonant type and (ii) Four Resonant type. Normally for 132 KV lines 2-R dampers are preferred while both 2-R type and 4-R type of dampers are in use for 220 KV lines. For Moose ACSR Conductors strung on 400 KV lines, 4-R dampers are known to be more effective in dampening the aeolian vibrations. The two dead weights in 2-R dampers are equal mass and similar in shape. The dead weights of 4-R dampers are neither equal in mass nor in size.

- v) **SPACERS :** The spacers are used for fixing the two conductors of each phase in 400 KV lines. The two conductors are held in cushioned grips of spacer consists of an aluminium alloy body provided with cushioned grips which is made of „NEOPRENE“. The cushioned grips which hold the two sub-conductors apart are fixed to the sub-conductors by means of armour rods made of Aluminium alloy. The spacers are suitably designed to provide subconductor spacing of 450 mm. The spacers are to be fixed at sub-span lengths of 80 meters each.

SPACER DAMPERS :- Spacer dampers are used on 400 KV lines instead of separately fixing dampers and spacers. A typical spacer-damper used in 400 KV lines is shown in Figure 2.15 below :



2.4.5 STATUTORY INSPECTION AND COMMISSIONING :

After the E.H.T lines are completed, statutory inspection is carried out to check for (i) ground clearances (ii) midspan clearances (iii) proper fixing of insulators and hardware. (iv) jungle clearance and (v) proper erection of super structures. Necessary relay settings and other arrangements are provided in the connected substations as per the stipulations of Grid Operation wing. The EHT line is first charged on no load to see whether it can stand O.K. Then the line is taken into commercial operation.

**NEW TECHNOLOGIES IN
TRANSMISSION LINE
MAINTENANCE
BY
HOTLINE TECHNIQUES**

1.0 INTRODUCTION

In the modern age, the electricity has become a major essential commodity after air, food clothing and water. In the daily life any development of the country depends on the availability of the energy resources in abundance. Even though the other mineral and natural resources are available Electrical Power is contributing major role for the development of the country.

It is our bound duty to maintain the Electricity uninterruptedly to achieve not only revenue earnings for the organization but also for the major industrial growth and thus development of the country in four fold. For maintaining the uninterrupted power supply one of the preventive maintenance techniques used in our organization is Hotline Techniques. The details are discussed below.

1.2 WHAT IS HOTLINE

Hot lines mean energized electrical power lines. Any equipment or machinery suffers from minor ailments which leads to major breakdowns. To prevent this timely action is always required as the proverb says “Stitch in time saves nine”. A adoption of the Live Line maintenance techniques for the power lines will suit to this proverb.

1.3 MAINTENANCE METHODS

Following are the methods adopted by all the Electrical Utilities (Companies) either in generation, transmission or distribution.

- i) Pre-arranged shut down methods after identifying the faults
- ii) Sudden faults developed as break downs and rectification is a breakdown maintenance.
- iii) Preventive Hotline maintenance

The paper is to study in detail and explain the august gathering the details of preventive maintenance of Electrical power lines by Hotline Maintenance Techniques.

2.0 HOTLINES

Hotlines techniques mainly deals with the maintenance of energized line without any interruption to the power from Low Voltage Line to Ultra High Voltage Line

2.1 Broadly there are two types of techniques at present in use.

- i) Hot Stick Technique
- ii) Bare Hand Technique

Hot Stick technique can be used from 11 KV to 220 KV lines where as Bare Hand Method is a must for Ultra High Tension lines i.e., from 400 KV and above. This organization is proud to present that the Bare Hand Techniques are being used for the preventive maintenance of 132 KV and 220 KV EHT lines and sub-stations also which is an unique feature in our country.

2.2 HOT STICK METHOD

In the year 1935 the lengthy bamboo dry sticks were used to remove cartridge fuses and for disconnection of isolators. In later days, after research, two types of woods were discovered to serve the above purpose. They are (i) OAKWOOD (ii) SITCA SPRUCE AND HIMALAYAN SPRUCE.

2.3 OAK WOOD

Oak wood having a property of high mechanical strength and high dielectric strength was used till 70s. Since the weight of the sticks made by this wood has become a constraint, these sticks were used for tension relieving purpose only, where high mechanical strengths were required.

2.4 SITCA & HIMALAYAN SPRUCE

The laminated light wood like SITCA Spruce and Himalayan Spruce were found and with them the laminated pieces are gloved and tools were made for the requirement. Eg. Tie sticks, Wire Tongs, Flexible Wrenches etc.

i) Tie stick will be used for tying or untying the insulator bindings where the pin binding were taken up and also in use for various applications.

ii) Wire tong holds the conductor or jumper and move them for a safe clearance of the crew who manipulates the works

iii) Flexible wrench – by fixing the suitable sockets of the required size, the bolt and nuts, of pad clamps, T clamps etc. can be tightened or loosened.

2.5 Likewise many more tools manufactured by this wood were in use upto 80s. But the above wood tools have got inherent property of absorbing moisture, even though they have outerly coated with Araldite and Teflon etc., loses their insulation values which requires heating chambers, air tight chambers and continuous insulation monitoring before use everyday at the work spot, which is a costly affair.

2.6 Even then, if the operation time is delayed, the wood sticks will absorb the moisture content present in the atmosphere and failures will occur and is dangerous to the crew members and may cause breakdown to the power line. Thereby the very purpose of preventive maintenance of the energized line by risking the crew will be lost.

2.7 To overcome the above constraints a further research was made on this and a new material i.e., Glass Fibre was introduced with trade name Epoxy Glass which is having very high dielectric strength, high mechanical strength and less weight than the wood sticks.

The glass Fibers have been soaked with Epoxy resin and wound to manufacture a hollow stick. The hollowed portion is filled with a Unicellular foam to prevent external moisture to enter inside the stick and thus insulation value of the Epoxy Glass Stick will be maintained.

2.8 With this advantage and inherent capacity of not absorbing moisture from the external atmosphere, though sudden rain comes the crew can leave the tools in engaged condition of the work and after rain lashes, they can complete the work.

Because of the presence of unicellular foam material the rain drop will not creep inside the hollow portion of the stick thereby insulation value will not be affected.

Due to aberrations even though the water enters inside the hollow portion of the Epoxy Glass Stick, the water will not creep inside the stick due to stuffed unicellular foam material inside the stick. If the stick gets watered in the rain, just wiping of the stick with moisture eater solution and little drying in the sun is quite enough to make the stick fit for the work.

Like wise, Epoxy Glass Sticks with all the above added advantages are better in use than the wooden sticks in the live line maintenance of the Hot lines.

For these Hot Sticks different suitable metal heads are fitted for carrying out number of operations like changing of broken insulators, flashed over insulators and all the connected parts of tension and suspension points of the live lines without interruption to the power or without availing any shut down. And also tightening or loosening of cut point jumper bolt and nuts, replacing vibration dampers, replacing suspension shoe clamps etc., of the EHT lines and Lifting up of the conductors, changing of cross arms upto 11 KV and 33 KV can be carried out by this Hot Stick method.

3.0 BARE HAND TECHNIQUE

Bare Hand Technique means to charge a person to the required voltage level on an insulated platform either by traversing the person by insulated ladder or by raising through an insulated boom, and carrying out the work on charged line with Hands. The chargeable person will wear a conductive suit comprising of cotton, asbestos and stainless steel threads, along with conductive shoes of copper threaded carbon sole with conductive socks and conductive hand gloves. Total continuity will be maintained from „Head to Toe“ covering the head with hood except the face.

- 3.1 The Bare Hand Technique is not a single man operation, it requires both Hot Stick Method as explained previously and a bare hand person.

By the effective utilization of this method the APTRANSCO erstwhile APSEB was commissioned additional transformers in 220 kv and 132 kv Sub-stations and further equipment like capacitor bank etc. without interruption to any equipment or without Bus shut downs.

- 3.2 By this Bare Hand Technique damaged Bus jumpers, T Clamps, Isolator Pad Clamps, Female Contacts are being replaced without the interruption to the bus bars, and conductor damages also being attended when sufficient clearances are there for operation.

- 3.3 By adopting this Bare Hand Technique lot of problems like taking Bus shut downs, line clear etc. can be avoided and thereby lot of time and revenue and also interruption are being avoided. APTRANSCO and APGENCO are extensively using this technique to avoid interruption, thereby the better consumer satisfaction and plant load factors are achieved.

4.0 THERMOGRAPHY

Thermography means projecting the Infra-red rays on an object and receiving the reflected image on the screen. Depends upon the temperature the colour intensity of the image will change. Depending upon the intensity of the colour, the fault is identified and predictivity is by human eye and experience only. Rectification will be carried out by depending upon gravity of the situation

4.1 With the latest version of Inframatics 760 system with Thermotronics software, the condition of the line jumpers, insulators, metal parts, connectors of transformers and current transformers, where the change of temperature is there, can be identified well in advance and behaviour of the metal part can be analysed in the computer. The temperature rise of any connector since being identified well in advance by the Thermovision Camera the same is being rectified well in advance even before deformity or red hot occurs for the clamp or connector. With this latest version of thermal imaging system the APTRANSCO is able to identify the internal faults of any electrical system in the Generating Stations and EHT substations and by the analysis of computer the rectification action is also being initiated.

4.2 The following are the major identified by the Thermal Imaging System :

- a) TURFOUNION 100 MVA transformer winding connectors at bushing end at Shapurnagar and Nellore EHT substations.
- b) VTPS Generator Transformers 3,4 & 5 of BHEL make winding terminals at bushing are identified and due to emergency immediate action initiated and saved huge damage to the Transformer and connected equipment.
- c) Sub-station equipment at almost all the EHT substations in the State and also major feeders connectors are scanned.

e.g	Ghanapur-Chandrayanagutta	220 kv Line
	Chandrayanagutta-Shapurnagar	220 kv Line
	VTs- Narketpally-Hyderabad	220 kv Line
	VTs- Tadikonda-Ongole	220 kv Line
	VTs-Nellore	220 kv Line

4.3 Rectification action already initiated and strengthened the weak points

5.0 OTHER HOTLINE WORKS

Apart from the above Hotline and Bare Hand Work, the Hotline sub-divisions are also taking up the special Hotline works, like removing and cleaning of the saline contamination of the insulators, cement dust deposits on the insulators and chemical deposits on the insulators by three types of methods.

- a) Dry washing b) Hot Spraying c) Wet washing

5.1 DRY WASHING

The Dry Washing and Spraying will be undertaken with huge hot air along with corn husk or paddy husk on peanut husk with lime stone granules. The hot spray of air through nozzles will clean the cement contamination.

5.2 HOT SPRAYING

To avoid the cement dust pollution and other chemical pollution the spraying of chemical on the insulators will be taken up. When once the cleaning of the insulators by dry washing is completed a thin film of silicon compound will be deposited on the insulators by Hot Spray.

5.3 WET WASHING

Previously the wet washing of the live insulators is used to be carried out by a small cylinder with carbon dioxide along with water to a limited extent.

- 5.4 At present with latest equipment and trigger controls etc. the ordinary water having the conductivity of less than 2 mhos is being sprayed directly on the live insulator to clear the salt contamination, dust and chemical contamination which is soluble in water.

The above works are being taken up at all the coastal areas, by one Sub-division trained for this special nature of work to carry out the operation with special equipment. Due to cost constraint only one equipment is purchased and being used wherever necessary in the State.

- 5.5 The special nature work of thermal imaging equipment is with Hyderabad and used in entire state.

Vijayawada Hot Lines sub-division is having the special nature equipment of Hot Spray and Dry Washing Kit and being used.

Visakhapatnam Hot Line Sub-division is having the Wet Washing Kit and being used.

Visakhapatnam Hot Line crew has taken up several lines to clear the salt deposits on the insulators with the help of wet washing and maintained the supply of power and contributing much to the entire State.

On Macheeryala, Tadepally, Yerraguntla and Vadapally EHT Lines Cement deposits on Insulators have been cleared to much extent by Vijayawada Hot Line Sub-division.

Hyderabad Hot line Sub-division attended many works by Bare Hand Technique as noticed by Thermovision camera in changing female contacts, jumper clamps and jumpers, and provided many repair sleeves on the live conductors.

Many additional transformers of 50 MVA and 100 MVA were commissioned in the sub station system by connecting the HV side and LV side jumpers to the existing 220 KV /132 KV Buses without availing any bus shut downs and interruption to the equipment.

6.0 AUTHORISATION AND APPLICATION :

In this Hotlines field the crew is authorized to carryout insulations changing, jumpers both tightening etc., and all the connected works of Hotlines by way of

training at Hotline Training Centre and a Certification from the Competent Authority.

The personnel who were trained in Hotlines shall only carry out the work under the trained Supervisor.

6.1 CONSTRAINT:

The IE Act 1948 and IE rules 1956 insisted the working personnel to obtain license to work on live line, but the present Hotline Training Centre at Bangalore is imparting training on Hot Stick Methods only, But not in Bare Hand Techniques.

6.2 In this juncture it is worth mentioning that the APTRANSCO (erstwhile APSEB) is the only organization carrying out the works of Bare Hand Technique in the entire Country. In the absence of training facility in Bare Hand Technique all the Hot line trained people are trained in Bare Hand Techniques also by Sri K.S.N.Murthy, Divl.Engineer,APTRANSCO but certification is a major constraint.

6.3 By these two techniques, Hotlines and Bare Hand APTRANSCO is able to save the Revenue to the tune of 2.20 crores every month. By the adoption of these Techniques the transmission system can be maintained upto the standards.

7.0 SET BACKS:

- a. At present the equipment like CTs, Wave Traps, Power transformers could not be attended without interruption to the equipment due to potential differences.
- b. Hotlines experienced personnel even though they can perform Bare Hand Works due to rules prevailing certificates could not be issued.
- c. Due to much risk involvement and extensive touring the new blood is not flowing into the Hotlines and this matter requires special attention.
- d. Since the tools are of imported once, paucity of funds is of major setback to equip the working personnel with T&P required while opening new working groups or wings. The tools and vehicle costs Rs.30 lakhs for each working group and revenue is 2.2 crores.

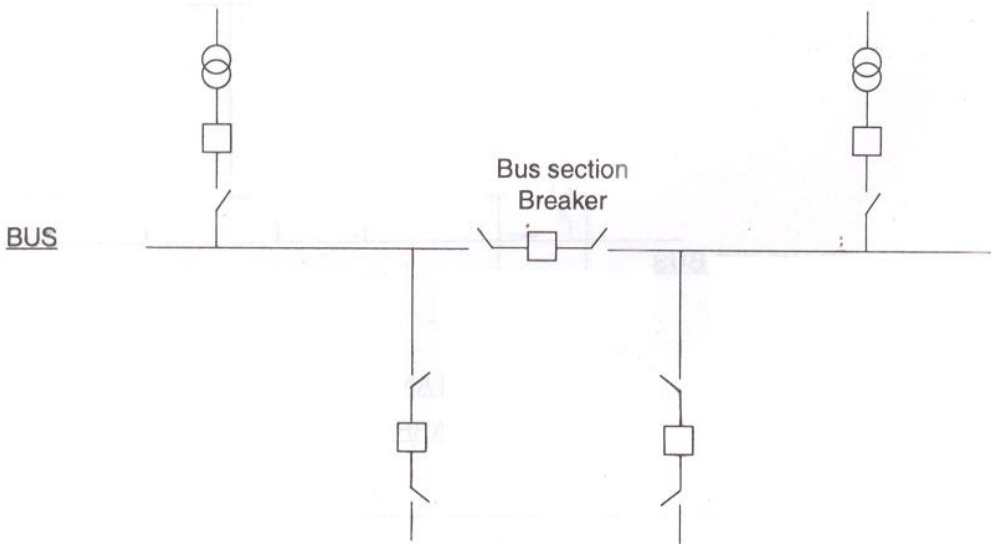
7.1 If the above bottle necks are overcome the transmission system can best utilize the Hotlines and bare hand techniques even upto 11 KV in the low level and 400 KV and above in the higher level and can maintain uninterrupted supply to the most extent and thereby the reputation of the organization will go high.

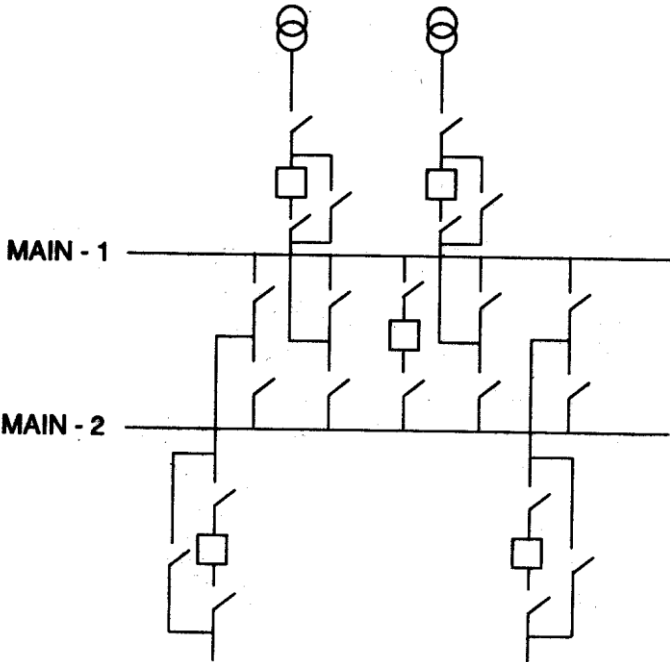
EHT SUB STATIONS

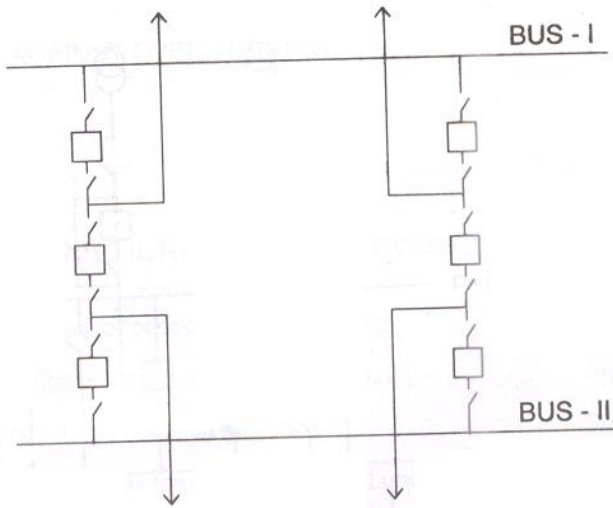
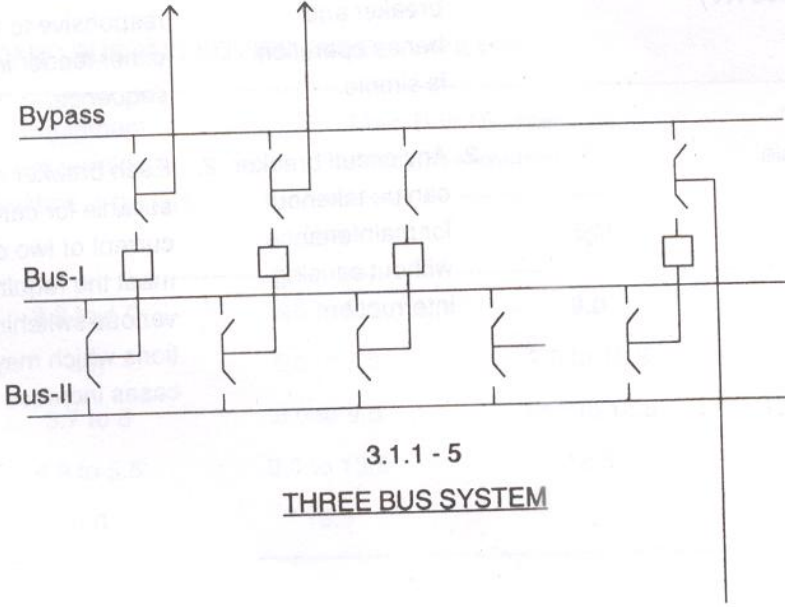
3.00 EHT SUB-STATIONS

3.1 LAYOUTS

3.1.1 The selection of bus system has to be made keeping in view the degree of reliability of supply required during maintenance of faults. Bus system adopted and being adopted in A.P Grid are as follows.

	Arrangement	Advantages	Disadvantages
1.	Improved Single Busbar Arrangement (33 KV, 132 KV & 220 KV)	Simple	1. In case of busfault or bus bar isolator fault or maintenance associated system is lost 2. In case of maintenance of transformer circuit breaker the associated transformer has also to be shut-down
 3.1.1 - 1 IMPROVED SINGLE BUS BAR ARRANGEMENT			
2.	Main and Transfer Bus Arrangement (132 KV)	Maintenance on any one feeder breaker at a time, is possible without main bus or feeder shut down	As in the case of single bus bar arrangement, in case of fault on the main bus-bar or the associated isolator, there is a complete shutdown of substation

3.	Duplicate-Bus bar Arrangement (220 KV)	Each circuit can be connected to either one of the bus bars.	Only one bus will be available during maintenance of any one Circuit Breaker. Consequently the disadvantage in Main & Transfer bus arrangement is eliminated.
 3.1.1 - 3			
4.	Breaker and a Half Arrangement (400 KV)	1. Load transfer is done through breaker and hence operation is simple. 2. Any circuit breaker can be taken out for maintenance without causing interruption.	1. Relaying is complicated. Since third breaker is to be responsive to the faults on either feeder in correct sequence. 2. each breaker has to be suitable for carrying the current of two circuits to meet the requirements of various switching operations which may in some cases increase the cost.

			
5.	Three Bus System (220 & 132 KV)	Since by-pass will be utilized for maintenance of breakers, two buses will be available for normal operation even during maintenance, thus increasing reliability.	This system cannot be adopted where space is restricted.
			

3.2 STRUCTURES

3.2.1 DESIGN LOADS:

3.2.1.1 WIND PRESSURE ON STRUCTURES: In regions other than coastal regions 125 Kg/Sq. m. on 1.5 times the projected area of members of one face for latticed structures and other non-cylindrical objects and on single projected area in the case of other structures. In coastal regions the wind pressure may be assumed as 260 Kg./Sq.m.

3.2.1.2 WIND PRESSURE ON CONDUCTORS : In regions other than coastal and hilly regions, 75 Kg/Sq.m on two thirds projected areas. Coastal areas 125/150 Kg. / Sq.m. In hilly regions 90 Kg. / Sq.m

3.2.1.3 Maximum tension per conductor of transmission line conductors strung from terminal towers to station structures or strung buses :

- 1) 33 KV and 11 KV 450 Kg.
- 2) 60 KV – 450 Kg.
- 3) 132 KV and 220 KV – 900 Kg.
- 4) 400 KV – 1000 Kg.
- 5) Ground wire Tension – 450 Kg.

3.2.1.4 MAXIMUM SPANS OF LINES ADJACENT TO STATIONS

33 KV and below – 60.00 m

66 Kv and above – 150.00 m

3.2.1.5 UPLIFT OF ADJACENT SPANS : Maximum slope (mean of the 3-phases) at the point of attachment 1 : 8 above horizontal.

3.2.2. FACTOR OF SAFETY:

3.2.2.1 FOR STEEL :

2.0 based on maximum loading conditions (on elastic limit for tension members and crippling load for compression members).

3.2.2.2 FOR R.C.C. :

3.5 on ultimate breaking load

3.2.2.3 FOR SAFETY AGAINST OVER TURNING

Steel – 2

R.C.C – 2.0

3.2.3 SLENDERNESS RATIO (L/R) SHOULD NOT EXCEED :

i) main members of cross arms and for leg	-	140
ii) other members having calculated stresses	-	200
iii) members having nominal stresses	-	250
iv) for members other than those covered under		
i) above and carrying tensile stress only	-	400
(Where L = unsupported length)		
R = Radius of gyration)		

3.2.4 STANDARD BAY WIDTHS IN METERS :

11 KV -	4.7
33 KV -	4.7
66 KV -	7.6
132 KV -	12.2 & 11
220 KV -	17.00
400 KV -	27.00

3.2.5 STANDARD BUS AND EQUIPMENT ELEVATIONS

Rated voltage (KV)	Equipment live terminal elevation in meters	Main Bus / Buses elevation in metres		Take-off elevation in metres
		Low	High	
11 & 33	2.8 to 4.0	5.5 to 6.5	9.0	6.5 to 8.5
66	4.0	6.0 to 7.0	9.0 to 10.5	9.5
132	3.7 to 5	8.0 to 9.5	13.5 to 14.5	12.0 to 12.5
220	4.9 to 5.5	9.0 to 13.0	18.5	15.0 to 18.5
400	8.0	15.5	--	23 M

3.3.1 BUS BAR MATERIAL

The materials in common use for strain type Bus bars are ACSR conductors. Bundled conductors (two or four) are used where high ratings for bus bars are required. The size of conductors commonly used are :

11 KV -	61/3.18 mm	ZEBRA	Twin
33 KV -	61/3.18 mm	ZEBRA	Twin
132 KV -	61/3.18 mm	ZEBRA	(Single/Twin)
220 KV -	61/3.53 mm	MOOSE	(Single/Twin/Quadruple)
	61/3.8 mm		
400 KV -	61/3.53 mm	MOOSE	Quadruple

3.3.2 STRINGING TENSIONS :

The insulators, bus bars and connections should not be stressed to more than one fourth of the breaking load or one third of their elastic limit whichever is lower.

3.4 CLEARANCES

The following are the minimum clearances for out-door equipment and rigid conductors in air.

Rated voltage (KV)	BIL Basic insulation level (KV)	Minimum Clearance between		Phase to phase spacing in isolators and switches	
		Phase to phase (mm)	Phase to earth (mm)		
11	75	400	310	610	920
33	170	400	320	760	120
66	325	750	630	1530	2140
132	550 650	1350 1600	1150 1380	2140	3050
220	900 1050	2300 2700	1960 2300	3400	4000
400	1425 1550	4000 5200	3500 3640		

3.4.2 Normally adopted phase spacings for strung bus are indicated below :

11 KV	-	1300 mm
33 KV	-	1300 mm
66 KV	-	2200 mm
132 KV	-	3000/3600 mm
220 KV	-	4500 mm
400 KV	-	7000 mm.

3.4.3 a) The minimum clearance of the live parts to ground in an attended outdoor sub-station and the sectional clearance to be maintained between live parts in adjacent sections for safety of persons while working with adjacent sections alive are given below

Voltage rating (KV)	Minimum Clearance to ground (mm.)	Sectional Clearance (mm.)
11	3700	2600
33	3700	2800
66	4600	3000
132	4600	3500
220	5500	4300
400	8000	7000

3.4.3 b) The bottom most portion of any insulator or bushing in service should be at a minimum height of 2500 mm above ground level.

3.4.4 The earthing practice adopted at generating stations, sub-stations and lines should be in such a manner as to provide :

- Safety to personnel
- Minimum damage to equipment as a result of flow of heavy fault currents
- Improve reliability of power supply

3.4.5 The primary requirements are :

The impedance to ground (Resistance of the earthing system) should be as low as possible and should not exceed 1 ohm in large sub-stations and 2 ohms in small sub-stations and 0.5 ohms in power stations. In distribution transformer stations, it could be 5 ohms

The step and touch potentials should be within safe tolerable limits

3.4.6.1 Resistance of the earthing system

$$R = \frac{P}{4r} + \frac{P}{L}$$

where P = Soil resistivity in ohm meter

L = Length of the conductor buried in meters

R = Radius in meters of a circle having the same area as that occupied by earth mat.

The value of „R “ should be within limits as specified in para 2.4.5 (a)

3.4.6.2 The size of earth mat conductor (steel strip) shall be:

$$\begin{aligned} A \text{ (Steel)} &= 26 \times 1 \sqrt{t} \text{ circular mils} \\ &\quad (0.0013 \times I \sqrt{t} \text{ sq. mm}) \text{ for bolted joints} \\ &= 21.6 \times I \sqrt{t} \text{ circular mils} \\ &\quad (0.011 \times I \sqrt{t} \text{ sq. mm}) \text{ for welded joints} \end{aligned}$$

Where A = Cross section

I = Fault current in amps., at the station

$$= \left[\frac{\text{Fault MVA} \times 10^3}{\sqrt{3} \times \text{system kv}} \right]$$

and t = Time in seconds during which current is applied

3.4.6.3 In order to take care of corrosion etc. some extra margin may be provided in the size of earthing strip.

3.4.7.1 The permissible values of step and touch potentials can be calculated as follows :

$$\text{i) Safe tolerable E step (Volts)} = \frac{165 + P_s}{\sqrt{t}}$$

where Ps is the resistivity of the ground in ohm meter just beneath the feet of a person (3000 for crushed rock). „t“ is the time in seconds to clear earth (fault by the concerned breaker (0.5 may be assumed)

$$\text{ii) Safe tolerable E touch (Volts)} = \frac{165 + 0.25 P_s}{\sqrt{t}}$$

3.4.7.2 The maximum attainable step and touch potentials can be calculated as follows.
(These potentials shall be less than the tolerable value, calculated under clause 2.4.7.1)

$$a) \quad \text{Maximum attainable E step} = \frac{K_s \cdot K_i \cdot P \cdot l}{L}$$

$$\text{Where } K_s = \frac{7}{22} \times \left(\frac{1}{2h} + \frac{1}{D+h} + \frac{1}{2D} + \frac{1}{3D} + n \text{ terms} \right)$$

- n = Number of parallel conductors in the grid
 D = Spacing of conductors in grid in meters
 h = Depth of burial in meters
 K_i = $0.655 + (0.172 \times n)$
 P = Average resistivity of the ground in ohm meters
 l = Maximum total RMS current flowing between the ground grid and Earth in amps
 L = Length of buried conductor in meters

$$b) \quad \text{Maximum attainable E touch} = \frac{K_m \cdot K_i \cdot P \cdot l}{L}$$

$$\text{Where } K_m = \frac{7}{44} \times \log_s \left[\frac{D \times D}{16 h d} \right] + \frac{7}{22} \times \log \left[\frac{3}{4} \times \frac{5}{6} \times \frac{7}{8} \times (n-2) \text{ terms} \right]$$

$$(\text{Approximately}) K_m = 7/44 \times \log_e(d^r / 16 h d) + 7/22 \text{ Loge } 0.25$$

- n = Number of parallel conductors in the grid
 d = Equivalent dia of conductor used in metres
 D = Spacing of conductors Ingrid in metres
 h = Depth of burial in metres
 K_i = $0.655 + (0.172 \times n)$
 P = Average resistivity of the ground in ohm metres
 l = Maximum RMS current following between the ground grid and earth in amps
 L = Length of buried conductor in metres

REFERENCES

- 1) LAURENT, P.G. "general fundamentals of electric grounding technique," Bulletin De La Societe Francaise Des Electriciens 1 (July 1951) 368-402.
- 2) A IEE committee report "Voltage gradient through the ground under fault conditions", A IEE Trans, 77 pt.III (1958) 669-692.

3.4.7.3 All exposed steel earthing conductors should be protected with bituminous paint.
PLATE EARTHS

i)EHT Substation - 1.3 M x 13 M.Ms cast iron plates 25mm thick Plates are to be buried vertically in pits and surrounded by finely divided coke, crushed coal or char coal atleast 155 mm all round the plates. Plates should not be less than 15 m apart and

should be buried to sufficient depth to ensure that they are always surrounded by moist earth.

3.4.7.5 PIPE EARTHING

- a) EHT substations Cast iron pipes 125 mm in diameter 2.75 m long and not less than 9.5 mm thick. Pipes 50.8 mm in dia and 3.05m long.

Pipes are to be placed vertically at intervals of not less than 12.2 m in large stations surrounded by finely broken coke crushed coal and charcoal atleast 150 mm around the pipe on the extra depth.

- a) Peripheral or main earth mat 100 x 16 m MS flat
b) Internal earth mat 50 x 8m MS flat to be placed at 5m apart
c) Branch connections Cross section not less than 64.5 sq.mm

i) Joints are to be kept down to the minimum number

ii) All joints and connections in earth grid are to be brazed, riveted, sweated, bolted or welded.

For rust protection the welds should be treated with barium chromate. Welded surfaces should be painted with red lead and aluminium paint in turn and afterwards coated with bitumen. Joints in the earthing conductor between the switchgear units and the cable sheaths, which may require to be subsequently broken should be bolted and the joint faces tinned. All joints in steel earthing system should be made by welding except the points for separating the earthing mat for testing purposes which should be bolted. These points should be accessible and frequently supervised.

3.4.7.6 In all sub-stations there shall be provision for earthing the following :

- a) The neutral point of each separate system should have an independent earth, which in turn should be interconnected with the station grounding mat
- b) Equipment frame work and other non-current carrying parts (two connections)
- c) All extraneous metallic frame work not associated with equipment (two connections)
- d) Lightning arrestors should have independent earths which should in turn be connected to the station grounding grid.
- e) Over head lightning screen shall also be connected to the main ground mat.

3.4.7.7 The earth conductor of the mat could be buried under earth to economical depth of burial of the mat 0.5 meters.

3.4.7.8 MEASUREMENT OF RESISTANCE :

3.4.7.8.1 The earth resistance can be measured by any of the following methods :

- i) Three point method
- ii) Four point method

3.4.7.8.2 THREE POINT METHOD : In this method, two temporary electrodes or spikes are driven, one for current and the other for voltage, at a distance of 150 ft. and 75 ft. respectively from earth electrode under test and ohmic values of earth electrode resistances are obtained from the earth megger. The earth resistance is calculated from the following formula :

$$R = \frac{P \log_{10} (4 L/D)}{2 L} \text{ where,}$$

- R = Electrode resistance in ohms
- L = Length in centimeters of the Rod driven under ground
- D = Diameter in cms. of the rod
- P = Earth resistivity in ohm-cm

3.4.7.8.3 FOUR POINT METHOD : In this method, four spikes are driven into the ground at equal intervals of „a“ cms. The depth of insertion of spikes into the ground must not exceed one twentieth of „a“. The two outer spikes are connected to the current terminals of earth megger while the two inner spikes are connected to potential terminals. The megger handle is rotated till a steady reading „R“ ohms is recorded. Assuming that the soil is homogeneous the earth resistivity „P“ in ohm s/ cubic centimeter (ohm/cm) is calculated from the following formula :

$$P = 2 a R$$

Increased spacing of spikes gives high values for „P“ and this effect is believed to be due to different strata in the earth's depth having different resistivities.

3.5 INSULATORS

3.5.1 Technical particulars of the tension and suspension type porcelain insulators shall normally be as that of line insulators. The post solid core type insulator shall be capable of being mounted either up-right or under hung.

3.6 GENERAL REQUIREMENTS :

The solid core insulators are intended for erection with 220 KV, 132 KV and 33KV isolators and for support purpose in the Board's E H T substations. The particulars of the system, the insulation levels to be withstood by the insulators and other particulars are indicated below :

	The values under columns (A), (B) and (C) shall correspond to their usage as 220 KV, 132 KV and 33KV insulators		
	(A)	(B)	(C)
Nominal System voltage	220 KV (Rms)	132 KV (Rms)	33 KV (Rms)
Highest System voltage	245 KV (Rms)	145 KV (Rms)	36 KV (Rms)
Standard impulse withstand voltage	1050 Kv (Peak)	650 KV (Peak)	170 Kv (Rms)
One minute Power Frequency withstand voltage	460 KV (Rms)	275 KV (Rms)	75 KV (Rms)
No. of insulator units per stack	Two	One	One
Height of each basic unit	1150 mm	1500 2.5mm	445 1
Total height of the stack	2300 3.5mm	1500 2.5 mm	445 1
Pitch Circle diameter (4 nos. holes of 17.5 mm dia on the base and top suitable for bolts of 16mm dia for each piece)			
Top	127 mm	127 mm	76 mm
Bottom	178 mm	178 mm	76 mm
Total creepage distance (Min.)	3800 mm	2250 mm	760 mm
Mechanical strength required (Min.)			
Cantilever (N)	4000	6000	4500
Tension (N)	80000	7000	30000
Torsion (N-M)	3000	3000	1500
Compression (N)	160000	1,40,000	60000

All other mechanical and electrical features shall be in conformity with post insulators designation C4-1050, C6-650 and C6-170 of IS: 5350 Part-II for 220 cu arce insulators respectively.

3.7 LIGHTNING SHIELDING

This protection could be achieved by overhead ground wires of 7/4.064 mm hot dip galvanized steel wire, mounted at a height above the power conductors maintaining minimum earth clearance. Lightning masts also could be used instead of ground wires.

- 3.7.2 When overhead ground wires used, all electrical equipment outside the area enclosed by the ground wires shall fall within the area covered by 30 degrees angle to the vertical on the outside of the outer most ground wires. All electrical equipment within the area enclosed by the ground wires shall within the area covered by a 60 degree angle to the vertical on the side of the ground wires.

If lightning masts or rod used all electrical equipment outside the area enclosed by the lightning masts or rods shall fall within the protective cone formed by rotating a line at 30 degrees to the vertical with the lightning mast or rod peak as apex through 360 degrees. All electrical equipment within the area enclosed by the lightning masts or rods shall fall within the protective cone formed by rotating a line at 60 degree to the vertical with the lightning mast or rod peak as apex through 360 degrees.

The ground wire and/or masts/rods shall be connected to the main station earthing system bus solidly (and not through supporting steel structures) for preventing difference of surge potential between the shield and other grounded parts of the station.

3.8 LIGHTING :

IS : 3646 (Part II) Schedule of values of illumination and glare index-recommends values of intensity of illumination. The following uniform illumination levels are being adopted.

- i) Switchyard – 25 Lux
- ii) Control room and Test room – 300 to 500 Lux
- iii) Carrier room MCC room, LT panels, Chargers, Offices, Conference Hall, Rest Room Reception, Workshop, Repair bay etc., - 300 Lux
- iv) Battery room, Corridors, PLCC room, Toilets, Store Room, Cloak room, Stairs etc. – 100 Lux

3.9 SURGE DIVERTOR (Lightning Arrestors)

3.9.1 Guide for selection of LA

3.9.1.1 Before selecting the L.A it should be ascertained whether the system is effectively earthed, non-effectively earthed or having isolated neutral.

3.9.1.2 The system neutrals are considered to be effectively earthed when the co-efficient of earthing does not exceed 80%. In this case, the reactance ratio X_0/X_1 (zero sequence reactance/positive sequence reactance) is positive and less than 3 and at the same time the resistance ratio R_0/X_1 (zero sequence resistance/positive sequence reactance) is less than 1 at any point on the system. For this system the arrester rating will be 80% of the highest phase to phase system voltage.

3.9.1.3 The L.A voltage rating corresponding to the system voltages normal are indicated below :

Rated system Voltage (KV)	Highest system Voltage (KV)	Arrester rating in KV Effectively earthed systems
11	12	9
33	36	30
66	72.5	60
132	145	120/132 (latex)
220	245	198/216 (latex)
400	420	336

3.9.1.4 The L.As are usually procured along with surge counters and leakage current ammeters, if available.

3.9.2 LOCATION OF LIGHTING ARRESTORS : The L.As employed for protecting transformers should be installed as close as possible to the transformer. The electrical circuit length between L.A and the transformer bushing terminal should not exceed the limits given below :

Rated system Voltage KV	BIL KV Peak	Max. distance between L.A and Transformer bushing terminal (inclusive of lead length) (in metres) Effectively earthed
11	75	12.0
33	200	18.0
66	325	24.0
132	550	35.0
	650	43.0
220	900	Closes to Transformer
	1050	
400	1425	
	1550	

3.9.3 Station type L.As should be installed on the H.V and L.V sides of power transformers in sub-stations.

3.9.4 Station type L.As should be provided on all feeders rated 33KV and below .

3.9.5 Long cables from the station to exposed Overhead lines should be protected by arrestors installed at the junction of the cable to O.H line.

3.10 ISOLATORS

Air break isolators or disconnecting switches are not intended to break load though these are meant for transfer of load from one bus to another and also to isolate equipment for maintenance. These are available mainly in two types vertical break type and horizontal break type. The later type requires larger width. However the space requirement can be reduced in this horizontal break isolators by having double break with a center rotating pillar. Pantograph and semi-pantograph disconnects involve vertical movements of contact arm and therefore require less separation between phases and thereby require less separation between phases and thereby help in reducing the sub-station area to a larger extent. The isolators could be operated mechanically or hydraulically or pneumatically or by electric motor. Earthing facility shall be provided wherever required.

Rated Insulation Levels (IS 1818 – 1972)

Sl. No.	Item	11 KV	33 KV	66 KV	132 KV	220 KV	400 KV
1.	Standard and impulse withstand voltage positive and negative polarity (KV peak)						
	a) Across isolating distance	85	195	375	750 / 630	1210 / 1035	1780 / 1640
	b) To earth and between poles	75	170	325	650 / 550	1050 / 900	1550 / 1425
2.	One minute power frequency with stand voltage (KV rms)						
	a) To earth and between poles	35	75	140	275 / 230	460 / 395	680 / 630
	b) To earth and between poles	35	75	140	275 / 230	460 / 395	680 / 630
	c) To earth and between poles in the case of oil immersed ones for routine testing after	28	70	140	275 / 230	460 / 395	680 / 630

(x) These values apply when the frame of the isolator is connected to the mid point of the voltage source.

Note 1. For earthing devices only, the test voltages to earth and between poles apply

Note 2. The table applies at the conditions of temperature, pressure and humidity which are 20 Degrees Centigrade, 760 mm and humidity which are 20 Degrees Centigrade, 760 mm and 11g of water/cub. Meter.

3.10.2 Switches controlling transformers or feeders should be capable of breaking their charging currents.

3.10.3 High pressure contact switches for outdoor service are generally with a contact pressure of 0.227 kgs per Amp. Capacity (rough guide)

3.10.4 Breaking capacity of switches :

Breaking current of ASEA switchs – Empirical formula

$$I = K \frac{L}{E}$$

Where

I = Breaking current in Amps (r.m.s)

- K = 0.06 when breaking a capacitor or unloaded cable
0.15 when breaking an unloaded overhead transmission line
0.20 when breaking unloaded transformer
0.40 when breaking load current
- L = Centre to Centre phase distance in mm. though not exceeding four Times the flash over distance across an open pole.
- E = Breaking voltage, Main voltage Kv-rms

1. MAINTENANCE SCHEDULE OF E.H.V. POWER TRANSFORMERS

Sl.No.	Item of Maintenance	Periodicity	Remarks
1.	Checking the colour of silicagel in the breather and replacement or reconditioning if colour changes from blue to pink say about 50% of the total quantity. Checking up the oil level of the oil seal (to be upto the level marked in the cup)	Daily	
2.	Checking of oil level in a) Main conservator b) OLTC conservator c) bushings and examining for leaks of oil	Daily	
3	Visual check for overheating if any at terminal connections and checking for unusual internal noises	Daily each shift	
4	Checking for noise and vibrations or an abnormality from oil pumps and cooling fans	Daily	
5	Checking up of oil and winding temperatures	Hourly	
6	Checking for pressure relief explosion vent diaphragm from cracks	Daily	
6 (a)	Forced cooling system: Checking for leakage of water into cooler (forced cooling system by oil pumps)	Daily	
7	Cleaning of bushings. Inspect for any cracks or chippings of the porcelain	Monthly	
8	Ensuring that oil comes out when air release valve is opened (of the main tank)	Quarterly	
9	Measuring insulation resistance of windings with an appropriate Megger (note down oil temp.)	Quarterly	
10 (a)	Checking up of winding and oil temperature. Bucholtz and surge relay and oil level trips for correct operation	Quarterly	
10 (b)	Checking up of Auto starting of pumps and cooling fans	Quarterly	
11	OLTC oil test for BDV and moisture content. Ensure oil level in OLTC	Quarterly	
12	Main tank oil testing for BDV and moisture content	Half yearly	
13	a) Checking of Bucholtz relay for any gas collection and testing the gas collected b) Checking of operation of Bucholtz relay by air injection c) Noting the oil level in the inspection glass or Bucholtz relay, arresting	Quarterly or during fault Half yearly or during shutdown Monthly or as when shut down availed	

14	Tap changer a) Lubricating / greasing all moving parts	Quarterly	
15	Checking of all connection on the transformer for tightness such as bushings, tank earth connection, etc.	Quarterly	
16	Forced cooling system a) Megger testing of motors (pump) lubricating the mechanical parts and cooling fans b) Cleaning of water jacket c) Cleaning of water jacket circuits of oil pumps and cooling fans for earth leakage overload trip alarm, etc. d) Checking of interlocks for pumps. Cooling of interlocks for pumps. Cooling Air Blast fans for Auto Start and Stop operation at correct temperature setting and for manual operation	Yearly Quarterly Quarterly Quarterly	
17	Oil level in oil seal and replacement	Quarterly	
18	Testing of oil for dissolved gas analysis for 100 MVA and above. If the results show abnormality, frequency of DGA may be increased as per the recommendations of R&D	Half yearly	Other Transformers such as 50 MVA, 31.5 MVA and 10/16 MVA Trs. Which are in service for more than 5 years
19	Pressure testing of oil coolers	Half Yearly	
20	Testing of motors, pumps and calibrating pressure gauges, etc.	Half Yearly	
21	Overhauling of pumps, motors and cooling fans	Yearly or as and when necessary	
22	Testing of oil in main tank for acidity, tan delta, IFT and resistivity	Yearly	
23	Bushings testing for tan delta	Yearly	
24	Calibration of oil and winding temperature indicator	Yearly	
25	Measurement of excitation current at low voltage at normal tap and extreme taps	Yearly	
26	Measurement of DC winding resistance	Yearly	
27	Ratio test at all taps	Yearly	
28	Checking the bushing CT for WTI for correct ratio	Yearly	
29	OLTC a) Inspection of contacts in diverter b) Driving mechanism visual check-up, overhauling if necessary	Depending upon the no. of operations as recommended by the manufacturer Yearly	
30	a) Tap position indicator	Yearly	

	b) Checking for proper working of remote tap position indicator, remote winding test indicator	Yearly	
31	Operating of Bucholtz relay for alarm and trip by draining of oil and injection of air with cycle pump	Yearly	
32	Checking for leakage in air cell (for transformers fitted with Air Cell)	Yearly	
33	Oil level in Thermometer pocket top up if required	Yearly	
34	Bushing partial discharge test and capacitance	Once in 5 years	
35	General Overhaul	Once in 10 years	
	a) Core tightening		
	b) De-sludging / washing of windings		
	c) Inspection of core and windings		
	d) Replacement of all gaskets		
	e) Check core bolt insulation		
36	Filtration of oil	Whenever oil test results are below permissible limits	

INTERPRETATION OF THE ANALYSIS OF GASES IN TRANSFORMERS AND OTHER OIL FILLED ELECTRICAL EQUIPMENT IN SERVICE

1.0 Introduction IEC 599 ANNEXURE – 1A

This standard is a result of a survey carried out jointly by the IEC and the CIGRE in order to compare available method of interpretation of gas in Oil analysis. One hundred samples were collected of faulty transformers for which the actual faults had been identified by the examination and the gas dissolved in oil and sometimes the Bucholz gas, had been analysed. The diagnostic methods given in this standard were applied. All these methods of interpretation appear to be capable of discriminating reliably between electrical faults and thermal faults. Exemption were rare and they perhaps reflect occasional mis-judgement rather than the inadequacy of the methods.

2.0 SCOPE

Electrical discharges of thermal stresses in the oil or solid insulation, for example, paper press board etc. of an oil filled transformer cause degradation of these materials with the formation of gases of various types. To some extent these gases dissolved in the oil filled electrical equipment and for the analysis of free and dissolved gases, they may be removed from a sample of the oil and analysed quantitatively by gas chromatography. This standard describes how the concentration of dissolved gasses or of free gases may be interpreted to diagnose the condition of a transformer in service and suggest future action.

These methods of interpretation have been developed for power transformers wound with copper conductors insulated paper of pressboard based solid insulation and filled with hydrocarbon mineral oil, in service on power networks until further experience has been gained the method should be applied with caution in relation to other materials. The method may also apply in principle to instrument transformers, oil filled cables, switchgears etc. but insufficient experience is available to formulate suitable interpretation and limits.

In any case, the indication obtained must be viewed only as a guide and resulting action must be undertaken with proper engineering judgement.

3.0 Recommended basic method for interpreting gas analysis :

3.1 Gases generated from oil :

The basic diagnosis is found upon the types and relative quantities of gases generated by the composition of oil under various fault conditions. It will be appreciated that oil either alone or as an impregnant is present practically everywhere that a fault can arise in large oil filled transformers. The most significant gases generated by the decomposition of oil are hydrogen (H₂) Methane (CH₄) Ethane (C₂H₆) Acetylene (C₂H₂) and Ethelene (C₂H₄).

Note : The hydro carbons quoted above are by no means the only one generated, for example, C4 hydrocarbons are also formed. But experience to date has shown that a satisfactory diagnosis can be made without accepting these gases and for the simplicity, they have been analysed and the method of interpretation described below. Where celulosic materials are involved at a fault, further gases, chiefly carbondioxide (CO₂) and carbon monoxide (CO) are also generated by the information obtained from concentration of these in supplementary to the basis diagnosis as explained in clause – 4.

The relative quantities of the above gases show how the energy available to decompose the oil is released at the fault and hence always characteristic type of fault, if fault is present.

Partial discharge has occurred in case of fault of low level energy (break down in gas filled voids oil filled impregnated material) the main cause of the decomposition in this case is ionic bombardment of the oil molecules and the gas produced is hydrocarbon. In other cases, the decomposition of oil is mainly caused by heat with variations, in the types of hydrocarbons produced mainly hydrogen and methane. Higher temperatures and higher energies are caused by hot spots or conductor overheating, temperatures from a little above normal operating temperatures (say 15 Deg. C) to as high as 100 deg. C may occur in such cases to decompose the oil. The principal gas produced by the low temperature hot spots is CH₄ but as the fault temperature at room rise C₂H₆ and C₂H₄ appear in increasing quantities. In the much higher temperatures occurring at sparking, flashovers or in power arcing where temperature of over 3000 deg. C may be produced C₂H₂ becomes significant. The recommended method of codifying these changing concentrations to enable ready diagnosis of a fault is given in the sub-clause 3.3

Note : The techniques described apply only where there is a single or predominant type of fault present where there are more types of fault each producing considerable quantities of gases, additional information may be obtained, periods of observations may be required.

Levels at which dissolved gases are significant : Before proceeding with any diagnosis method it is necessary to be satisfied that the measured gas contents are significant. There are questions to be answered.

- 1) Are the measured values well above the sensitivity of the analysis methods and equipment ?
- 2) If they are, are the gas concentration high enough to warrant further investigations as to whether there may be a fault in the transformers ?

The answer to the first question depends on the analysis method and equipment. IEC publication 567 sets requirement for the sensitivity of the analysis. Before considering that any gases present insignificant quantity, its concentration should be atleast 10 times these sensitivity limits.

The answer to the 2nd question related to the likelihood of a gas being present in a transformer due to normal operating conditions, without any fault being present. Even

in re-impregnated transformer, gases may be present in quantities sufficient to be misleading. Sources of these gases may be :

- gases formed during the refining processes and not completely removed by oil degassing
- gases formed during drying and impregnating the transformer in the factory
- gases formed on the occasion of previous faults and not completely removed from the oil-impregnated insulation before being refilled with degassed oil :
- gases formed during repairs by brazing welding etc.

To overcome this problem it is suggested that the initial gas contents of the oil in transformer should be established as a matter of routine by analyzing gases from an oil sample obtained shortly before or a limited period after, energizing the transformer at site. The result of this analysis is taken as a “benchmark” at which examining later analysis which are regarded as indicative of trouble only if the concentration of gases substantially exceed the benchmark values.

During ordinary operation also gases are formed, particularly CO₂ and CO by normal aging processes in a transformer, so that concentrations of all gases may be expected to increase over the life of a transformer (along with some times stable values are reached, set by interchange with the air at the conservator. Actual values of concentrations for various ages of transformers vary, widely as a result of different operational methods and transformer designs, it is strongly recommended that each utility should endeavour to build up data from which these normal concentrations) or “norm s” for healthy transformers of various ages may be known. If, on carrying out a routine analysis of the gases in the oil of particular transformer “norm s” are found to be exceeded, this does not necessarily indicate that there is a fault, but does indicate the greater attention to that transformer is advisable.

One would usually institute more frequent sampling any analysis but the urgency and nature of action would to some extent depend on the amounts by which actual concentrations are found to exceed the “norm s” as well as on the particular composing of dissolved gases. INTERNATIONAL data covering all types of transformers and all operating methods will be published by CIGRE. However, since these are average values covering very many cases, they are by no means reliable as those built up by experience by a particular manufacturer.

3.3 DIAGNOSIS OF FAULTS FROM RELATIVE CONCENTRATION OF INDIVIDUAL GASES DISSOLVED IN OIL

A convenient basis for fault diagnosis is the calculation of ratio of the concentrations of the gases listed in sub clause 3.1. The ratio used in the following interpretation scheme are :

$\frac{C_2H_2}{C_2H_4}$	$\frac{CH_4}{H_2}$	$\frac{C_2H_4}{C_2H_6}$

other ratios can be used for further discrimination

Table-I shows various limits of the ratios corresponding to normal ageing and to various types of faults from which a diagnosis of the nature of a fault may be obtained. The table shows code for each range of the ratios of the characteristic gases numbers as have been allowed so that code 000 represents normal ageing conditions.

Table –III shows a flow chart summarizing action following the taking of a routine oil sample and steps that should be followed after diagnosis shows a fault to be likely.

In clause 4 and 5 are given methods of obtaining information supplementary to the above main diagnosis. The significance of CO₂ and CO content in relation to deterioration of cellulosic is discussed in clause – 4 ; the significance of free gases is gas collecting relays and the application of the above diagnostic methods to these gases are discussed in clause 5.

NOTE

Additional information concerning diagnostic methods can be found in the review Electra, No.42, October 1974 (pages 51-52)

CODE FOR EXAMINING ANALYSIS OF GAS DISSOLVED IN OIL

NUMERICAL TABLE-1

RATIOS OF CHARACTERISTIC GASES

		CODE OF RANGE OF RATIOS			
RATIOS OF CHARACTERISTIC GASES		$\frac{C_2H_2}{C_2H_4}$	$\frac{CH_4}{H_2}$	$\frac{C_2H_4}{C_2H_6}$	
< 0.1		0	1	0	
0.1 – 1		1	0	0	
1 – 3		1	2	2	
> 3		2	2	2	
CODE CHARACTERISTIC FAULT					TYPICAL EXAMPLES
No.	Fault				
0	No fault	0	0	0	Normal ageing
1	Partial discharge of low energy density	0 (but not significant)	1	0	Discharge in gas filled cavities resulting from incomplete impregnation, or super-saturation or cavitation or high humidity
2	Partial discharge of	1	1	0	As above, but leading to tracking or deformation of solid insulation
3	Discharges of low energy (see notes)	1-2	0	1-2	Continuous sparking in oil between bad connections of different potential or to floating potential breakdown of oil between solid materials
4	Discharges of high energy (see notes)	1	0	2	Discharges with power follow through, arcing, breakdown of oil between windings of coils or between coils or between coils to earth
5	Thermal fault of low temperature 150°C (see note.2)	0	0	1	General insulated conductor overheating
6	Thermal fault of low temperature (range 150°C – 300°C)	0	2	0	Local overheating of the core due to concentration of flux increasing hot spot temperature varying
7	300°C - 700°C				

8	Thermal fault of high temperature > 700°C (see note.4)	0	2	2	from small hot spots in core. Shorting links in core. Overheating of copper due to eddy current, bad contacts joint (pyrolytic carbon formation) upto core and tank circulation currents

NOTES:

For the purpose of this table there will be a tendency for the ratio C_2H_2 / C_2H_4 to rise from a value between 0.1 and 3 to above 3 and for the ratio C_2H_4 / C_2H_6 from a value between 0.1 and 3 to above 3 as the spark develops in intensity.

In this case the gases come mainly from the decomposition of the solid insulation, this explains the value of the ratio C_2H_4 / C_2H_6 .

This fault condition is normally indicated by increasing gas concentrations. Ratio CH_4/H_2 is normally about 1. The actual value above or below unity is dependent on many factors such as design of oil preservation system, actual level of temperature and oil quality.

An increasing value of the amount of C_2/H_2 may indicate that the hot point temperature is higher than 1000°C.

REMARKS:

1. Significant values quoted for ratios should be regarded as typical only.
2. Transformers fitted with in tank on load tap-changers may indicate fault of type 202 102 depending on seepage of transmission of arc decomposition products in the diverter switch tank into the transformer tank oil.
3. Combination of the ratios not included in Table-1 may occur in practice. Consideration is being given to the interpretation of such combinations.

4. Degradation of Cellulosic insulation :

Degradation of cellulosic materials characteristically produces CO_2 and CO together with much smaller quantities of other gases. Both CO_2 and CO are produced at normally operating temperatures as a result of normal ageing of the insulation. Also, the factory drying and impregnating processes cause some degradation of the cellulose from which some CO_2 and CO may remain. When a transformer has been shipped filled with CO_2 instead of oil, it is nearly impossible to remove all of this gas from the impregnated insulation and this will account for some quantity of CO_2 in the operating transformer. In the case of conservator transformer, CO_2 may enter the oil from the atmosphere-up to about 300 of oil may be so introduced. Thus, where there is suspicion that a fault might have involved cellulose, the significance of these two gases must be considered against the possibility that both gases may have been present in moderately high concentrations before the fault occurred.

4.1 Examining CO_2 and CO concentration found dissolved in oil :

For cellulose degrading by heat along at normal operating temperatures statistical analysis for normally operating conservator transformers gives a ratio CO_2 / CO of about 7, although conservator – with a wide spread of values (standard deviation of about 4). High temperature degradation of cellulose, no matter how cased (e.g., hot-

spot or rate) tends to increase the relative amount of CO₂. However, the rates of CO₂ and CO production depends great on oxygen availability, moisture content and the temperature of degradation. Consequently, any case in which CO₂/CO is below about 3 or above about 11 should be regarded as perhaps indicating a fault involving cellulose, provided results obtained according to Sub Clause 3.3 are also indicating excessive oil deterioration. If possible, the ratio should be compared with previous values for the same transformer, or with values for similarly loaded transformers of the same design.

In sealed transformers, where the concentrations of CO₂ and of CO are low during the earlier life of the transformer the ratio CO₂/CO is generally below 7 but the ratio is likely to increase as normal ageing proceeds.

4.2 Examining CO₂ and CO concentrations in fresh gases found the gas collection relay :

As a rule, serious involvement of cellulosic insulation may be assumed if concentration of carbon oxides in the free gas are significantly higher than they would be equilibrium with the concentrations found in the oil (for calculation of the equivalent concentrations - see clause 5) the implication being that sufficient of these gases has been generated and sufficiently rapidly, to pass into the relay without coming into equilibrium with the body of the oil (compare the parallel case of an arcing fault, discussed below).

5. Application of diagnostic method to free gases in a gas-collecting relay :

During a fault, the rate of production of gases of all types is closely linked to the rate of energy liberation. Thus, the low rate of energy liberation in partial discharges, or in a low temperature hot spot, will cause gases to evolve slowly and there is every probability that all the gas produced gets dissolved in the oil.

The higher rate of energy liberation at high temperature core fault for example, can cause moderately rapid evolution of gas: the resulting gas bubbles ascending towards the conservator will usually partially dissolve in the oil and exchange with gases already dissolved) but some gas may well reach the gas collecting relay or as cushion: this gas may approach equilibrium with the gases dissolved in the oil.

The very high rate of energy liberation associated with a power arcing fault causes a rapid and substantial evolution of gas (the resulting pressure surge normally operated the surge element of the gas collecting relay): the large gas bubbles rise quickly to the relay and exchange little gas with the oil so that the gas that collects in the relay is initially far from being in equilibrium with the gases dissolved in the oil. However, if this gas is left for a long time in the relay, some constituents will dissolve, modifying the composition of the gas collected: acetylene, which is produced in significance quantities by an arcing fault and which is very soluble, is a noteworthy example of a gas which may dissolve comparatively quickly to produce misleading results.

In principle, analysis of free gases from a gas collecting relay or from a gas cushion may be evaluated in the same way as gases dissolved in the oil. However, where the surge element has operated and gas has accumulated in substantial quantities is

rarely any doubt that there is a serious fault, and analysis of gases should be undertaken on identify the fault.

Where gas has accumulated slowly, assessment of the gases dissolved in the oil is more informative than that of the free gases : the gas-in-oil determination is also essential in order to determine the total rate of evolution of gases and thus check whether the fault is growing, which is a most important matter to investigate. When analysis of free gases is undertaken, it is necessary to convert the concentrations of the various gases in the free state into equivalent concentrations in the dissolved state before applying the diagnostic methods set out in Table-I.

Applying the principles set out above, comparison of the actual concentrations in the oil with the equivalent concentrations in the free gas may give valuable information how far gas bubbles may have risen through the oil and hence on the rate of gas evolution.

5.1 Calculation of dissolved gas concentrations equivalent to free gas concentrations

This calculation is made by applying the Ostwald co-efficient for each gas separately. For a particular gas, the Ostwald co-efficient K is defined as :

$$K : \frac{\text{Concentration of gas in liquid phase}}{\text{Concentration of gas in gas phase}}$$

The Ostwald Co-efficients for various gases in mineral insulating oils at 20°C and 50 °c are given in Table below :

TABLE

Gas	K at 20°C	K at 50 °c	Gas	K at 20 °c	K at 50 °c
N2	0.09	0.09	CH4	0.43	1.40
O2	0.17	0.17	C2H6	2.40	1.80
H2	0.05	0.05	C2H4	1.70	1.40
CO	0.12	0.12	C2H2	1.20	0.9
CO2	1.08	1.00			

NOTE :

Data given in this table represent mean values obtained on some of the current transformer oils. Actual data may differ a little from these figures. Nevertheless, data given above may be used without influencing conclusions drawn from recalculated test results.

The Ostwald co-efficient is independent of the normal partial pressure of the gas concerned. The gas and liquid phases are assumed to be at the same temperature: this is rarely the case but the error introduced by any difference will not invalidate the conclusions reached.

2. Maintenance Schedule for Circuit breakers of 33 KV and above

S.No.	Item of maintenance	Periodicity	Remarks
1. A. SULPHUR HEXA FLOURIDE (SF6) GAS CIRCUIT BREAKER			
1	SF6 density monitoring	Daily in each shift	If appreciable change is observed compared to earlier readings, leakage check to be carried out
2	Measurement of Humidity of SF6 gas	Yearly	Use Dew Point meter. If deviation from standard norms is observed, the evacuation, recycling and refilling of SF6 gas is to be carried out
3	Acid concentration measurement of SF6 Gas	Yearly	
4	Air content measurement of SF6 gas	Yearly	
5	SF6 gas leakage test	Yearly	Check the complete breaker for SF6 gas leakage including the seal assembly of driving rod. If any leakage is detected the same should be arrested in consultation with manufacturer and after arresting the leakage the SF6 gas pressure is to be brought upto rated pressure by topping up SF6 gas
6	a. Checking of insulation of control circuit wirings	Yearly	Minimum 2 Mega Ohms with a 500 V megger
	b. Measurement of Insulation resistance across contacts (with breaker off) and pole to earth with breaker on	Yearly	To be done by 2.5 KV megger or above
7	Evacuation, recycling and refilling of SF6 gas	5 yearly	This may be done whenever the humidity in SF6 gas in excess of permissible value.
8	Checking the Br.level with spirit level	Yearly	
B	AIR BLAST CIRCUIT BREAKER		
1	Checking of air pressure	Daily in each shift	If appreciable changes is observed, compared to earlier readings, leakage check to be carried out
2	Draining out condensed water from HP cylinders	Twice daily at 6 AM and 6 PM	Frequency of draining may be increased during rainy season and winter
3	Draining out condensed water from circuit breaker tanks	Monthly	-do-
4	Visual checking of oil level in the dash pot; checking of manometer readings	Monthly	
5	Capatiance measurement for Grading capacitors	Yearly	

6	Measuring insulation resistance of control circuit wiring and measuring IR values	Yearly	Minimum 2 Mega Ohms with a 500V Megger
7	Measurement of IR values across contacts (each break) with breaker off and pole to earth with breaker ON	Yearly	Minimum 2.5 KV megger to be used
8	Checking the Br. Level with spirit level	Yearly	
C. VACCUUM CIRCUIT BREAKERS			
1	Measuring I.R values of the poles with breaker open (i.e., across contacts) and breaker closed (pole to earth)	Monthly	Record the value and compare with earlier values
2	High voltage test across contacts of each vacuum interrupter	Yearly	To ensure dielectric strength of vacuum interrupters
3	Measuring insulation resistance of control circuit wiring	Yearly	Minimum 2 Mega ohms with a 500 V megger
4	Anti condensation heaters	Daily	Ensure that heater is on and is working
D. MINIMUM OIL CIRCUIT BREAKER			
1	Checking of oil leakage from guage glass, drain valve and other joints	Daily	
2	Testing of oil samples for dielectric strength	Quarterly	If the valve is low oil should be replaced with fresh tested oil. Oil shall also be replaced after 12 trippings on fault or as per recommendations of manufacturer. Oil filling instructions given by the manufacturer s hall be followed.
3	Measuring IR values across contacts with breaker off and pole to earth with breaker on	Quarterly	NOTE : Before closing MOCB on a fault, the operator should ensure that adequate oil level is available in the breaker by observing the guage glass and if adequate oil is not available, the breaker should not be test charged.
4	Checking the Br. Level with spirit level	Yearly	
E. GENERAL MAINTENACE (Common to all Breakers)			
1	Operating time including Pre-insertion resistor (wherever applicable)	Yearly	Circuit breaker analyser may be used. Results are to be recorded and compared with the commissioning test result. If
2	Contract travel	Yearly	
3	Speed curves	Yearly	

4	Pole discrepancy (for individual pole operated)	Yearly	there is difference in the values, or if the values are beyond limits prescribed by the Manufacturer, the manufacturer has to be informed and all the operation checks are to be made in the presence of manufacturer & remedial measures are to be taken
5	Functional checks duty cycle operation including rapid reclosing	Yearly	
6	Checking of all operational lock outs	Yearly	
7	Checking of all interlocks	Yearly	
8	Contact resistance measurement	Yearly	Not to exceed 100 Micro ohms (by measuring DC voltage drop)
9	Checking of pressure setting and calibration of meters	Yearly	
10	Through checking up of close and trip coils	Yearly	Resistance and pickup voltage are to be checked and compared with previous values (pre-commissioning results)
II	OPERATING MECHANISM		
A	SPRING OPERATING MECHANISM		
i)	Checking conditions of spring tension	Quarterly	
ii)	Lubricating the motor bearings	Quarterly	
iii)	I.R values of motor winding	Quarterly	
iv)	Checking interlocking mechanism	Quarterly	
B	PNEUMATIC OPERATING MECHANISM		
i)	Checking of air pressure	Daily	
ii)	Draining of moisture from air receiver, visual inspection cleaning	Daily/ Weekly	Daily for central compressor unit and weekly for individual compressor unit
iii)	Checking of tightness of compressed air pipes work and coupling	Yearly	
iv)	Checking of cumulative running hour of compressor	Once in each shift	Action to be taken as per manufacturer's recommendations
v)	Checking of air pressure drop during duty cycle operation	Yearly	Pressure drop in the air pressure to be checked for each sequence of operation and to be compared with data sheets
vi)	Check for compressor running sound	Monthly	
vii)	Lubrication, greasing of moving parts of the compressor	Yearly	
viii)	Blowing out dust in the windings of compressor motor	Monthly	
ix)	Checking for proper functioning of safety valves in compressed air system	yearly	

x)	Overhauling of compressor motors	Yearly	
xi)	Checking interlocks low and high air pressure and correct operation	Yearly	
C	HYDRAULIC (ELECTRO) OPERATING MECHANISM		
i)	Checking of oil pressure and level	Daily	If appreciable change is observed as compared to previous readings, leakage check is to be carried out
ii)	Visual check for oil leakage	Daily	
iii)	Checking for cumulative pump running hours	Once in each shift	
iv)	Replacement/topping up of oil	As and when required	
v)	Visual checking of accumulator, main valves and operating cylinders	Weekly	
vi)	Checking of printing pressure of nitrogen, nitrogen replenishment (if necessary)	Yearly	
vii)	Checking operating pressure of safety valve	Yearly	
viii)	Checking oil pressure drop during duty cycle operation	Yearly	Drop in pressure of oil to be checked for each sequence of operation and to be compared with data sheets.
ix)	Checking condition of oil	Yearly	If the oil is found to be contaminated, drain the oil and clean both oil tank and oil filter.
x)	Overhauling of oil pump	Yearly	
xi)	Checking for tightness of oil pipe work and couplings	Yearly	
xii)	Checking of various pressure switches for proper operation	Yearly	
	MAJOR MAINTENANCE AND OVERHAUL OF CIRCUIT BREAKER		
1	Evacuation, recycling and refilling of SF6 gas	5 yearly	Assistance of manufacturer may be availed
2	Replacement of gaskets		
3	Operating rod cleaning and inspection		
4	Dismantling, cleaning and reassembly of operating mechanism		
5	Interrupting chamber overhaul		
3	Maintenance schedule for Batteries/Battery chargers/ DC Distribution system		
S.No	Item of maintenance	Periodicity	Remarks
1	Cleaning of battery surface joints and all connections	Daily	To be done on rotation so as to cover all the cells in 10 days
2	Specific gravity measurement of pilot cell	Daily	-do-
3	Voltage reading of pilot cells	Daily	-do-
4	Visual checking of battery room ventilation and lighting	Daily	-
5	Checking of electrical connections for tightness	Weekly	-

6	Application of petroleum jelly to joints and cell connections	Weekly	-
7	Checking electrolyte level and topping up with DM water	Weekly	-
8	Shallow discharge (10 hour rate) and recharging	Yearly	The discharge to be done for a specified period
9	Readjustment of specific gravity	Yearly	-
10	Checking of healthiness of AC supply to the charger	Daily	-
11	Checking of float charging current (DC)	Daily	-
12	Output voltage check	Daily	-
13	Charger cleaning with blower	Fortnightly	-
14	Checking control chords	Yearly	-
15	Complete overhaul	Yearly	
16	Checking for DC earth fault	Daily	Earth fault to be attended immediately
17	Check of emergency lights	Daily	Fused lights to be replaced immediately
18	Auto-start and running up of DG set	Daily	-
19	Checking DC distribution		
	i. External	Daily	-
	ii. Internal	Quarterly	-
20	Checking of all electrical connections of charger panel for tightness and cleaning	Quarterly	-
21	Calibration of all meters and relays in the charger and the DCB Bs	Yearly	-
4. Maintenance Schedule for Lightning Arrestors			
S.No.	Item of maintenance	Periodicity	Remarks
1	Visual Inspection	Daily	If chipping / crack in the insulators is observed replacement action may be taken
2	Surge counter reading	Daily	-
3	Leakage current reading and analysis	Once for shift	Should be in green zone
4	Earth resistance	Quarterly	-
5	Leakage current analysis	Quarterly	For gapless lighting arrestors only
6	IR value	Yearly	Compare results with those obtained previously
7	Connections	Yearly	-
8	Calibration of leakage current ammeter	Yearly	-
9	Cleaning of Insulator	Yearly	-
5. Maintenance Schedule for Isolators			
S.No.	Item of maintenance	Periodicity	Remarks
1	Visual inspection	Daily	Visual inspection for cleanliness of insulation, proper alignment of contact arm blades, any abnormal noise and arcing will be carried out.
2	(a) Main contacts checking including	Yearly	Opportunity of shut down

	earth switch high voltage terminal tightening contact resistance checking including cleaning and lubrication of main contacts		should be availed of whenever possible, the checks and measurements should be performed without disturbing the connections
2	(b) Main blades and main contacts checking of (i) alignment (ii) bolts, nuts, washers, cotterpins, terminal connectors, are in place and tight. Examine the contacts, heck to determine that they are aligned and contact surfaces bear with a firm uniform pressure, check contact surfaces, replace any pitted or burnt contacts or smoothen down the surface of the contacts with fine sand paper depending upon the condition of the contacts.	Yearly	
	See the bolts, nuts, washers, cotter pins and terminal connectors are in place and tight. If the switch in group operated inter phase linkage, line operating parts, rods, levers, bearings etc. should be cleaned and lubricated, as required to the manufacturers recommendations		
3	Operating mechanism		
	Checking of - Linkages including transmission gears - Stopper bolts - Limit switch setting - Greasing of drive - Greasing of auxiliary switch contacts - Position and tightening of cable glands (before start of the rainy season)	Quarterly	Check the isolator operation. If the operating efforts appear to be excessive check the rotor bearings, all the linkages for the proper operation
4	Insulators MOM box cleaning and lubrication of operating mechanism hinges locks, joints on levers, etc, check all mounting booth for tightness	Yearly	Opportunity of shut down should be availed of whenever possible
5	Visual check of Auxiliary contact	Quarterly	The check should be done for any arcing marks on contacts, burning of switch housing etc.
6	Checking for proper functioning of space heaters, illumination etc.	Quarterly	
7	Checking of electrical/ mechanical inter locks	Yearly	
8	Earth-switch – checking of - Alignment of earth blade - Contact cleanliness	Yearly	

	- Correct operation of earthin switch - Alluminium/Copper flexible (if provided)		
9	Checking of earth connections	Yearly	
	- Structure - MOM Box		
Standard Acceptance Norms for Isolator during preventive maintenance			
S.No	Type of Isolator and name of Manufacturer	Voltage (KV)	Current rating/ Value of contact resistance Between terminal pads
1	220 KV HEB - SMC - HIVELM	245 KV 245 KV	1600A/100 micro ohms 1600A/175 micro ohms
2	13 KV HEM - BIMCS - SSPL	145 KV 145 KV	1250A/146 micro ohms 1250A/200 micro ohms

NOTE : The values of contact resistance given above are the measured during type tests, the measured values during site tests should be within 120% of the values indicated.

	6. Maintenance Schedule for Current Transformers		
S.No	Item of Maintenance	Periodicity	Remarks
1	Visual check (Porcelain, Unusual noise, discolouration of terminals etc.)	Daily	
2	Oil leakage	Daily	Visual check only
3	Oil level	Monthly	To be recorded
4	Space heater and lighting of marshalling box	Monthly	Operation check
5	Cleaning of marshalling box and junction boxes	Half- yearly	
6	All connections	Yearly	Check for looseness
7	IR value	Yearly	Compare with pre-commissioning test results
8	Earth resistance	Yearly	
9	Tan Delta test	Yearly	Compare with factory test results
10	Cleaning of Insulator	Yearly	
11	DGA oil sample including BDV and moisture content	4 to 5 days after first charging	Oil sample to be taken after obtaining permission from manufacturer
Maintenance for CVTs			
S.No	Item of Maintenance	Periodicity	Remarks
1	Oil leakage	Daily	Visual checks
2	Cattering sounds	Daily	If present, measure capacitance and compare with the designed value
3	Oil level	Monthly	To be recorded

4	Earthing of PLCC link (in case it is not being used)	Monthly	-
5	H.F. Bushing	Monthly	Check for any breakage
6	Spartik gap cleaning	Yearly	If accessible
7	Cleaning of insulator	Yearly	
8	Capacitance measurement	Yearly	Compare with the factory test results/designed value
9	Earthpit resistance	Yearly	

8. Maintenance schedule for earth pits in sub-stations			
S.No	Item of Maintenance	Periodicity	Remarks
1	Watering of earth pits	Daily	
2	Measurement of earth resistance of individual pits	Half-yearly	
3	Measurement of combined earth resistance of all the pits	Half-yearly	
4	Checking of interconnections between earth pits and tightness of bolts and nuts	Quarterly	

Special Note :

Complete and comprehensive record of pre-commissioning test result for each equipment is to be maintained and periodical test values must be compared with the pre-commissioning Test results for taking appropriate action.

The following are guidelines for maintaining voltage and specific gravity of the cells at a uniform value :

- When the battery is to be stored for long period, before putting into service, necessary care is to be taken for proper storage, other-wise there may be possibility of oxidation which may have adverse impact on the porosity of the plates. The Cells will develop uniform porosity only after repeated charge/discharge cycles and adjustment of specific gravity has to be made thereafter in all the Cells.
- Variation in the quantity of Distilled water while topping up or failure to top up some cells may also contribute to the variations in cell voltage and specific gravity
- After installation of the battery, if voltages and specific gravities are not uniform and varying then equalizing charge shall be made by adjustment of electrolyte, ie., in addition or removal of electrolyte and/or addition of Distilled water is made until the specific gravities are uniform. This adjustment may be repeated after some cycles of operation ie., after 30 or 45 days.

- d. Batteries should not be kept under continuous Boost Charge. Batteries shall be on float charge only. After sufficient discharge of the Battery (as indicated by the Voltage and specific gravity of the Cell, Battery shall be kept under Boost charge for the required number of hours only to get the normal voltage and specific gravity.

GUIDELINES FOR SHIFT PERSONNEL TO THE EHT SUBSTATIONS

1. Sub-station layout in detail including various equipment, particulars of Power Transformers, Breakers, CTs, PTs, Isolators, LAs, Batteries and Battery Charges, Station Transformers, Fire fighting equipment, Capacitor banks etc.,
2. In-feeding sources
3. Outgoing feeders and important load centers connected to their sub-station
4. Normal infeed and alternate in feeds – Comprehensive idea of the grid and location of the substation with reference to grid. A grid map showing the in-feeding sources and important load centers connected to the substation to be prepared and displayed.
5. Importance of various equipment available in the substation including capacitor banks
6. Thorough knowledge of normal operations and emergency operations to be carried out.
7. Battery charger operation – change from Float to Boost and Boost to Float rates changing in each mode.
8. Paralleling and deparalleling operation of transformers
9. Operating instructions for all contingencies including issue and receipt of line clear.
10. Lock-out values of gas pressures minimum air pressure where compressors shall start automatically and hydraulic fluid pressure where pump shall start automatically for different makes of Circuit breakers. A chart showing make, type, reference to P.O of power transformers, and breakers and the available and set parameters such as temperature alarms, trips Auto start and stop of cooler fans in respect of power transformers and gas pressures, air/hydraulic pressures, densities in respect of breakers shall be displayed for ready reference.
11. CT available and adopted ratios, relay settings meaning of relay indications on all circuit breakers.
12. Bucholtz and differential relay indications. All annunciations and meaning and consequences of each.
13. Knowledge of all the relays and their functioning, purpose and shall be able to interpret correctly to decide whether the equipment can be charged again or to be kept isolated for further inspection/check-up by the concerned Maintenance/MRT personnel (especially when lockout relays, pressure relief relays, temperature relays, bucholtz relay sand differential relays operate)
14. The works being done by MRT/Maintenance staff in the sub-station whenever they attend to the same shall follow the works being done by them.
15. While taking over the shift duty, he shall go through the entire log of operations from the time last handed over to charge to know the important events happened, works done, condition of the equipment, line clears pending etc.
16. While taking over shift duty he has to check condition of communication equipment, lines, battery charger, batteries, feeders and transformers, breakers as pressures, air pressures, healthy trip circuits, any relay indications not reset etc.
17. Whenever any feeder/equipment is loaded beyond normal load due to emergencies, such equipment shall be kept under close observation until normalcy is restored, temperature on transformers under such overloading conditions and cooler fans operation shall be constantly monitored.

18. In case of certain emergencies where operations started in particular shift are likely to be carried out during next shift the personnel of both the shifts shall be available till the operations are completed and normalcy is restored. Shift duties should not be handed over to successor staff in the middle of an emergency.
19. Whenever new ADEs/AEs are posted to shift, senior personnel of other cadres in the Station shall be attached to them atleast for a fortnight, so that, new personnel get themselves acquainted with the operations and equipment
20. Red hot joints at the substation shall not be continued even for brief periods. They shall be attended on priority. Each day during evening peak hours, the yard lighting should be switched off for a while and bad clamps joints should be identified and intimated to maintenance staff.
21. Operating instructions shall be available in the control room on the shift incharge table. All the shift supervisory personnel shall sign in the operation instruction booklet to the effect that they have read the same and understood them completely.

CHECKS & OBSERVATIONS TO BE MADE DURING SHIFTS

1. Voltages 220 KV, 132 KV, 33 KV and 11 KV shall be observed and to be maintained nearest to the rated values by operation of tap changes of transformers. A little higher voltage is to be maintained (not exceeding 10%) so that tail end voltages are normal. Constant monitoring of capacitor banks.
2. Healthy trips of all the breakers. Healthy trips of all breakers shall be checked every hour. If healthy trip fails, the breaker shall immediately be hand tripped, fault in the healthy trip circuit shall be immediately attended and rectified. Only after ensuring DC supply, the breaker shall be closed. Healthy trip indicating lamps shall be in working condition.
3. Battery voltages, DC leakage, Charger condition, AC switch to charger (once in a shift) and observe any fall in DC battery voltage.
4. Communication equipment such as PLCC, P&T and wireless shall always be in working condition. They are to be treated on par with all other equipment at the Substations.
5. Check the loading on the transformers and capacitor banks. Load current in all the three phases and in neutral circuit (wherever available) to be checked. Any difference in phase currents shall be brought to the notice of maintenance staff and the concerned transformer or capacitor bank shall be cut off from service for detailed examination.
6. Note the oil and winding temperature and physically check-up by feeling the temperature of transformers by hand.
7. Note the tap position of various transformers. The tap position of the transformers in parallel shall be same i.e., the voltage corresponding to the tap shall be same.
8. Note the oil levels in conservator tanks
9. Check up for any oil leaks and red hots.
10. Check-up dehydrating breathers of transformers
11. Ensure that alarms and indications on annunciation panel are working
12. Check the diesel generator and trial run for 5 minutes daily once in the morning shift and note down the voltage.
13. Check the condition of Air compressors provided either common or separately for each breaker and drain the moisture accumulated once in a day during morning shift. During Rainy season this should be done once in each shift. Drain sufficient air to ensure auto start of compressors.
14. Running hours of each station compressors to be noted periodically and they shall be changed „stand by“ to „running“ to „stand by“. Register of running hours of each station compressor shall be maintained.

15. Check the entire yard for any unusual sounds, sparkings and red hots during evening shift.
16. Compressed air lines to be checked for any air leakage. The oil levels in air compressors are to be checked
17. Check oil levels and condition of breather if available for the MOCBs
18. Check up gas pressures in SF 6 breakers.
19. Check up for any sparking and flash over marks in the earth pits specially whenever feeders trip on faults.
20. Watering of earth pits to be done daily.
21. Ensure proper working of Energy meters on all CBs. If the energy meters are slow or not working, check the potential supply to the meters, fuses etc.
22. Ensure the tripping of breakers on activation of relays whenever the LCs are issued on breakers.
23. When LC is issued on Power Transformers, Alarms and Trips are to be invariably checked up with the assistance of MRT/maintenance personnel
24. Check-up fire fighting equipment once in a week.
25. OLTC counter reading to be noted.
26. Ensure that lightning arrestor's micro ammeter reading is in safe zone (Green)
27. Whenever feeders trip, find out the position of breakers at other end and note down relay indications if any at other end.
28. Whenever the relays of feeders/Transformers become due for periodical testing intimate the same to Divisional Engineer in charge of sub-station and give a message to MRT for testing the same.
29. Check-up the marshalling boxes of breakers, CT junction boxes, PT junction boxes etc. and ensure that no creepers can enter into the same.
30. Check up the batteries, exhaust fans in the battery room for proper operation once in every shift, and report any abnormalities to the maintenance staff immediately.
31. Ensure that hind doors of all control and relay panels are properly closed, and the panels are properly sealed from the bottom and made vermin proof.

CAPACITORS :

Installation :

- i) Clean capacitors thoroughly
- ii) Tighten up all electrical connections and other screws and nuts
- iii) Measure the IR values with a 500 V meggar between handed terminals and earth. Minimum value shall be 50 Mega Ohms. Do not put a unit with less than 50 Mega Ohms into service
- iv) Ensure free circulation of air around capacitor units. Adequate clearances as per the drawing shall be maintained
- v) Temperature of atmosphere surrounding capacitor units shall be within their temperature category under steady working conditions.
- vi) Adequate earthing of capacitor banks (structures etc.) to be ensured.
- vii) Neutral of star connected capacitor banks with residual voltage transformer should not be earthed.
- viii) Before commissioning a capacitor bank, capacitance of each capacitor shall be measured with a capacitance meter. These shall be compared with the value obtained by calculation using the formula

$$C = \frac{KVA_r \times 10^9}{2 \pi f (V)^2} \text{ Micro Farads}$$

where V is the rated voltage of capacitor and KVAR is the rated KVAR of capacitor. As per IS the tolerance in the capacitance value for a capacitor unit is + 10% to – 5% .

Operating instructions :

- a) The following points may be checked before energizing the capacitors :
- b) Supply voltage, frequency and temperature of the area with the rating plate
- c) Ensure no hardware or tools are left inside the rack assembly. This may cause short circuit and breakdown.
- d) Ensure proper ventilation
- e) Ensure all electrical and technical connections are done properly and tightly.
- f) Ensure that there is no oil leakage from terminal at collar of the bushin and welded seam of the capacitor unit

After charging the capacitors, the following checks shall be made :

- a) Voltage : Within 110% of rated voltage especially during light load periods
- b) KVAR : Operation KVAR are within 130% of the rated KVAR at the highest system voltage
- c) Temperature rise : Contained temperature should not exceed 75 Deg. C. This should be measured by having a thermometer fixed with the wall of the container, keeping the bulbs at one quarter of height of capacitor box down from the top edge.
- d) Fuse : ensure correct type of fuse
- e) Light Load : At light load capacitors cause voltage rise in the system exceeding the permissible value some times. They may have harmful effects on capacitor or on other electrical equipment. Voltage at no time should go beyond the rated voltage by more than 10%.

While removing the faulty/defective capacitor units the remaining healthy capacitors are connected in such a way that all the phases are balanced with equal number of units and phase capacitance. Operation with unbalance phases may cause further damage.

For capacitor banks operated with series reactors, operating the bank with less number of units than the originally supplied, may cause the capacitor with series reactor tuned to fifth harmonics.

Best way to check the healthyness of a capacitor is to check the capacitance with a capacitance meter, partial or complete failure of a capacitor can be established from this. Shorting of one internal series group on a capacitor results in a predictable increase in the capacitance level. This is the basis for the capacitances of partially failed capacitors.

Vaccum Circuit Breakers :

Vaccum interruptors have a long contact life due to less arcing time.

Ideally suited for special applications :

1. Frequent switching duty
2. Rapid auto reclosing
3. Capacitor switching
4. Arc furnace duty
5. Freedom from fire hazards.

DEFECTS IN CAPACITORS CAUSES AND REMEDY

Sl.No	Symptom	Cause	Remedy
1	Leakage of impregnant	Leak in welded seam Leak from terminal cap	After cleaning and abrading by emery cloth apply Araldite or solder the spot carefully
2	Overheating of units	a) Poor ventilation b) Excessive ambient temperature c) Over voltage	Increase spacing for free circulation of air Arrange for forced ventilation Reduce voltage or switch of capacitors (OR) adjust over voltage relay tripping to achieve below 10% of rated voltage of bank
3	Current below normal value	a) Low voltage b) Loose connection	Usual Tighten carefully
4	Noise inside the unit	Internal fault	Disconnect the unit properly balance remaining units. Refer to company
5	Fuse blowing	a) Short circuit in unit	Measure insulation resistance between terminals and case. If the reading is zero the units is shorted and not fit. No repair is possible.
		b) Over current due to over voltage and harmonics	Reduce voltage and reduce/eliminate harmonics by adding suitable series reactors after advice by the company
		c) Short external to the unit	Check and remove the short and ensure the unit O.K after checking insulation resistance
6	Abnormal bulging/ bursting	Gas formation due to internal arcing causing unit to bulge or burst	Replace the unit. Refer to the manufacturer
7	Capacitor Bank tripping on unbalanced protection but expulsion fuse not blown	Co-ordination of expulsion fuse blowing with neutral protection not proper	Check and control manufacturer's application Engineers.

GUIDELINES TO SHIFT ENGINEERS OF EHT SUBSTATIONS :

1. 220/132/33/11 KV Bus Voltages, frequency and station load
2. Check healthy trip of all the breakers
3. Check battery voltages, D.C leakage, charger condition. Switch off the charger and note battery voltage
4. Check whether the battery is in Boost or Trickle charge condition

5. Check the Carrier Phones in all directions and intimate the Telecom wing in case of trouble. Similarly wire-less and P&T phones are to be checked up.
6. Check the diesel generator and make a Trial run for 2 minutes once in a day. Check the voltages.
7. Check the annunciation panels. Press the lamp test and report the failure of lamps to Maintenance wing.
8. Check the load on each feeders.
9. Check the Power Transformers physically. Note the oil and winding temperatures, load and tap position, cooling fans condition and oil levels in the conservator, tap changer Diverter Switch, Bushings and Dehydrating Breather.
10. Check the condition of the Air Compressor. Note the amperage, air pressure, air pressure at different locations (i.e wherever pressure gauge is available).
11. Check the entire yard for any unusual sounds.
12. During night shift check for sparking at joints / jumpers
13. Check for compressor air leak at all locations where the main line is tapped.
14. Check the oil level in the MOCBS
15. Check the Gas pressure in SF₆ C.Bs and oil level in the Air Compressor.
16. Check for any sparking or flashover marks at the earth pit connections and intimate the maintenance staff
17. To note the running hours of each compressor and periodically change over the compressor. Separate Register for running of the compressors to be maintained.
18. Check for proper watering of EARTH-PITS
19. Check whether all the energy meters of the feeders are working or not. Report to maintenance staff on defect noticed
20. Activate protection trip whenever L.C is issued on any feeder / Transformer besides ensuring hand tripping.
21. Check the Fire Fighting Appliances availability at assigned locations.
22. Ensure that all the relevant Relays flags are in Reset position
23. Note down the OLTC counter
24. Ensure that the L.A Micro Ammeter reading is in safe zone (green band)
25. Whenever a feeder tripping occurs, contact the other end station and note down the Relay indications
26. When the C.B is provided within a separate compressor / Air Tank, drain Air to sufficient quantity for ensuring auto-start of Air Compressor

PERIODIC MAINTENANCE ASPECTS

a) Daily

- i) The floating voltage of the charger across the battery should be noted at the charger end, as well as at the battery end and it should be ensured that the floating voltage is kept at 2.16 volt per cell stabilized within 1%.
- ii) The float charger has to be examined to check whether the same is working in „Auto“ mode only which the 1% voltage stability across the battery can be guaranteed. If the float charger has gone defective in the Auto mode and can work only in manual mode, the charger manufacturer has to be called, to set right the float charger for ensuring its working in Auto mode.
- iii) Electrolyte specific gravities of a few chosen cells, have to be taken everyday, 5% of the cells of the battery bank can be used as pilot cells for daily specified gravity measurements.

- iv) The cell containers, stands, insulators, connectors, vent plugs, terminals, etc., have to be cleaned everyday.
- v) In order to ensure that the full battery is available across the DC lead terminals, it is necessary to switch-off the float charger, for a one-minute duration everyday, at a specific time to note the battery discharging through the load of the busbar. This will also ensure that battery is healthy and that there is no open circuit anywhere.

b) Weekly

In addition to the daily maintenance procedure detailed above, the following additional maintenance has to be done every-week

- i) Check the electrolyte level in each of the cells to ensure the electrolyte level to correspond to the top red mark on the float-guide. If the level is lower, top-up with pure battery grade distilled water.
- ii) Tighten the various inter-connections so that there is no loose contact and apply petroleum jelly at the battery terminals to avoid sulphation.

c) Monthly

In addition to the daily and weekly maintenance procedure it is necessary to adopt the following procedures, every month.

- i) Check the electrolyte specific gravity of all the cells to ensure the same to be within 1.200 – 0.005. If the specific gravity is higher than the upper limit, replace a little quantity of electrolyte, by an equal of distilled water by using judgement. If the specific gravity of any or more cells is lower than the lower limit, charge the battery bank as a whole for a short duration at a current equal to two and half percent of the Ampere-hour capacity to that the lower specific gravity of the cells could improve.
- ii) Only when it is found that the specific gravity are not uniform, discharge the battery bank for a short duration of 15 minutes to 30 minutes at 10 hour rate current or even less and then recharge thereafter at equalizing charge current, which is at a current equal to two and half percent of the AH capacity and the voltage applied could go upto 2.35 to 2.40 V per cell. A specific gravity adjustment may be done at the end of this equalizing charge, using only distilled water.

d) Quarterly:

Apart from the daily, weekly and monthly maintenance procedures, we recommend you adopting the following procedure of curative discharge and recharge once in three month, after switching-off the float charger.

Discharge the battery at its 10 hours rate discharge current for a period of 2 hours and recharge the battery at the normal recharging current till the specific gravities stabilize within 1.200 – 0.005 or adjust if required. This discharge for 2 hours called the curative discharge, helps to correct some imbalance. Also a battery continuously floated, when made to discharges, has a higher probability of a longer life. However, certain situation of clients prohibit any discharging for duration of one-hour at the 10-hour rate current may be adopted. However, whenever shutdowns can be arranged by the user, the battery can be discharged for period of 10-hours at the 10-hours rate current, to be recharged back to the full charged state.

OPERATION AND MAINTENANCE
LEAD ACID STATIONARY BATTERIES AT EHV SUBSTATIONS
(220 VOLTS 80 AH AND 200 AH)

S. No.	Particulars	STANDARD BATTERIES		AMCO BATTERIES		UBHEC BATTERIES		ELECTROFLO BATTERIES	
		80 AH	200 AH	80 AH	200 AH	80 AH	200 AH	80 AH	200 AH
1	INITIAL FILLING OF CELLS								
	Electrolyte specific Gravity	1.190 @ 27°C	1.180 @ 27°C	1.190 @ 27°C	1.190 @ 27°C	1.190 @ 27°C	1.190 @ 27°C	1.190 @ 27°C	1.190 @ 27°C
	Soaking Time	12 to 16 Hrs., but not more than 24 Hrs.	12 to 16 Hrs., but not more than 24 Hrs.	Not less than 12 Hrs., and not more than 24 Hrs.	Not less than 12 Hrs., and not more than 24 Hrs.	12 to 24 Hrs.,	12 to 24 Hrs.,	Minimum of 12 Hrs., and not exceeding 24 Hrs.	Minimum of 12 Hrs., and not exceeding 24 Hrs.
2.	FIRST CHARGE								
	Initial charging Duration	100 Hrs.	100 Hrs.	80 Hrs.	80 Hrs.	80 Hrs.	80 Hrs.	100 Hrs.	100 Hrs.
	Rate of charging	5% of C10 60 Hrs., @ 4 Amp., rest for 4 Hrs., @ 4 Amp.	5% of C10 60 Hrs., @ 10 Amp., rest for 4 Hrs., @ 10 Amp.	4% of C10 80 Hrs., continuously @ 3.2 amps	4% of C10 80 Hrs., continuously @ 8.0 amps	80 Hrs. continuously at 4 amps.	80 Hrs. continuously at 4 amps.	5% of C10 60 Hrs., @ 4 Amps., rest for 4 Hrs., @ 4 Amp	5% of C10 60 Hrs., @ 10 Amps., rest for 4 Hrs., @ 10 Amp
	Max. permissible temperature					While charging if the temperature of the cell rises 40°C charging rate should be decreased. If temperature rises above 50°C charging should be discontinued. After cooling, further charging should be done, increasing charging time proportionately.			
	During charging Reading at the end of charge	50°C	50°C	50°C	50°C	50°C	50°C	50°C	50°C
	Voltage specific gravity	2.25 V	2.25 V	2.40 v	2.40 v	2.70 V	2.70 V	2.60 V	2.60 V
	@27°C	1.200 + 0.005	1.200 + 0.005	1.200 + 0.005	1.200 + 0.005	1.200 + 0.005	1.200 + 0.005	1.200 + 0.005	1.200 + 0.005
3.	CAPACITY / DISCHARGE TEST								
	(Discharge Current (I=0.1 C10))	8 Amps	20 Amps	8 Amps	20 Amps	8 Amps	20 Amps	8 Amps	20 Amps

Test Procedure : After completion of First charge, allow the battery to stand on open circuit for not less than 12 hours, but not more than 24 hours. Discharge the battery through a variable resistance OR Acidulated water load at a constant current equal to $I=0.1 \times C_{10}$ amps. Discharge shall be stopped when closed circuit voltage of the battery falls to 1.85 volts in each cell and specific gravity falls to 1.130 contained duration shall be a minimum of 10 Hrs., deg. C

S. No.	Particulars	STANDARD BATTERIES		AMCO BATTERIES		UBHEC BATTERIES		ELECTROFLO BATTERIES	
		80 AH	200 AH	80 AH	200 AH	80 AH	200 AH	80 AH	200 AH
4	RECHARGING								
	Normal Recharge current & End voltage per cell	8 Amps upto 2.35 to 2.4 V	20 amps upto 2.35 to 2.4 V	112 Amps upto 2.4 volts	28 Amps upto 2.4 volts			8 Amps upto 2.4 volts	20 Amps upto 2.4 volts
	Furnishing charge current	4 Amps upto 2.55 to 2.65 V	10 amps upto 2.55 to 2.65 V	5.6 Amps. 2.4 or full vol.	14 amps upto 2.4 or full vol.			4 Amps upto 2.6 volts	10 Amps. Upto 2.60 volts
	End specific gravity @27°C	1.200+/- 0.005	1.200+/- 0.005	1.200+/- 0.005	1.200+/- 0.005			1.200+/- 0.005	1.200+/- 0.005
	Maximum charging rate	12 Amps	30 Amps	16 amps	40 Amps.			12 Amps.	30 Amps.

CARE, CLEANLINESS & SAFETY

1.	Maintenance	a) Keep the battery room well ventilated b) Keep the battery and its surrounding dry & clean c) Check and keep the electrical connections always tight d) Always keep the top surface of the battery clean and dry e) The joints and cell connections shall be kept clean and smeared with Vaseline and petroleum jelly f) Remove traces of corrosion promptly by cleaning with pure distilled water g) Metal vessels should not be used topping up h) Protective measures (wearing apron & rubber gloves) should be taken when handling electrolytic concentrated acid. i) Care must be taken when using metal tools to prevent them from coming into accidental contact with connectors and causing short circuit j) Naked lights, smoking of cigarettes are anything which may create a spark should be avoided in battery room.
2.	Temperature correction	If cell temperature is different from 27°C correction to specific gravity to be applied is +/-0.0007 per each degrees of variation above or below 27°C respectively
3.	Topping up	a) Top up often as necessary with distilled water (as per IS:1069) or demineralised water to avoid the necessary of adding a large quantity of water at a time which would cause pronounced drop in the specific gravity b) Top up the black mark of the float is just visible above the surface of the float guide and the level should never be allowed to go so low that the red mar on the float-steer comes in line with the top surface of the plug. c) It is advisable, if necessary to top up cells during early part of charging or before charges so that the water would link (mix) with the electrolyte during charge
4	Weak Cells	Cells which do not pick up specific gravity inspite of repeated charging are called “W E A K C E L L S” The weak cells must be removed from the battery and charged

		separately at normal charging rate until gassing point is reached and the reduced to half the normal rate. When the cells appear to be in fully charged condition (i.e.) specific gravity of the acid seems to be stationary the charging should be stopped for an hour and then be resumed at half the normal rate until free gassing again takes place. Again after another one hour stop, charging should be resumed at half the normal rate. These stops of one hour duration alternated by charging should be repeated until gassing starts instantaneously with switching on the charging current.
5	Caution	While preparing the acid solution (electrolyte) it is very much important to note that always acid is added to the water and never add water to acid

TROUBLE SHOOTING

Sl.No.	Battery Troubles	Symptoms / Cause	Remedies
1.	Over charging	a) Excessive gassing b) Falling active positive plates c) Buckling of plates d) Increased temperature	a) Reduce the Boost / Float voltage or charging rate reduced to lower value till the specific gravity attains 1.200 b) Add distilled water c) Check the accuracy of voltmeter in the charger if necessary
2	Under charging	a) Low specific gravity	a) Increase the float voltage 2.16 to 2.20 volts per cell or increase the charging rate till the specific gravity attains 1.200 b) Check for leakage of electrolyte of current conductors in the charge and battery circuit c) Reversal of cell voltage d) Buckling of plates
3	Corrosion of plates	Electrolyte impure	a) Remove electrolyte b) Flush with distilled water c) Refill with pure electrolyte
4	Shedding of active material	a) Over charging of plates b) Charging done at high rate c) Material improperly applied on plates	Charging and discharging limits should be maintained at 2.40 volts and 1.85 volts respectively
5	A) Loss of voltage B) Battery voltage falling too rapidly on discharge	Excessive sulphation a) Loose connections b) Corroded terminals	Sulphation at initial stage can be cured by low rate of repeated charging and discharging. Contact manufacturer / supplier for special treatment a) Check up connections b) Corroded parts should be cleaned with warm distilled water and coated with vaseline
6	Continuous lowering of	a) Leakage of electrolyte b) Loss of water in the electrolyte due to evaporation by too high floating voltage or excessive charging	a) Replace container immediately in case of leakage b) Addition of distilled water to maintain the electrolyte level in the leaking cell will result in diminution of capacity and continuous lowering of specific gravity

7	Overflowing in cells due to increase in electrolyte level even without the addition or distilled	Due to dump atmosphere in the battery room causing condensation on the cell covers	Improve ventilation in the Battery Room

- i) Oil in the diverter switch compartment of all power transformers in service for more than 2 years shall be replaced with filtered and tested oil. Before replacing with fresh oil, flushing of the diverter switch with oil shall be done and the flushed oil sucked out.

Thereafter the oil sample shall be tested once every six months and values recorded. If the results are poor the oil shall be immediately replaced availing shutdown. This is compulsory

- ii) A plan of action for thorough inspection of diverter switch for loosening of bolts and connected parts, excessive or uneven burning of the contacts, damage to braided contact leads, carbonization of oil and deposition of carbon on diverter switch, etc, shall be made, on all the diverters of power transformers in service for over 5 years and the defective diverters rectified within a span of 6 months.

33 KV Capacitor Banks – Maintenance and balancing of capacitors in the event of failure at one or more capacitor units guidelines - Issued

In the 33 KV Capacitor banks existing at various substations, the capacitor units are connected in two or three series groups to maintain uniform voltage distribution depending upon the rated voltage of the capacitor units. At present capacitor units are supplied at rated voltage of 7.3 KV or 10.3 KV. Also to obtain the required MVAR, the capacitor units are connected in parallel (numbering 2 to 9) in each series group. Typical examples of Parallel / Series combination of capacitor units in each case are given below in Fig.(1) and Fig(2).

Whether it is single star or double star, the number of series groups / phase depends upon the rated voltage of the capacitor unit viz., 3 series groups if the rated voltage is 7.3 KV and 2 series groups if rated voltage is 10.3 KV.

In the event of failure of one capacitor unit (say in R-phase) it is observed that balancing is done by removing one capacitor each from Y and B-phases as shown in Fig(3)

The above arrangement is not correct, since it results in unequal voltage distribution between the capacitors in series groups.

It can be seen from the figure that against a voltage distribution of $V/3$ across each series group, the series group containing less capacitors in parallel gets $V/2$ (i.e.) gets overstressed. Whereas, the other series groups have $V/4$ (i.e.) are understressed. This result in ultimate failure of the over-stressed capacitors.

It is therefore necessary that number of capacitor units in parallel in each series group in all the three phases on one star bank shall be same.

The correct arrangement of capacitors in the given example is illustrated in Fig(4).

FIG. - 1

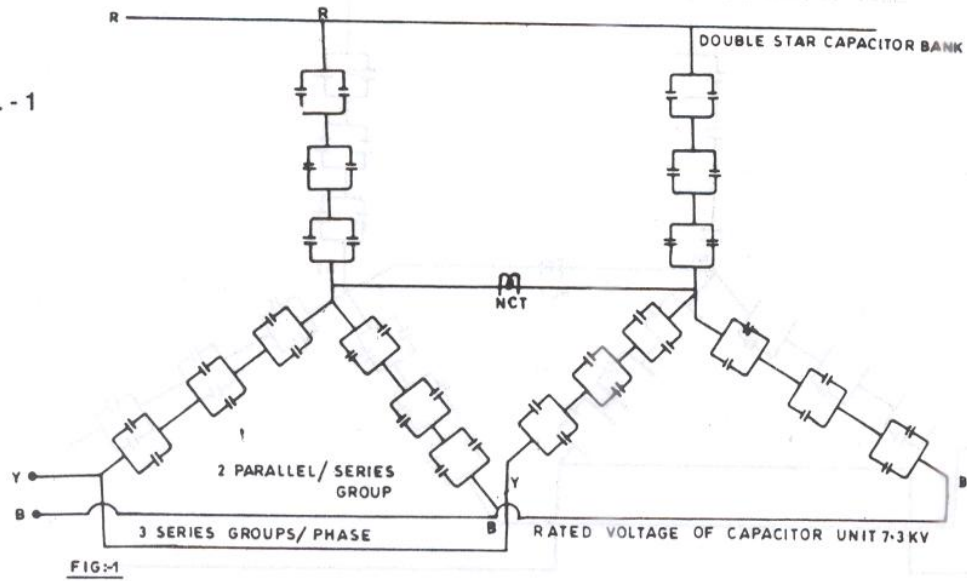


FIG. - 2

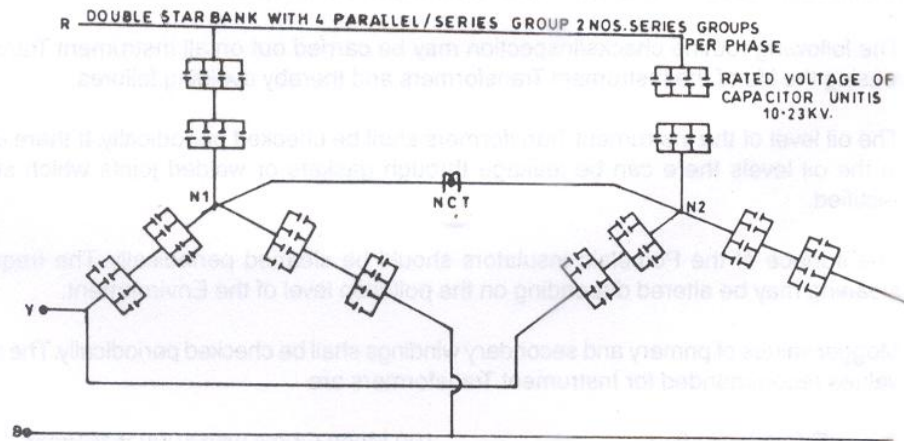
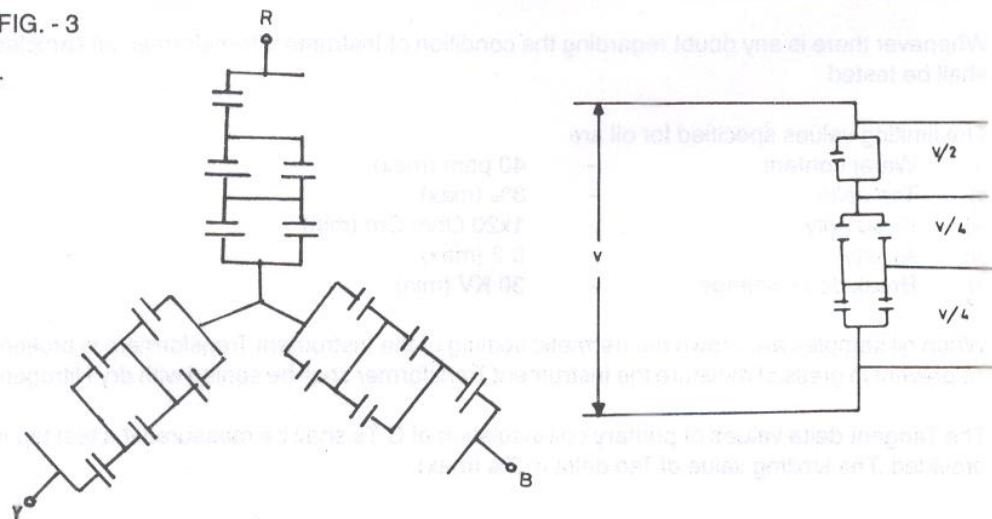
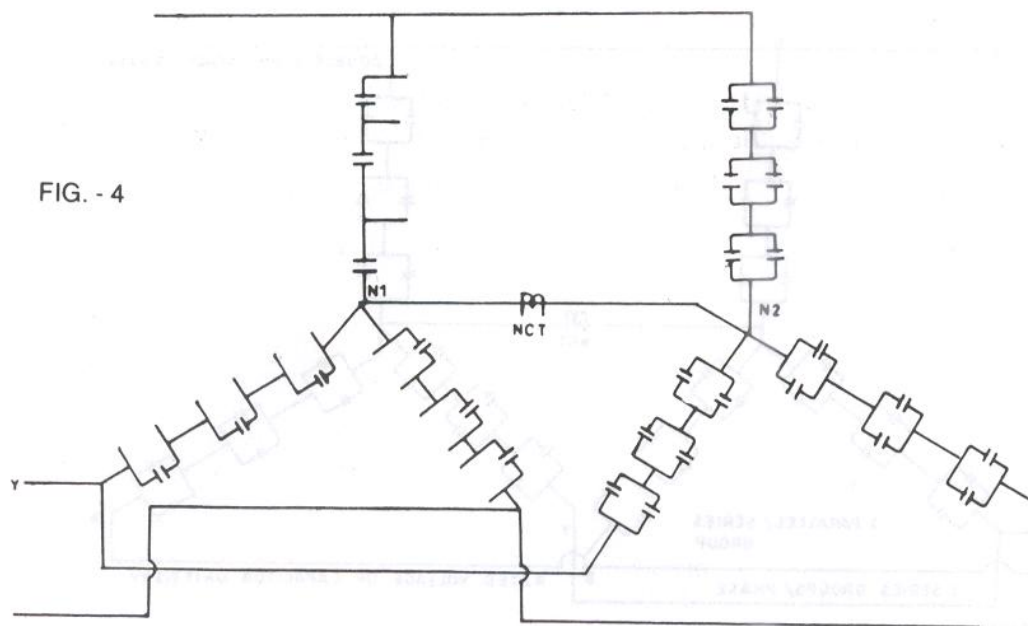


FIG. - 3





Maintenance schedule for Instrument Transformers – Instructions - Issued

The following routine checks / inspection may be carried out on all Instrument Transformers for increasing the life of the Instrument Transformers and thereby avoiding failures.

- a) The oil level of the Instrument Transformers shall be checked periodically. If there is any fall in the oil levels there can be leakage through gaskets or welded joints which should be rectified
- b) The surface of the Porcelain insulators should be cleaned periodically. The frequency of cleaning may be altered depending on the pollution level of the Environment.
- c) Megger value of primary and secondary winding shall be checked periodically. The minimum values recommended for Instrument Transformers are
 - a. Primary Winding - 100 Mega Ohms with 1000 V Megger
 - b. Secondary Winding - 20 Mega Ohms with 500 V Megger
- d) Whenever there is any doubt regarding the condition of Instrument Transformer, oil samples shall be tested.

The limiting values specified for oil are

- i) Water content - 40 ppm (max)
- ii) Tan delta - 3% (max)
- iii) Resistivity - 1×10^{12} Ohm Cm. (min)
- iv) Acidity - 0.2 (max)
- v) Breakdown voltage - 30 KV (min)

- e) When oil samples are drawn the hermetic sealing of the Instrument Transformers is broken. To prevent ingress of moisture the Instrument Transformer shall be sealed with dry Nitrogen.
- f) The Tangent delta values of primary coil insulation of C.Ts shall be measured if a test tap is provided. The limiting value of Tan delta is 3% (max)

14.5 USEFUL LIVES OF PLANTS
(Extracted from the Electricity (supply) Act, 1948 and as amended upto 1968)

	Description of asset	No. of years of period
A.	Land owned under full title	Infinity
B.	Land held under lease:	
	a) for investment in the land	The period of the lease or the period remaining unexpired on the assignment of the lease.
	b) for cost of cleaning site	The period of the lease remaining unexpired at the date of clearing the site.
C.	Asset purchased now:	
	a) plant and machinery in generating stations, including plant foundations. i) Hydro-electric ii) Steam-electric iii) Diesel-electric	Thirty-five Twenty-five Fifteen
	b) Cooling towers and circulating water system	Thirty
	c) Hydraulic works forming part of a Hydro-electric system including i) dams, spillways, weirs, canals, reinforced concrete flumes and syphons. ii) Reinforced concrete pipelines and surge tanks, steel pipe lines, sluice gates, steel surge tanks, hydraulic control valves and other hydraulic works.	One hundred Forty
	d) Buildings and civil engineering works of a permanent character, not mentioned above: i) Offices and showrooms ii) Containing thermoelectric generating plant. iii) Containing hydro electric generating plant. iv) Temporary erections such as wooden structures. v) Roads other than kucha roads. vi) Others.	Fifty Thirty Thirty five Five One hundred Fifty
	e) Transformers, transformer kiosks, substation equipment and other fixed apparatus (including plant foundations): i) Transformers (including foundation) having a rating of 100 kilovolt amperes and over. ii) Others	Thirty five Twenty five

	f) Switchgear, including cable connections switching arrestors i) Station type ii) Line type iii) Synchronous connections	Twenty Twenty Fifteen Thirty five
	g) Batteries	Ten
	h) i) Underground cables including joint boxes and disconnecting boxes. ii) Cable duct system.	Forty Sixty
	i) overhead including supports: i) Lines on fabricated steel supports operating at nominal voltage higher than 66 KV. ii) Lines on steel supports operating at nominal voltages, higher than 132 KV but not exceeding 66 KV. iii) Lines on steel or reinforced concrete supports. iv) Lines on treated wood supports	Thirty five Thirty five Twenty five Twenty
	j) Meters	Fifteen
	k) Self-propelled vehicles	Seven
	l) Static machine tools	Twenty
	m) Air-conditioning plant: i) Static ii) Portable	Fifteen Seven
	n) i) Office furniture and fittings ii) Office equipment iii) Internal wiring including fitting and apparatus. iv) Street-light fittings	Twenty Ten Fifteen Fifteen
	o) apparatus let out on hire i) Other than motors ii) Meters	Seven twenty
	p) communication equipment: i) Radio and high frequency carrier system ii) Telephone lines and telephones	Fifteen Twenty
D.	Assets purchased second hand and assets not otherwise provided for in this table.	Such reasonable period as the state Government determines in each case having regard to the nature, age and condition of the asset at the time of its acquisition by the owner.

DISTRIBUTION

VOLTAGE REGULATION

Introduction :

Owing to the variations in the current flow through a transmission line, there is variation in the voltage drop in the line. Thus the receiving changes with changing load. It is necessary under electricity rules to maintain the voltage at the receiving ends of O.H. line within permissible limits as given below:

Declared voltage of supply to consumers

i)	Not greater than 250 Volts	+6%
ii)	Medium voltage not greater than 650 Volts	-
iii)	H.V. not greater than 33, 000 Volts	+6% -9%
iv)	Extra High Voltage above 33,000 Volts	$\pm 12.5\%$

Procedure:

The vector diagram for known receiving end voltage conditions, for lagging PF is indicated below. The voltage drop per phase is given by the equation.

$$= 1 (R \cos \phi + X \sin \phi) \text{ for lagging power factors}$$

The voltage regulation is usually considered as the percentage drop with reference to the receiving end voltage.

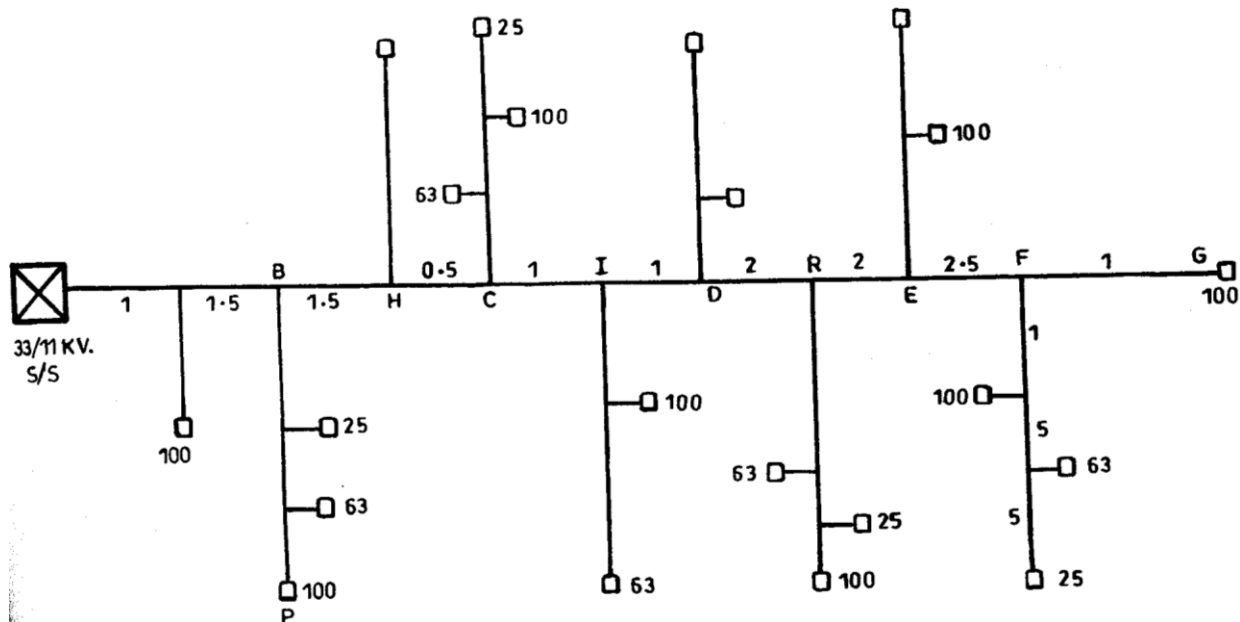
$$\text{Percentage regulation} = \frac{100 (E_S - E_R)}{E_R}$$

Where E_S = Sending end voltage
 E_R = Receiving end voltage

Sample Calculations :

Voltage Drop calculations for 11 KV lines (Annexure - 1)

Let us consider a 11 KV feeder emanating from a 33/11 KV S/S with 7/2.59 mm ACSR for the main feeder and 7/2.11 mm ACSR for tap lines with the connected distribution transformers and distances as indicated below:



Total connected transformer capacity on the 11 KV line is:

$$\begin{aligned}
 1) \quad & 10 \times 100 = 1000 \text{ KVA} \\
 2) \quad & 6 \times 63 = 378 \text{ KVA} \\
 3) \quad & 5 \times 25 = 125 \text{ KVA} \\
 \hline
 \text{Total} \quad & 1503 \text{ KVA}
 \end{aligned}$$

Total calculating the voltage regulation of the main feeder, it is assumed that the loads on the tap lines are concentrated at the point of tapping and taking moments about the section we have.

OA	=	1503	×	1	=	1503.0
AB	=	1403	×	1.5	=	2104.5
BH	=	1215	×	1.5	=	1822.5
HC	=	1115	×	0.5	=	557.5
CI	=	927	×	1	=	927.5
IO	=	764	×	1	=	764.0
OR	=	601	×	2	=	1202.0
RE	=	413	×	2	=	826.0
EF	=	288	×	2.5	=	720.0
FG	=	100	×	1	=	100.0
Total KVA KM						10526.5

$$\% \text{ Regulation} = \text{Total KVA KM} \times \text{Regulation constant per 100 KVA KIM} / 100 \times \text{DF}$$

Assuming a diversity factor of 2.5, Regulation constant for 7/2.59 ACSR at 0.8 Power factor is 0.08648 from table 2.

$$\% \text{ Regulation} = 10526.5 \times 0.08648 / 100 \times 2.5 = 3.64\%$$

Similarly the regulation of the tap lines also can be calculated.

Let us consider the farthest tap lines and find out the regulation at M taking moments in KV KM for the main feeder with 7/2.59 mm ACSR; we have

1)	1503	×	1	=	1503.0
2)	1403	×	1.5	=	2104.5
3)	1215	×	1.5	=	557.5
4)	927	×	1.0	=	927.0
5)	927	×	1.0	=	927.0
6)	764	×	1.0	=	764.0
7)	601	×	2.0	=	1202.0
8)	413	×	2.0	=	826.0
9)	288	×	2.5	=	720.0

Total KVA KM	10,426.5

For tap line FM with 7/2.11 mm ACSR we have

1.	188	×	1.0	=	188
2.	88	×	0.5	=	44
3.	25	×	0.5	=	12.5

Total KVA KM	224.5

1)	% Regulation on 11KV main feeder	=	10426.5 x .08648 / 100 x 2.5
2)	% Regulation 11 KV tap line	=	244.5 x 0.12115 / 100 x 25
		=	0.118%
	% Regulation at the point M of tap line	=	3.6.1 + 0.118 = 3.728%

VOLTAGE REGULATION OF CONDUCTORS

DETAILS OF THE CONDUCTOR	PERCENTAGE REGULATION PER 100 KVA PER KM		
	415	11KV	33KV
7/2.00 (SQUIRREL) 20 Sq. mm.	83.75	0.1211	
7/2.50 (SEASEL) 30 Sq. mm.	59.4	0.08062	
7/3.15 (RABBIT) 20 Sq. mm.	40.09	0.05853	0.0064
7/4.26(DOG) 100 Sq. mm.	-	0.03294	0.00394

SERVICE CONNECTIONS - PROCEDURES

The entire activity in the Board from generation to transmission and distribution is intended for serving the people whom we call 'consumers'. The consumer is the ultimate BOSS whose satisfaction is of paramount importance.

Power is generated at hydro or thermal power stations at comparatively lower voltages say 13 KV and stepped upto 400 KV or 220 KV at the power station itself. The power is transmitted over long distances by tower lines at 220 KV or 132 KV and stepped down to 33 KV at EHT substations. Power is carried by 33 KV lines to various sub-stations where it is stepped down to 11 KV. Then 11 KV lines are run over the entire area (urban or rural) and the power is stepped down to 415 V by employing distribution transformers of 11 KV/433 KV.

- I. 415 Volts is termed as low tension.
- II. above 415 and upto 30,000 V-High Tension
- III. above 33,000 V upto 400,00 V - Extra High tension
- IV. above 400,000 V - Ultra High Voltage

All activity of distribution work is within the sphere of laying 11 KV lines, erection of distribution transformers laying LT lines and release of services at low tension 240 V single phase or 415 V three phase.

The voltage at which the supply is released to the consumers is as follows :

i)	1 phase LT supply	:	upto 15 HP or 25 KW
ii)	3 phase LT supply min 3 KW to Cat. I	:	upto 56 KW/75HP
	min 5 KW to Cat.II	:	upto 150 HP for Industrial (optional)
iii)	HT supply	:	Above 70 KVA upto 1500 KVA
iv)	HT supply (33 KV)	:	1501 KVA to 5000 KVA
v)	HT supply (132 KV)	:	above 5000 KVA
	or 220 KV as may be decided by Transco.		

With reference to the HT consumers, they have to erect the equipment for stepping down the voltage to the level of user requirements including switchgear etc.

The functions and duties of each office from Assistant Engineer to Chief Engineer are defined in APSEB Manual Valhi. The chapter on 'Sale of Power' deals with the procedures laid down.

The AP TRANSCO published a book "Terms and Conditions of Supply"

"Tariff" wherein the charges to be paid under each category of service are laid down. This tariff is revised from time to time by the APSEERC. The rate at which energy is charged is dependent on the purpose for which energy is used like domestic", "non-domestic", 'public lighting', 'industrial' and 'agricultural', 'cottage industries' Temporary supply in low tension. Similarly categories are made out among HT consumers also and different tariffs applied. There are seasonal loads like sugar factories, ice factories etc.

The AEs in-charge of distribution should be thoroughly conversant with the Tariffs.

Subsequent paras deal with the procedures laid down for release of new services.

While releasing new service the primary points to be checked regarding technical and economical viability are

- i) Whether there is adequate line capacity or transformer capacity.
- ii) Whether voltage regulation is within limits with this additional load.
- iii) Whether any extensions / modifications or laying of new sub-station, lines or distribution transformers are necessary to release this new load.
- iv) Whether the expenditure to be incurred is commensurate with the revenue we are likely to get when the service is released (i.e.) "is the scheme remunerative to AP TRANSCO" etc.

It is, therefore, necessary that the AE in charge of the distribution is fully conversant and should be in possession of the latest lay-out of the HT and LT systems in his jurisdiction and also neighboring areas. He should also be through with conductor sizes, capacities etc. One who is technically through can only deliver goods and can win the respect from subordinates or support from superior officers.

There is another important duty of the AE in charge of distribution. That is called 'consumer servicing'. He has to ensure fairly un-interrupted power supply, reasonably constant and good voltages, quick attendance to consumers' complaints, prompt disconnections for non-payments of bills in time and prompt re-connections after dues are cleared etc. The Meters fixed are to be got tested by MRT as per periodicity fixed by the APSEERC. He has to promptly replace 'stuck up' and 'burnt meters', he has to maintain 'Distribution Transformers' following the periodicity fixed by the AP TRANSCO. The HT & LT lines should be properly maintained so that they do not break down even in extreme weather conditions etc. Periodical Maintenance of DT's as fixed by the same above.

Who is a consumer :

1. A consumer is the most important person either in person or by mail.
2. A consumer is not dependent on us - we are dependent on him.
3. A consumer is not an interrupter of our work. He is the purpose of it. We are not doing a favour by serving him. He is doing us a favour by giving us the opportunity to do so.
4. A consumer is not some one to argue or march.
5. Wits with - nobody has ever won an argument with a consumer.
6. A consumer is a person who brings us his wants. It is our job to handle them profitably to him and do needful.

and also Consumer means :

"Any person who is supplied with electrical energy by the Board and includes any person whose premises are for the time being connected for the purpose of receiving the electrical energy with the works of the AP TRANSCO and shall also include an intending consumer or a consumer who has been disconnected".

**For Taking Domestic Service for Residential Purpose and for Commercial Purpose :
Requisition for supply of energy:**

Application-com-Agreement form (commonly called 'A' form) which can be had free of charge is to be filled for taking service connection from any "Consumer Service Centre" which is under the control of Addl. Assistant Engineer / Assistant Engineer. The domestic service comes under category I which will be released only for residential purpose. If the supply is being utilized for other than residential such as for shops, office, business etc. the service will be given under commercial category under Category II.

The requisition in the prescribed 'A' form shall be made by the owner or occupier of the premises for which supply is required and shall indicate his full name and address and communication address. Any assistance or information required in filling up the form will be given to the applicant at the local office of the AP TRANSCO (now it is called "Consumer Service Centre")

The applicant should pay the application fee of Rs. 25/- for cat I & V and Rs.50/- for other LT categories. Rs.100/- for HT service (in favour of SAO/Central Office) for registering the application in cash at Asst. Accounts Officer of concerned ERO of the area in the city and DD in favour of "Assistant Accounts Officer / AP TRANSCO" in rural areas. The applicant should submit the following with his application.

- a) proof of ownership of the premises.
- b) completion-cum-wiring certificate from the Licensed Electrical Constrict approved by the Electrical Licensing authority of the Government.

- c) should submit the "no objection certificate" from the owner of the premises for taking commercial supply to the tenant in his name.

Obligation to Supply Electrical Energy :

Subject to the provisions of the Indian Electricity Act 1910 and Electricity (Supply) Act 1948 the Board shall not be bound to supply energy to the consumer is remunerative.

If the scheme does not work out to be remunerative on the basis of the standards prescribed by the Board from time to time, the Board may stipulate special guarantee in such cases.

Service Lines :

After receipt of a requisition, subject to availability of power, an Engineer or Line Inspector of the AP TRANSCO will inspect the premises and fix the point of entry of the service line and the position of the service cutouts and meters in consultation with consumer and/or his Licensed Electrical Contractor, prior notice of which will be sent to the consumer. The position of the circuit breakers and the meter shall be so fixed as to permit easy access for the employees of the AP TRANSCO at any time.

After the inspection of the premises, an estimate will be formulated and go sanctions by the Asst. Engineer from the appropriate authority.

After having agreed on the conditions laid above, the Assistant Engineer will intimate the consumer for payment of (a) Service Line charges (form extension works); (b) Development charges. (c) Security deposit (this deposit will be taken normally for 3 months consumption charges) as noted in Annexure I or amended from time to time.

After receipt of the above payment from the consumer the same will be entered into the payment register and at the end of the month the Assistant Engineer will apply Bunch Work Order under simplified procedure in the prescribed work order application. The Asst. Divisional Engineer of the sub-division will issue the work order for the metering equipment.

The service lines and the metering equipment will be laid and erected by the AP TRANSCO in the order of the date of receipt of payment for service line charges. The service lines once laid shall not be transferred or interfered with or shifted from one place to another except with the permission of the AP TRANSCO. The consumer shall provide service wire and these shall remain the property of the AP TRANSCO. The AP TRANSCO will provide meter and MCB and service lines will be connected to the mains and the service will be released and the test report will be collected in the prescribed proforma and sent to ERO for billing.

Capital Extension :

In case of capital extensions upto 100 ft. (30 M) length from the existing lines, the Board will bear the cost of service lines and after 30 M the consumer has to pay the service line charges for his portion. The Service wire shall not be more than 30 meters.

The estimate for an amount of Rs. 2,000/- will be sanctioned by Asst. Engineer and upto Rs. 10,000/- the sanction will be accorded by Asst. Divisional Engineer of the sub - division. The consumer will be intimated for payment of service line charges, Development charges and security deposit as in force to time.

After receipt of the payment from the consumer, the Asst. Engineer will apply for the work order and after receipt of work order from Divisional Engineer/Operation, the work will be taken up by the Asst. Engineer. The service will be released to the consumer after completion of the works by the Department and the test report will be collected from the consumer.

Category III - LT Industrial Supply:

A consumer requiring supply for industrial purpose shall obtain the necessary license or permission from the local authority or any other competent authority as might be required under the statute, prior the requisitioning of supply from the Board, the consumer must give minimum one month notice before the supply or additional supply's required.

The estimate will be formulated by the Asst. Engineer and the Asst. Divisional Engineer will sanction the estimate if the supply is existing near the consumer's premises.

After the sanction, the consumer will be intimated for payment of the charges such as service line charges, security deposit and Development charges. The consumer has to enter into an LT agreement with the Board for a minimum of period of two years. The ADE/Operation will conclude the LT agreement.

Inspection & Testing:

After the receipt of work order from Asst. Divisional Engr. The AE inspects the premises and tests the installation of the consumer. The insulation resistance of the entire installation to earth shall be tested from the installation side of the Board's terminals after closing of switches of all fittings such as lights, fan motors etc. In the consumer premises. The insulation resistance in mega ohms of an installation measured shall be not less than 50 divided by the number of points on the circuit, provided that the whole installation need not be required to have an insulation resistance greater than one mega ohm. Every LT consumer using induction using Induction motors shall install LT shunt capacitors of specified rating. (page VI - 74)

After completion of the above tests and inspection the service will be released by the AE and the test report collected will be sent to ERO for billing.

Category IV - Cottage Industries:

Applicable for supply of energy to bonafide small scale cottage industries having contracted load not exceeding 5 HP. Applicable for community Dhobighats of washerman using motive power for pumping water for washing purpose.

Category V - Agricultural Service:

Applicable for supply of energy for irrigation and agricultural purposes upto a connected load of 75 HP.

The application - cum - agreement form with an application fee of Rs.25/- for registration to be handed over in the office of Section Officer of the area.

Estimates for extension of pump sets are prepared after field survey by the section Officer. Wherever applications are available a cluster approach is adopted and estimate sanctioned on the basis of the average cost per pump set as per the norms set by the Board.

The fact of sanction of estimate will be informed to the applicant. If the application cannot be sanctioned on technical/financial grounds the party will be informed accordingly within six months. Such application will be again reviewed every six months and sanctioned when they became feasible.

An amount of Rs. 30/- per HP is to be paid as security deposit and Rs. 25/- per HP as service connection charges in the form of crossed DD payable to Asst. Accounts Officer (Revenue) and Asst. Accounts Officer (Expenditure), AP TRANSCO accordingly. The consumer will have to enter into an agreement with Board for a minimum period of 2 years in the prescribed form supplied by Board free of cost.

The applications are registered in seriatim and the sanction for the viable estimates will also be given in the same priority. The priority will be followed waver for release of service connections. No time limit is fixed for release of agricultural services as the demand is for more than the annual targets. However, strict seniority of sanction will be followed and priority list and Manual action planes listing the beneficiaries will be put up on the Notice Board and also placed before the constituency advisory committee. Two months before the probable date of release, the section officer will send intimation to the prospective consumer about the same.

Category VI - Public Lighting:

Applicable for supply of energy for lighting on public roads, streets, through fares including parks, markets, cart stands, bridges and for traffic signaling. The requisition for supply will be from panchayats, Municipalities and from Corporations. The entire cost of the estimate will be come by the requisitioned authority for supply of energy on the public places. Applicable for PWS schemes in the local bodies.

Category VII - General Purpose:

Applicable for supply of energy to places of worship like churches, temples, mosques, guru wars, educational institutions and student hostels, charitable institutions and recognized service institutions. The procedure will be same as above under Category 1 & II.

Category VIII - Temporary Supply:

For supply of energy to all categories other than irrigation and agriculture. The supply will be released to the consumer with short notice after collecting the deposit including urgency charges for the period contracted. The estimate will be formulated for the contracted load x no. of dary x no. of hours (6 Hours/day as per transformer) x rate.

HT Supply - Category I & II:

The tariff applicable for supply of electricity to HT consumers having loads with a contracted demand of 70 KVA and above.

In case of HT consumers, longer notice which may extend to six months or more may be required to enable the TRANSCO to make necessary arrangement for such supply, which will be subject to its availability in the system. The application for requisition should be given in six copies with Rs. 100/- application fee and registered in SE/OP Office.

MRT Inspection for fixing location of metering point:

The consumer has to execute HT agreement in 4 copies for a minimum period of 5 years. T he consumer is at liberty to seek reduction or termination of the agreement by giving three months notice in writing at any time after the period of two years from the date of commencement of agreement. The TRANSCO can terminate the agreement at any time after giving on week"s notice if the consumer violated the terms of the agreement or the terms and conditions of supply prescribed but the TRANSCO from time to time.

HT - Category I:

The billing shall be the maximum demand recorded during the month or 80% of the contracted demand whichever is higher.

Energy charges will be billed on the basis of actual consumption or 50 units per KVA of billing demand whichever is higher.

HT - Category II:

The billing demand shall be the maximum demand record during the month or 80% of the contracted demand whichever is higher.

Energy charges will be billed on the basis of actual consumption of 25 units per KVA of billing demand, whichever is higher.

H.T - Category III Power Intensive industries - Deleted and merged with H.T. Category I

H.T - Category IV Irrigation and Agricultural.

H.T - Category V Railway Traction - No Demand charges and only Energy charges to be paid.

H.T - Category VI Townships and residential colonies. No demand charges and only Energy charges to be paid.

Too (Coml) 173 dt. 10.5.99.

The electricity tariff rates for the Software Development Units and Hardware manufacturing units certified by the Information Technology Department shall be charged at the tariff rated applicable for Industrial category, i.e. T.T.Category - III (A). The units selling Hardware and Software as well as Computer Coaching Centres will be classified under Non - Industrial (H.T.Category - II), Non - Domestic (Lt Category II i.e. Commercial Category).

TRANSMISSION CORPORATION OF ANDHRA PRADESH LIMITED
SCHEDULE I

Application - cum - Agreement for supply of Electricity

The
.....
.....

Sir,

I/We request you to supply electricity at L.T my/our premises situated at
.....

The requisite information is furnished below.

(a) Name of Consumer

(b) Address for Communication

(c) Status of consumer (consumers should state his legal status (i.e.) whether he is individual, partnership firm or limited company or any other legal person. In case of partnership it should be stated whether it is registered, location or unregistered, location of its Head Office, names and addresses of all partners and a copy of partnership deed should be filed. In case of a company it should be stated whether it is private limited or public limited names or present directors and copy of Memorandum or articles of association should be furnished. In case of any other type of legal person full details and name and address of person competent of represent the consumer should be stated)

(d) Location of premises where supply is required

(e) Category of supply

(f) Purpose of supply

(g) Contracted load

(h) Details of connection load at the time commencement of supply

(2) I/We undertake to agree to pay at the tariff prescribed by the APTRANSCO and to abide by the terms and conditions of supply notified by the Board from time to time which shall given the supply of electricity to me/us in all respects.

(3) I/We request that the Board should provide necessary meter/meters/metering equipment.

(4) I/We shall avail supply within three months from the date of issue of intimation that supply is available as and from the date of supply is availed of or from the date of expiry of three months from the date of issue of intimation that supply is available, whether date is earlier. I/We shall be bound to pay the Board all charges in accordance with tariffs as may be prescribed by the Board from time to time and made applicable to me/us and scale of Miscellaneous and General Charges and terms and conditions of supply notified by the Board and I/We shall abide in all respects by those terms and conditions.

- (5) Monthly minimum charges.

I/We shall pay minimum charges every month as prescribed in tariff and terms and conditions of supply every if no electricity is consumed for any reasons whatsoever and also if the charges for electricity actually consumed are less than minimum charges. The minimum charges shall also be payable by me/us even if electricity is not consumed because supply has been connected by the Board because of non - payment of electricity charges, pilferage or other malpractices or for any other valid reason.

- (6) I/We shall pay the APTRANSCO inspection fees, cost of service line and other charges as may be demanded by the APTRANSCO.

- (7) I/We hereby agree that if I/We am/are found indulging in theft of energy or any malpractice in respect of use of electricity. I/We shall pay additional charges as may be levied by the additional charge have right to disconnect supply of electricity to my/our premises for such period as may be decided by the Board.

- (8) I/We and APTRANSCO shall be at liberty to determine the contract by giving in writing one month's notice expressing such intention at any time after the date of expiry of two years. I/We agree that the APTRANSCO may terminate this contract at any time by giving one week's notice, if I/We violate the terms of this agreement or the terms and condition of supply notified by the APTRANSCO from time to time or the provisions of any law touching this agreement including the Electricity (Supply) Act , 1948 the Indian Electricity Act, 1910 and Rules made hereunder.

This agreement shall remain in force until it is terminates as above indicate.

Signed by the consumer in my presence.

Signature of the consumer

- (1) Signature

Name and address

Date

- (2) Signature

Name and address

Date

TARIFF

For a load of Nature

TRANSMISSION CORPORATION OF ANDHRA PRADESH LIMITED

Detailed Estimate for Domestic/Non Domestic Service connection to

Name of the Party: Smt/Sri

L -

L 1

Capacity of the Meter

Sl. No.	Descrip - tion of service	Estimate of total service connection	Cost to the borne by the board for laying 30.48m or less of service line of public road	Amount payable by the consumer to Board towards the labour charges
1.	Single Phase Domestic/ 240 V.A.C. (2.5/400m)			

Amount requiring for settlement Rs.

Rs.

Rs.

To be collected

To be refunded

Security Deposit

LINE INSPECTOR

ASST. ENGINEER

ASST. DIVISIONAL ENGN.

TRANSMISSION CORPORATION OF ANDHRA PRADESH LIMITED
INTIMATION FORM
SCHEDULE - III

Form

To

Addl. Asst. Engineer/Asst. Engineer

Shri/Smt _____

Operation

No. _____

Dear Sir /Madam/Sirs,

Ref : Your application dated _____

1. With reference to your application for supply of L.T. energy to your premises. I request you to take action to :

- (i) Please pay a sum of Rs. _____ towards consumption deposit in the form of Bank Draft drawn in favour of

Asst. Accounts Officer / Electricity Revenue Office/ _____

- (ii) Please pay a sin of Rs. _____ being the amount payable by you towards service line charges in the shape of a Bank Draft in favour of Divisional Engineer/Operation.

OR

A sum of Rs. _____ being the amount payable by the Board shall be paid after the work is completed.

- (iii) Please produce the competition - cum - test report in respect of wiring of you installation.
- (iv) Please ensure that the materials required for service connecting are as per the bill of materials in the sketch enclosed. The materials should be standard type conforming to Indian Standard specification, and with I.S.I. marks for wire. The Service connection work in your premises should be executed through the agency or a Licensed Electrical contractor as per I.E.E. Rules 1956 and kept ready as per the plan in the sketch enclosed. The PVC wire duly clipped to the bearer wire should be kept ready in your premises.
- (v) Please ensure that earthling for the installation in your premises is carried out as per the Indian Standard Specification 3043/1966.

2. Please note that your request for release of service will not be complied with, if the material need for service connection is not as per the specification prescribed by the Board.

Yours faithfully,
Addl. Asst./Asst.Engineer

Consumer No. _____

Acct. _____ Circle _____

FROM - B
APPLICATION FOR INCREASED SUPPLY ELECTRICITY

To

The _____

Sir,

I / We hereby request you to give an additional permanent supply of Electricity Energy in accordance with the conditions set forth on Form 'A' of application signed by me on _____ for the following number of lamps, fans etc.

Lighting Circuit	Power Circuit	Purpose	Remarks
Lights	Power Plugs	Domestic	
No.of lights Watts	Single phase	Commercial	
Fans	No. Watts	Industrial	
No.of Fans --- Watts	P.P. three Phase	agriculture	
	No. Watts	Industrial	
Radios, Heaters	Motors	Agriculture	
		Domestic	
No.of Items Watts	Single Phase	Commercial	
	No. H.P.	Industrial	
	Motors. Three phase	Agriculture	
		Domestic	
		Commercial	
		Industrial	
		Agricultural	
Particulars of existing	L.P.	Total Load	Watts.
	W.P.		H.P.
	P.P.		
	F.P.		
	Motors etc.		
			L.C.
			P.C.

Nature of premises for which load is required:
Residential/Non-residential / Business / Industrial.

Signature of Consumer _____

Address
.....

FOR OFFICE USE ONLY:

Please state the below particulars

Consumer's Engineer

The Account at Present is running is the name of _____

Deposit Rs. _____

Dues Rs. _____

In case of power consumers

Demand Charges

T.S. Details

Accountant
Cons. Accounts Section.

**TRANSMISSION CORPORATION OF ANDHRA PRADESH LIMITED
OPERATION CIRCLE**

- A) Sanction No. _____ TEST REPORT
S.C.No. _____
- B) W.O.No. _____
Distribution _____
- C) Board's portion _____
Date _____
estimated charge _____

PART - A

(To be filled in by Distribution Engineer)

1.
 - A) Name of the Consumer:
(Full Surname and Name in Block letters)
 - B) Father's Name in block letter
 - C) In case the consumer is not owner
of the premises specify owners
name and address full
2. Premises to which supply relates specify
 - i) Nature of Businesses :
f case of non domestic/
 - ii) Purpose if case of non domestic/
Industrial supply:
 - iii) Type of Industry:
(Specify small scale or cottage)
3. Particulars of premises to which supply
relates Door No.
S.F.No.
Street
Town / Village
4. Permanent Address of Consumer :
Door No.
Street
Town / Village

5. Other S.C.No. / Distribution in the name of the above consumer under the A.P.S.E.B. (Full details to be furnished)

6. a) Whether the service now released is for a new premises or an old premises to a new consumer (Specify the S.C.No. if any available already under disconnection):

b) Whether a clearance certificate is obtained from the Electricity Revenue Office before releasing the supply to a new consumer in the old premises:

7.	Particulars of connected Load	No. of Points	Wastage Points	Total Wastage
i)	Lighting: Lights Fans Convenient wall plugs for light and fans			
ii)	Domestic / Non-domestic Electrical Apparatus: Cookers Water Heaters Pump sets Motors Other purposes (Specify details) Convenient wall plugs 5 amps/5 amps			
iii)	Street Light: No. of Fixtures Installed by Board/Consumer connected load	Ordinary filament lamps M.V.Lamps Fluorescent Lamps Blended Lamps		
iv)	INDUSTRIAL: Rice Hulling Oil Pressing Ginning Other purposes (Specify nature of Industry) MOTORS: (Furnish name plate details make etc. of the moor installed)			

v)	AGRICULTURAL: Pump sets Other purposes (Specify details)		
		Total	----- -----

7. (b)	i) Installation between conductor and earth: ii) Insulation between Phases.		

	PLOYPHASE / SINGLE PHASE		
	Meter capacity	Multiplying initial meter	
	No. & Type	Factor reading rent	

8.	Nature of supply :		
9.	Particulars of Meter Whether owned by consumed / Board		
10.	Particulars of seals fixed to the meter:		

Location	No. of seals	Impression on seals	type of sealer	Sl. No. of seals
a)	Meter Cover			
b)	Terminal Cover			
c)	Meter Box			
d)	Cut out			

11.	Tariff applicable :	Monthly Minimum / annual minimum	
12.	Security Deposit	DD No. & Date	P.C.B. No. & Date
13.	Agreement position: (Dispatch No. Agreement Regd. item No. etc.)	(in words)	
14.	a) Connected load b) Connected load (as per the sanctioned estimate)	(in words)	

15. Tariff guarantee: Rs. per H.P.
a) Special Guarantee Rs.

16. Date of commencement of supply:

17. a) Date of expiry of three months notice
(for power services)
b) Whether the U.C.M. charges were paid before
releasing the services (furnish PCB No. and
date of DD No. etc./Receipt No. of the ERO
where payment is made at ERO)

18. Whether the land or the premises relates to the
owner (consent letter of the owner or indemnity
bond to be enclosed)

I am a witness to the above particulars and seals were put on my presence.

1. Witness

2. Witness

Signature of the Consumer

LINE INSPECTOR
Div. Engin.

Addl. Asst. Engineer / Asst.

DISTRIBUTION : WITH

DATE

Forwarded to AAO/ERO _____

Assistant Divisional Engineer
Engineer

Addl.Asst.Egnineer / Assistant Divisional

PART - B

1. Security Deposit Register:

Item No.
Folio No.
S.D.Vol.No.

2. Service connection Register:

I dm No.
Folio No.
Vol No.

3.	Agreement Register:	Item No. Folio No. Vol No.
4.	A.M.G. Calendar:	Item No. Folio No.
5.	Consumer Ledger:	Folio No. S.C.No.

Ledge Folio Opened Top entries completed Meter Card opened.

Asst. Accounts Officer
Electricity Revenue Office

Billing Superintendent

Accountant

-
- Note :** a) No. Column should be left unfilled.
- b) S.F.No. should invariably be recorded for all the agricultural service so link up the services with the agreement.

TRANSMISSION CORPORATION OF ANDHRA PRADESH LIMITED
VIDYTSOUDHA, HYDERABAD - 500 049

ABSTRACT

Service Line Charges and Development Charges - Release of New Low Tension and High Tension Services and Additional loads in existing services - Revised rates of Service Line Charges - Orders - Issued.

B.P.(Opn-Comml) Ms.No.8

Dt: 28.4.97

Read the following:

1. B.P.(Opn-Comml) Ms.No.263, dt.28-2-96
2. B.P.(Opn-Comml) Ms.No.16, dt.25-5-96
3. B.P.(Opn-Comml) Ms.No.106, dt.21-9-96
4. B.P.(Opn-Comml) Ms.No.149, dt.4-11-96

PROCEEDINGS:

1. In the B.Ps, read above, the Andhra Pradesh State Electricity Board notified the revised "Unit Rates" of Service Line Charges and Development Charges payable by prospective consumers for new and additional loads. The Andhra Pradesh State Electricity Board reviewed the "Unit Rates" of Service Line charges consequent to revision of cost data and decided to enhance the "Unit Rates" of Service Line Charges. The Board also reviewed the rates of Development Charges and decided to retain and continue the existing rates of Development charges. Accordingly the A.P.S.E.Board in exercise of powers conferred by section 49 and section 79(j) of Electricity (supply) Act, 1948 (Central Act No.9 of 1910), hereby notify the revised "Unit Rates" of Service Line Charges for the purpose of Clauses 7 of the Terms and Conditions of Supply in super cession of the rates notified in the B.Ps. read above and also notify the rates of development charges to be continued for the purpose of Clause 8 of the Terms and Conditions of Supply.
2. The Development Charges and Service Line Charges payable by different categories of consumers for new/additional loads are indicated in the "Annexure-I" enclosed to this order.
3. These rates of Development Charges and Service Line Charges shall be applicable for those who pay the Development Charges and Service Line Charges on or after the date of this order.

4. The service connection cable required for release of service shall be provided by consumer.
5. The Development Charges notified are applicable in the case of temporary services also where the period of temporary service is for more than ten days.
6. The policy of release of new Agricultural services is yet to be notified by Government along with the Service Line Charges and development charges to be collected in respect to LT Agricultural connections. The same will be notified separately.
7. The zonal Chief Engineers and Superintending Engineers (Operation) are requested to take further necessary action accordingly.

(BY ORDER AND IN THE NAME OF THE A.P.S.E.BOARD)

A.K.KUTTY
Member Secretary

ANNESURE-I
Service Line Charges & Development Charges for New service and/or Additional load on the existing services

Tariff Category	Category of Service	Development Charges	Service Line Charges
H.T.	H.T.Services	Rs.1,500 per KVA or	11 KV Line -
	Rs.1,06,800 per KM	part thereof, of the	33 KV Line -
	Rs.2,04,000 per KM	Contracted Demand	132 KV Line -
	Estimated Cost		220 KV Line -
	Estimated Cost		Cable Feeders -
	Estimated Cost		
LT-I	Domestic services		
	i) Upto 250 Watts	A) For SC/ST-Rs.1000/-	a) UG Cable -
	Estimated Cost		
	Contracted Load	B) For toehrs-Rs.300/-	extensions
	ii) Upto 251 Watts	Rs.1,000 per service	b) LT OH Line -
	As per Date-I below		
	to 1000 Watts		
	iii) Above 1000 Watts	Rs.1,000 + 1000 per KW or part thereof of Constricted Load	
	Non-Domestic /	Rs.2,000 per KW or part	a) UG Cable -
	Estimated Cost		
	Commercial Services	thereof of Contracted	extensions
		Load	b) LT OH Line -
	As per Data-I below		
	Industrial Services	Rs.1,500 per HP or part	a) UG Cable -
	Estimated Cost		
		thereof of Contracted load	b) LT OH Line -
	As per Date-I below		
	Cottage Industries	Rs.1,500 per HP or part thereof of Contracted load	a) UG Cable extensions -
			b) LT OH Line -
	As per Data-I below		
	Local Bodies	Rs.1,000 per KW or part	a) UG Cable -
	Estimate Cost		
Tariff Category	Category of Service	Development Charges	Service Line Charges

	A) Public Lighting	thereof of the Connected load	extensions b) LT OH Line	-
	As per Data-I below			
	B) Protected Water Supply Schemes			
	i) Major and Minor Panchayats	Rs.1,000 per HP or part thereof of the Connected load		
	ii) Municipalities and Corporations	Rs.1,500 per HP or part thereof of the Connected Load		
LT-VII	General Purposes	Rs.2,000 per KW or part	a) UG Cable	-
	Estimated Cost below			
		thereof of the Connected Load	extensions b) LT OH Line	-
	As per Date-I below			
	MULTISTORIES DOMESTIC & COMMERCIAL COMPLEXES	Rs.1000 per KW of contracted load of	a) Cable feeders	-
	Estimated Cost			
	NEW HOUSING COLONIES	Domestic Complex	b) LT OH Line	-
	As per Date-I below			
	OF URBAN DEVELOPMENT AUTHORITIES Etc.	Rs.2000 per KW of contracted load for commercial Compels		

Data-I

LT Single Phase, cost of service.	Rs.63,650/KM	1.	The cost of First 100' of line shall be deducted from the
Two wire Lines			line extension for collection of the Service Line Charges.
LT Single Phase, premises like.	Rs.80,900/KM	2.	In respect of Board's Equipment installed in consumer
three wire Lines			D.P Structures, Switchgear, Distribution Panels,
Breakers, MCCB, Ring Main			units and any other special equipment the entire
estimated cost of this			equipment shall be collected from the consumer.
LT Three Phase, structures	Rs.99,330/KM	3.	For alteration of existing lines and / or involving special
Crossings, Telephone			line 4-Pole Structures, River Crossing. Railway
consumer.			Crossing etc. The entire cost shall be collected from the
LT Three Phase Service, the service	Rs.1,16,400/KM	4.	Where ever 11 KV line is involved for release of LT
Fire wire lines			Line Charges applicable for 11 KV lie shall also be
collected from the consumer			

Note:

ANDHRA PRADESH STATE ELECTRICITY BOARD
VIDYUT SOUDHA, HYDERABAD-49

Ref: CE(Comml)/PO2/543/96 dt.18-7-96

* * *

The Development charges and service line charges shall be collected as per B.P. (Opn-Comml) Ms.No.263 dated 28-2-96 and B.P.Ms.No.16, dated 27-5-96 in respect of multistoried complexes.

The electrical equipment and distribution panels mentioned against item (c) under service line charges for multistoried domestic and commercial complexes, do not include the distribution transformer and its switchgear such as A.B.Switch and HG fuse, transformer. To be precise, service lien charges, need not be collected for distribution transformer, its structure including AB switch and HG fuse.

The development charges are to be collected as per the rates prescribed in the said B.Ps even for Multistoried complexes. In cases, where the prospective consumers are permitted to procure the Distribution Transformer, the Development charges are to be collected as clarified in Board's Memo. No.CE(Comml)/POs/SLC/375/96, dated 14-5-96.

TRANSMISSION CORPORATION OF ANDHRA PRADESH LIMITED
VIDYUT SOUDHA, HYDERABAD-49

Ref: B.P.(Opn-Comml) Ms.No.15 dt.7-5-96

* * *

INITIAL CONSUMPTION DEPOSIT:

The consumer shall deposit with the Board a sum in cash equivalent to estimated three months consumption charges. The consumers coming under the following LT categories shall however pay at the following rates per Kilowatt or part thereof of connected load:

a)	Rs.100/- per KW or part thereof of connected load	For domestic, public lighting and and general purpose categories
b)	Rs.200/- per KW or part thereof of connected load and	For non-domestic, commercial categories
c)	Rs.200/- per KW or part thereof of connected load	For cottage industry and LT industrial categories
	and	
d)	Rs.30 per HP or Part thereof connected load	For Agricultural Pump sets

Provided that the Board may, in the case of Industrial consumers, accept by way of consumption deposit a sum equivalent to two months consumption charges during a period of three years from the date of first release of supply of electricity.

TRANSMISSION CORPORATION OF ANDHRA PRADESH LIMITED
VIDUYTH SOUDHA, HYDERABAD - 500 049

Ref: Memo No.CE(O) F/D.No. 148/97 Dt.28-6-97

* * *

1. The release of service and issue of meters should be entered in a register on the same day. The S.C.No. for which the meter is issued be painted on the meter at Section Office before issue.
2. Meters form Rolling stock of replacement of defective meters or new meters for release of services etc., should be issued only after an entry in the "Meter Issue Register" as per format enclosed which should be updated continuously.
3. In the case of issue of a meter to replace an existing meter, the meter particulars of removed meter along with final reading should be noted in red ink in the same column and attested by Section Officer of having received the removed meter.
4. The maintenance of 'Meter Issue Register' is already in vogue in Vizag and Vijayawada Zone and this is to be followed by every operation section from 1st July '97 onwards WITHOUT FAIL. The painting SC.No. on meters at section office shall also be done and every meter shall be installed only at the specific service for which it is allotted.

METERS ISSUE REGISTER
(To be maintained at Section Office)

Format with example of entries

Sl. No.	S. C. No.	Cat	Distri- bution	Meter issued					Purpose for issue of meter	Dt., initial of person who received the meter	Meter Removed					Signature of AE who received the removed meter
				Make	Serial No.	S ph/ 3 ph	Amps	Initial Rdg			Make	Serial No.	S ph/ 3 ph	Amps	final Rdg	
Date																
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1	46	I	Rampur	ECE	26317	S ph	2.5-10 amps	0001	Replacement of stuck up meter	Sd/- 26-6-97 LM	BHEL	4366	S ph	2.5-10	3619	Sd/- 27-6-97 A.E.
2.	955	II	Laxmapur	ECE	36991	3 ph	10amp	0001	New Service	Sd/- 26-6-97 L.M.						
3.																
4.																
5.																

SEALING OF TERMINAL COVERS

Ref: CE(O)/De/MT/AE2/1561 dt. 3-5-96

1. Numbered lead seals shall be procured by Superintending Engineers and used for sealing of terminal cover. These seals are marginally costlier than ordinary seals but will help in prevention of theft.
 2. The seals shall be issued to the line staff and acknowledgement taken for the batch number given to them.
 3. The field staff should seal terminal cover with numbered lead seals and obtain an acknowledgement from consumer. A copy of the acknowledgement from consumer. A copy of the acknowledgement is also to be given to the consumer. The proforma for acknowledgement is given in the annexure. The private agency may be requested to print the acknowledgement in duplicate.
 4. The terminal cover seal number shall be entered in the consumers master by opening an additional field in the database. The private accounting agency shall be asked to organize data entry.
 5. The monthly bills issued should print the terminal cover seal number on the bill.
 6. A pamphlet should be printed informing the consumer that
 - ♦ The terminal covers are sealed by the Board with the sealed number indicated on the bill.
 - ♦ They shall check the seal number for correctness and inform APSEB if any discrepancy is noticed.
 - ♦ They are responsible for proper maintenance of seal.
 - ♦ If the seal is not available or tampered, they shall be booked for theft of energy.
- A format for the notice to be printed and is given in annexure and same shall be printed and served on the consumer along with bill.
7. Whenever a meter is removed for any reason, a revised certificate shall be obtained on the consumer for terminal cover seal.

8. After completion of the sealing, whenever officer finds that the terminal cover seal is not available or terminal cover seal number is not tallying with what is printed in the bill, a case for theft of energy is booked and preferably prosecute the consumer.
9. Terminal converse shall be procured by Superintending Engineers to provide the same, wherever it is missing. A common terminal cover for most brands of single phase is designed by SE/ secunderabad and the same may be adopted by all Circles.
10. It is seen that whenever a meter is removed from consumer premises, the terminal cover is retained at section office and only meter is handed over to MRT. On return from MRT, the terminal cover is not linked up with meter and meters are installed without terminal covers. Hence forth, all meters shall be handed over to MRT with terminal covers, duly tagged. No meter should be accepted by MRT without terminal cover. MRT should issue also the meter in complete shape with terminal cover.

NOTICE

The terminal cover of meter installed for your service is sealed with lead seal Bearing No. and acknowledgement is obtained as proof of sealing. A copy of acknowledgment is also handed over to your representative available at your premises. The seal number is printed on electricity bills served.

Please check the seal number indicated on your bill with the number available on the seal bit and inform the under-signed if any discrepancy is noticed.

Please note that consumer is responsible for safe custody of seals and any interference is punishable crime as per Clause (d) of Section 44 of I.E.Act, which is reproduced below.

"The meter, indicator or apparatus if under the custody or control of the consumer, whether is his property or not, it shall be presumed, until the contrary is proved, that such connection communication, alteration, prevention or improper use, as the case may be, has been knowingly and willfully caused by such consumer".

Divisional Engineer (Operation)

ACKNOWLEDGEMENT FOR METER TERMINAL, COVER SEALING

Service Connection No.

Distribution Name

Name of Consumer

Category

Address:

Meter Make

Meter No.

Your meter is sealed with lead seal bits bearing the following numbers

1.

2.

and the same is shown to you or your representative on _____

Name & Designation of
APSEB officer sealing the terminal cover

Received the above acknowledgement

Signature of Consumer or his representative

Name of the Consumer or his representative

Weekly report on sealing of Meter Terminal Covers

Sl.No.	Name of Division	Category	Total No. of Services	No. of Services sealed
1.	XXX	Domestic High Value Domestic Other than High Value Commercial High Value Commercial Other than High Value Industrial Other Services High Value Other Services other than High Value		

**ANDHRA PRADESH STATE ELECTRICITY BOARD
NORMS FOR FUNCTION & DUTIES VARIOUS OFFICES**

Ref: CEO-16/D.No.784 dt.11.12.96				
Activity	CE	SE	DE/DE	AE
1. Annual inspection of offices	SE's Offices & also one division office in each circle annually. Also one sub-division in each circle per year	DE's Offices	ADE's Offices	AE's
2. HT services with CMD above 1MVA				
a) Meter readings	Quarterly review	Monthly review of Meter Reading	Monthly reading	
b) Check readings	CE to take check readings for all services with CMD above 4 MVA once in an year	SE to Cover all services once in an year		
c) Inspection	As and when repetitive complaints on Metering come	Once in 6 months	Once in an year by DE/MRT	
3. HT services upto 1 MVA as CMD				
a) Meter readings	Review once in 6 months of all services	Quarterly review of all readings	Monthly review of all readings	Monthly meter reading
b) Check readings	-	Check readings of 10 service per month	Check readings for all services once in an year	
c) Inspection	-	-	All HT services once in half by DE (J) and DE (MRT)	

4.	LT High value services					
	a) Meter readings	Annual review by CE of all MRBs	1/2 yearly review of all MRBs	Quarterly review MRBs all MRBs	Monthly review of all MRBs	Monthly meter reading
	b) Check readings	- Check readings at exceptional quarterly	40 check readings per month	40 check readings per month		
5.	LT services other than high value					
	a) Meter Reading	- Review of MRBs annually once	Every MRB once in 6	Every MRB Monthly once in 8 review		
	b) Check Reading	- -	Check readings at repetitive exceptional	100 check readings per month	1% services per month	
6.	Complaints & exceptional					
	a) consumption too high above 120% of normal		Repetitive occurrence more than twice if it is high value service	Subsequent occurrence	on first	
	b) Consumption too low below 80% of		- do -	Subsequent occurrence	AE on Occurrence	
	c) Readings not furnished		Repeated more than twice	2 nd occurrence	1st occurrence	
	d) Door lock		- do -	- do -	- do -	
	e) Progressive reading at disconnected service					
	(i) high value	Repetitive occurrence	- do -	2nd occurrence	1st Occurrence	
	(ii) Others		Repetitive occurrence	- do -	1st occurrence	
	f) Negative reading	Repetitive at high value services	Repetitive at low value	2 nd occurrence	1st occurrence	
	g) Stuck-up					
	1st occurrence	-	-	-	AE	
	2nd occurrence		-	DE if high value	ADE for low	
	3rd Repetition		SE if high value	-	-	-

h) Burnt					
	1st occurrence	-	-	-	AE
	2nd occurrence	-	DE for high value	ADE Low Value	
	3rd Repetition	SE if high services	DE for low value	-	-
(i) Meter change		If done thrice in an year for HV services	If done twice in the same year for HV services	If done twice in the same year for L.V.	AE
7.	Inspection of other than offices				
	SPM sheds	Once in an year	1/2 year	Every month by DE (MRT)	-
	EHT stations	Once in an year	Quarterly by SE (L & SS)	-	-
	33KV sub-station	Only where power transformer failed	once in an year	Once in 6 months both Operation & MRTs	once in 3 months
	EROs	One ERO in each circle per year Also the SAO in the Zonal office has to inspect one ERO/& it sub month in each circle month	One ERO per month Also the SAO in the circle in the circle of the circle are to inspect & their sub EROs one per	one ERO/- sub ERO per month	-
Ref: CEO - 16/FLT/D.No.266/95 dt. 14-5-95.					
10.	Meter board loses/slant or	Meter reader/LM/LI to	HV services		AE

Schedule and Responsibilities for Review of
Meter Reading and Check Reading

	Activity	CE	SE	DE	ADE	AE
1.	HT Service with CMD above 1 MVA					
a)	Meter readings	Quarterly review	Monthly review of Meter reading	Monthly Reading	-	-
b)	Check readings	CE to take check readings for all services with CMD above 4 MVA once in an year	SE to Cover all services once in an year			
c)	Inspection	As and when repetitive complaints on Metering come	Once in 6 Months	Once in an Year by DE/MRT		
2.	HT services upto 1 MVA as CMD					
a)	Meter readings	Review once in 6 months of all services	Quarterly review of all readings	Monthly review of all readings	Monthly meter reading	
b)	Check readings	-	Check readings of 10 services per month	Check readings for all services once in an year	-	-
c)	Inspection	-	-	All HT services once in half year by DE(O) and DE (MRT)	-	-
3.	LT High value Service					
a)	Meter readings	Annual review by CE of all MRBs	1/2 yearly review of all MRBs	Quarterly review of all MRBs	Monthly review of all MRBs	Monthly meter reading
b)	Check readings	-	Check readings at exceptional quarterly	40 check readings per month	40 check readings per month	
4.	LT services other than high value	-	Review of MRB annually once	Every MRB once in 6 months Check readings at repetitive exceptional	Every MRB once in 3 months 100 check readings per month	Monthly review of MRB 1% services per month

SCHEDULE AND RESPONSIBILITIES FOR REVIEW OF
EXCEPTIONAL REPORTS

		First Occurrence	Subse- quent Occurrence	Repetition More than 3 times
I. Readings				
a.	Consumption too high (Over 100% of normal)	AE	ADE	DE - High Value ADE - Others
b.	Consumption too low (below 80% of normal)	AE	ADE	DE - High Value ADE - Others
c.	Reading not furnished	AE	ADE	DE
d.	Door lock	AE	ADE	SE - High Value DE - Others
e.	Disconnected service Showing progressive reading	AE	ADE	SE - High Value DE - Others
f.	Negative Reading	AE	ADE	DE
g.	Comparison of consumption for similar units per HP	AE	ADE	SE - High Value DE - Others
II. Meter Defects				
h.	Stuck up	AE	ADE	SE - High Value DE - Others
i.	Burnt	AE	ADE	SE - High Value DE - Others
j.	Not existing	AE	ADE	SE - High Value DE - Others
k.	Meter Change	AE	ADE	SE - High Value DE - Others
III. Services Status				
l.	Under disconnection for more than 3 months	AE	ADE	DE to ensure that services under dis- connection for more than 6 months are dismantled after due procedure. SE to do the same in respect of high value.
m.	To be dismantled	AE	ADE	
IV. Inspection of HT Services				
n.	Low power factor	ADE - 1 MVA & below, DE- above 1 MVA	DE/MRT	SE
o.	Stuck-up	DE(O)/DE/MRT	SE	CE
p.	Un-metered due to CT/PT or meter defective	DE/OP	DE/MRT	SE
q.	Max. demand low or high	DE/OP	DE/MRT	SE

PERFORMANCE OF

Distribution / Subdivision/ Dn

Date of Review

Name of AE/AEE Date of Review

1. Details of Category wise Services:

Cat-I	Cat-II	Cat-III	Cat-V	Other LT	Total LT	HT	Grand total

2. Questionnaire:

- a) Are meter readers being changed
- b) are meter observation registers opened & maintained
- c) How missing seals are being reported to AE
- d) Is the AE taking HV reading personally
- e) Is RC fees being collected after issue of 'D' lists
- f) Are the 'D' lists being received by 23rd
- g) Are operated 'D' lists being returned promptly
- h) Action taken toward UDC services
- i) is BP Ms. No. 18 being followed in respect of D/L & RNF services
- j) Are all the S phase & 3 phase meters drawn since last 1 yr accounted for

3. Exceptional as per latest PAA reports of all groups put together

Month	No. of metered Services Cases	Stuck up	Burnt	Door lock	Nill consn	RNF	Total	%exceptional excl. NIL & UDC	UDC
(a)	(b)	(c)	(d)	(e)	(f)	(g)	(c to f)	(h)	(i)
N-2 month									
N-1 month									
Nth month									

4. Sealing of meters

	Total existing	Nos. Sealed	Balance to
be done			
No. of Single phase meters			
No. of 3 phase meters			
Nos. Sealed in last 1 months			
Program & date by which sealing			
will be completed			

5. No. Of D. Trs

Above 250 KVA	250 KVA	100 KVA	63 KVA	Other Capacities	S.ph.	Total

6. Failure of D/Ts

Total existing	Failure in 95-96	Failures in 96-97	% in 95-96	% in 96-97	increase/decrease in 96-97 compared to 95-96

7. Energy Audit

Month	Av.monthly in out to section (lakh units)	Av.Sales as % (lakh units)	Balance as % (loss)

N-1 month

Nth month

8. Energy Audit on D/Ts

No.of D/Ts for which meters are fixed	Nos.For which EA is done	Nos.with range of losses

Below 10%	11-20%	21-30%	31-40%	41-50%	Above 50%

9. Monthly demand of section

N-2 month

N-1 month

Nth month

Collection of Section

Closing Balance

CB as No.Of days demand

10. Specific Consumptions in the section

Category	No.Of services	No.sof units sold in 96-97
Domestic	Nos	
Commercial	Nos	
Indl	Nos	
	HP	

In case of Industrial units per HP per year

11. Action taken to reduce losses

Name of D/t attempted	Date of first audit	% loss during 1st audit	Date of subsequent audit after plugging up leakages	% of losses during subsequent audit	Reduction in losses %

12. Workorder closing

	1995-96	1996-97	Total
S.C. WOs			
Capital W.O.			
Other W.Os			
W.Os pending closure as on date			

13. Theft of materials

Sl.No.	Date of occurrence	Material	Cost of materials lost	Present status

14. Action towards TE/MP cases

No.of cases inspected By DPE	By On.	No.of cases detected By DPE	By On.	Amount assessed Rs.(lakhs) By DPE	By On.

15. Registers & Returns

- a) Review of MRBs :
- b) Review of register of check readings :
- c) Review of D'lists - % of services in D'list/Attended :
- d) Review of S.C.ledger :
- e) Review of A form Register :
- f) Review of returns being sent :
- g) Are test reports sent upto last month end :
- h) Review of meter change slips :

PERFORMANCE OF D-LIST

Total services	Month	No. of services appeared in D-list	% of Services appearing in D-list

**MINIMUM CLEARANCES
INDIAN ELECTRICITY RULES, 1956**

Rule 77, Clearance above ground of the lowest conductor

- 1) No conductor of overhead line, including service lines, erected across a street shall at any part thereof be at a height less than
 - a) for low and medium voltage line 5.791 metres (19 ft.)
 - b) for high voltage line 6.096 meters (20 ft.)

- 2) No conductor of all overhead line, including service lines, erected along any part thereof be at a height less than
 - a) for low and medium voltage lines 5.486 metres (18 ft.)
 - b) for high voltage lines 5.791 metres (19 ft.)

- 3) No conductor of an overhead line including service lines, erected else-where than along or across any shall be at a height less than
 - a) for low, medium and high voltage lines 4.5742 metres (15 ft.)
upto and including 11,000 volts, if bare
 - b) for low, medium and high voltage liens 3.963 metres (13 ft.)
upto and including, 11,000 volts, if insulated
 - c) for high voltage lines above 11,000 fts. 5.182 metres (17 ft.)

- 4) For extra-high voltage lines the clearance above ground shall not be less than 17 ft. plus (1 foot) for every 33,000 volts or part thereof by which the voltage of the lines exceeds 33,000 volts or part thereof by which the voltage of the liens exceeds 33,000 volts; Provided that the minimum clearance along or across any street shall not be less then, 6.096 metres (20 feet)

Rule 79. Clearance from buildings of low and medium voltage lines and service lines

- 1) Where a low or medium voltage overhead line passes above or adjacent to or terminates on any buildings, the following minimum clearances from any accessible point, on the basis of maximum sag. shall be observed :
 - a) for any flat roof, open balcony, verandah roof and lean-to roof
 - i) When the line passes above the building a vertical clearance of 8 feet from the highest point, and
 - ii) When the line passes adjacent to the building a horizontal clearance of 4 feet from the nearest point, and

- b) for pitched roof
 - i) When the line passes above the building a vertical clearance of 8 feet immediately under the lines, and
 - ii) When the line passes adjacent to the building a horizontal clearance of 4 feet.
- 2) Any conductor so situated as to have a clearance less than that specified in sub-rule (1) shall be adequately insulated and shall be attached at suitable intervals to a bare earthed bearer wire having a breaking strength of not less than 700 lbs.
- 3) The horizontal clearance shall be measured when the line is at a maximum deflection from the vertical due to wind pressure.

Rule 80: Clearance from buildings of high and extra-high voltage lines

- 1) Where air high or extra-high voltage ever head line passes above or adjacent to any building it shall have on the basis of maximum sag a vertical clearance above the highest part of the building immediately under such line, of not less than
 - a) for high voltage liens upto and including 33,000 volts. 12 ft.
 - b) for extra-high voltage line 12 ft. plus 1 ft. for every additional 33,000 volts or part thereof
- 2) The horizontal clearance between the nearest conductor and any part of such building shall, ion the basis of maximum deflection due to wind pressure be not less than
 - a) for high voltage lines upto and including 11,000 volts. 4 ft.
 - b) for high voltage lines above 11,000 volts and upto and including 33,000 volts 6 ft.
 - c) for extra-high voltage lines 6ft. plus 1 foot for every additional 33,000 volts or part thereof

Responsibility for Check over Meter Reading

Ref: CE (O) - 16 / D.No. 96/96 dt.27-4-96

ANNEXURE-A

		First Occurrence	Subsequent occurrence	Repetition more than 3 times
I. READINGS				
a)	Consumption too high (Over 12% of normal)	A.E.	A.D.E	D.E.High value A.D.E. Others
b)	Consumption too low (below 80% of normal)	A.E.	A.D.E	
c)	Reading not furnished	A.E.	A.D.E	D.E
d)	Door lock	A.E.	A.D.E	D.E
e)	Disconnected service showing progressive reading	A.E.	A.D.E	S.E.High value D.E.others
f)	Negative reading D.E.others	A.E.	A.D.E	S.E.High value
g)	Comparison of consumption for similar units per HP			
II. Meter defects				
h)	Stuck up	A.E.	A.D.E.	S.E.High value D.E.Others
i)	Burnt	A.E.	A.D.E	S.E.High value D.E.Others
j)	Not existing	A.E.	A.D.E	S.E.High value D.E.Others
k)	Meter change	A.E.	A.D.E	S.E - if meter is changed thrice in a year
III. Service Status				
l)	Under disconnection for more than 3 months	A.D.E	D.E. to ensure that the services under disconnection for more than 6 months are dismantled after due procedure. SE to do the same in respect of high value.	
m)	to be dismantled	A.D.E		
IV. Inspection of HT services				
n)	Low power factor	ADE - 1 MVA & BELOW DE 1 MVA ABOVE		
o)	Stuck-up		D.E.	S.E
p)	Unmetered due to CT/PT or meter defective			
q)	Max. demand low or high			

ANNEXURE-B

	Meter Reader S.E. (O & M)	AE/AAE C.E/Zone	A.D.E	D.E.
LT Services (Which are not high value)	Meter reading Review of MRB annually each section	Check readings 1% per month Review of MR registers-once in a month month	Review of MRB once in 3 months and 100 check readings per	Review of MRB once in 6 months and check of services with repetitive exceptional
Cat I % II				
LT High value Cat.I & II services and all	Once in 6 months by Se and check once exceptions	Meter reading by AE Industrial	Monthly review Annually of MRB by ADE 40 per month	Quarterly review of MRB by DE 40 per month
HT Readings 1000 KVA and below	quarterly Review quarterly by SE and in six check readings months for 10 services by CE per month		Meter reading Once (monthly)	Monthly review by DE/On and also DE/MRT and check readings at all HT services in one year Monthly
HT Readings above 1000 KVA	Monthly review by Se and check readings for all CE and services in one check year	Quarterly reading for	review by	Meter reading
Sealing of Terminal cover etc. and upkeep of Security of metering	Reading Every HT by meter service above reader and 1000 KVA once repeated sealing by in 6 months	AE for HV As and services when compla-	ADE for HT services below 1000 KVA LM/LI	DE/On to check HT service once in 6 months. DE(O) to check every HT in a year

ANNEXURE-1

**Formula for assessment of Consumption when
Meters are stuck-up/Burnt/Not working/Door lock etc.
Connected load in KW x Diversity factor x number of working hours
per day x No. of days in a month.
The factors to be adopted are**

Sl. No.	Category	Diversity factor	Load factor	No.of working hours per day	No.of days per month
1.	Domestic	50%	40%	24	30
2.	Non-Domestic and commercial	90%	90%	10	25 or 30 as the case may be
3.	Indl. Including cottage Industry	Unity	80%	8,16,24 depending on No.of shifts	25 or 30 as the case may be
4.	Agri.	Unity	80%	10	30
5.	Public lighting	Unity	100%	10	30

ANNEXURE-2**PROFORMA FOR WEEKLY REPORT**

Sl. No.	Date	Action as per Annexure (A)			Action as per Annexure (B)		
		Check reading taken No. of service	Weekly progress	Cumulative from 1st of the month	Exceptional checked No.of exceptional received in the month	No.of checked in the week	Cumulative checked during the month

Signature
and date of
Officer with

ANDHRA PRADESH STATE ELECTRICITY BOARD
VIDYUT SOUDHA, HYDERABAD - 500 049.
Memo.No.CEO-16F.Misc/D.No.367/95, dt.7.12.95

Sub: Collection of LT arrears - Disconnection of Services - Reg.

1. Separate disconnection lists shall be got prepared for High value services and group-wise for other services
2. The disconnection of High value services should be given first priority. Others (Bi-monthly services) shall be classified into four groups as indicated below. The officers who shall watch the disconnection of these services is also indicated against each group.

Services with arrears more than	Rs.20,000	SE
Services with arrears	Rs.20,000 to 5,000	DE
Services with arrears	Rs.5,000 to 1,000	ADE
Services with arrears less than	Rs.1,000	AE

3. Divisional Engineers are authorized to enter into Chit and K-2 agreements for O & M services with approval of Superintending Engineers in Board's Memo CEO-16/F.Misc/D.No.214/95, dt.14.8.95. Some of the field officers have represented, particularly from Telangana Districts, that number of services under 'D' list are 50% to 80% of total services and it is not possible to arrange disconnection of all these services by (O % M) staff. It is hereby clarified that all the services should be disconnected by giving the work on contract, if required. Non-disconnection of services will be considered as dereliction of duty and diplomacy action will be taken. All the disconnections should be made at pole only. Such dereliction of duty shall be mentioned in the Annual Appraisal Report by the Reporting Officer. The Divisional Engineer should organize the disconnections distribution wise, Section-wise, fixing the dates, ear-marking the staff contracted to attend the same. All services should be disconnected by 31-12-95 positively.
4. It is seen that large number of services are shown as 'Door locked' for year together. If a service is under door lock for two consecutive meter readings, a notice shall be served for disconnection of service, and staff should be sent for meter reading every month thereafter. If the service is 'Door locked' for third meter reading also, it shall be got disconnection at pole. In respect of two consecutive door locks, the next higher official to the one normally recording reading, shall go for recording the meter reading.
5. The arrears of categories other than agricultural, particularly Cat. I & II, is large. Hence special attention shall be paid for disconnection of Cat. I & II services, particularly in Urban areas. All efforts shall made to bring down the arrears under Cat. I & II.

6. Huge arrears are due from Municipalities and Government departments. The service other than street lights, essential services, Hospitals, Water works, Traffic Signals, Police Stations, etc. shall be got disconnected. Divisional Engineers and Superintending Engineers shall write D.O.letters to District Officials to pay the amounts giving adequate time and also contact them and disconnect the services. Thereafter services may be reconnected on part payment only. If Municipality is in arrears for street lights, their services for Municipal Offices may be disconnected. The amount in dispute, for example water works tariff for major panchayats, should not be considered arrears for the purpose of disconnection.
7. All the services under disconnection for more than three months shall be dismantled. Non-dismantling of services will be considered as dereliction of duty. All services in urban area due for dismantlement shall be got dismantled, if necessary by giving the work contract. All services due for dismantling shall be got dismantled, if necessary by giving the work contract. All services due for dismantling shall be dismantled positively by 31.12.95.
8. It is reported that in a number of villages wherever domestic services are disconnected, supply is availed by direct tapping of LT lines. It is also reported that the transformer fails frequently due to extensive usage of heaters by domestic service consumers. In all such cases, the village distribution is to be converted to single phase high voltage distribution system by erecting single phase transformers and LT AB cable and consumers should be informed that they will be responsible for failure of their transformers and repair costs have to be borne by them.

**ANDHRA PRADESH STATE ELECTRICITY BOARD
VIDYUT SOUDHA, HYDERABD-49**

- a) Every meter change should be approved by ADE/De as follows.
- | | | |
|------|---|----------|
| I) | In respect of HT services | By S.E |
| II) | IN respect of Industrial
High value services with C.Ts
& meters of 50A and above capacity | By D.E |
| III) | In respect of all other LT
3 phase services | By A.D.E |
| IV) | In respect of LT single phase services | By A.E. |
- b) The meter change should be approved by the competent authority after reviewing consumption patter, reasons for which the meter change sought for etc.
- c) The meter change slip should invariably be sent to Revenue wing with signatures of consumer. Officer who has changed the meter and should be countersigned by the Officer who has authorized the change of the meter. This slip should be countersigned by the Officer who has authorized the change of the meter. This slip should be handed over along with removed meter to MRT.
- d) Any change of meter without following the above procedure will be treated as MISCONDUCT and disciplinary action as deemed fit will be taken.

**ANDHRA PRADESH STATE ELECTRICITY BOARD
VIDYUT SOUDHA, HYDERABAD-49**

Sale of Electricity - Consumers - payment of C.C.charges - Granting of Installments -
Revised orders - Issued

RefL B.P.(On. - Comm) Ms.No.13 dated 14-5-97

The A.P.S.E.Board in consultation with Government of Andhra Pradesh, decided to stipulate the following procedure for granting installments keeping in view the recommendations of the Committee on Public undertakings, in suppression of orders issued in the reference cited:

Sl. No.	Particulars	Maximum number of installments	Authority
L.T.SERVICES			
1.	(a) Dues of C.C.charges upto Rs.5000/-	3	Asst.Accounts Officer (ERO)
	(b) Dues of C.C.charges above Rs.5000/- and	3	Superintending Engineer (On.)
2.	Consumers whose C.C. charges dues are above Rs.25000/-	3	Chief Engineer / Zone
H.T.CONSUMERS			
	(a) Non-BIFR cases	3	Member (Accounts)
	(b) BIFR cases (current dues)	3	Member Secretary
	(c) Cases seeking more than three installments in (a) or (b)	6	Chairman

The following guidelines shall be followed while granting installments as above.

1. No Further installments shall be permitted unless the installment schedule granted earlier is fully complied with.
2. The dues at any point of time shall not be more than the consumption deposit available with the Board.
3. In cases where supply is under disconnection, the reconnection should not be permitted unless a minimum of 30% of the dues are paid as the first installment.

4. Written consent should be taken from the consumer for payment of additional charges as per clause-32.2.1 and interest charges as per clause-34(a) of the Terms and Conditions of supply. The additional charges/interest charges payable for installment of previous month shall be collected along with the installment of current month. In case of last installment the same shall be collected along with the next C.C.bill.
5. Extension of time payment of C.C. charges beyond the due date specified in the bill, without disconnection, shall be considered as single installment and attracts interest charges as per clause-34(a) of Terms and Conditions of supply, apart from additional charges.

ANDHRA PRADESH STATE ELECTRICITY BOARD
VIDYUT SOUDHA, HYDERABAD-49

Ref : Memo.No.DP/DM(MPP)/MPP I - A2/402/97-1.Dt.30-4-97

1. A Meter Observation Register is to be maintained and the meter reader shall record his observation in case he suspects or finds any incriminating evidence at the time of his visits. These should be got verified and findings recorded by Assistant Engineer / Additional Assistant Engineer with date of inspection. The format for register is as indicated below.

Sl. No.	Date of Observation	Name of the Meter reader	Sc.No. and Category	Incriminating points noticed or suspected	Intials
(1)	(2)	(3)	(4)	(5)	(6)
	Date of action	Action taken by AE/AEE	Initials of AE/AEE with Date	Review by inspecting Officer with date	
	(7)	(8)	(9)	(10)	

QUALITY & RELIABILITY OF SUPPLY

1.0 Introduction :

- 1.1 With the rapid expansion of economic activity, the necessity of maintaining continuity of supply in power system as well as maintaining proper voltage and frequency has assumed increased importance in our country. Interruption means direct loss to the Public Exchequer in terms of revenue and indirect loss, which is a multiple of direct loss, to the nation due to reduced output in factories and fields. The power system operation at voltages and frequencies beyond maximum acceptable variations causes tremendous loss and inconvenience in various spheres and gradually set up a vicious circle tending to further deteriorate the system operating conditions. It will be appreciated that keeping in view the constant low voltage conditions prevailing in our system, the consumers tend to install over-capacity induction motors with a view to escape damage. The induction motors when run under loaded, operate at a low power factor and low efficiency. Consequently, the system voltages falls further and system losses tend to increase. Similarly operation for system at abnormal frequencies is suicidal for certain types of loads. Obviously line losses and quality of supply go hand in hand. It is for these reasons that the utility engineer is now required to ensure a better quality of service both in the planning and lay out as also in the operation and maintenance of the power system.

2.0 Preventive Maintenance:

- 2.1 While a proper layout and design of the power system is the fundamental requirement for maintaining a dependable supply of power, the development of suitable maintenance organization is equally important. A well coordinated and adequately equipped maintenance crew are highly essential for ensuring a good quality of supply. Not line working can bring about substantial improvement in the continuity of supply.

3.0 Faults and Equipment:

- 3.1 Various measures required to be taken by an electricity supply undertaking to ensure continuity of supply on overhead sub-transmission and distribution systems, entail a careful selection of the controlling circuit breakers, their proper coordination and maintenance goes a long way towards minimizing the frequency of breakdowns and their durations. Outages on overhead sub-transmission lines are mostly due to lightning surges. On the 11KV overhead distribution feeders, breakdowns are largely due to birdcage use of insulator breads on jumpers suitable gang operating switches, autoreclosures and adequate clearance between phase conductors and earth wires reduce the interruptions to a substantial extent. Power transformers can give more efficient and longer service, if properly installed, maintained and protected against lightning surges and frequent heavy fault current.

- 3.2 In the Grid sub-stations the faults on the grid sub-stations though usually rare, are the most important because the result in discontinuance of supply to the entire area fed from the grid. The faults on the grid sub-stations may be due to failure of circuit breakers, bus bar faults and faults on HT feeders. Failure of breakers may be due to inadequate rupturing capacity of circuit breakers, lack of proper upkeep and maintenance of storage battery, burnt contacts, burnt Cuts, improper relay coordinating, etc.
- 3.3. On distribution sub-station, the distribution transformer is a rugged piece of apparatus and if proper care is exercised at the time of its installation and thereafter in maintaining, it gives a trouble free service for a long period. The faults in there may be due to the fall in the dielectric loading of transformers, improper or oversized fuses, defects in GO switch, etc.
- 3.4 Faults on the LT system are comparatively of less importance because the area is limited. However, number of interruptions resulting from these faults will be significant unless due attention is paid to remove the causes of these faults. The faults in LT system are due to the use of higher rating fuses, deteriorated insulation of mains and sub mains, improper T joints, leakage in service, defect in consumer installation, etc.

4.0 Statistical Data of Breakdowns:

- 4.1 It is obvious that before thinking of improving service continuity to consumers, we should have better knowledge of the performance of our distribution system with adequate data of the frequency and duration of interruption the various causes for the interruptions, etc. EL should have adequate statistical data to review the quality of service we provide to consumers and establish standards to be followed. Maintenance of adequate statistics is not an easy matter.
- 4.2. The magnitude of the task assumes greater proportions in Transmission corporations with large distribution networks spreading into remote rural areas.

5.0 Yard sticks for Service Interruptions:

- 5.1 Though we are at present actively engaged in our various plan programmes, it is time we give the thought to reporting of troubles and interruptions recording them in a systematic manner and analyzing them with a view to effect necessary improvements in the design, operation and maintenance of distribution system. It is desirable that common methods of reporting and yard-sticks for measuring service interruptions are arrived at and agreed to by the various State electricity Boards and Licenses in India so that a uniform practice is obtained for the whole country. Such a procedure would help:

- i) To enable the designing and operating personnel in each power supply undertaking to determine the specific causes of interruptions and take suitable remedial measures to improve the standard of supply.
- ii) To determine whether any improvement in service continuity is necessary to any consumer or group of consumers and to ensure that expenditure on improvements is incurred when it is most needed.
- iii) To keep a State Electricity Board informed of the performance of its various operating systems or divisions.
- iv) To compare with and assess the performance of the various State Electricity Boards as a whole.

5.2 Maintenance of Statistical data on service interruptions would help in tracing the causes for interruptions and evolving suitable methods for improvements in service continuity. When data on interruptions on a whole system are analyzed, basic improvements generally applicable as a standard throughout the system are often indicated.

REACTIVE COMPENSATION FOR DISTRIBUTION FEEDERS

Introduction:

Though an unloaded transmission or distribution line is capacitive in character a fully loaded line has inherent inductive and resistive characteristics. On main transmission lines operating at near unity power factor, the power which can be transmitted is determined largely by the system stability limit in which the phase angle between the voltage at the sending and receiving ends does not exceed a certain critical value. On distribution system, especially those operating on low power factors, the inductive reactance makes a major contribution to the voltage drop, and it is the voltage drop consideration which frequently dictates the amount of power which can be distributed.

The effect of inductance in power network is to cause:

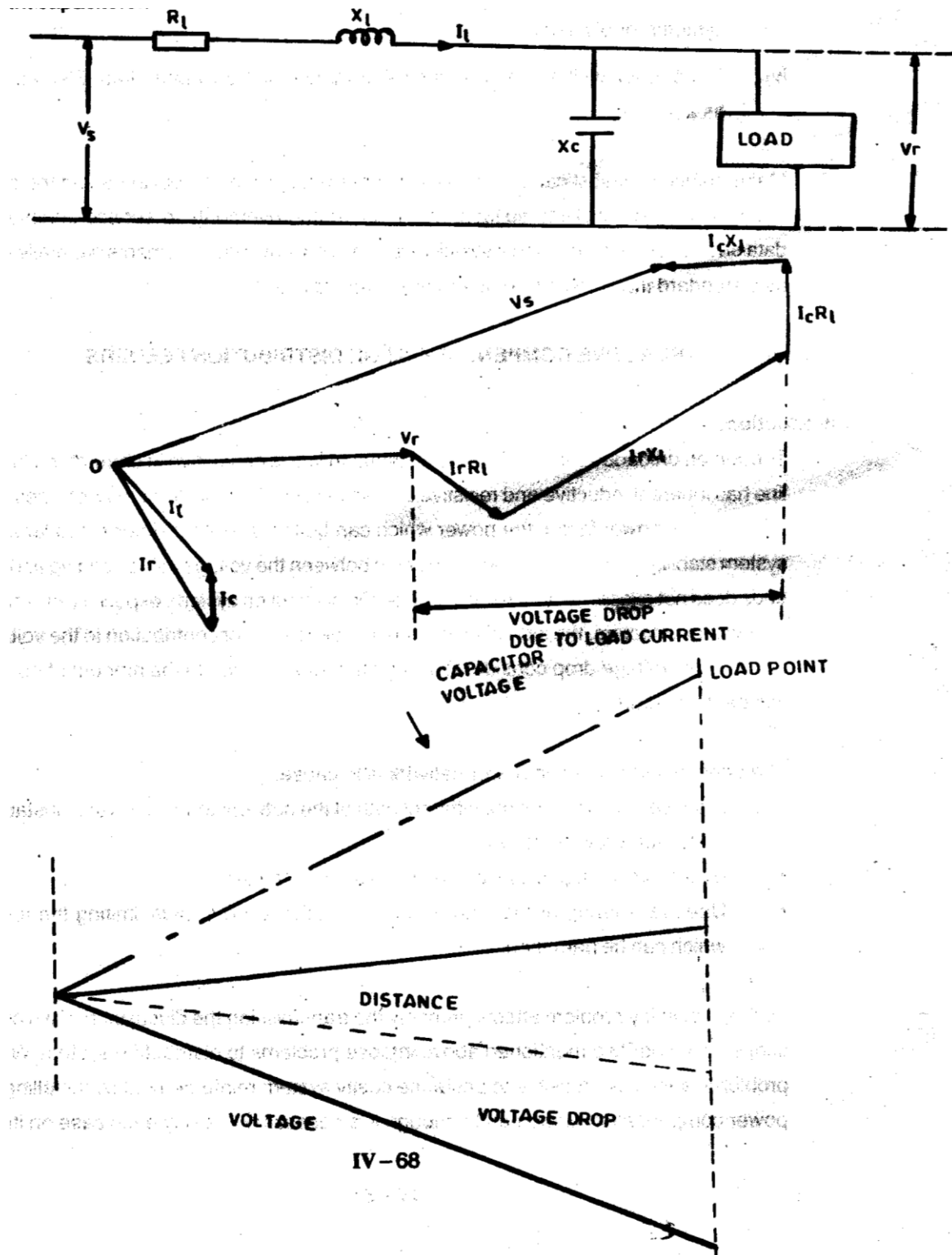
- ♦ A phase shift between the different parts of the network tending towards instability at undesirably low power level.
- ♦ Excessive voltage drops between the ends of feeders.
- ♦ Unequal sharing of the load between parallel feeders, thus limiting the total power which can be permitted.

Of these stability problems which affect primarily the transmission the discussion of which is out of scope and other two mentioned above impose problems to distribution system. When such problems arise it is possible to postpone costly system reinforcement by installing reactive power compensation equipment, although it is necessary to study each case on its merits. Overall improvements in operating condition will be brought about by means of reducing the system reactance or by reducing the phase between the system current and voltage. In distribution system this can be done by installing static equipment namely:

- ♦ Shunt Capacitors.
- ♦ Series Capacitors.

Shunt Capacitors:

The reduction of the phase angle between the voltage and the current is obtained by connecting shunt capacitors.



Shunt capacitors supply the fixed amount of reactive power to the system at the point where they are connected. This, in turn, causes the reduction in enactive power flowing in the line and the consequential benefits are listed here.

i) Improvement in power factor of the system:

The capacity of bank required to improve the power factor is given by

$$\text{Capacitor KVAR} = \text{KW} (\tan \phi_1 - \tan \phi_2)$$

ϕ_1 = uncorrected phase angle

ϕ_2 = corrected phase angle

ii) Reduction in losses:

$$\text{Loss in KW} = 3 I^2 R \times 10^{-3}$$

$$\text{But } I = \frac{P}{3 E \cos \phi}$$

$$\text{Line loss in KW} = \frac{P^2 R \times 10^{-3}}{E^2 \cos^2 \phi}$$

From this it can be seen that the line loss decreases until it reaches the ultimate value of

$$\frac{P^2 \times R \times 10^{-3}}{(ER)^2} \text{ at unity power factor.}$$

iii) Voltage profile improvement:

The voltage improvement due to capacitor installation is given by:

$$E = Qq^{xc} \times 10^{-3}$$

- iv) Decrease in KVA loading on the source, i.e., generators, transformers and line upto the location of capacitors to relieve over loading conditions or provide additional capacity for load growth. The capacitor KVAR per KVA of load increase is of particular interest. Resultant of the product of this quantity and the cost per capacitor KVAR is the average cost of supply each additional KVA of load. Further as the load power factor approximates unity, smaller and smaller incremental gains are obtained for incremental increase in capacitor KVAR.
- v) To reduce system improvement cost per KVA of load supplied. Location of shunt capacitor bank: The effect of shunt capacitor is felt in the circuit from the point of location of the capacitor towards source only. Hence, the location of shunt capacitor has to be as near the load point as possible for maximum benefits. Thus the location of the shunt capacitors at load points which is to be switched on and off along with load, is very attractive as the loss reduction is maximum and compensation occurs only when needed. However, this involves large investment, as the quantum of compensation required is large due to diversity of load. Further it is difficult to implement the proposal in practical systems due to large number of units involved. Hence it may be economical to provide group compensation on lines and at sub-stations.

The ratings have to be determined for shunt capacitors i.e., voltage and KVA rating.

$$\text{KVAR rating } Q_p = E^2 / X_C \times 10^3$$

Operating problems of shunt capacitors:

- i) The output of shunt capacitor is proportional to the square of the voltage of the circuit at its location, i.e., $Q_p = E^2 / X_C$. Thus, reactive power supplied by shunt capacitor to system gets considerably reduced at the time of peak load conditions due to its voltage.
- ii) The shunt capacitor supplies constant reactive power to the system at a location and is independent of the load. Hence, optimal compensation provided for peak load conditions may result in over-compensation at light load. The effects of over compensation may result in rise of voltage beyond permissible limits and undesirable operation of system at leading P.F. Hence, automatic switching schemes are expensive and this, in turn, limits the number and thus minimum capacity of capacitor bank that has to be provided on a feeder.
- iii) As a system power factor approaches unity, large increments of shunt compensation is required for further incremental improvement of P.F.
- iv) In respect of heavily loaded lines, (on KVA/KM basis) to attain the voltage profile within statutory limits, the shunt compensation required is very large. This is not only uneconomical but may result in over-compensation.

Series CAPACITORS:

Series capacitors are used for compensating the line reactance and the equivalent current diagram is as shown

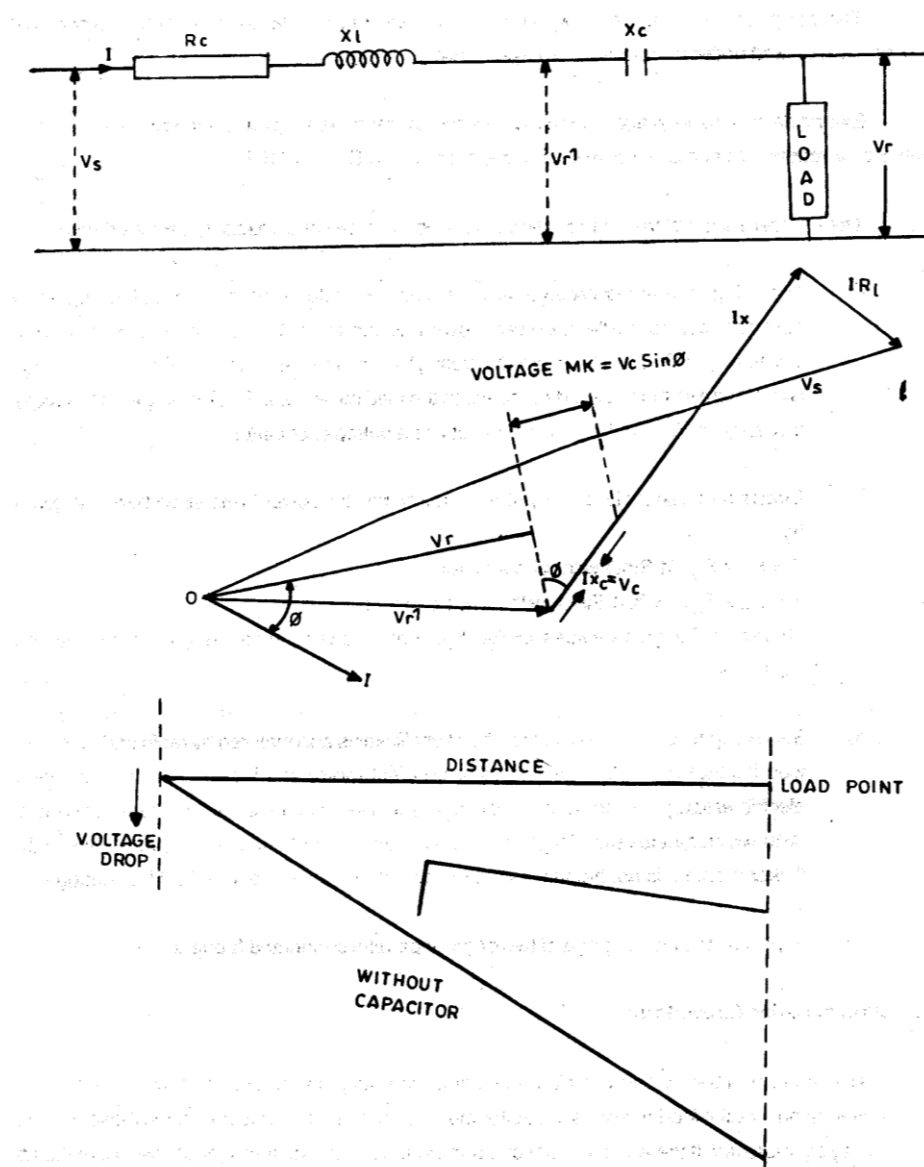


Diagram shown voltage drop with distance and effect of service capacitors.

From the above the phase to neutral voltage drop between V_S & V_R can be expressed as

$$\text{Voltage drop} = I [R_L \cos \phi + (X_L - X_C) \sin \phi]$$

The conditions $X_L < X_C$, $X_L = X_C$ and $X_L > X_C$ are referred to as overcompensation, full compensation and under compensation respectively.

Examination of the regulation formula above shows that by varying the granting X_C the regulation can be increased or decreases at will, provided that $\sin \phi = 0$ i.e., at UPF.

The compensation of the line reactance obtained with series capacitor has the effect of

- i) Improving voltage regulation chiefly at the point of Installation. It improves the regulation automatically as the load current flows through the capacitor. Voltage drop without capacitor $= I (R \cos \phi + X \sin \phi)$; voltage drop with capacitor $I [R \cos \phi + (X - X_C) \sin \phi]$ Here voltage rise is dependent on the load current and P.F. A change in produces a change in V_C and the capacitor acts as a voltage regulator.
- ii) Effects on tie line. The steady stat stability limit for power transfer on tie line is given by
 $P = E_R \times E_S / X \sin \phi$ without capacitor
 $P = E_R \times E_S / (X - X_C) \sin \phi$ with series capacitor
 Therefore, for given values of E_R , E_S , $\sin \phi$, power transfer is greater with series capacitor.
- iii) Series capacitors are best suited when light flicker is encountered by rapid and repetitive load fluctuation such in the cases of frequent motor starting, electric arc furnaces, electric welding etc. The series capacitors neutralize instantaneously the transient voltage drop which causes the light flicker. Application of shunt capacitors to tackle the light flicker problem is not helpful, as shunt capacitors cannot be switched fast enough.
- iv) Improves the load sharing of two or more parallel connected feeders.

Location of Series Capacitors:

The effect of a series capacitors on a circuit is form its point of location towards load end. Hence on a radial feeder, series capacitor must be located at source and load whose voltage is to be improved. If there are number of tapped loads distributed throughout, the rule of thumb for the best location of series capacitors is at, about one third of electrical impedance of the feeder from source bus.

Rating of Series Capacitors:

The ratings have to be determined for series capacitors i.e., KVAR, voltage and current. As series capacitor has to carry full line current in the circuit where it is inserted, its continuous current rating should be at least equal to peak line current and preferably greater than the peak line current for the purpose of catering further load growth. The value of X_C depends upon the percentage of compensation required. The voltage rating is (IX_C) and KVAR rating per phase is $(3I^2 X_C)$

Operating Problems with Series Compensation:

- i) Under fault conditions, the full fault current passes through the capacitor and voltage across capacitor may exceed the permissible limits and may damage the capacitor, even though the capacitor can withstand about 200% of their rated working voltage for a brief period. Hence the series capacitors have to be provided special protection schemes to take care of fault conditions.
- ii) The series capacitor causes sudden rise in voltage at its point of location and as such, the capacity of capacitor that can be provided at a location is dependent on the upper limit of permissible voltage at its point of location.
- iii) The cost of series capacitor per KVAR is higher than that of shunt capacitor.
- iv) A transformer bank when energized draws a high transient exciting current. If a series capacitor is in the circuit, it may create a resonant condition that causes the high current to continue to flow. This is known as Ferro resonance. The spark gap of the capacitor takes care of this contingency.
- v) When an induction motor is started through a series capacitor, the motor may lock in and continue to rotate at a speed below normal or synchronous speed. This condition is known as sub synchronous resonance. It is caused by the capacitor whose capacitive reactance in conjunction with inductive reactance of the circuit and motor establishes a resonant circuit at if the largest motor requires less than 20% of circuit rating. Sub-synchronous resonance can be prevented by providing a resistor in parallel across capacitor or a resistor in series in supply leads to motor at the time of starting.

Combined Series and Shunt Compensation:

The principles of operation of series and shunt capacitors indicate the relatively shunt compensation is best suited for minimization of line losses and series compensation for improving voltage profile. Further that neither series nor shunt compensation could alone raise the voltage profile lie in statutory limits during peak load and off peak load. Hence to achieve the objectives of minimum losses and best voltage profile, a combination of shunt and series compensation is an ideal choice.

CHOICE OF SERIES OR SHUNT CAPACITORS:

1. With a series capacitors the regulation or reduction in voltage drop achieved depends mainly on reactive power of the load and this type of capacitor is of little use unless the conditions are such that reactive power is consumed by the load.
2. With a shunt capacitors the regulation achieved depends mainly on the reactance of the system, and a useful increase in voltage will be obtained only if the reactivity is substantial.
3. If continuous and automatic voltage regulation is the main objective a series capacitor installation is most likely to satisfy the need.
4. A shunt capacitor bank with means of automatically increasing or decreasing the number of sections of the bank in service, will provide a measure of regulation, all be it in steps and with some delay.
5. A capacitor connected in series with a line must have a current rating equivalent to that of the line, the output of reactive power from the capacitor being dependent upon the line current.

$$\text{OUTPUT} = \frac{I^2 \times C}{10^3} \text{ KVAR / Phase}$$

6. With a shunt connected capacitor the output of the bank is independent of the current compensation being determined by the applied voltage.

LINE LOSSES - CAUSES & REMEDIES

Introduction:

The consumption of electrical energy in a country is a major indicator of the level of its development. India, being predominantly a rural and agricultural based country, the progress of its rural areas is an important indicator of its development. Realizing the crucial role of electricity in the integrated development of rural areas through increased agricultural production by providing assured irrigation for crops through energized pump sets and promotion of rural industries, rural electrification gained increasing momentum in India over the years since independence. By the end so Sep '88, 438981 villages were electrified representing 75.40% of the total number of villages in the country. Besides, 73,75,897 agricultural pump sets have been energized.

At the same time, to meet the national goal of self-reliance, India has developed a large industry base and the growth of industrial units continues at a fast rate. Large quantity of electric power is required for running the industry. Thus, a vast network of HT/LT lines run across India to cater to the power needs of urban and rural consumers. Because of fast development activities in developing countries, the power system is expanding rapidly. This has led at times to haphazard and unplanned growth of distribution systems both primary and secondary. This haphazard expansion has resulted in causes contributing towards high losses in the power system.

Disadvantages of Line Losses:

Like any other system, the power system should be efficient. This means that the ratio of the power utilized by the ultimate consumers of electric power to the power produced at the generating stations must be as high as possible. In other words the losses occurring in carrying electric power from the generator to the consumers must be kept at the minimum. These losses are called "Line Losses" and occur in the transmission and sub-transmission lines. Step up and step down transformers primary and secondary distribution line and distribution transformers.

These losses are I^2R losses in the resistance of the conductor and equipment in the line, iron losses in the transformers etc.,

Low line losses result in a low cost per unit to the consumer.

For the country as a whole, low line losses mean better utilization of the sources of energy, such as oil and coal.

In India, line losses vary from region to region from 15-30%. This is extremely high compared to about 8-10% in the developed countries of Europe, America and Japan.

This shows that the percentage losses need to be brought down to a reasonable level in order to improve the efficiency of the distribution system.

This assumes great urgency and importance in view of the acute shortage of power.

Factors Contributing Towards Increase Line Losses:

The major amount of losses in a power system are in primary and secondary distribution lines; while transmission and sub-transmission lines account for only about 30% of the total losses. Therefore the primary and secondary distribution systems must be properly planned to ensure losses within acceptable limits.

The factors contributing to the increase in the line losses in the primary and secondary systems:

1. Lengthy Distribution:

In practice, 11 KV and 415 volts lines, in rural areas are hurriedly extended over long distances to feed loads scattered over large areas. Thus the primary and secondary distribution lines in rural areas; by and large radially laid, usually extend over long distances. This results in high line resistance and therefore high I²R losses in the line.

Because of the above reason, the rural loads contribute towards increased line losses.

2. Inadequate Size of Conductors:

As stated above, rural loads are usually scattered and generally fed by radial feeders. The conductor size of these feeders should be adequate.

The size of the conductor should be selected on the basis of KVA x KM capacity of standard conductor for a required voltage regulation.

Table 1 & 2 give the length of lines for 11 KV and 415 volts corresponding to different loads for the voltage regulation prescribed by IE Rules; for different sizes of conductors respectively.

Table - 1**Length of 11 KV line corresponding to different loads**

Size of conductor (with code No.)	KVA-KM for 8% voltage drop at 0.8 PF	Maximum of length of line (KM)	Load that can be connected (KW)
50 MM ² ACSR	10,640	30	355
Rabbit			
30 MM ² ACSR	7,200	20	360
Weasel			
20 MM ² ACSR	5,120	15	341
Squirrel			

- ♦ The figures are for a conductor temperature of 60⁰ C. For a conductor temperature of 50⁰ C, the above figures shall be about 3% higher and for a temperature of 70⁰ C about 3% lower.

Table - 2**Length of 415 volts line corresponding to different loads**

Size of conductor (with code No.)	voltage drop at	KW-KM for 8% length of at 0.8 PF (KM)	Maximum of Load that can be line connected (KW)
30 MM ² ACSR	11.76	1.6	7.35
Rabbit			
20 MM ² ACSR	7.86	1.0	4.86
Weasel			
13 MM ² ACSR	5.58	1.0	5.58
30 MM ² AAC ANT	12.06	1.6	7.54
16 MM ² AAC Gnat	6.96	1.0	6.96

- ♦ The figures are for a conductor temperature of 60⁰ C. For a conductor temperature of 50⁰ C, the above figures shall be about 3% higher and for a temperature of 70⁰ C about 3% lower.

3. Distribution Transformers not Located at Load center on the Secondary Distribution System:

Often DTs are not located centrally with respect to consumers. Consequently, the farthest consumers obtain an extremely low voltage even though a reasonably good voltage level is maintained at the transformers secondary. This again leads to a higher line losses. (The reason for the line losses increasing as a result of decreased voltage at the consumers terminally are explained in para - 5)

Therefore in order to reduce the voltage drop in the line to the farthest consumers, the distribution transformer should be located at the load center to keep voltage drop within permissible limits and thus minimize the losses.

4. Over-rated Distribution Transformers and hence their Under-Utilization:

Studies on 11 KV feeder have revealed that often the rating of DTs is much higher than the maximum KVA demand on the feeder. Over rated transformers draw an unnecessarily high iron losses. In addition to this iron losses in over rated transformers the capital costs locked up is also high.

From the above it is clear that the rating of DT should be judiciously selected to keep the losses within the permissible limits.

For an existing distribution system the appropriate capacity of distribution transformer may be taken as very nearly equal to the maximum KVA demand at good PF (say 0.85) Such an exercise have been carried out for a number of distribution systems and transformers with capacity of 25, 63, 100, 160, 315 KVA and standardized for different systems with power factors and diversity factors.

5. Low Voltage (less than declared voltage) Appearing at Transformers and Consumers Terminals:

Whenever the voltage applied to induction motor varied from rated voltage, its performance is affected. Within permissible voltage variation of $\pm 6\%$ of the affect practice, the supply voltage varies by more than 10% in many distribution systems. A reduced voltage in case of induction motor results in higher currents drawn for the same output.

For a voltage drop of 10%, the full load current drawn by the induction motors increase by about 10% to 15% the starting torque decreases by nearly 19% and the line losses in the distributor increases by about 20%.

As the bulk load of rural areas and small scale industrial areas consists of induction motors, the line losses in the concerned distribution systems may even touch 20%.

The above situations is corrected by operating an "on-load-tap changing" in the power transformers situated at high voltage sub-stations 66/11 KV and 33/11 KV sub-stations and providing on the 11 KV feeders a combination of switched capacitors and automatic voltage regulators.

Further, the "off load tap changing" in distribution transformers is adjusted prior to the commencement of agricultural load season which is readjusted before the on-set of mansions when the rural load is small if the off-load tap changing gear is available.

6. Low Power Factor:

In most LT distribution circuits, it is found that the PF ranges from 0.65 to 0.75. A low pF contributes towards high distribution losses. For a give load, if the PF is low, the current drawn in high. Consequently, the losses proportional to square of the current, will be more.

Thus, line losses owing to the poor PF can be reduced by improving the PF. This can be done by application of shunt capacitors.

Shunt capacitors can be connected in the following ways:

- i) Shunt capacitors are connected on the secondary side (11 KV side) of the 33/11 KV power transformers.

Table 3 shows from the studies carried out on 11 KV lines, how the improvement of power factor results in considerable reduction of losses.

Table - 3

Reduction of Line Losses with Improvement in Power Factor

Load (KIW)	PF	KVA	Current (A)	Line Loss (KW)	Remarks
300	0.7	428	38.9	27.2	Before
300	1.0	300	27.2	13.4	After

- ii) Line losses in LT distribution lines may also be considerably reduced by installing shunt capacitors of optimum rating at vantage points.

The optimum rating of capacitor banks for a distribution system is 2/3rd of the average KVAR requirement of that distribution system. The vantage point is at 2/3rd the length of the main distributor from the transformer.

A study made in an urban distribution system fed from a 200 KVA, 11 KV/415 volts transformer with 300 HP CL of more than 200 consumers having small loom loads showed the range of PF of the distribution system varied from 0.65 to 0.70. The reactive power requirement was 135 KVR. The inductive loads occurred on the distribution system between 7 AM and 8 PM; on all the working days with almost constant load-cycle. The capacitor bank rating 42.5 KVAR were installed at 2/3rd the distance from the transformer on the main distributor and were switched on and off manually at 7 AM and 8 PM respectively on all working days. The loss reduction was thus found to be 6-7%. The released capacity in this particular study was 42 HP which could be supplied to the additional consumers.

- iii) A more appropriate manner of improving this PF of the distribution system and thereby reduce the line losses is to connect capacitors across the terminals of the consumers having inductive loads. The extent of reduction of line losses in this manner depends mainly on the extent to which the PF of consumer is improved. In this case, the capacitor is connected in parallel directly to the terminals, the capacitor being switched on and off together with the equipment itself.

Many electricity supply authorities are modifying their tariff conditions to make it compulsory for the consumers to provide capacitors for all types of installations with connected loads of 5 HP and above.

By connecting the capacitors across individual inductive loads, the line loss is reduced from 4-9% depending upon the extent of PF improvement.

7. Bad Workmanship Resulting in Poor Contacts at Joints and Connections:

Bad Workmanship contributes significantly towards increasing distribution losses. Efforts should, therefore, be made to have the best possible workmanship. In this context, the following points should be borne in mind.

- i) Joints are a source of power loss. Therefore the number of joints should be kept to a minimum. Proper jointing techniques should be used to ensure firm connections.
- ii) Connections to the transformer bushing-stem, drop-out fuse, isolator, LT switch etc. should be periodically inspected and proper pressure maintained to avoid sparking and heating of contacts.
- iii) Replacement of deteriorated wires and services should also be made timely to avoid any cause of leakage and loss of power.

Pilferage of Energy:

In addition to the factors discussed above, causing an increase in line losses there is, unfortunately, a certain amount of theft of electrical energy.

Since it is often not possible to find out culprit, the stolen energy cannot be measured and, therefore, can not be charged to any one. Stolen energy is, therefore, considered as a part of line losses.

Unscrupulous consumers extract energy illegally either by-passing the energy meter or by connecting leads directly to the distribution lines. Electricity supply authorities take various measures to stop theft of energy as below:

- 1) Surprise inspections are carried out by vigilance squads.
- 2) The energy meter is housed in a separate box sealed and made inaccessible to the consumers. The fuse cut-outs are provided after the meter.
- 3) Multi-core PVC cables are used as service mains instead of single core VIR wires.
- 4) The energy meter manufacturers are asked to provide the potential link inside the body of the energy meter rather than inside thermal cover. This prevents the potential link to be disconnected by the consumer.
- 5) Heavy fines are imposed on consumers found committing theft of energy.

Conclusion:

In conclusion, it must be stated that the consumer stealing energy is imposing an extra financial burden on honest law-abiding consumers. Further high line losses result in increased consumption of fuel, oil etc., used in the generation of electric power. Therefore, it is in the national interest for the line losses (including pilferage of energy) to be kept down to a minimum.

A unit saved is a unit earned for the system and this slogan is well worth remembering.

DISTRIBUTION SYSTEM CONSIDERATIONS

In determining the design of the distribution system, three broad classifications of choice needs to be considered.

- 1) The type of electric system: Ac, single phase or poly-phase.
- 2) The type of delivery system: radial loop or network: Radial systems include duplicate and throw over systems.
- 3) The type of construction: overhead or Underground.

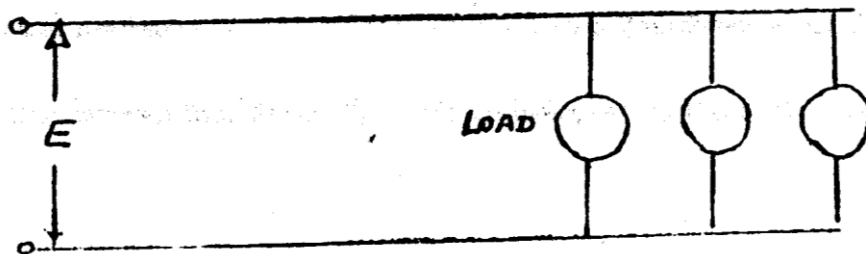
Desired Features:

Electrical Energy may be distributed over two or more wires. The principal features are safety, smooth and even flow of power as far as practical and economy.

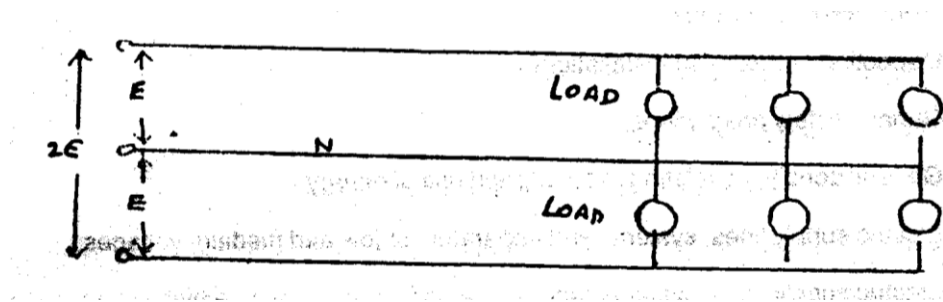
- 1) **Safety** : The safety factor usually requires a voltage low enough to be safe when the electric energy is utilized by ordinary consumer.
- 2) **Smooth and Even flow of power** : A steady, uniform, non-fluctuating flow of power is highly desirable both for lighting and for the operation of motors for power purpose.
- 3) **Economy** : The third factor requires the minimum use of conductors for delivery of electric energy. This usually calls for use of higher voltages where condition permits the elimination of some conductors by providing a common return path for two or more circuits.

Types of Electric Systems :

- i) **AC single phase two wire system** : It consists of two conductors between which a relatively constant voltage is maintained, with the load connected between the two conductors.



- ii) AC single phase, 3 wire system : It is a combination of two two-wire systems with a single wire serving as a neutral of each of the two wire systems as shown in figure below.



If the load is balanced the two (two wire) systems, the common neutral conductor carries no current and the system acts as a two-wire system at twice the voltage of the component system.

Alternating Currents 3 Phase Systems :

It is most widely used system. The voltage of each phase is 120 out of phase with the voltages of the other two phase, but one conductor is used as a common conductor for all of the system. The neutral is usually grounded. Single phase loads may be connected between one phase wire and the neutral, but may also be connected between phase wires if desired. In this latter instance the voltage is 3 times (1.73 times) the line to neutral voltage. 3 phase load may have each of the separate phases connected to the 3 phase conductors and the neutral.

Power delivered is equal to the sum of the powers in each of the 3 phases. Power loss is equal to the sum of the I^2R losses in all 4 wires.

Three wire system :

If the load is equally balanced on the three phases of a four wires system, the neutral carries no current and hence could be removed, making a 3 wire system. It is not necessary, however, that the load be exactly balanced on a 3 wire system.

Indian Electricity Rules :

The IE Rules among other things deal with the following important points.

- 1) Preliminary definitions
- 2) Inspection of Electrical Installations
- 3) General safety precautions
- 4) General conditions relating to supply and use of energy
- 5) Electric supply lines, systems and apparatus for low and medium voltages
- 6) Electric supply lines, systems and apparatus for high and extra high voltages
- 7) Over head lines

Determination of Size of Conductor for a Distribution System:

In fore going paras, the parts of a distribution systems namely the feeder, distributor were discussed. In brief, feeders carry bulk power from secondary sub-station to distribution sub-stations, distributors carry power from distribution sub-station to service lines and service lines deliver power from suppliers nearest support to consumer's premises upto energy meter.

The lines have inherent resistances inductances and capacitances, resulting in a voltage drop in the line so sending end. The declared voltage at the consumers premises in India are 415V/240V. All appliances and motors give good performance for a long duration if this voltage is maintained. In case of large variation in the voltages (more than +6% of declared volts) appliances will get damaged or will give poor performance. There are, therefore, regulations which lay down limits to variation of voltage permissible at the consumers terminals. The question regarding the voltage drop in lines, thus, assumes importance and must be considered while designing the lines.

The main basis of the selection of the size of a distributor is the voltage drop. Obviously, the distributor must also be capable of carrying the required current without excessive temperature rise. However, it is found in practice that a distributor is of ample size if its voltage drop is within required limits.

ACSR and AAAC conductors are used for secondary distribution systems. ACSR conductors are preferred to AAC for long spans owing to their greater tensile strength. In selection of conductor size, the following should be considered.

1. Current carrying capacity
2. Tensile strength of the conductor

The size of conductor for a distributor is determined in the following manner.

The load on the distributor is known. From this, the current that the distributor has to carry is calculated. From standard tables a conductor size, capable of carrying this current at the ambient temperature of the area is calculated. The next step is to ensure that the voltage drop taking place in the conductor is within permissible limits. Thus, calculating the voltage drop in the distributors assumes significance.

Current carrying capacity of conductors :

Squirrel	7/2.11 - 115 A
Weasel	7/2.59 - 150 A
Rabbit	7/3.35 - 208 A

THE LOAD CHARACTERISTICS

Connected loads : The capacity of all electric devices (lamps, appliances, equipment etc.) that consumers can connect to their supply system. The ratings of the devices at specified voltage limits are usually contained on the name plate.

Lighting loads : Under this category comes incandescent and fluorescent lamps, neon lights and mercury vapor, sodium vapor and metal halide lights. The nominal voltage specified for lighting is 240 volts.

Power loads : Included in power loads are motors of all sizes direct current shunt, compound and series types, AC single phase and poly phase, inductor and synchronous types.

Heating loads : The heating category may be divided into residential and industrial (large) applications. Under industrial heating the electric furnaces, welding, high frequency heating, induction heating and dielectric heating can be given as examples.

Electronic loads : The electronic load category includes radio, television, X-rays, laser equipment, computers, digital time and timing devices, rectifiers, oscillators for high frequency current production and many other electronically operated devices. In general, these employ electron tubes or solid state devices such as transistors, semi conductors etc. practically all of these devices operate at voltages lower than the commercial power sources and employ transformers or other devices to obtain their specific voltages of operation. They are all affected by voltage variations.

Consumer factors : Normally an individual consumer is not apt to be using all of electrical devices that constitute his or her 'connected load', at the same time or to their full capacity. It would evidently be unnecessary to provide facilities to serve such a total possible load, and much more economical to provide only for a probable load, the load creating the demand on the distribution facilities.

Maximum demand : The actual load in use by the consumer creates a demand for electric energy that varies from hour to hour over a period of time but reaches its greatest value at some point. This may be called the consumer's instantaneous maximum demand. In practice however, the maximum demand is taken as that which is sustained over more definite period of time usually 15, 30 or 60 minutes.

Demand factor : The ratio of the maximum demand to the total connected load is called the demand factor. It is a convenient form for expressing the relation-ship between the connected types of loads and by averaging a large number of loads of each type, typical demand factors can be obtained. These values are important in determining the size of facilities to be installed for a particular; they are extremely useful in making estimates in planning new distributor systems or in expanding existing ones.

Load factor : The load factor is a characteristic related to the demand factor, expressing the ratio of the average load or demand for a period of time (say a day) to the maximum demand during that period. This provides a means of estimating particular consumers maximum demand if both their consumption and a typical load factor for their kind of load are known.

Diversity : Consumer load diversity describes the variation in the time of use, or of maximum use, of two or more connected loads. Load diversity is the difference between the sum of the maximum demands of two or more individual consumers loads and the maximum demand of the combined loads.

Diversity factor : The diversity factor is the ratio of the sum of maximum demands of each of the component loads to the maximum demand of the load as a whole. This is the most important factor in the economical planning and design of distribution facilities.

Coincidence factor : The coincident factor is the ratio of maximum coincident total demand of a group of consumers to the sum of the maximum demands of each of the consumers.

Utilization factor : The ratio of the maximum demand of a system to the rated capacity of the system is known as the utilization factor. Both the maximum demand and the rated capacity are expressed in the same units. The factor indicates the degree to which a system is being loaded during the load peak with respect to its capacity. The rated capacity of a system is usually determined by its thermal capacity, but may also be determined by voltage drop limitations, the smaller of the two determining the capacity.

Power factor : The ratio of power (in watts) to the product of voltage and current (in volt amperes) is called the power factor. It is a measure of the relation between current and voltage out of phase with each other brought about by reactance in the circuit (including the device served). Since facilities must be designed to carry the current and provide for the losses which vary as the square of the current, and for voltage drops which are approximately proportional to the current, it is necessary that current values are known. the power factor enables loads and losses designated in watts to be converted to amperes. Transformer sizes, wire and cable sizes, fuses, switch rating etc., are all based on values on values of current they must carry safely and economically.

Consumer classification : Consumers may be classified into a certain categories such as Residential, Commercial, Industrial and Agricultural. As aids in planning, load densities can be expressed in KVA per square kilometer. Further, classification may be bases on such items as dependence on electric service because of critical nature of the consumer's operations, under either normal or emergency conditions; the resultant cot is critical processes are interrupted; or sensitivity of load small voltage deviations.

Accommodation Norms

ANDHRA PRADESH ELECTRICITY BOARD
VIDYUTH SOUDHA, HYDERABAD

ABSTRACT

Buildings - Pvt. Buildings - occupied by A.P.S.E.B. offices - Fixation of rent - Modification & rationalization orders of the present system of selection and fixation of rent for the Pvt. Buildings taken on lease by the A.P.S.E.B. - orders - Issued.

General Services

B.P.(P & B - Gen) Ms.No.112

Dated 8-8-1997

Read the following :

- (1) B.P.Ms.No.688 Dt.1-7-88
- (2) G.O.Ms.No.1302 Dt.18-5-66
- (3) B.P.Ms.No.263 Dt.30-12-95
- (4) G.O.Ms.No.35 Dt.27-2-97

Proceedings:

1.0 In the reference 3rd Cited, Board has issued orders for adoption of the procedure laid down in the Andhra Pradesh Government G.O.Ms.No.1302 Dt.18-5-66 for accommodating the offices in different parts of the State and powers were delegated to the Chief Engineers and Superintending Engineers for sanction of rent with certain conditions.

2.0 In the reference 4th cited the Government of Andhra Pradesh has issued modification and rationalization orders on present system of selection and fixation of rent for the private Buildings taken on lease by Government Departments duly fixing maximum ceiling of rents to have 6 tier classification of places.

3.0 The Chief Engineer / Civil (O & M) has submitted proposals to adopt the Government Order cited (4) for approving the rents to the private buildings accommodating the Board offices.

4.0 After careful consideration, the Board has approved the proposal of Chief Engineer / Civil (O & M) to adopt the procedure laid down in G.O.Ms.No.35 Dt.27-2-97 for fixation of rents for the accommodation occupied by the Board offices from the date of issue of this B.P. for the buildings taken on rent.

5.0 The modified and rationalized system of selection and rent fixation for the private buildings taken on lease / rent by the Board is as indicated hereunder.

5.1 The 6 tire classification of places with maximum ceiling of rents are indicated against each category.

S.No.	Classification	Maximum ceiling of rent
1	2	3
a)	Corporation of Hyderabad & Secunderabad	Upto Rs.5.00 per Sft.
b)	Corporation of Vijayawada and Visakhapatnam	Upto Rs.3.50 per Sft.
c)	All other Corporations and Special Grade and Selection Grade Municipalities	Upto Rs.2.75 per Sft.
d)	All Grade Municipalities	Upto Rs.2.25 per Sft.
e)	All other Municipalities and Mandal Head Quarters	Upto Rs.1.50 per Sft.
f)	All other places	Upto Rs.1.25 per Sft.

5.2 The above amount would be payable only for net usable area which cannot be more than net carpet area plus 10% but within austerity standards.

5.3 The requirement of the building by any office is to be advertised in the District edition of local news paper like Enade etc. indicating the requirement of space as per austerity standards.

5.4 In response to the above advertisement Building owner having vacant space has to quote a specific lease rent per month they want as rent.

5.5 Committee comprising of the following members shall be constituted at the level of circle for selection of accommodation and scrutiny of rent proposals for approval.

- 1) Superintending Engineer of the circle
- 2) Senior Accounts Officer of the circle
- 3) Asst. Executive Engineer / Civil of the circle

5.6 The rent committee will check the suitability of the building starting with the lowest offer. In case the lowest offer is not suitable the second lowest offer will be inspected and evaluated for selection.

5.7 Board also delegates powers to the Chief Engineers and Superintending Engineers for sanction of rents as indicated below :

C.E.... Chief Engineer's Office, Superintending Engineer's Office

S.E....Section Office, Subdivision Office, Division office, E.R.O. office

5.8 The norms for accommodation of each type of office based in cadre strength of each office considering austerity standards, along with provision for Toilets, Record room, Stationary room, Visitors room, Meeting hall and Consumers waiting room etc. as relevant to the office are indicated below. These figures indicate the maximum limit for the area for each type of office but are to be worked out bases on actual staff strength duly considering austerity standard.

	Office Plinth area in	
	Sq.Meter	Sq.Ft.
E.R.C.	231.34	2500.00
Section	32.53	350.00
Sub-division	32.53	350.00
Division	162.64	1750.00
Circle	464.68	5000.00
Zonal	302.97	3260.00

Then norms for accommodation are to be revised as and when the offices are reorganized based on the following standards :

1)	Officers of the rank of Chief Engineer, Financial Adviser of Chief controller of Accounts....	240 Sq.ft. each
2)	Officers of the rank of superintending Engineers.....	160.00 Sq.ft. each
3)	All other officers upto the level of Assistant Divisional Engineers Assistant Accounts Officers....	120 Sq.ft. each
4)	Technical Staff...	60 Sq.ft. each
5)	Non-Technical Staff....	40 Sq.ft. each
- 5.9 If the rent fixed in accordance with the above procedure works out to an amount higher than the one which is accepted by the lesser, rental certificate should be issued for Lower amount only.
- 5.10 Before leasing the private building, it is to be ascertained whether any Board / Government building is available or not and the certificate to that effect to be recorded.
- 5.11. Plan showing the entire building along with details of the other occupancy on the site area to be recorded.
- 5.12 Rent reasonability certificate to be recorded by the committee formed for the purpose.
- 5.13 Once the building is selected within the maximum ceiling rent indicated in para 5.1 above, it can have an escalation factor at 5% for a block period of every 2 years thereafter.
- 6.0 The above order is issued in supersession of all the orders in existence on selection of private buildings and fixation of rent there on lease for the purpose of accommodation of the A.P.S.E.Board offices.

EARTHING PRACTICES AT SUB-STATIONS

INTRODUCTION

Earthing practices adopted at Generating Stations, Sub-stations, Distribution structures and lines are of great importance. It is however observed that this item is most often neglected. The codes of practice, Technical reference books, Hand books contain a chapter on this subject but they are often skipped considering them as too elementary or even as unimportant. Many reference books on this subject are referred to and such of those points which are most important are compiled in the following paragraphs. These are of importance to every practicing Engineer in charge of Substations.

IMPORTANCE OF EARTHING & PRACTICES

- ♦ The earthing is provided for
 - a) Safety of personnel
 - b) Prevent or at least minimize damage to equipment as a result of flow of heavy fault currents.
 - c) Improve reliability of Power supply.
- ♦ The earthing is broadly divided as
 - a) System earthing (Connection between part of plant in an operating system like LV neutral of a Power Transformer winding) and earth.
 - b) Equipment earthing (Safety grounding)
Connecting bodies of equipment (like motor body, Transformer tank, Switch gear box Operating rods of Air break switches, LV breaker body, HV breaker body, Feeder breaker bodies etc.) to earth.
- ♦ The system earthing and safety earthing are interconnected and therefore fault current flowing through system ground rises the potential of the safety ground and also causes step potential gradient in an around the Sub-station. But separating the two earthing systems have disadvantages like higher short circuit current, low current flows through relays and long distance to be covered to separate the two earths. After weighing the merits and demerits each case, the common practice of common and solid (direct) grounding system designed fiord effective earthing and safe potential gradients is being adopted.

- ♦ The earth resistance shall be as low as possible and shall not exceed the following limits :

Power Stations	-	0.5 ohms
EHT Stations	-	1.0 ohms
33 KV Stations	-	2.0 ohms
D/t structures	-	5.0 ohms
Tower foot resistance	-	10.0 ohms

Definition of General Earthling Terms :

- 1) **Soil Resistivity** : This is the Resistivity of a Typical sample of soil
- 2) **Earth surface voltage** : The voltage between a specified point on the ground around the rod and reference earth.
- 3) **Earth electrode** : These are conductors which are in direct contact with the soil and provide the conductive part in electrical contact with earth. They can include rods, tape, still reinforcing bars.
- 4) **Step Potential** : Step Potential is the difference in voltage between two points which are one meter apart along the earth when ground currents are flowing.
- 5) **Touch Potential** : Tower Potential is the difference in voltage between the object touched and the ground point just below the person touching the object when ground currents are flowing.

Definition of Terms associated with power systems :

- 1) **Neutral point** : The common point of star connected Poly phase system or the earthed mid-point of a single phase system.
- 2) **Independent Earth electrode** : An earth electrode located at such a distance from other electrodes that its electrical potential, is not significantly affected by electric currents between earth and other electrodes.
- 3) **Exposed conductive part** : Conductive part of equipment and which is not normally live, but which can become live when basic insulation fails.

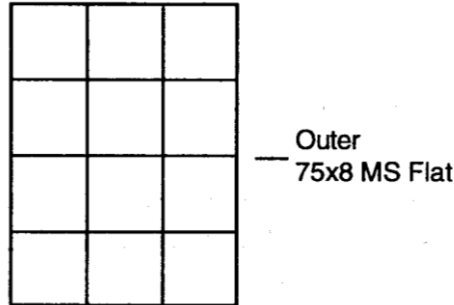
Importance of Betonies Compound :

Betonies compound reduces the earth mat resistance to 1/4 level of its original. Betonies consists of a clay which, when mixed with water swells to many times its own volume. It absorbs, moisture from the soil and can retain it for a long time. Hence it doesn't require frequent watering to earth electrodes. It is recommended that this backfill material be used to surround vertical electrodes and used to bed horizontal electrodes to improve the overall earth resistance.

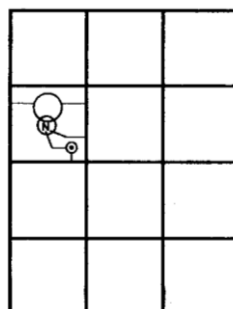
It is important to stop using coke / cinders and salt as a backfill material as it is corrosive, especially to mild steel and cast iron.

Point of searching :

- 1) Earth mat of 75 x 8 Ms flat should be laid as outer of the switch yard compulsorily and see that all the pole structures and all metallic parts are enclosed in the outer mat.
- 2) Make vertical and horizontal sections for the outer mat as shown in the figure. The internal vertical and horizontal sections may be 75 x 8 or 50 x 6 Ms. flat.

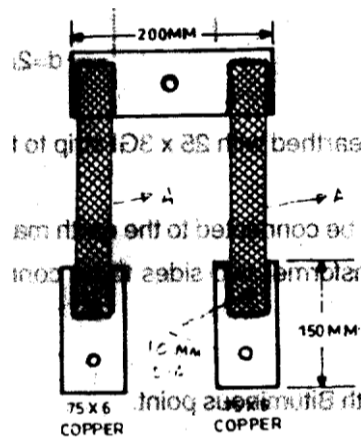


- 3) The earth mat should be laid minimum 600 mm. below the ground level under the earth mat pure betonies power is to belied upto 25 mm. and over the earth mat, the same Betonies compound with Black cotton soil a mixture of 1:6 ratio is to be placed upto 100 mm and the remaining earth trench is to be back billed with the soil. It is therefore important to ensure the earth conductor (MS flat) is laid at least 0.6 M deep, but preferably deeper, say 1M as this will reduce the surface potentials.
- 4) See that each and every pole structure is earthed with 50 x 6 Ms flat to the earth mat.
- 5) For every breaker there will be five earth connections to the earth mat with 50 x 6 MS flat. (a) breaker body (b) relay panel (c) Cuts of the breaker (d) and two sides of the breaker structure.
- 6) Lighting arrester is to be connected one end directly to the earth mat and the other end is to the nearer earth pit or to the earth mat.
- 7) Line Isolators are to be connected directly to the earth mat.
- 8) The Power Transformer body is to be connected two sides to the earth mat.
- 9) Twin neutral earthing should be done to power transformer as shown in the fig. one earth flat or size 75 x 8 mm MS flat is directly connected to the earth pit and the earth pit is again connected to the earth mat. The second neutral is directly connected to the earth mat with the support of 75 x 40 x 6mm MS channel.

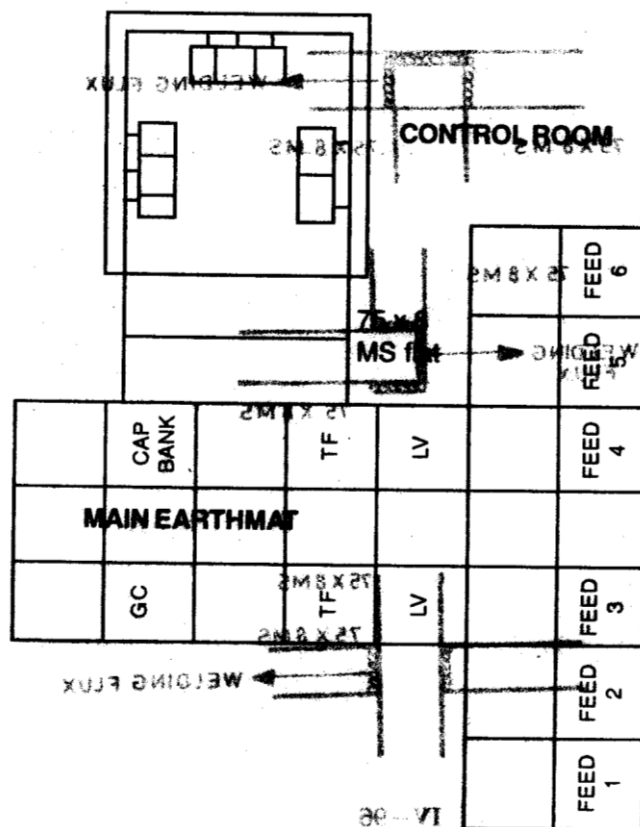


**Typical plan of
Sub station Earth Mat**

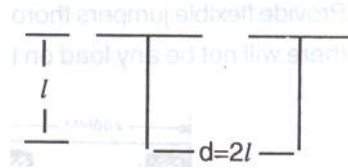
- 10) Provide flexible jumpers thoroughly brazed as shown in fig. by providing flexible jumper's there will not be any load on the transformer neutral bushing.



- 11) All AB switch operating rods are to be provided with coil earths and the AB switch support is to be earthed to the earth mat.
- 12) All the exposed earth flat which are dropping down from the breakers, CT's structures should be applied with Bituminous paint which is non corrosive.
- 13) 75 x 8 MS flat is to be laid around the control room from main switch yard earth mat and the panels of the breakers, mid point of the battery and battery stand structures are to be earthed to the earth flat and make a section in front of the control room as shown in fig.

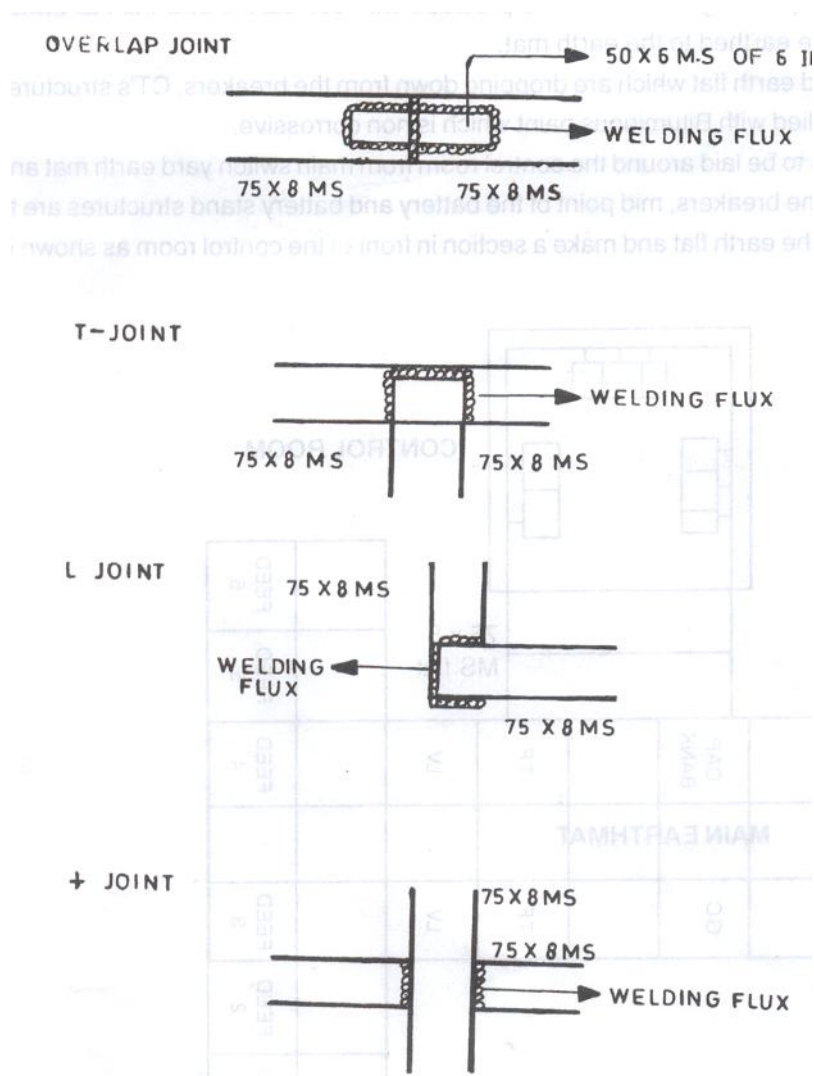


- 14) The distance between any two earth electrodes should be twice the length of the Electrode.
If 'l' is length of electrode. distance between two electrodes $d = 2 \times l$



- 15) The cable (11 x 33 KV) sheaths are to be earthed with 25 x 3GI strip to the earthmat.
- 16) The neutral of the station transformer is to be connected to the earth mat directly with 25x3GI strip. The body of the station transformer two sides to be connected to the earth mat with 25x3GI strip.
- 17) All the welding joints should be painted with Bituminous point.

Various joints in Earth mat



Specification of Earthling

Depending on soil resistivity, the earth conductor (flats) shall be buried at the following depths.

	<u>Soil Resistivity</u> <u>in ohms/metre in metres</u>	<u>Economical depth of Burial</u>
1)	50-100	0.5
2)	100 -400	1.0
3)	400 -1000	1.5

To keep the earth resistance as low as possible in order to achieve safe step and touch voltages, an earth mat shall be buried at the above depths below ground and the mat shall be provided with grounding rods at suitable points. All non-current carrying parts at the Substation shall be connected to this grid us as to ensure that under fault conditions, none of these part are at a higher potential than the grounding grid.

Plate Earths

Taking all parameters into consideration, the size of plate earths are decided as

Power Stations & EHT Station	-	Main	100 x 16mm
		Auxiliary	50 x 8mm
Small Stations	-		75 x 8mm

The complete specifications for providing earth mats at EHT & 33 KV Substations, Distribution transformers & Consumers premises are reproduced below.

Specification for Earthling system

I) EHT Substations

1. The earth mat shall be as per the approved layout. The earth mat shall be formed with the steel flats buried in the ground at a depth of 750mm on edge.
2. The earth mat shall extend over the entire switchyard as per the layout.
3. All the junctions of the steel flats while forming the earth mat and taking risers from the earth mat for giving earth connections to equipment, steel structures, conduits cable sheaths shall be pro pertly welded. All joints shall be provided with suitable angle pieces for proper contact between flats.

4. Provisions shall be made for thermal expansion of the still flats by giving smooth circular bends. Bending shall not cause any fatigue in the material at bends.
5. The earth mat shall be formed by welding 50×8 mm steel flat to the 100×16 mm peripheral earth conductor. The grounding grid shall be spaced about 5 meters i.e. in longitude and about 5 meters in the transverse directions. After the completion of earth mat, the earth resistance shall be measured. In case the earth resistance is more than one ohm the earth mat shall be extended by installing extra electrodes, so that the earth resistance is less than one ohm.
6. All fence corner posts and gate posts shall be connected to the ground by providing 32mm dia M.S. rods of 3 meter length near the posts and connected to the main grounding mat.
7. All paint enamel and scale shall be removed from surface of contact on metal surface before making ground connection.
8. The risers taken along the main switchyard structures and equipment structures (upto their top) shall be clamped to the structures at an interval of not more than one meter.
9. 50×8mm ground conductor shall be run in cable routes and shall be connected to the ground mat at an interval of 10 metres.
10. Grounding electrodes of 32mm dia 3mtr. long MS rods shall be provided at the peripheral corners of the earth mat. The grounding rods shall be driven into the ground and their tops shall be welded to a clamp and the clamp together with the grounding rods shall be welded to the ground mat.
11. Lightning arrestors shall be provided with earth pits near them for earthing.
12. Cast iron pipes 125mm in dia and 2.75 metres long and 9.5mm thick shall be buried vertically in the pits and a mixture of bentonite compound in the black cotton soil a ratio of 1:1 is to be filled 300 mm dia and the pipe for the entire depth. Where it is not possible to go to a depth of 2.75 metres, 1.3×1.3 MM plates, 25 mm thick shall be buried vertically in pits of 2 metres depth and surrounded by Bentonite mixture at least 2 metres away from any building or structure foundation. The plates shall be at least 15 metres apart. These earth pits in turn shall be connected to the earth mat.

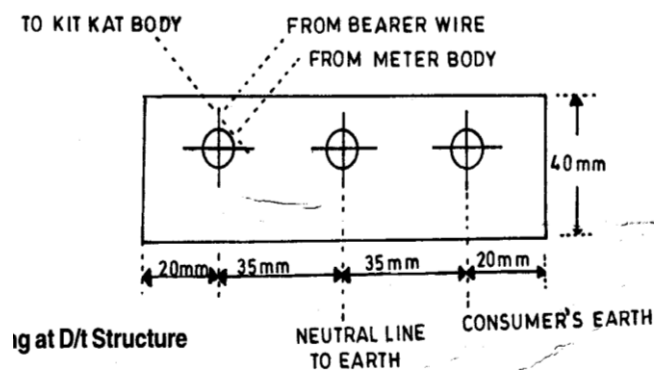
II) Earthing at 33 KV Substations :

1. Providing of earth pit and earth matting include the following connected works:
 - a) Excavation of earth pits of size 21/2ft×21/2ft×9ft in all type of soils.
 - b) Providing of CI pipe of 3 inch diameter 9ft length with flange. All connections to CI pipe shall be with GI bolts and nuts.
 - c) Filling of earth pit excavated with Bentonite with Black cotton soil (1:6) around the pipe with 1 foot radius.
 - d) Providing of cement collar of size 2ft diameter 2ft height 1 inch below the ground level.
 - e) The top of the CI earth pipe should be at the surface level of the ground.

2. Providing of matting with MS flat 75×8mm including the following connected works:
 - a) Excavation o trench in all types of soils of size 2 1/2 ft. depth and 1ft width.
 - b) Laying of M.S.Flat 75×8mm in the excavated trench.
 - c) Inter connecting all earth pits and welding properly at jointing location and junctions.
 - d) Back filling of earth complete.
(see Sketch enclosed)

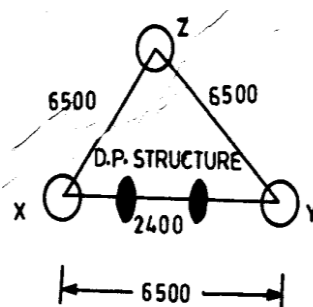
III) Earthing at Consumer's premises

The earthing at consumer's premises shall be as per sketch below using a 6mm thick plate.



IV) Earthing at D/t Structure

Three electrodes forming an equilateral triangle with minimum distance of 6500mm, so that adequate earth buffer is available. Electrode shall be 'A' grade G1 pipe of 2 inch thick and 8ft long and buries vertically so as to leave about 4 inch pipe length above ground level to fix a 'B' shaped clamp.



Note:

1. The connections to the three earth can. Electrodes should be as follows.
 - (A) To one of the earth electrodes on either side of double pole structure(X or Y)
 - (i) One direct connection from three 11 KV Lightning Arresters.
 - (ii) Another direct connection form the L.T.Lightening Arrestors if provided
 - (B) To each of the remaining two earth electrodes.
 - (i) One separate connection from neutral (on the medium voltage side) of the Transformer(Two wires)
 - (ii) One separate connection from the Transformer body and the handle of the 11 KV A.B.Switch.(Two separate body earths to tank)
 - (iii) One separate connection from the Earthling Terminal of poles.
 - (C) 4mm G.I. wire should be used for earth leads.

JOINTS

- a) There shall be minimum joints preferably no joints enroute to earth electrodes.
- b) Where joints are unavoidable, they shall be brazed, riveted or welded (and painted with red lead and aluminum paints on eater the other and finely coated with bitumen)

TOWER LINE GROUNDING

1. Ground rods are driven at the base of the tower. Where it is no feasible, an electrode is located within a distance of 200ft of the tower and grounding rods are provided at that point and tied to the tower base by a single buried wire.
2. If low resistance is not obtained watts 200ft, crow foot counterpoise with 4 wires in installed. The counterpoise conductors shall be 6SWG galvanized steel wires taken always from the tower at mutually right angles and kept at least 50ft apart. Each of these wires is terminated at a rod at the nearest point where low resistance is obtained. If counterpoise wires cannot be terminated within half span from the tower the wire is carried through a continues counterpoise to the next tower the procedure is repeated.

MEASUREMENT OF EARTH RESISTANCE

The measurement of earth resistance is made using three terminal earth muggers or four terminal earth muggers.

Three Terminal: Two temporary electrodes are spikes are driven in straight line one for current and the other voltage at a distance of 150 feet from the earth electrode under test and ohmic values of earth electrode is read in the mugger.

Four Terminal: Four spikes are driven in straight line into the ground at equal intervals. The two outer spikes are connected to current terminals of earth meter and the two inner spikes to potential terminals of the mugger. Then the earth resistance is measured by totaling the mugger till a steady value is obtained.

MAINTENANCE OF EARTHING SYSTEM

The following Maintenance schedule is mandatory at each of the substations

Sl.No.	Item	Periodicity
1.	Watering of Earth pits	(not required for Betonies treated earth pits)
2.	Measurement of earth resistance of individual earth pits	Half yearly @
3.	Measurement of combined earth resistance at all the pits	Half yearly.....
4.	Checking of inter connections between earth pits and tightness of bolts and nuts	Quarterly

@ Earth resistance of individual earth pits can be measured up by disconnecting the earth connections to the electrode. This is possible if the connections are made to a common clamp which is in turn is fixed round the pipe.

The diagram illustrates the electrical layout of a 33 KV BAY and an adjacent 11 KV BAY. The 33 KV BAY is a vertical section with three horizontal busbars. The top busbar is labeled '75 X 8 mm MS' and has three earth electrodes (11, 10, 9) above it. The middle busbar has a '33 KV. GC' (Grounding Capacitor) connected to it. The bottom busbar is also labeled '75 X 8 mm MS' and has three earth electrodes (1, 2, 3) below it. A '33 KV. PT' (Potential Transformer) is connected to the top busbar. The 11 KV BAY is a horizontal section with two vertical busbars. The left busbar is labeled '75 X 8 mm MS' and has three earth electrodes (12, 13, 14) to its left. The right busbar is also labeled '75 X 8 mm MS' and has three earth electrodes (7, 6, 5) to its right. A '11 KV. PT' is connected to the left busbar. A 'STN T/F' (Station Transformer) is connected to the right busbar. A 'CONTROL ROOM' is shown on the left, with a '11KV. PT' connected to it. The diagram includes a legend for symbols: a circle with a dot for '1 to 20 EARTH ELECTRODES', a rectangle with a line for '11 KV. & 33 KV. BREAKERS', and two overlapping circles for '33/11KV. T/F.'.

75 X 8 mm MS

33 KV. GC

75 X 8 OR 50 X 6

75 X 8 OR 50 X 6

75 X 8 mm MS

CONTROL ROOM

11KV. PT

STN T/F

33 KV. BAY

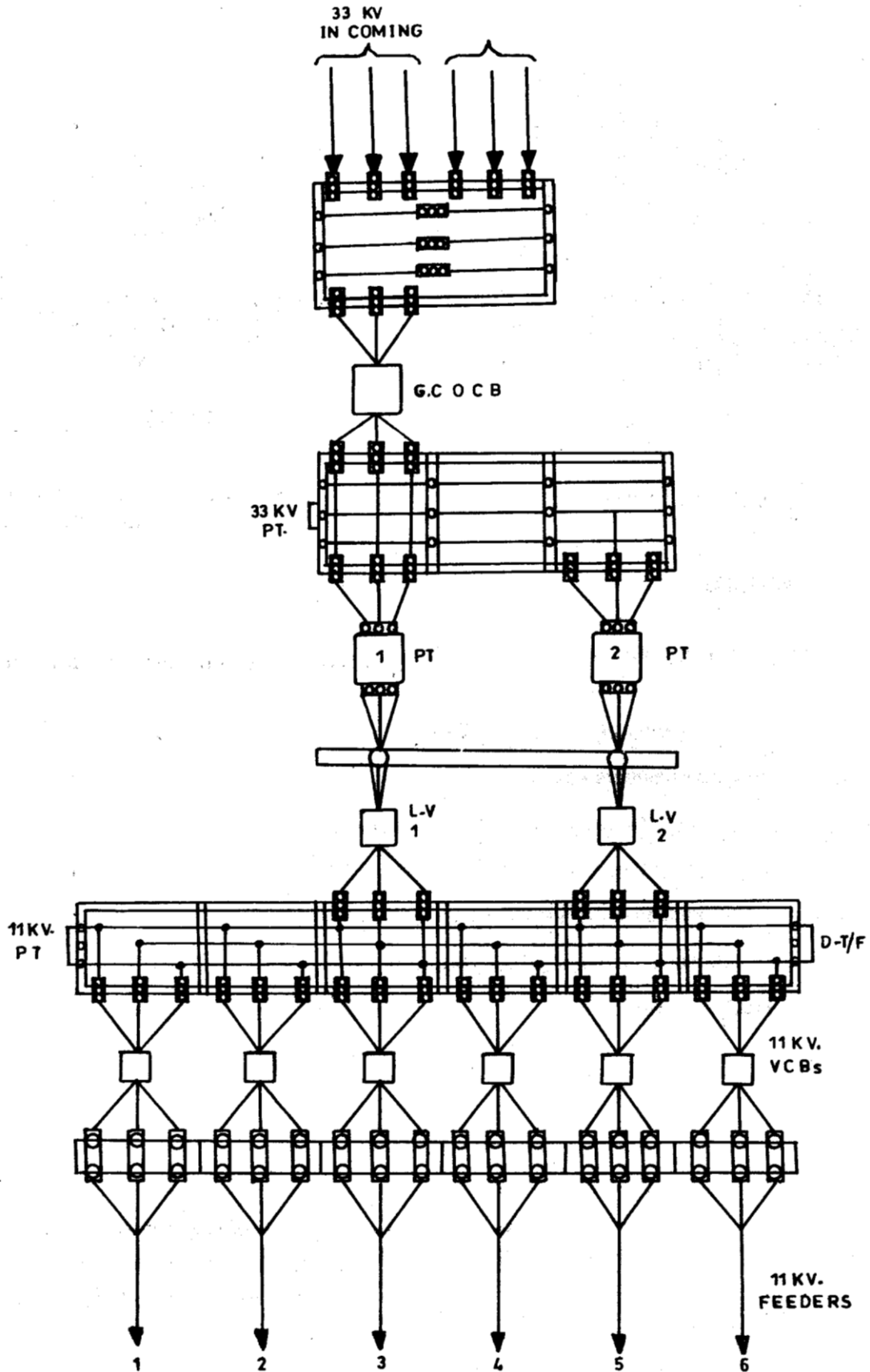
11 KV. BAY

1 to 20 EARTH ELECTRODES

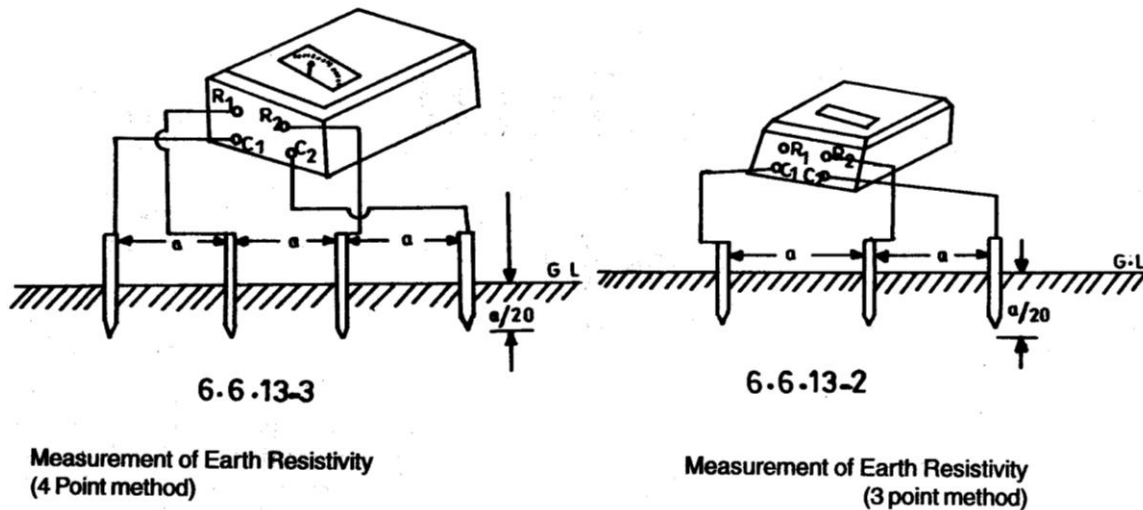
11 KV. & 33 KV. BREAKERS

33/11KV. T/F.

STRUCTURAL LAY-OUT OF OUT DOOR SS



..... Combined earth resistance shall be the same at every earth pit unless it gets disconnected from the earth mat.



CONCLUSION

The above information is collected from various sources to be of use in charge of Substations.

1. Code of Technical Instructions - TNEB
2. APSEB Engineers Association Hand book
3. Power Sub-Transmission & Distribution systems
Prevailing practices in India CBI & P Publication No. 198
4. Engg. graduate's Training Centre course materials on
Distribution (Chapter of Sri N.Krishna murthy)
5. REC Standards

DISTRIBUTION LINES - CONSTRUCTION

Introduction:

Before construction of any new sub-transmission and distribution lines is taken up we should acquaint ourselves with Indian Electricity Rules. 1956 is amended from time to time. As per Rule No.29, all electric lines and apparatus shall be sufficient in power and size and of sufficient mechanical strength for the work they may be required to do, and shall be constructed, installed, protected, worked and maintained in such a manner as to prevent danger.

Sub-transmission and Distribution Line Voltages:

REC has standardized the following voltages

(1)	240 - 415 Volts	..	Low and Medium Voltages
(2)	11,000 Volts	..	Primary Feeders
(3)	33,000 Volts	..	Sub-transmission Lines

Survey of Lines:

In order to determine the route along which the line is to be laid, it becomes necessary to survey the area. The survey of the line should be carried out accurately. The proposed route of the line should be the shortest practicable distance. The first thing to do is to select the route and plot it on a map. The second step is to conduct a walk over survey to determine the topography of the area and any obstacles likely to come across. This is followed by a detailed survey from which the quantity of material required for the construction of line is determined.

Choice of Route:

The proposed route shall be of the shortest practicable distance. However, attention should be kept on the possibility of taking the line as close as possible to the roads for easy maintenance and approach during emergency. The following areas should be avoided as far as possible.

- a) Rough and difficult countryside
- b) Urban development area
- c) Restricted access for transport vehicles
- d) Abrupt changes in the line route
- e) Difficult crossing
- f) Proximity to aerodromes
- g) Natural hazards

Survey for Low and Medium Voltage Lines:

The low and medium voltage lines are directly tapped for consumer services in towns, cities and villages. As such they are confined they are confined within the limits of the towns and cities and within small distances say 2 to 3 KM. in rural areas.

The Steps in survey work are

1. In case of agricultural load, to locate the position of consumers and mark the route of the distribution line.
2. In case of village to mark the position of the distribution line along the lanes of the villages.
3. In case of cities and towns, to mark the position of the distribution lines along the streets.

After marking the route of the line on the map as discussed above, the lines and poles are plotted to scale on the map by carrying out the walk over survey of the route. i.e., the survey party actually walks along the route of the line marked on the map and finalizes the position of the poles by making physical measurements using survey charts or tapes.

Lines in Rural Areas:

For conducting a survey of distribution lines in villages, a scaled map of the village is taken and following are marked on he map.

1. The nearest HT lines from which the tapping will be taken for the distribution transformer.
2. The location of distribution transformer after taking into consideration the distribution of load.
3. The layout of the LT lines network with locations of angle poles and road crossings.

Lines in Urban Areas:

The power lines should be plotted on the map of city or town after a consultation with the municipal authorities.

The following should be taken into consideration.

1. Road crossings
2. Private lands
3. Railway track crossings
4. Telephone line crossings
5. Crossing over buildings

Agricultural Field Area:

While surveying for laying power lines for agricultural loads it should be borne in mind that the transformer should be at the load center; so as to reduce the length of LT lines and consequently voltage drop.

Survey for HT Lines (11 & 33 KV)

The survey of HT lines is done in two stages viz. (a) preliminary survey and (b) detailed survey. The steps to be followed for the preliminary survey of the outer of HT lines is the same as described for the LT distribution lines. Having marked the position of the line on the map, on the basis of the walk over survey, a detailed survey is carried out to mark the exact position of the poles.

Right of Way:

Before taking up the erection of lines both HT/LT along the roads the concerned authorities should be contacted and approval obtained for location of all poles, crossings, tree cuttings, or trimming and guy locations. In some cases, it may be necessary also to contact local town planning authorities for approval if the lines are to be drawn in the urban areas.

Tree Clearances:

The width of the tree clearance will depend upon the voltage and the importance of the line. According to the prevailing practice in some State Electricity Boards the following clearances may be adhered to as far as possible.

Voltage of Line Relaxation		Tree Clearance Required	
1.	Low & Medium Voltages 240 & 415 Volts	Left to the discretion of the field staff	Nil
2.	11 KV (Normal)	All growth within 4.572 m (15 Ft) on either side the center line of the support and all trees which may fall & foul the lines	In case of betel leaf garden all growth within 3.048 Mt (10 ft) on either side of the line
3.	11 KV/33 KV Trunk Lines	All growth within 6.096 mt. (20 ft) from the center line of support and all trees which may fall and foul the lines	Nil

Railway & Road Crossings:

The railway and road crossings should be as minimum as possible. The crossings of the railway line should be done beyond the outer signal of the nearest railway station and the structures and clearances above the railway track should conform to the latest railway regulations in this regard.

Crossing of Telecommunication Line by Power Lines:

Approval of state level PTCC may be obtained before taking up the construction work.

Construction, Testing and Commissioning of 11 KV & LT Lines

Construction of 11 KV & LT overhead lines may be divided into the following parts

1. Erection of supports
2. Providing guys to supports
3. Mounting cross arms, pins and insulators
4. Stringing line conductor
5. Jointing of conductors
6. Sagging and tensioning of conductors
7. Earthling
8. Testing and commissioning

REC has standardized the following sizes and types of supports for 11 KV and LT lines.

Type	Length	Voltage	Max. Span (Mts)	Type of	With or without earth wire
PSCC	8.0 Mt.	11 KV	107	-do-	Without earthwire
PSCC	8.0 Mt.	415/240 V	67	Vertical	-do-

Alignment of the Line:

A detailed route survey for the line has to be made and alignment of the line should be done before excavation of pits are started.

Erection of Supports:

After the final survey of the line and after marking of the pole locations with per excavation works has to be commenced. Excavation is generally done by pickaxes, crowbar and although sometimes earth augers are used. Excavation of pole pits in very hard rock or rocky soil or in rock beds may involve blasting of rocks. The pits of the supports are excavated in the depression of the line as this will facilitate the erection of supports in addition to giving lateral stability. The depth of the foundation to be vacated for poles shall be 1500 mm.

After the excavation of pits is completed, the supports/poles to be erected may be brought to the pits location by manual labour. Then the pole may be erected inside the pit. For erection of support we may use either X-shaped structure made of two wooden cross arms or Bipod. Before the pole is put into the pit, suitable base plate may be given below the pole to increase the surface contact between the pole and soil. The padding will distribute the density of the pressure due to weight of the pole on the soil.

Having lifted the pole, the same should be kept in a vertical position with the help of manila rope of 20/25 mm dia using the rope as temporary anchor.

As the poles are being erected, say from one angle point to next angle point, the alignment of the poles are to be checked and set right by visual check. The verticalities of the poles are to be checked with a spirit level on both transverse and longitudinal directions.

Having satisfied that the verticalities and alignment are all-right, earth filling is to be done.

In swampy and special locations, however before earth filling, the poles are to be concerted upto the ground level of the pit.

After the poles have been set, the temporary anchors are to be removed.

Erection of Double Structure for Angle Locations:

For angles of deviations more than 10° , double pole structures may be erected. The poles are to be excavated along the bisection of the angle of deviation. The concreting of the poles may be done with cement, granite chips of size 20/30 mm and sand in the ratio of 1:3:6. Before lifting the pole in the pit, concrete padding of not less than 75 mm thickness may be put for the distribution of the load of the support on the soil.

After the concreting is done, the pit may be filled with earth after the curing of the concrete is completed.

Stays are to be provided fiord the support with 7/3.15 mm or 7/2.5 mm GI stay wire and 16mm stay rods.

Four stays along the line, two in each direction and two stays along the bisection of the angle of deviation, or as required depending on the angle of deviation are to be provided. Stay concreting may be done with 1:3:6 concrete mixture.

Special care has to be taken where black cotton soil is encountered.

In such locations, mass concrete foundations are to be adopted to avoid collapse of foundations in black cotton soil

Anchoring and Providing Guys for supports:

Normally the guys are provided to the supports at the following places:

1. Angle locations
2. Dead end locations
3. Tee-off points
4. Steep gradients locations to avoid uplift on the pole

Sometimes storm guys are provide along the straight run at equal intervals where wind pressure is more than 50 Kg/M²

The installation of guy will involve the following works.

1. Excavation of pit and fixing of stay rod
2. Fastening of guy wire to the support
3. Tightening guy wire and fastening to the anchor

The marketing of the guy pit for excavation, the excavation of pits and setting of the anchor rod must be carefully carried out. The stay rod should be placed in a position such that the angle of inclination of the rod with the vertical face of the pit is 35⁰/50⁰ as the case may be. The concreting of the stays at the bottom should then be carried out. The back filling and ramming must be well done thereafter and allowed to set for at least 7 days. The free end of the guy wire is passed through the eyes of the anchor rod, bent back parallel to the main portion of the guy and bound after inserting the GI thimble. The loop is projected by the GI thimble where it bears on the anchor rod where the existence of the guy wire proves hazardous, it should be protected with a suitable asbestos pipe, fitted with concrete about 2 Mt. length above the ground level, duly painted with white and black stripes so that it may be visible at night. The turn buckle shall be mounted at the pole end of the stay and guy wire so fixed that the turn buckle is half way in the working position, thus giving the maximum movement for tightening or lessening.

Guy insulators are placed to prevent the lower part of the guy from becoming electrically energized by a contact of the upper part of the guy when the conductor snaps and fall on them or due to leakage. Guy insulator shall be located at 2/3 of its length from the ground. The minimum breaking load of guy insulator shall be 9900 Kg. for 11 KV and 4000 Kg. for LT lines.

Fixing of cross Arms and Insulators:

After the erection of supports and providing guys, the next step would be to mount the cross arms on the support. The practice of fixing of cross arm before the pole is erected is followed in some states. In case the cross arm is mounted after the support is erected, the lineman should climb the support having requisite tools with him. The cross arm is then tied to a hand line and pulled up by the ground man through a pull till the cross arm reaches the lineman. The ground man should station himself well to one side so that if any material drops from the top of the pole it may not strike him. All the materials required should be lifted or lowered by means of the hand line. In no case the material or the tools should be dropped or thrown from the pole top.

Insulators :

The pin insulators are fixed in the holes provided in the cross arms and the pole top brackets. The insulators are mounted in their places over the pins and tightened. In the case of strand or angle supports, where strain fittings is placed over the cross arm. The nut of the straps is so tightened that the strap can move freely in horizontal directions; as this is necessary to fix the strain insulator.

Stringing of the Line Conductor:

REC has standardized the following sizes of conductors for 33 KV, 11 KV and LT lines.

Voltage Class		No. and Diameter of Wire	Type of Conductor
33 LV lines	i)	7/3.35 mm (50 mm ²)	ACSR (AAAC)
	ii)	7/4.09 mm (80 mm ²)	ACSR (")
	iii)	6/4.72 mm + 7/1.57 mm (100 mm ²)	ACSR (")
11 KV lines	i)	7/2.11 mm (20 mm ²)	ACSR (")
	ii)	7/2.59 mm (30 mm ²)	ACSR (")
	iii)	7/3.35 mm (50 mm ²)	ACSR (")
LT lines	i)	7/2.11 mm (20 mm ²)	ACSR (")
	ii)	7/2.59 mm (30 mm ²)	ACSR (")
	iii)	7/3.35 mm (50 mm ²)	ACSR (")
	iv)	7/2.21 mm (25 mm ²)	AAC (")
	v)	7/3.10 mm (50 mm ²)	AAC (")

Conductor Erection:

The erection of overhead line conductor is very important phase in construction.

The erection of conductor can be divided into 4 parts.

1. Transport of conductors to work site
2. Paving and stringing of conductors
3. Tensioning and sagging of conductors and
4. Jointing of conductors

At important crossings of roads, canals, navigable rivers, railways etc., flagmen should be in attendance to ensure that normal services are not unduly interrupted. These crossings should only be carried out in conjunction with the approval of the proper authorities concerned.

Having transported the conductor drum to the tension point, the drum should either be mounted on the cable drum supports or jacks or hung by means of chain pulley of suitable capacity suspended from a tripod. The conductor should be passed over the pole on wooden or aluminum snatched pull blocks provided with low friction bearings. The conductor shall be raised to a minimum height of 5 mt. above ground by rough sagging.

The mid span joints of conductors can be carried out by twisting joint or compression joints. The twisting joints for aluminum conductors and ACSR consist of relatively thin walled aluminum sleeves, the end of the wire should project a few centimeters beyond the end of the sleeves. The projected wires are given a sharp bang to keep them from slipping out of the sleeve. Twisting Tongues are preferable to be used for joints and jumpers.

Sagging and Tensioning:

On completion of the paving of conductors and making mid span joints if any, tensioning operation will commence temporary guys will have to be provided for both anchoring supports. At the tensioning end one of the conductors is pulled manually upto a certain point and then come-along clamp is fixed to the conductor to be tensioned. The grip of the come along clamp is attached to double sheave pull block or the pull lift (TIRFOR) machine and gradually tensioned.

The conductor should then be sagged in accordance with the sag temperature chart for a particular conductor and span. The sag should then be adjusted in the middle span of the section.

The stretch of the conductor has to be taken out before stringing in order to avoid the gradual increasing due to setting down of the individual wires. There are two ways of accomplishing this

1. Prestressing
2. Over tensioning

1. Pretressing: In this method, the conductor is pulled upto a tension considerably above the correct figure, but never exceeding fifty percent of breaking load for a short period of say 20 minutes. As this method requires more time and involves the use of stronger tackle to secure high tension, the other method of over-tensioning is commonly adopted.

2. Over-tensioning: The method consists of pulling up the conductor to a tension a little above the theoretical tension for the prevailing, temperature and fixed it up at that tension with a correspondingly reduced sag. After a certain time the conductor will settle down to the correct sag and tension. A tension of 5% to 8% more than the theoretical value has been found to be suitable for the sizes of ACSR and AAC conductors. The ambient temperature during the sagging may recorded correctly.

Conductors can be sagged correctly only when the tension is the same in each span throughout the entire length of the section. Use of snatch blocks reduces the friction and chances of inequality of tension in various spans.

Sagging can be accomplished by several different methods, but most commonly used method for the 11 KV line is "SIGHTING" by use of targets placed on the supports below the cross arms. The targets may be light strip of wood clamped to the pole at a distance equal to the sag below the conductor when the conductor is placed in snatch blocks. The lineman sees the sag from the next pole. The tension of the conductor is then reduced or increased; until the lowest part of the conductor in the span coincides with the lineman's line of sight.

When sagging is completed, the tension clamps shall be fixed. The clamps can be fitted on the conductor without realizing the tension. A mark is made on the conductor at a distance from the cross arm equal to the length of complete strain insulators. Before the insulator set is raised to position all nuts should be free. A come along clamp is placed on the conductor beyond the conductor clamp and attached to the pulling unit. The conductor is pulled in sufficiently to allow the insulator assembly to be fitted tot he clamp. After the conductor is clamped to the insulator assembly unit may be released gradually. After the stringing is completed, all poles, cross arms, insulators, fittings etc. are checked up to ensure that there have been no deformities.

The next step is to place the conductor on the top of the pin insulator from the snatch block and removing snatch blocks. Conductors are then fastened to insulator by the use of aluminum wires.

Before teeing the conductor to the insulator, two layers of aluminum taps should be wrapped over the conductor in the portion where it touches the insulator.

Normally is straight lines the conductors are run on the top of the insulators. When there is a small angle of deviation the conductor is placed inside groove and banded.

Earthing of Distribution Lines:

1. Metal Supports - All metallic supports shall be earthed.
2. RSC/PCC poles - The metal cross arms and insulator pins shall be bonded together and earthed at every pole for HT lines and at every 5th pole at for LT lines.
3. All special structure on which switches transformers, fuses etc. are mounted should be earthed.
4. The supports on either side of a road railway or river crossing span should be earthed.
5. All supports (metal, PSCC) of both HT & LT lines passing through inhabited areas; road crossings and along such other places, where earthing of all poles is considered desirable from safety considerations should be earthed.

In special locations, railways, telegraph line crossings, special structures etc. pipe/rod type earthing should be done.

In other locations, coil earthing may be done.

The earth resistance should be allow as possible and should not exceed 10 Ohms.

Ant climbing Devices:

In order to prevent unauthorized persons from climbing and of the supports of HT and LT lines suitable ant climbing devices should be provided to the supports (such as barbed wires)

Testing and Commissioning:

When the line is ready for exercitation, it should be completely inspected, and after visual inspection, the conductor is tested for continuity / ground by means of a mugger. At the time of testing through mugger, no person should climb on the pole or touch the conductor, guarding or guy wire etc.

Before charging any new line, it should be ensured that the required inspection fees for the new line is paid to the Electrical Inspector and approval obtained from him for changing the line.

The line should be energized before the officer who has been authorized by the Board in this regard.

Before energizing any new line, the officer in charge shall notify to the workmen that the line is being energized and that it will be no longer safe to work on line. Acknowledgement of all workmen in writing should be taken in token of having intimated them.

Vide publicity should be arranged in all the localities through which the line (to be energized) passes intimating the time and date of energizing.

The officer-in-charge of the line shall personally satisfy himself that the same is in fit state to be energized.

Pole Schedule of Overhead Lines (Bill of Material)

Before the construction of 11 KV line and LT liens is taken up, the Asst. Engineer is required to prepare a detailed list of material for completion of the job.

Bill of material of 1 KM of the 11 KV line and 1 KM of LT line are given below as a guide.

Bill of Material for 1 KM of 11 KV Line (100 Mt.Span)

Sl.No.	Description of Material	Quantity
1.	PSCC Poles (8 Mt. Long)	11 Nos.
2.	ACSR 20 mm ² size	3.1 KM
3.	11 KV Pin insulator with pins	27 Nos.
4.	11 KV Disc insulators with pins	6 Nos.
5.	11 KV Strain insulators with hardware	6 Nos.
6.	Jointing services for ACSR	3 Nos.
7.	PG Clamps for 20 Sq.mm ACSR conductor	6 Nos
8.	Danger plates	11 Nos
9.	Earthling sets	3 Nos.
10.	Guy sets (HT)	6 Nos.
11.	GI wire 7/8 SWG	40 Kgs.
12.	M.S. Flat 50 x 10 mm	40 Kgs.
13.	M.S. Channel 75 x 40 x 6 mm	140 Kgs.
14.	Binding Wire for HT	1 Kg.

15.	Binding Tape for HT	1 Kg.
16.	GI Wire 8 SWG	13 Kg.
17.	Nuts & Bolts of required sizes	25 Kg.
18.	Barbed Wire	22 Kg.
19.	Aluminum paint	2 Lts.
20.	Cross arms one for each pole	11 Nos.
21.	Top jumpers for intermediate poles	9 Nos.

**Bill of Materials for 1 KM LT Lines 3 Phase
(Span 53 m approx)**

Sl.No.	Description of Materials	Quantity
1.	PSCC Poles 8 (Mts. long)	20 Nos.
2.	ACSR Conductor 30 mm ² Al.	3.15 Km.
3.	ACSR Conductor	1.05 Km.
4.	LT Shackle insulator with hardware	80 Nos.
5.	Jointing services	6 Nos.
6.	PG Clamps	6 Nos.
7.	Earthling set, LT	5 Sets
8.	Complete guy set	8 Sets
9.	Guy wire 7/10 SWG	40 Kg.
10.	M.S.Flat 50 x 60 mm	35 Kg.
11.	Al. Flat 50 x 60 mm	2 Kg.
12.	Al. Binding wire	2 Kg.
13.	GI Wire 8 SWG	12 Kg.
14.	Nuts & Bolts of required sizes	40 Kgs.
15.	Aluminum paint	2 Lts.

**OVER HEAD LINES – CROSSINGS – RAILWAYS / RIVERS / P & T LINES/
ROADS – REGULATIONS**

Railway Crossings:

Before commencing work on any crossing, approval of the Railway and the Electrical Inspector in writing shall be obtained for the proposed location and detailed design of the crossing. For this purpose, data, design and drawings relating to the crossing shall be submitted in duplicate by the owner to the Railway and the Electrical Inspector.

Classification of Crossings : For the purpose of these regulations, electric over head lines crossings are classified in accordance with the clearances required under the following categories.

- 1) Category „A" : Tracks electrified on 1500 volts DC system in the Bombay area.
 - 2) Category „B" : Tracks already electrified or likely to be converted to or electrified on 25 KV AC system within the foreseeable future.
 - 3) Category „C" : Tracks not likely to be electrified in the foreseeable future.
2. The crossings shall be constructed in accordance with the approved design and drawings; with good materials and workmanship.
 3. The owner shall notify his intention to bring the crossing into use at least 15 days in advance to railways.
 4. A certificate shall be submitted to the Railways indicating that the works have been constructed in full compliance with the regulations and in conformity with design / drawings approved by the Railways.
 5. Methods of Crossings, overhead or under-ground:
 - a) For tracks already electrified or to be electrified in the foreseeable future (Categories A & B) – all low and medium voltage crossings (upto 650V) shall be by means of under ground cables, for high voltage crossings above 650V upto 11 KV, the use of under ground cable is recommended. For high voltages crossings may be overhead or underground as preferred by the owner.
 - b) For non-electrified tracks, (Category C), the crossing may be either over head or under ground as preferred by the owner. For low and medium voltage (upto 650V) under-ground crossings are recommended.

6. No work involving removal, alteration or maintenance of any crossings shall be under taken without obtaining the consent in writing from Railways.
7. Each installation shall be inspected by the owner periodically to determine its fitness for service. Defects noticed or pointed out by the Railways shall be rectified by the owner as soon as possible. The crossing shall be maintained so as to reduce hazards to life and property.
8. The crossing spans and two adjoining spans shall be kept free by the owner as far as practicable from over hangings, or decayed trees which might fall on the spans.
9. If steel poles or fabricated steel structures are not galvanized, they shall be painted periodically.
10. Earthling arrangement shall be inspected and tested annually. Where earth resistance is higher than 10 Ohm, the owner shall take necessary steps to improve the earth resistance. (i.e. lowering the values to within the limits)
11. If shifting, or modifications to, or dismantling of the crossings are required for the proper functioning of Railway, such works shall be carried out by the owner expeditiously and to the satisfaction of Railways.

“The cost of such works shall be borne by the Railways except in those works where the need for such works on account of Railways anticipated developments was foreseen and the owner had agreed in writing prior to the construction of the crossing to meet the cost of such works”.

12. Normally an over head crossing shall be effected at right angles to the railway track and a deviation to the extent of 30° may be permitted.

13. **Structures :**

- i) The minimum distance of the supporting structures for the crossing span from the center of the nearest Railway track shall normally be the height of the structure above ground level plus 3 meters.
- ii) Steel poles, fabricated steel structures, or reinforced, or pre stressed concrete poles either of the self supporting or guyed type conforming to the latest IE Rules shall be used on either side of the track at the crossing span steel structures shall preferably be galvanized.
- iii) The crossing span shall not be more than 80% of the normal span for which the structures are designed.
- iv) **Wind pressure :** Maximum wind pressure on the structure shall be determined from the recommended maximum wind pressure for the area.
- v) **Temperature :** The maximum and minimum temperature for the conductors and the ground wires shall be $130^{\circ}\text{ F} - 50^{\circ}\text{ F}$.

14. The factor of safety of all conductors, guards, guys and ground wire in the crossing shall be in accordance with IE Rules 1956.
15. No conductor in the crossing span having a breaking strength less than 560 Kgs. Shall be used.
16. All Guard Wires shall be of galvanized steel of not less than 6 SWG for bearer wires and 10 SWG for cross wires.
17. All guy wires shall be galvanized steel and shall not be less than 7.41 SWG.
18. No jointing shall be permitted in the crossing span.
19. Minimum clearance between the over head lines and Railway Tracks:
 - i) Crossing over tracks already electrified shall normally be located at mid spans of the over head traction conductors, but in any case shall not be less than 6 meters from the nearest traction mast.
 - ii) The minimum height above rail level of the lowest portion of any conductor under conditions of maximum sag shall be as follows.
 - i) For category A & C

Voltage	Broad gauge		Metro / Narrow gauge	
	Inside station limits	Outside station limits	Inside station limits	Outside station limits
Upto and Including 11 KV	10.0 m	7.6 m	8.6 m	6.3 m
Above 11 KV Including 33 KV	10.0 m	7.6 m	8.8 m	6.4 m

Note ; Low and Medium voltage (upto 650V) crossing of category A only will be obligatory by means of underground cables. (m – meter)

ii) For Category B:

Voltage	For Broad, Meter and Narrow gauges	
	Inside Station limits	Outside station limits
Upto 650 Volts	Only by Cable	Only by Cable
Above 650 Volts Upto 33 Kava	12.5 m	10.5 m

Note : If the crossing is located on a meter gauge or a narrow gauge section, likely to be converted to broad gauge; clearance applicable to broad gauge shall be adopted.

20. Minimum clearance between conductors and any Railway Structure:

The minimum vertical and horizontal clearances between any conductors and any Railway buildings and structure other than traction supports and over head equipment under the most adverse conditions shall be in accordance with Rule 80 of IE Rules, 1956.

21. Minimum clearance between owners and Railway conductor:

The minimum clearance between any of the owners conductor or guard wires and the railway conductor shall not be less than 2 metres.

22. Insulators:

Categories A & B: Double set of strain insulator strings shall be used in the crossing span in conjunction with a yoke plate where necessary. It is recommended that each string of such strain insulator shall have one insulator disc – more that used in normal span of the over head line.

Category „C”: Strain insulators, suspension insulators or pin insulators may used as required.

Guarding: The minimum height above the rail level to the lowest level of any cradle guard and guard wires under conditions of maximum sag shall be as follows:

Category „A & B”: The same clearances as given in clause 19(1) shall apply.

Category „C”: The minimum height of 6.9 m shall apply for broad gauge and 6.1, for meter and narrow gauges.

23. The minimum height between any guard wire and live crossing conductor under the most adverse conditions shall not be less than 1.5 mts.

24. Anti climbing devices and warning notices:

Where the voltage exceeds 650V, the supporting structures on railway land shall be provided with approved anti climbing devices and warning notices shall be erected at appropriate locations.

25. Protection from Moving Road Vehicles:

Supporting structures including guys, adjacent to road ways shall be so located that the danger of being struck by moving road vehicles is avoided or reduced to the minimum. Wherever required guard rails, suitable painted to make them conspicuous shall be provided for the purpose.

Earthing : All supporting structures, guarding and guy wires of the crossing span shall be efficiently earthed. A separate earth shall be provided at each supporting structure.

B. RIVER CROSSINGS:

For the rivers on which the crossing is to be done, the dates of high flood level of at least the previous 20 years is to be obtained from the revenue authorities and the structures are to be erected so that in rainy season also they will be approachable under the flooded conditions of the river. In case of navigable rivers, the structures should be so designed as to give sufficient clearance between the lowest conductor and the highest flood level. Consultation with Navigation authorities is necessary. In case of non-navigable rivers, the structures should be designed in such a way that the lowest conductor should be 3 mts above the maximum flood level. This is necessary because flood water may carry trees and their branches.

C. CROSSINGS OVER TELEGRAPH OR TELEPHONE LINES AND P.T.C.C.

Communication circuits coming under the influence of electric field of high voltage power lines experience extraneous induction which may introduce noise in communication equipment and cause danger to the equipment and persons handling them.

Therefore, it is very essential that whenever power lines and communication lines pass close to each other suitable measures are taken. Approval of PTCC (Power Tele-communications Co-ordination Committee) may be obtained.

Further, while crossing the telecom lines, the following points may be observed.

- 1) The power lines cross over the telecom lines because the Sag of power line conductors is generally greater than telecom line conductors.
- 2) The angle of crossing shall be as far as possible 90° , but shall not be less than 60° .
- 3) A safe clearance between the communication lines and overhead power lines has to be maintained in accordance with the PTCC code of practice.
- 4) Power contact protectors are to be installed on all conductors of telecom lines at crossings with HV power lines.
- 5) The telecom lines shall be erected close to the support of the OH power lines for increased clearances.

D. ROAD CROSSINGS:

The ground clearance of the guard wire and strength of the supports on either side of the road have to be considered in installing a cradle guard at the road crossings. The supports on either side of the road on which the cradle guard terminates are earthed separately and the line should not cross at an angle less than 80° . The safe minimum distances between support of OH lines and road have to be kept in view while planning road crossing.

The clearances above ground level of the lowest conductor shall be in accordance with Rule No. 77 of IE Rules 1956.

(ELECTRICAL ACCIDENTS) (SEE RULE – 44)

1. Date and time of Accident
2. Place of Accident & District
3. System and voltage of supply
4. Name of the licenses or person/
persons or supplier or user of
energy in whose premises or
jurisdiction the accident occurred
5.
 - a)
 - i) Name of person
 - ii) Animal (please specify the
name and address of the
owner)
 - iii) Names of persons killed or
injured.
 - b) Address of such / each person:
6. Occupation & Designation of such person/
persons and in particular whether employed
in electrical works or else where.
7. Brief description of the job undertaken,
if any
8. Authority under which such person/persons
was / were allowed to work on the job

State also whether he/they was/were
authorized person/persons.
9. Described fully nature and extent of
injuries, e.q. fatal, disablement of any
portion of body or other injury etc.
10. Detailed causes leading to the accident.
11. Action taken regarding First Aid Medical
attendance etc. Immediately attn. The
occurrence of the accident.

12. Whether appropriate Government, Dist. Magistration and Police Station informed (if so give the address)
13. Name and designation of the persons assisting the persons killed or injured.
14. What safety equipment were given to & used by the persons/s who met with this accident (e.g. rubber gloves rubber mate, safety belts and ladder etc.)
15. Whether isolating switches and other sectionalizing devices were employed to dead on the sections for working on the same if so whether these were earthier
16. Whether the work on live lines was undertaken under the direct supervision of authorized person. If so, the name and designation of the person under whose supervision the person under whose supervision the work was being carried out.
17. Whether artificial resuscitation treatment was given to the person who met with electric accident. If yes, for how long was it continued before is abandonment.
18. Steps proposed to be taken to avoid recurrence.
19. Names and designations of persons present at the time of accident.

TRANSFORMERS

1.01 INTRODUCTION :

In the following notes the construction, operation, maintenance and causes of failure of transformers are explained briefly. Specific stress is made on what is likely to happen if a particular item of maintenance is not done in time.

The power generated at various power stations is stepped up and transmitted on extra high tension lines of 132 KV or 220 KV. The voltage is again stepped down to 33 KV or 1 KV at various distribution transformers where voltage is stepped down to 440/400 V before supply is made available at Consumer's installations. It is roughly estimated that the power generated is transformed 3 or 4 times before it reaches a consumer's system is 10-12 times its generating capacity in a capacities have to be provided at various stages. In the distribution net work a transformer is the most common of all electrical equipment.

1.02 THE MAIN FEATURE OF A DISTRIBUTION TRANSFORMER ARE:

1. Magnetic Circuits : Comprising core limbs, Yokes & Clamp & structure
2. Electric Circuits : The primary and secondary winding, insulation & bracing devices.
3. Terminals : Tapings, tap switch, insulators i.e., Bushings & Leads.
4. Tank, Oil, cooling devices, conservator, breather and ancillary apparatus.

1.03 CONSTRUCTION FEATURES:

A) CORE:

Special alloy steel of high resistance and low hysteresis losses is used on laminated form. The laminations are insulated between one another. The laminations are enameled or sprayed (after punching) with a mixture of flour chalk and water and then baked. No burns are allowed as they establish contact between adjacent plates. In building the core high pressure is used to minimize air gaps between plates to avoid losses and also to minimize noise during operation.

The core plates are fixed by clamping devices. The core bolts are insulated. The present trend is to utilize CRGO steel laminated cores.

B) H.V. & L.V. WINDINGS:

The L.V. and H.V. windings are generally circular and concentrically arranged. When a transformer is opened the H.V. coils are seen first. When the H.V. coils are lifted the L.V. coils are seen. A typical picture is given below:

The L.V. Coil is normally of copper strip insulated by Manila paper. In between the L.V. coils and H.V. coils places concentrically : A separator is used made of Leatherwood paper on a bakelite cylinder. The H.V. coils are normally of double paper covered or double cotton covered or enameled copper wire of suitable gauge wound in layers. IN between layers pressman paper or manila paper is used for insulation 2 to 16 Nos. of coils in each H.V.limb are used in which 2 are tapped coils.

Generally the gauges of wire used in H.V. coils are follows :

1.	250 KVA	14 SWG Copper
2.	200 KVA	16 SWG Copper
3.	100 KVA	18 SWG Copper
4.	75 KVA	19 SWG Copper
5.	50 KVA	20 SWG Copper
6.	25 KVA	22 to 24 SWG Copper

The insulation between HV and LV windings and between L.V. windings and core comprises of bakelite papers, cylinders etc.

The connecting leads between coils and from coils and from coils to tapping switch are insulated by sleeves.

C) BUSHINGS:

Upto 33 KV voltage ordinary porcelain bushings are used. Above this voltage condenser and oil filled terminal bushings or a combination of both are employed.

D) COOLING:

The cooling of a transformer is carried out by the following methods.

ON: Majority of transformers are oil immersed with natural cooling i.e., the heat developed in the cores and coils is passed on to the oil and hence to the tank walls from which it is dissipated. This has an advantage that moisture cannot easily affect insulation

OB: In this method the cooling of an ON type transformer is improved by air blast over the outside tank.

OFB: For large transformers artificial cooling may be used. This method comprises a forced circulation of oil to a radiator where oil is cooled and again let into the transformer.

OW: An oil immersed transformer of this type is cooled by the circulation of water in cooling tubes.

E) BUCHOLZ RELAY:

The Bucholz relay is a protective device intimately connected with the structure of the transformers and the non-electrical effects of fault conditions. This system is applicable to oil immersed transformers.

The principle is simple and depends on the fact that less violent generation of gas. A broken joint, for example produces a local arc, and vaporizes the oil in the vicinity. An earth fault has the same result. Sudden short circuits rapidly increase the temperature of the windings, particularly the inner layers, and pocketed oil is vaporized. Discharges due to insulation weakness (eg.) by deterioration of the oil, will also cause oil dissociation accompanied by the generation of gas. Core faults such as short circuits due to faulty core clamp insulation; produce local heating and generate gas.

This relay is hydraulic device arranged in the pipe line between the transformer and the separate oil conservator.

The vessel is normally full of oil. It contains two floats of b1 & b2 which are hinged so as to be pressed by their buoyancy against two steps. If gas bubbles are generated, in the upper part of the relay chamber thereby displacing the oil and lowering the float B1. This sinks and eventually makes the mercury contact C1 which closes an alarm circuit to give Bucholtz alarm.

When the fault is severe enough the lower float B2 gets tipped up to make mercury contact C2 which closes the trip circuits of the IN and OUT breakers of the transformer.

When this alarm operates, the operation staff have to check up whether the alarm is freakish or genuine. It can be examined whether there is gas collected in the Bucholtz relay chamber through the inspection cover. Switch off the Transformer if there is no gas collection and the alarm is freakish and after rectifying the circuit the transformer can be taken into service.

If however there is gas collection the gas can be collected for sampling by opening the upper stop cock into a test tube and if the gas is passed through silver nitrate solution a colour precipitation is formed and the following table give the probable faults.

Colour	Cause
White	Destroyed paper
Yellow	Damaged wood
Black or Grey	Dissociated Oil

F) BREATHER:

The transformer breathes out whenever it is on load or as temperature rises and it inhales fresh air from outside through the breather when temperature comes down. Just as the nose in a human body contains media to eliminate dust and injurious elements going into the human body the breather contains „silicagel" to stop any moisture entering the transformer as the presence of any moisture is injurious to the life of a transformer. The air bubbles through and then through a column of silicagel. Silicagel is „Hygroscopic" i.e., it absorbs moisture readily. The silicagel which is blue in colour turns pink when it absorbs moisture fully. When the colour turns pink the silicagel has to be reactivated by simple drying up over hot pans. There are other types of silicagel also a non-indicating type, non-activating type.

G) VENT PIPE & DIAPHRAGM

The vent pipe is a pressure relief device for the _____ provided for oil to gush out whenever faults develop in transformers. This is only safety device to avoid major damage inside or to prevent the tank from bursting. The vent pipe is closed at the end by a diaphragm. In fact for some makes of transformers two diaphragms are provided one at the bottom and the other at the mouth of the vent pipe. The diaphragm gets broken when pressure is developed in the tank and oil gushes out. It is to be ensured that this diaphragm is intact and air-tight as otherwise moisture may enter through this and cause damage to the oil in the transformer

H) CONSERVATOR:

This is a reservoir for oil. Whenever oil in the transformer contracts during low temperature the oil is drawn from this and when the temperature is high the oil expands and the excess volume of oil goes into this and is stored.

1.04. FUNCTIONS OF A TRANSFORMER:

The transformer is used wherever a step down or step up of voltage is required. The capacity of the transformer is the extent of power in KVA that can be passed through the transformer while it does the voltage transformation at the predetermined ratio.

The number of turns in HV and LV windings decide the voltage ratio.

Supposing the primary windings has NP number of turns and the secondary windings NS number of turns the primary and secondary voltage VP and VS are as follows:

$$\frac{V_P}{V_S} = \frac{N_P}{N_S}$$

Therefore the number of turns on HV and LV windings decide the voltage ratio and the size of the windings wire decide the capacity of the transformer.

The tapings for distribution (i.e., for voltages variations to be obtained) are generally in 5 stages of –3, normal, +3, +6 and +9% over the rated voltage on secondary side. This is achieved by adjusting the number of turns in the High voltage windings. From among the H.V. coils certain of them are selected as tapped coils and the coils are tapped at desired turns and taken out. When the tap switch is operated definite number of turns on H.V. side get either included or excluded or excluded to give the desired voltage on the secondary side. This is achieved by means of a tap switch.

The tapping are normally done on high voltage side as for the same power carried the current carried on H.V. side a lower. If I_p and I_s are the currents in primary and secondary whose voltage V_p & V_s .

$$V_p I_p = V_s I_s$$

It is noticed that failure of transformers are also occurring due to tap charring. Some times tap changing switch is not operated fully; or even when it is operated in full as can be observed from outside the tap changing operation is not complete in all 3 phases inside the transformer.

The operation staff may do the following test after each tap change with off load switches.

1. Mugging test for continuity on H.T. side between all the phases. Delta primary gives wrong readings and cannot be relied as a confirmatory test.
2. Remove L.T. fuses charge the transformer and ensure equal voltages in all the 3 phases (i.e., between phase & phase & between each phase and neutral) before putting it on load.

Whenever alternative 440 V 3 phase supply is available apply the same to the H.T. bushings and measure the voltage on L.V. side and ensure them to be equal between each two phases and between each phase and neutral.

Incidentally one can know whether the desired step up or step down in voltage is achieved by the tap changing.

1.05 CAUSES OF FAILURE AND PREVENTION :

From the study of the various causes of failures of a transformers it is easy to know what is to be done to prevent them. The various probable causes of failures and the preventive maintenance necessary are given below :

As explained earlier, the transformer mainly consists :

1. Magnetic Circuits
2. Electrical Circuits
3. Insulation (Dielectric) terminals
4. Tank, Oil, etc.

In any electrical plant, a failure in one part renders the whole equipment unfit for service:

The faults that may lead to transformer failure can be mainly classified as follows and these often react on one another. It becomes most difficult to identify between the reason and the consequence. Most evidence is lost in the very nature of the failure of the equipment.

1. Failures due to mechanical damages (about 5% failures are on account of these and can be rectified quickly if spares are available).
2. Failures due to poor dielectric comprising of oil and deterioration of major insulation.
3. Failures due to damages in windings which include, coils, minor insulation, terminal ~ gear (70 to 80% failures are on account of this).
4. Failures due to defective, magnetic circuits (cases are negligible).

All these may occur due to :

- a) defective manufacture (poor design, faulty materials and bad workmanship).
- b) defective or abnormal operation (careless dry out, careless installation, inadequate supervision & maintenance and sustained operating conditions)

Failure due to mechanical damages:

There are generally (1) oil leaks (2) Flash over of bushings.

1. The welding of the main tank may be defective and also the fittings may be leaky. This causes oil to leak and cause heating of windings and a possible breakdown of" equipment. Rough handling during transit may also contribute to leaks. The gaskets etc., used at each of the flanges fittings and main covers should be properly places secure and uniformly tightened.
2. Deposits of coal dust, saline or chemicals on the bushings may cause a flash over. Applying of silicon compound or Metro are compound as a thin layer on the bushings results in protect the bushings from flash over due to such deposits. This has been successfully tried at an important 55 like Coromandel Fertilizers 132 KV substation, where difficulty due to chemicals depositing on the Insulators was being minimized.
3. Wrong paralleling of transformers cause undue overloading of one of them. Transformers to be operated in parallel may preferably contain the same turns ration of resistance to reactance voltage drops. Otherwise one of them may get unduly overloaded and heated up also resulting in a breakdown. It is important that the difference in impendence . percentages of transformer to be parallel does not exceed 8 to 10% (maximum).

4. Sufficient place around a transformer to dissipate heat must be provided. If two transformers are kept close the surfaces may get lagged and the oil temperature increases endangering coil insulation.
5. Vapours at the top of an oil cooled transformer may be explosive. Bringing naked lamps at the places may cause damage.
6. In water cooled transformers, the tubes may get clogged and the coil may get heated up. They have to be therefore cleaned periodically.
7. Water may infiltrate into oil through the tubes due to corrosion. It is therefore better to use copper coils. Also the static pressure of oil must be maintained above that of later by means of a pump working against a regulated valve.

Failure in Di-electric Circuits:

1. Moisture entering the tank by “breathing action” of the transformer reduces the dielectric strength of the oil. This results in breakdown from coils or terminal lead to tank or core structures. The greatest danger is however the inter turn short in the coils.
2. Deterioration of oil may also due to prolonged overloading of the transformer. This action is aggravated by presence of copper and lead. When oil temperature increases, formation of sludge, water and acid is accelerated.

Safe values for oils:

Di-electric strength	:	30 KV for 1 minute (between gap of 4 mm or 0.178")
Acidity	:	Upto 0.7 milli grams of KOH per gram of oil-satisfactory.
Above this value	:	Careful observation on the acidity value is to be made by frequent sampling. When this reaches 1.0; the oil is to be discarded.
3. During service certain amount of oil gets lost due to evaporation and oxidation. Periodical topping up of oil level with fresh tested the unit gets overheated.
 4. Narrow oil ducts & improper ventilation reduce the serviceable life of a transformer. Coil insulation turns brittle and may get punctured on account of this.
 5. Sometimes the clearance provided between phases is insufficient. Also insertion of press board barriers may aggravate as they may upset the dielectric stress to throw too much stress across the coil spaces and across the barriers.
 6. Wooden ducts provided for taking the terminal leads over them should be properly dried. These may cause short circuit between tapping leads.
 7. Suspended foreign particles reduce the di-electric strength of the insulating oil and may cause a flash over resulting in serious breakdown of the transformer.

8. When the acidity value of the oil increases, it will promote oxidation of the metal parts and results in a breakdown.

Faults in Electric Circuits:

1. When moisture manages to ingress through the fabric insulation of the coils, short circuits between turns occur sooner or later. Impregnation of coils by applying varnish so that it penetrates deep enough to the inner layers of the coils is to be ensured. Failures from this cause are most common.
2. Presence of sharp edges on the copper conductors may cause a short circuit between adjacent turns then the transformer vibrates on load or when the windings are subjected to repeated electro magnetic shocks due to short circuit or switching surges as the sharp edges are likely to emerge out through the insulation and cause adjacent turns coming into contact.
3. One or more turns in a coils may get dislodged and a short circuit between them may result when heavy external short circuit occurs and if the same is not cleared by fuses in time. Breakdown may not immediately occur but when the transformer vibrates on load with the dislodged coils, abrasion of insulation between adjacent dislodged coils may take place causing a break down.
4. Improper drying out and applying full voltage with poor I.R. values will result in failure of insulation between adjacent layers.

The safe I.R. values for a 33/11 KV Power Transformer and a 11 KV 1440 V Distribution Transformers are given below:

The I.R. values in Mega ohms are to be taken with a 1000 v Megger.

Temperature degrees C)	33/11 KV Transformer			11 KV 1440 V Transformer		
	HT to E Meg ohms	LT to E Meg ohms	HT to LT Meg ohms	HT/E Meg ohms	LT/E Meg ohms	
60°C	65	25	65	50	25	50
50°C	130	50	130	100	50	100
40°C	200 above	100 above	260 above	200 above	100 above	200 above
30°C	250	200	250	200	100	200
	*Nearer to infinity as can be read in a megger			Nearer to infinity as can be read in the megger		

*Whenever readings are taken at ambient temperature:

The temperature also is to be noted and generally in our districts the temperature will be ranging from 30-40 Degrees C.

5. Sudden changes in load cause sudden expansion and contraction of conductor and is likely to damage the insulation fabric.
6. Where individual coils (H. V.) are designed to have too great a radial depth compared to its height, hot spots may develop in the interior of the coils due to inadequate oil passage allowed. The insulation becomes brittle and short circuit between turns may result.
7. Overheat on load occurs at badly soldered joints and oil gets carbonized locally. The heat at the joints will be conducted to a certain length in the copper coil and the insulation may get carbonized to a little extent resulting in a short circuit between turns. The joint itself, may give way causing an open circuit.
8. When external short circuit occurs the coils get displaced violently as a result of the internal imbalance in electro-magnetic conditions.
9. Sustained heavy overloads produce high temperature through out the transformer. The coil insulation becomes brittle and in the course of time flakes off the conductors at places resulting in short circuit between turns. The deposits again cause excessive heating making it a cumulative effect. Transformers with a high ratio of copper losses to iron losses are less able to withstand overload and are therefore more liable to fail on account of sustained overloading.
10. The tap adjusting leads should be carefully handled to ensure that wrong leads are not joined. Otherwise part of windings may get short circuited and heavy currents circulate in the short circuited windings which would produce a fault between turns.

Whenever H.G. fuse or) one of the phases blow off and supply continued through the other two phases, this is injurious to transformer as well as the 3 phase motors of consumers, immediate cutting of the transformer from service and renewal of the H.G. fuse is necessary.

11. It is to be ensured that bolted joints and all connections are tightly secured and locked lest they may become loose in service due to vibrations produced and such joints get heated up rapidly.
12. The transformers for use on large systems are generally provided with adjustable coil clamping device for the purpose of taking up any shrinkage of insulation which may occur under service. This adjustment is to be made with utmost skill lest undue mechanical pressure may be exerted on the windings and a few conductors may get dislodged resulting in short circuit between them.
13. When a transformer is switched off the magnetizing current and thus the magnetic flux tends to collapse instantaneously. Due to various reasons this some times does at a much more rapid rate than this corresponding normal cyclic rate of change and as a result high voltage rises may occur.

14. Short circuit between turns, breakdown of windings to earth and puncture of insulation may take place due to the following transient phenomena.

Lightning surges reaching the transformer. Usually for the damage in the surge impedance and coils get damaged as they take the brunt of the shock.

- * Excessive voltage set up by surges may be accentuated at open tapings, at any point of change of surge impedance like at the termination of conductor reinforcement where employed; space between series coils, at the neutral or midpoint. Extra insulation is to be provided at these places. Employment insulation is to be provided at these points.
15. In large power systems where many power stations are inter connected; or at places very near to large generating stations the fault levels are usually high and for similar faults the transformers are bound to fail more at these places. Employment of current limiting reactors is to be thought of at these places.

Failures in Magnetic Circuits:

1. The laminations are clamped together by inserting bolts through cores and yokes. The bolts are provided with insulation around them which may give way. This tantamount to a short circuit on lamination causing local eddy currents. When this trouble occurs; in the two bolts simultaneously they form a short circuited turn through which magnetic flux passes.

If one of the bolts situated at the ends of the limb fail simultaneously with an adjacent bolt in the yokes; the path between the two bolts is threaded by almost the entire value of the magnetic flux when passing from the core to the yoke. The heat generated is so severe to cause a distortion of the whole core also causing of the insulation and a resultant short circuit between turns of adjacent windings.

2. Failure may occur of insulation between laminations and insulation between yoke and clamping bolts. The nature of damage is similar to the one explained in the foregoing paragraph. This registers an increase in the from losses of the transformer.
3. Core clamping bolts should be securely tightened and locked lest vibration will set up causing damage of core insulation and produce failures as explained above.
4. Care should be taken to ensure that the edges of the core and yoke lamination do not develop burns which produce local short circuit in the lamination.
5. No metallic filings should be allowed to be present in between laminations in a finished transformer which cause short circuit.

It can be therefore be seen that:

1. Almost all the parts in a transformer are liable to failure. On opening a failed transformer it is often very difficult to say definitely the reasons for the failure as all evidence is eliminated by the very nature of the breakdown. Consequently the cause of a failure is only a matter of guess. At best a close idea of the real cause may be obtained by a careful study of the transformer and the operating conditions obtaining at the time of failure of transformer and also the weather conditions. It is therefore necessary that these particulars are recorded accurately.
2. Careful design and construction on the part of the manufacturers, without subordinating quality to competition in market is necessary. On the part of the purchasers also the economics behind the purchase should not be arrived at by cost alone but by performance guarantees.
3. Timely preventive maintenance is the back bone for safe and efficient operation of any electrical plant. The maintenance schedules as well as the construction standards drawn up by the APSE Board are exhaustive enough to detect and prevent a possible failure ahead. If these are adhered it may be possible to reduce the failures to a large extent.
4. It is also seen that in several cases the field officers are misclassifying the transformers. That is several units handed over for periodical overhaul are found sick after receipt in M.R. T. and instances are not remote when good units are handed over as sick.

1.06 PRE COMMISSIONING TESTS:

The following tests are to be done by the field staff before commissioning a distribution transformer. These are termed pre-commissioning tests.

A) Megger Test:

This test is to be done with a 1000 V mugger. At normal ambient temperature obtained in our state the I.R. values should not be less than following: It is therefore necessary that these particulars are recorded accurately.

H. T. to body	:	150 Meg. ohm
L.T. to body	:	100 Meg. ohm
H. T. to L. T.	:	150 Meg. ohm

- B) Whenever possible and alternate L.T. supply is available L.T. supply may be given to the H.V. terminals and the voltage on L.V. side measured between phase and neutral.

This not only confirms the correctness of tap operations and healthiness of transformer but also gives scope to identify the neutral busing.

However it can be taken as a thumb rule that “facing the L.T. side of the transformer the external right terminal is neutral.

Several cases where a phase, terminal is earthier with mistaken identify for a neutral causing of the windings are reported. Hence this caution.

1.07 TESTS BEFORE DECLARING THE TRANSFORMER SICK:

Instances are not remote when section officers have handed over healthy transformers as sick units. They appear to have been mistax by repeated blowing off the H.G. fuses presumably due to placing lower fuses or due to reasons other than faults in the transformers. Replacing of H.G. fuses is to be properly done. Usage of under size fuses result in frequent blowing off of H.G. fuses and switching surges decrease the useful life of a transformer.

They are advised to do the following test at site if L.T. supply is available or at their section offices before declaring it sick.

- A) Mugger Test: Mugger test H. V. to body and L.V. to body and see if satisfactory I.R. values; are obtained. If not it can be declared sick straight away.
- B) If the I.R. values are O.K. conduct ratio test. If unequal voltage are obtained the transformer is sick.

1.08. GENERAL INFORMATION:

The dimensions of a typical H.G. fuse set are given at the end of the article for the guidance of the Section Officers.

1.09. GENERAL REMARKS:

The timely preventive maintenance as approved by Andhra Pradesh State Electricity Board and contained in the technical reference books of Government Electrical Engineers Association for Power and Distribution transformers is appended herewith. The statements also explains in simple form the importance behind each item.

From the foregoing chapters it can be known how the schedules are drawn up covering up i the probable reasons for failure of the equipment.

PRECOMMISSIONING TESTS:

The following tests shall be conducted before commissioning a transformer

1) I.R. Values Test: IR values of windings with reference to transformer tank and between windings are to be measured & recorded. In case of 2 winding transformers the following measurements are taken.

HV to Body

LV to Body

HV to LV

In case of Auto transformer with tertiary winding the following measurements are taken.

Main winding to Body

Tertiary to Body

Main winding to tertiary

- * Upto 11 KV /430 V transformers 1000 V 0-2000 M.o. range meggers are to be used.
- * For Power transformers of 33/11 KV rating 2.5 KV meggers are to be used.
- * For EHT rating transformers, 5 Kv meggers are to be used.

AT 60°C temperature

- I) Upto 33/11 KV rating the IR values shall be more than 60 MW.
- II) For EHV transformer the values shall be more than 75 MW - @EHV transformers with star connected windings are generally with graded insulation.

When the measurements are taken at lower temperatures, for every 10°C drop in temperature the values shall be double the previous value i.e. at 40°C temperature the minimum values to be maintained are

For 33/11 KV transformers -240 MW

For EHV transformers -300 MW

I.R. Values noted without reference winding temperature carry no meaning.

2. Turns Ratio Test: The Turns ratio test is to be conducted either with 3 Phase Turns ratio tester or single phase Turns ratio meter at various tap position. The test is to find out ratio of H.V. turns to L.V. turns for different phases at various tap positions.

In case of D/Y transformers of 33/11 KV voltage rating the ratio measured in between the HV winding in AB with LV winding and similarly HV winding in BC with LV winding in an and HV winding in CA with LV winding in cn.

Being delta wound on HV & star wound on LV the voltage ratio between HV winding & LV winding in each phase limb at normal tap is $\frac{33 \text{ KV}}{11 \text{ KV}/\sqrt{3}}$ or $\frac{33\sqrt{3}}{11} = 3 \times 1.732 = 5.196$

This is a numerical value.

At higher taps (i.e. high voltage taps) less number of turns are in circuit than normal. Hence ratio values increase by a value equal to

$$5.196 + \left\{ 5.196 \times (\text{No. of steps above normal}) \times \frac{(\text{Percentage raise or each taR})}{100} \right\}$$

Similarly at lower taps than normal the ratio is equal to

$$5.196 - \left\{ 5.196 \times (\text{No. of steps above normal}) \times \frac{(\text{Percentage raise Rer each taR})}{100} \right\}$$

The values for a Y/Y transformer of 132 KV /33 KV will be

$$\text{At normal tap} \quad \frac{A_n}{a_n} = \frac{B_n}{b_n} = \frac{C_n}{c_n} = 4$$

At other taps the formula as calculated above will be

$$\text{At Higher} = 4 + \left[4.0 \times (\text{No. of steps above normal}) \times \frac{(\text{Percentage rase for each taR})}{100} \right] \text{ tap to normal}$$

$$\text{At Higher} = 4 - \left[4.0 \times (\text{No. of steps above normal}) \times \frac{(\text{Percentage rase for each taR})}{100} \right] \text{ tap to normal}$$

The ratio test values are measured & tabulated

Sl. No.	Tap No.	Theoretical value of Turns ratio	Actual Turns Ratio		
			AB/an	BC/bn	CA/cn

For Star/Star Transformers

Sl. No.	Tap No.	Theoretical value of Turns ratio	Actual Turns Ratio		
			An/an	Bn/bn	Cn/cn

Measurement of turns of ratio by turns ratio meter is to be done invariably. In case turns ratio meter is not available. The ratio test can be done by applying 3 phase L.T. supply on H.V. side and measuring the phase to phase, phase to neutral voltages on L.V. side at various tap positions. Particularly when there is a problem in transformer or OLTC the ratio test shall be done by a turn ratio tester, to have an accurate assessment of the condition of winding.

3. D.C. Resistance Measurement: The resistance of windings on H.V. side as well as on L.V. side is to be measured at Normal taps extreme taps between phases and between various phases to neutral. The values are to be measured with Precision milli ohm meter or a potentiometer or Whetstone's bridge and recorded duly noting the transformer temperature at which readings are taken. The values are to be got tallied with test report reading furnished by the manufacturer.

4. Magnetization Current: L.T. 3 phase supply is applied on HV side of the transformer with L.V terminals open and magnetization current is measured with precision milli ammeter. Similarly 3 phase L.T. supply is applied on L.V. side and magnetization current on L.V. supply is applied on L.V. side and magnetization current on L.V. side is measured. The values obtained in field are to be got tallied with those noted in test report.

5. Short circuit Test: 3 phase L.T supply is given to H.V. terminal of the transformer with all LV side terminal shorted together perfectly using sufficient size of copper stranded wire (keeping transformer tap in normal position). The currents in each phase & neutral both on HV side & LV side are measured.

The currents in each of the phases on HV side will be equal to

$$\frac{\text{Voltage applied on HV side}}{100} \times (\text{rated F.L HV current of the transformer}) \times (\text{percentage impendancy})$$

rated HV voltage of the transformer under test

The current flowing through neutral will be less than 1 % of rated full load current.

The phase current on Lv side will be equal to

(Phase current on HV side as measured above) x (Voltage ratio of transformer under test)

This test may also be done at extreme taps & valves recorded.

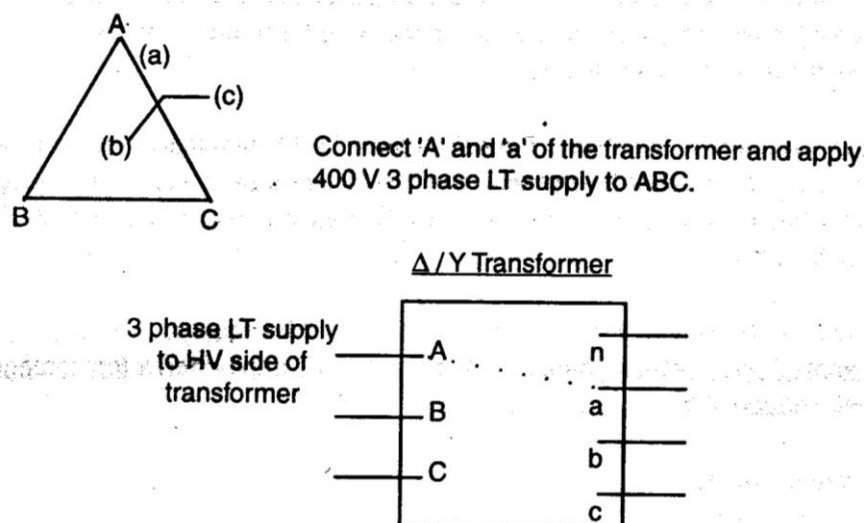
6. H.V. Test: High Voltage at the rated frequency will be applied as shown below gradually from zero values to _____ for 60 Secs. for checking up insulation levels of the transformer before commissioning.
7. Separate Source Voltage Test: Double the rated voltage at double the rated frequency is applied to the transformers to check-up inter turn insulation levels for about 1 minute.
8. Vector Group Testing :The transformer generally used are of DYII or YYo.

For parallel operation of the transformers, the following conditions to be satisfied:

- 1) Voltage ratio of the transformers shall be same including number of taps and percentage (raise/lower) at each tap.
- 2) Percentage impedance shall match since transformers share load in direct ratio of capacities and indirect ratio of impedances.
- 3) Vector group shall be same. Hence checking up of vector group is quite essential before commissioning any power transformer.

There are pairs of matching vector groups and pairs are non parallel able vector groups given separately in this chapter. Particularly when there is a problem in transformer or OLTC the ratio test shall be done in a turn ratio tests, to have an accurate assessment the condition of welding.

The Vector group test is done as shown below:



MAINTENANCE SCHEDULES FOR POWER TRANSFORMERS

1.	Checking the colour of silicagel in the breather and also oil level of the oil seal. If silicagel colour changes from blue to pink by 50% the silicagel is to be reconditioned or replaced.	Daily
2.	Observation of oil levels in (a) main conservator tank (b) OLTDC	
3.	Visual check for overheating if any at terminal connections (Red hots) and observation for any unusual internal noises,	Daily in each shift
4.	Checking for noise, vibration or any abnormality in cooling fans & oil pumps of power transformers standby pumps & fans are also to be run condition to be observed.	Daily
5.	Observation of oil & winding temperatures & recording	Hourly
6.	Visual check of explosion vent diaphragm for any cracks	Daily
7.	Checking for any water leakage into cooler in case of forced cooling System	Daily
8.	Physical examination of diaphragm of vent pipe for any cracks	Monthly
9.	Cleaning of bushings, inspect for any cracks or chippings of the porcelain and checking of tightness of clamps and jumpers	Monthly
10.	Measurement of I.R values of transformer with 2.5 KV mugger upto 33 KV rating and 5.0 Kv mugger above 33 KV rating. Recording of the values specifying the temperature which measurements are taken.	Monthly
11.	Cleaning of Silicagel breather	Monthly
12.	Checking of temperature alarms by shorting contacts by operating the knob.	Monthly
13.	Testing of main tank oil for BDV and moisture content	Quarterly
14.	Testing OLTC oil for BDV & moisture content Quarterly	Quarterly
15.	Testing of Bucholtz surge relays & low oil level trips for correct Quarterly Operation	Quarterly
16.	Checking auto start of cooling fans and pumps	Quarterly
17.	Checking of bucholtz relay for any gas collection and testing the or during gas collected	Quarterly or during fault
18.	Checking of operation of bucholtz relay by air injection ensuring actuation alarm & trip	Half yearly or during shutdown
19.	Noting the oil level in the inspection glass of bucholtz relay and arresting of oil leakages if any.	Monthly
20.	Checking of all connections on the transformer for tightness such as bushings. tank earth connection	Quarterly
21.	Lubricating/Greasing all moving parts of OLTC mechanism	Quarterly or as given in manual
22.	Checking of control circuitry, interlocks of oil pumps and cooling fans for auto start and stop operation at correct temperatures and also for manual operation	
23.	Testing of motors, pumps and calibrating pressure gauge	Half yearly
24.	Pressure testing of oil coolers	Half yearly

25.	Testing of oil samples for dissolved gas analysis (for 100 MVA transformers)	Half yearly
26.	Testing of oil for dissolved gas analysis of EHV transformer upto 100 KVA capacity	Once in a year
27.	Overhauling of oil pumps and their motors also cooling fans & their motors.	Once in year
28.	Testing of oil in main tank for acidity, tan delta, interface tension specific resistivity	Once in year
29.	Busing testing for tan delta	Once in a year
30.	Calibration of oil & winding temperature indicators	Repeats
31.	Measurement of magnetizing current at normal tap and extreme taps	Once in a year
32.	Measurement of D.C. winding resistance	Once in a year
33.	Turns ratio test at all taps	Once in a year
34.	Inspection of OLTC mechanism and contacts its diverter witch	Once in a year of number of operation as recommended by manufacturers are completed whichever is earlier.
35.	Overhaul of tap changer and mechanism	One in year
36.	Replacement of oil in OLTC	Once in year or when-ever number of operations as recommended by manufacturer are completed which-ever is earlier.
37.	Calibration of thermometers (temperature indicates) and tap position indicator.	Yearly
38.	Remaining old oil in thermometer pockets, cleaning the pockets and filling with new oil.	Yearly
39.	Checking oil in the air cell (for transformers of 100 MVA & above capacity)	Yearly
40.	Bushings partial discharge test and capacitance (EHV transformers)	One in 5 years
41.	Filtration of oil/replacement of oil and filtration	Whenever the IR values of transformer are below permissible limits and oil test results require replacement/replacement of oil
42.	General overhaul (consisting) 1) Inspection of core & winding (2) Through washing of windings (3) Core tightening (4) Check-up of core bolt insulation (5) Replacement of gaskets (6) Overhaul of OLTC	One in 10 years

d)	Assembly	:	Cleaning of all core plates, core assembly for tightness insulation of through bolts, placements of insulator drums between LV & Core, HV & LV tap leads insulation placement of separator of horizontal ducts quality of jointing, Provision of end rings
e)	Dry out & reconditioning core & windings	:	I.R. values after dry out at temperature of 60 Degrees C. Hot air chamber environment the time taken to put in hot oil from the time the core & winding are taken out from hot air chamber.
f)	Filtration & reclamation of oil	:	Vacuum applied: I.R. values before flushing with oil & after completion of filtration, whether oil is reclaimed before use etc.
e)	Testing	:	All tests as per IS 2026

9. Any suggestion for improving quality of repairs.

Signature and Date

ANDHRA PRADESH STATE ELECTRICITY BOARD

VIDYUT SOUDHA, HYDERABAD

Ref : CE/T/229/97. Dt. 17.7.1997

TIPS TO REDUCE FAILURES OF DISTRIBUTION TRANSFORMERS

1. Switch over to open wiring in place of LT cables.
2. Providing new transformers under OYT and releasing over load.
3. Providing perfect earthing by providing a new earth electrode.
4. Deployment of a mobile maintenance squad in every division by pooling up one person from each sub-division to attend to maintenance on transformers and revamping the structures.
5. Quality control in SPM sheds and private repair sheds (measuring neutral currents, magnetizing currents, quality of winding wire, ITR values at 60°C, load test etc.)
6. Providing spacers for LT lines with loose spans.
7. Ensuring proper fuse protection.
8. Restoration of lightning arrestors.
9. Re-adjustments of loads on DTs taking village as a unit.
10. Transformer committees to be formed with consumers fed by the transformer to maintain vigilance on erring consumers.

ANDHRA PRADESH STATE ELECTRICITY BOARD
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- The heating chamber should be so designed and heaters fixed at such height so that the core and windings are getting heated properly. They shall be placed below the level of the heaters.
- The filtering should be done with the oil at temperature of 60°C to 65°C. It is to be noted higher oil temperature deteriorates the quality of oil.
- The number of turns of HV and LV windings of transformers should be ascertained if necessary from the manufacturers and the same are to be maintained during repairs. The total number of turns should not be reduced than the designed number of turns.
- Meters used for testing and HV testing equipment should be got calibrated annually and error charts should be exhibited.
- All joints and formation of delta and neutral are to be made with lugs properly crimped.
- A circulating fan has to be provided in the heating chamber to ensure uniform heating of the entire core and windings.
- GI trays are to be provided for keeping the core during examination and repairs so that the oil does not leak on the floor.
- Clean and tested oil should be used for filling after repair.
- Fire fighting equipment is to be provided at a convenient location from the heating chamber.
- Tanks should be cleaned by brushing to remove deposited sludge.
- Filtering of oil is to be cleaned by oil under pressure by providing a separate pump, so that the sludge is removed.

H.T POWER MEASUREMENT

H.T. METERING-POSSIBLE WRONG CONNECTIONS AND EFFECTS ON METERING

1.0 Power is supplied to major bulk loads at high tension and the usual norms adopted areas follows:

Upto 70 KVA	Low Tension
71 KVA to 1500 KVA	at 11kV
1501 KVA to 5000 KVA	at 33 kV
	at 132 kV or 220 kV
	(norms of AP TRANSCO)

The maximum demand of supply of electricity to a consumer during a month shall be twice the largest number of kilo voltampere hours (KVAH) delivered at the point of supply to the consumer during any consecutive 30 minutes in the month. However, for consumers having a contracted demand above 4000 KVA, the maximum demand shall be four times the largest number of Kilovolt ampere hours (KVAH) delivered at the point of supply to the consumer during any consecutive 15 minutes in the month (norms of AP TRANSCO).

1.01 The power supplied at high tension is billed on two-part tariff i.e., based on Maximum demand and units. Also a check is maintained on the power factor and surcharge is levied for P.F. lower than 0.85. The three vector components of KWH, RKVAH and KVAH are all metered and the meter employed for assessing billing parameters at high tension services is called Trivector Meter.

2.0 The metering equipment consists of a polyphase potential transformer, two current transformers, one Trivector meter and connecting cables and leads and test-terminal block. The principle of two-watt method is employed for registration of energy and the meter consists of two elements Blue (leading element) and Red (lagging element).

This is assuming standard positive phase sequence of RYB. The red elements is connected to 'R' current and 'RY' voltage and the Blue Elements is 'B' current and 'BY' voltage. The name used for this connection is called 'association' of proper currents and voltages.

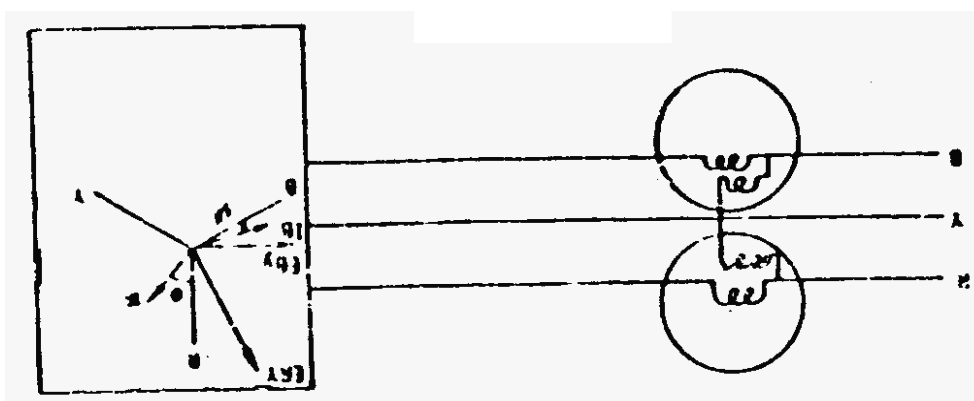


Figure 1

CALCULATIONS

Blue element register:	$EI (\cos (30^\circ - \phi))$
Red element register:	$EI (\cos (30^\circ + \phi))$

Next registration:

$$\begin{aligned} & EI (\cos (30^\circ -) + \cos (30^\circ +)) \\ & EI (\cos 30^\circ \cos + \sin 30^\circ \sin \\ & \sin + \cos 30^\circ \cos \\ & \sin 30^\circ \sin \\ & EI (2 \cos 30^\circ \cos) \\ & EI (2 \cdot \frac{3}{2} \cos) \\ & 3EI \cos \end{aligned}$$

2.01 It is necessary to maintain appropriate association of currents and voltages i.e., R current with RY voltage and B current with BY voltage apart from maintaining correct polarities. The vector grouping in the polyphase P.T. should also be Yyo with no phase shift between primary and secondary voltage vector.

3.0 The general arrangement of connections between a metering set, Test block and Trivector meter are as shown in Figure 2.

3.01 Checks of Polarities & Ratios

Three phase 415V supply is given to High Voltage terminals of the P.T. and the secondary voltages between phase-to-phase and phase-to-neutral are measured to ensure the P.T. ratio. Correct phasing can be identified by giving voltage only one phase after another. Polarity is checked by touching the primary terminals with leads from a 6 volts battery and observing the direction of deflection on a center zero D.C.voltmeter connected to the corresponding phase as the secondary side.

3.02 Current Transformers

The ratio is determined by primary injection kit. This test assumes greater importance when C.Ts have multiple ratios. As the energy to be computed is very large in case of bulk loads, this test is to be done very meticulously. By applying low voltage from a D.C. battery on the primary side and observing the deflection in a center zero low range D.C. Voltmeter on the secondary for determining CT polarity is not advisable, as the core may get saturated during the test process and residual magnetism may affect accuracy. 240V AC supply source is taken and the potential coil and also current coil (through a loading transformer connected to the same supply) are connected to a single-phase Wattmeter or energy meter. Potential leads may be interchanged if necessary to get forward direction. The current coil is then connected to the secondary of the C.T. and direction of meter noted.

4.0 SEVERAL POSSIBLE CONNECTIONS AT SITE

It can be seen that the meter can be connected erroneously with either wrong association and reverse polarities in one or two C.T. currents.

The Y lead of potential supply is earthed at the P.T. and this lead is therefore, easily identified. The connection of the other two potential leads R and B is to be done correctly. The identity can be confirmed best by check up of physical continuity of the leads.

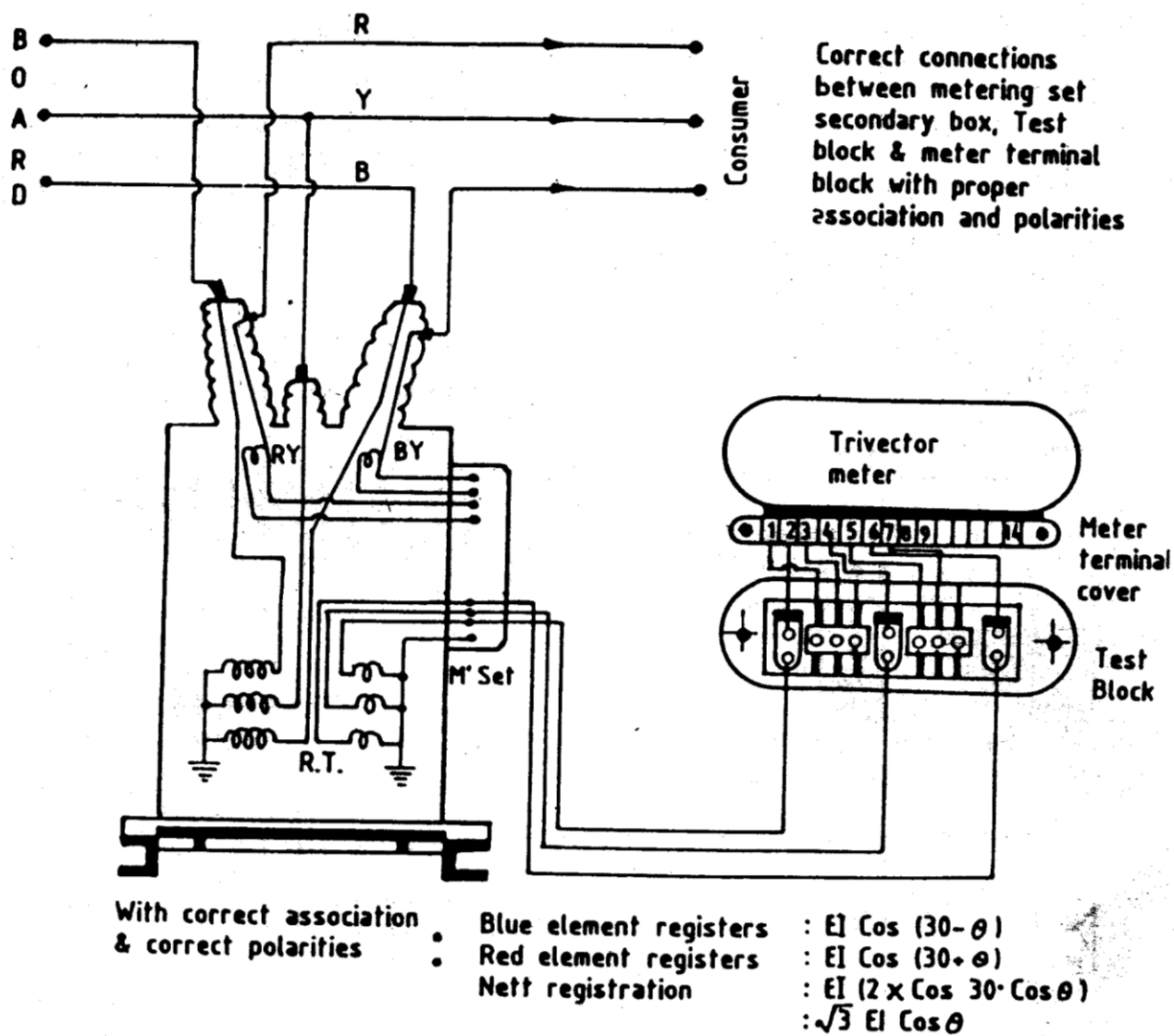
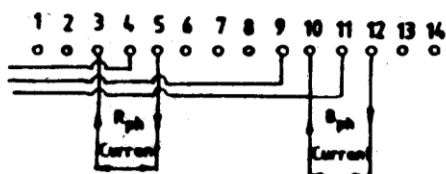
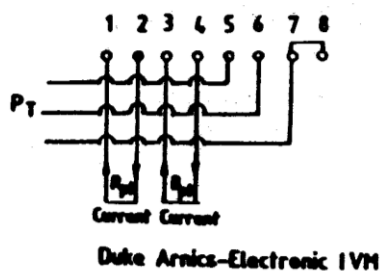
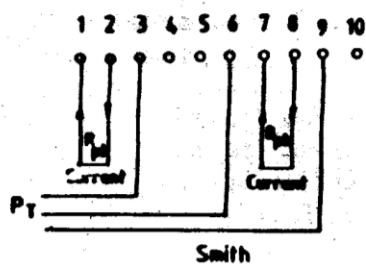
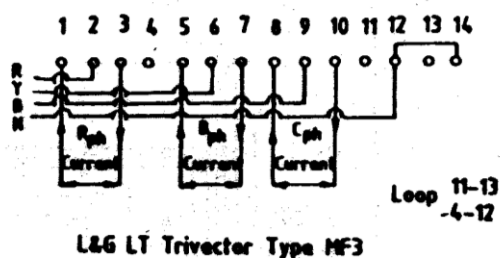
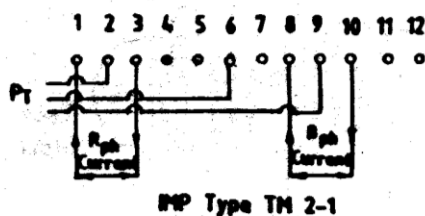
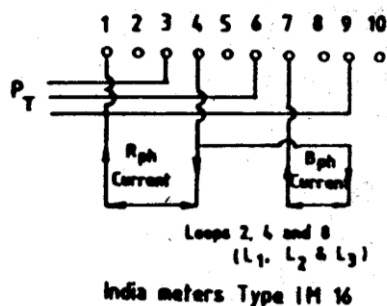
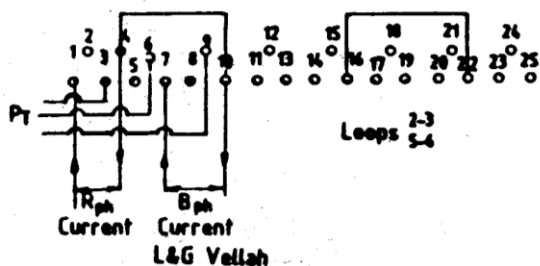
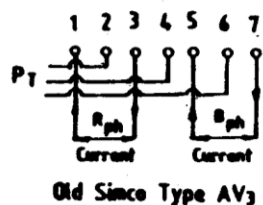
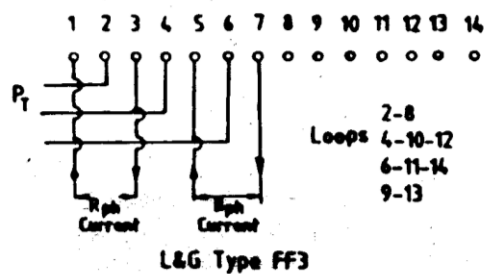


Figure - 2



Terminal Connections for Trivector Meters of Different makes

Figure 3

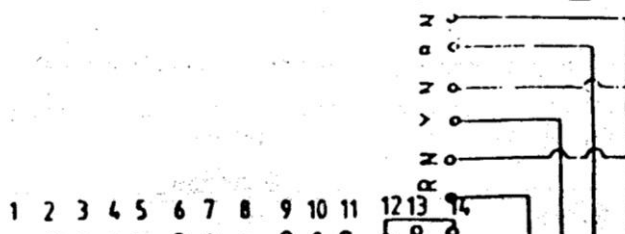


Figure – 3 (contd.)

4.01 The possible connections assuming that Y potential lead is correctly identified are as follows:

Sl. No.	Association	Polarity of R current	Polarity of B current
1.	Correct	+ve	+ve
2.	Correct	-ve	+ve
3.	Correct	+ve	-ve
4.	Correct	-ve	-ve
5.	Wrong	+ve	+ve
6.	Wrong	-ve	+ve
7.	Wrong	+ve	-ve
8.	Wrong	-ve	-ve

4.01 The effects of the above possible connections are as follows:

(1) Association Correct & both polarities Positive:

(RY with +R)
(BY with +B)

Blue element registers	El Cos (30-)
Red element registers	El Cos (30+)

Net Registers	3El Cos

Forward

(2) Association correct and R current Negative:

(RY with -R)
(BY with +B)

Blue element registers	El Cos (30-)
Red element registers	El Cos (30+)

Net Registers	El Sin

Forward lagging P.F.

(3) Association correct and B current Negative:

(RY with +R)
(BY with -B)

Blue element registers	El Cos (30-)
Red element registers	El Cos (30+)

Net Registers	El Sin

Reverse

(Lagging PF) Forward
(leading PF)

(4) Association correct R and B both Negative:

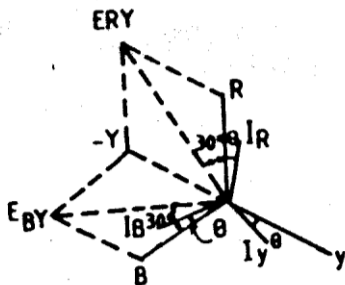
(RY with -R)
(BY with -B)

Blue element registers EI Cos (30-)

Red element registers EI Cos (30+)

Net Registers 3EI Sin

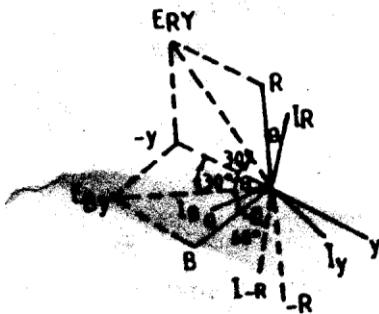
4.02(1)



Angle between ERY and $I_R = 30^\circ +$
Angle between EBy and $I_B = 30^\circ -$
Blue element : $EBy \cdot I_B \cos(30^\circ -)$
Red element : $ERY \cdot I_R \cos(30^\circ +)$
Net registration : $EBy I_B \cos(30^\circ -) +$
 $ERY I_R \cos(30^\circ +)$
 $= \sqrt{3} EI \cos$

Association: Correct
Both the Polarities
Correct

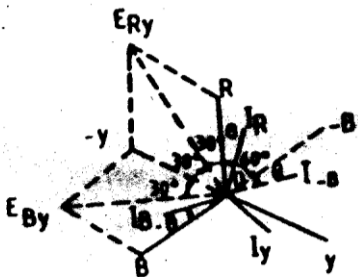
4.02(2)



Angle between ERY and $I_R = 150^\circ -$
Angle between EBy and $I_B = 30^\circ -$
Blue element : $EBy \cdot I_B \cos(30^\circ -)$
Red element : $ERY \cdot I_R \cos(150^\circ -)$
Net registration : $EBy I_B \cos(30^\circ -) +$
 $ERY I_R \cos(150^\circ +)$
 $= 2 EI \sin$

Association: Correct
Polarity B : Positive
Polarity R : Negative

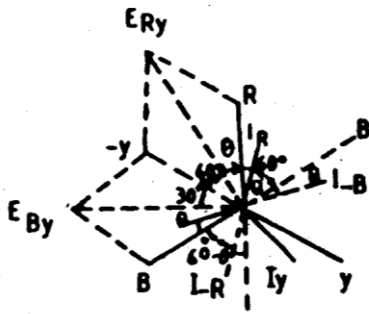
4.02(3)



Angle between ERY and $I_R = 30^\circ +$
Angle between EBy and $I_B = 150^\circ +$
Blue element : $EBy \cdot I_B \cos(150^\circ -)$
Red element : $ERY \cdot I_R \cos(30^\circ +)$
Net registration : $EBy I_B \cos(150^\circ +) +$
 $ERY I_R \cos(30^\circ +)$
 $= -EI \sin$

Association: Correct
Polarity B : Negative
Polarity R : Positive

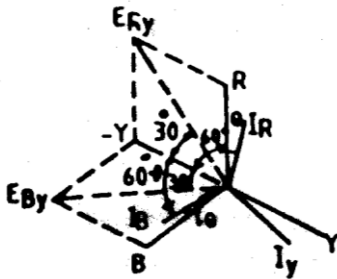
4.02(4)



Angle between ERY and $I_R = 150^\circ +$
 Angle between EBy and $I_B = 210^\circ +$
 Blue element : $EBy \cdot I_B \cos(210^\circ -)$
 Red element : $ERY \cdot I_R \cos(150^\circ +)$
 Net registration : $EBy I_B \cos(210^\circ +) +$
 $ERY I_R \cos(150^\circ +)$
 $= \sqrt{3} EI \cos$

Association: Correct
 Polarity the Polarities
 Reverse

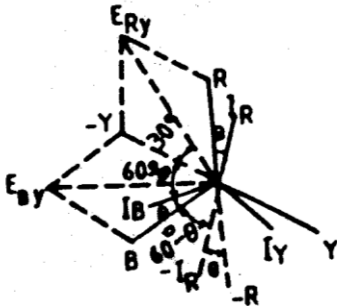
4.02(5)



Angle between ERY and $I_B = 90^\circ -$
 Angle between EBy and $I_R = 90^\circ +$
 Blue element : $EBy \cdot I_R \cos(90^\circ -)$
 Red element : $ERY \cdot I_R \cos(90^\circ +)$
 Net registration : $EBy I_R \cos(90^\circ -) +$
 $ERY I_B \cos(90^\circ +)$
 $= \text{zero}$

Association: Wrong
 Polarity : Both Correct

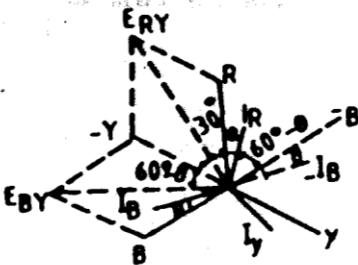
4.02(6)



Angle between ERY and $I_B = 90^\circ -$
 Angle between EBy and $I_R = 90^\circ +$
 Blue element : $EBy \cdot I_R \cos(90^\circ -)$
 Red element : $ERY \cdot I_B \cos(90^\circ +)$
 Net registration : $EBy I_R \cos(90^\circ -) +$
 $ERY I_B \cos(90^\circ -)$
 $= 2EI \sin$

Association: Wrong
 Polarity B : Positive
 Reverse

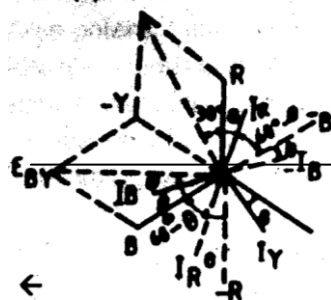
4.02(7)



Angle between ERY and $I_B = 90^\circ -$
 Angle between EBy and $I_R = 90^\circ +$
 Blue element : $EBy \cdot I_R \cos(90^\circ +)$
 Red element : $ERY \cdot I_B \cos(90^\circ +)$
 Net registration : $EBy I_R \cos(90^\circ +) +$
 $ERY I_B \cos(90^\circ +)$
 $= 2EI \sin$

Association: Wrong
 Polarity B : Negative
 Polarity R : Positive

4.02(8) ERY



Angle between ERY and $I_{-B} = 90^\circ +$
 Angle between EBY and $I_{-R} = 90^\circ -$
 Blue element : $EBY \cdot I_{-R} \cos(90^\circ -)$
 Red element : $ERY \cdot I_{-B} \cos(90^\circ +)$
 Net registration : $EBY I_{-R} \cos(90^\circ -) +$
 $ERY I_{-B} \cos(90^\circ +)$
 $= \text{zero}$

Association: Wrong
 Both The Polarities
 Reverse

(always reverse)
 Reverse

(5) Association wrong Both currents positive:

(RY with +B)
 (BY with +R)

Blue element registers	$-EI \sin$
Red element registers	$+EI \sin$
Net Registration	<u>0 (zero)</u>

(STOP)

(6) Association Wrong: Blue current +ve and Red Current reverse:

(RY with +B)
 (BY with -R)

Blue element registers	$EI \sin$
Red element registers	$EI \sin$
Net Registration	<u>$2EI \sin$</u>

Forward
 (lagging PF)

(7) Association wrong: Polarities of Blue Reverse (ve) and Red Positive:

(RY with -B)
 (BY with +R)

Blue element registers	$-EI \sin$
Red element registers	$-EI \sin$
Net Registration	<u>$-2EI \sin$</u>

Reverse
PF lagging
Forward
(PF lagging)

(8) Association wrong: Both polarities wrong

(RY with -B)
(BY with -R)

Blue element registers	+EI Sin
Red element registers	-EI Sin
Net Registration	<u>-0 (-zero)</u>

(STOP)

4.03 It can be seen that out of the eight possible connections shown above item (1) are correct connections and item (5) is done as a test (called cross potential test) for ensuring that the earlier connections (before crossing the potential leads) are correct.

4.04 The above observations are summarized in the table given below:

TABLE
Indicating registration by meter for different set of connections of an H.T.Meter

Sl.No.	Connections	Blue element	Red element	Net	Remarks
1	2	3	4	5	6
1.	RY to +R BY to +B	EI Cos (30-)	EI Cos (30-)	$\sqrt{3}$ EI.Cos	Correct Connections
2.	RY to -R BY to +B	EI Cos (30-)	-EI Cos (30+)-	EI Sin.	
3.	RY to +R By to -B	-EI Cos (30-)	+EI Cos (30+)	-EI Sin.	Cross potential test
4.	RY to -R By to -B	-EI Cos (30-)	-EI Cos (30+)	$\sqrt{3}$ EI Cos	
5.	RY to +B By to +R	EI Sin.	+EI Sin.	zero	
6.	RY to +B By to -R	+EI Sin.	+EI Sin.	2 EI Sin.	
7.	RY to -B By to +R	-EI Sin.	-EI Sin.	-2 EI Sin.	
8.	RY to -B	+EI Sin.	-EI Sin.	Zero	

5.0 Certain cases are observed with „R" current or „B" current is not given to the meter though the three potential leads were connected. The registration varies with power factor and it is found feasible to arrive at the octal registration that should have been recorded based upon the registration of the meter with missing current. The assumption in the case is that proper connections following association

and polarities are made and the missing current is either due to loose contact or inadvertent short circuiting of one current at test block etc.

5.01 The following Table gives the details of meter registration at various power factors and the registration shown against the particular element (for which current inflow to meter is missing) can be identified as not registered.

Sl. No.	Case	W1.Red Element	W2.Blue Element	Nett
1.	= 30^0 P.F. = 0.866	0.866 EI (28.87%)	1.732 EI (57.73%)	2.59 EI (86.6%)
2.	= 60^0 P.F. = 0.5	0.0 (0)	1 1/2 EI (50%)	1.5 EI (50%)
3.	= 90^0	-3/2 EI (-50%)	+ 3/2 EI (+50%)	0.0 (0)
4.	= 0^0	1.5 EI (50%)	1.5 EI (50%)	3 EI

This table will be useful while assessment and back billing becomes necessary.

6.00 One practice existing in few places is to check the torques of individual elements by current reversals.

If connections are given correctly and P.F. is between 0.5 lag and unity, Blue element possesses greater torque than Red element, and both torques are positive. For power factors below 0.5 lag, Blue element possesses positive torque and Red element negative torque.

However, if P.F. is leading; the Red element possesses greater torque. The red element possesses positive torque at 0.5 lag and negative torque when P.F. is greater than 0.5. As such this method of checks by observing torques is not advisable. This is much more so because all loads are not balanced.

7.00 Interchange of potentials R & B with „Y“ undisturbed causes the meter to come to stop as explained in case 5 under para 4.02 above. This is also made a part of the checks to be conducted at the time of release of a servive as well as during annual checks and this is popularly known as “Cross potential Test.” However for this test to be true; the P.F. is to be brought to lagging side if necessary by switching off the capacitors if any in service.

8.00 Maintaining standard association of currents and voltages the potential connection at the meter may be RYB, YBR or BRY.

8.01 For every possible potential connections as above; there are eight possible connections of currents as explained in Para 4.01 above. Therefore, there are in all, 24 possible connections to the meter. The set of connections described in all the paragraphs above is for RYB potential connections as normally potential connections as never given wrong because of easy identification.

8.02 If potential connections, are given as YBR two elements get potential of YB and RB.

8.03 If potential connections are given as BRY the two elements get potential of BR and YR.

8.04 The table below gives the registration by the meters for such connections.

9.00 The Andhra Pradesh State Electricity Board has issued instructions for ensuring that the metering points at the High Tension consumers are maintained reasonably pilfer proof. A list of 60 numbers guidelines were issued in Board's Memo No. As (MISC) 3804/PI/75-I dated 6 December 1975 and these instructions are more popularly known as 60 Point formula for H.T. services. There are appended to this article to make the required information about H.T. services complete. Similar instructions by other Utilities as amended to their convenience can be issued.

9.1 H.T. Meter Testing

The following tests are prescribed during annual check of H.T. Services. A copy of the format for H.T. Test Report is enclosed as Appendix 1

Sl.No.	Connections	Blue element	Red element	Net Sketch
1.	RB to B YB to R	-EI (Cos (30+)	EI Cos (90-)	3 EI Cos (60+)
2.	RB to -B YB to -R	EI (Cos (90-)	EI Cos (30-)	-3 EI Cos (60+)
3.	RB to R YB to B	EI (Cos (30-)	EI (-Cos (30-)	-0-
4.	RB to -R YB to -B	-EI -Cos (30-)	+EI (-Cos (30-)	-0-
5.	RB to B YB to R	-EI (-Cos (90-)	EI (Cos (30+)	EI (Sin (30-)
6.	RB to B YB to -R	-EI (-Cos (30+)	-EI (Cos (90+)	-EI Cos (30-)
7.	RB to R YB to -B	-EI (Cos (30-)	EI (Cos (30-)	EI (2 Sin (30-)
8.	RB to -R	-EI (Cos (30-)	-EI (Cos (30-)	-EI (Cos (30-)

H.T. METERING-POSSIBLE WRONG CONNECTIONS

- (1) Voltage Checks
- (2) Current Polarity Checks:
- (3) Torques by shorting individual currents:
- (4) Errors for : KWH

Full load u.p.f
 Full load 0.5 PF
 1/10 Full load u.p.f.
 RKVAH Full Load ZPF
 Full Load 0.866
 1/10 Full Load ZPF
- (5) Dial Test : at 0.866 p.f. and full load.

9.2 Procedure for Testing

Two Nos. RSS Meters, one for active power (KWH) and the other for reactive power (RKVAH) are used. The RSS meters are designed to retain their accuracy for long periods of time. They can be read upto 0.01 of a revolution and the starting and stopping can be controlled by means of a "click switch" which controls the potential circuit.

- 9.21 The current coils of the RSS meters and MUT (Meter Under Test) are connected in series and their potential coils in parallel. The number of revolutions made by the RSS to second decimal place are read for a fixed number of revolutions of MUT and accuracies checked.
- 9.22 The connection diagram for test is given in Figure-4.
- 9.23 The number of revolutions the RSS meter has to make for corresponding 10 revolutions of the MUT (or any fixed round figure) is computed and checked by "click switch". While counting the revolutions, the moment at which the end of the pointed mark crosses the vertical mark on the meter is taken.

Example for deciding ratio of revolutions for MUT and RSS.

Meter Constant (as per name plate on MUT)	X	P.T. Ratio for which dial is calibrated (MUT)	X	C.T. Ratio for which dial is calibrated (MUT)
Constant of RSS Meter	X	Sec. Voltage at MUT	X	Sec. current at MUT

Working: Say meter constant is 12 Rev./Unit.
 C.T.Ratio: 10.5 & P.T. Ratio is 11 KV/110 V.
 Constant of RSS = 1800 at 5 Amps, 110 Volts
 (direct reading)

$$\frac{12 \ 100 \ 2}{1800 \text{ (direct reading)}} \quad \frac{2400}{1800} \quad \frac{12}{9}$$

(i.e.,) for every 12 revolutions of MUT the RSS shall record 9 revolutions at Zero error.

Supposing RSS has to make 10 revolutions for every 'X' Nos. of revolutions of main meter and the observations are as follows:

EXAMPLE :	RSS	%ERROR
	10	Zero
	9.98	+0.2
	10.20	-1.96

NOTE: The RSS meters themselves carry an error and the net error is to be arrived at by compounding both the errors. The RSS meters are to be get calibrated at standard laboratories (say CEIG Madras) once every years.

9.24 The readings are repeated at loads and power factors given in the notes for KWH element and RKVAH element (both) before clearing the meter and after cleaning the meter. These readings are noted as „BA" and „AA" meaning „before adjustment" and „after adjustment". By adjustment, it is meant adjustment of errors so that the errors are within the limits of +2.5%.

9.25 Then the tests of Minimum running current, creep at 120% of rated voltage (with no currents) and also dial test with full load and 0.866 p.f. are done. During the dial test all parts of the meter including cyclometer and M.D. indicating mechanism are covered. The test should be for one complete integrating cycle of the meter.

9.26 A list of seals available with serial numbers and impressions before testing and a list of new seals affixed with serial numbers and impressions after test are made out. All these details are noted in the "Test Record" a field book used by MRT. The test report with all these details is to be sent to all concerned officers. As test blocks are provided for shorting the currents and delinking potentials to the meter during test; the readings of KWH, KVAH, KVARH and M.D. before and after test and also the duration of tests are to be given in the report, so that computed consumption for the period of test can be added while rendering the bills. The fact of MRT test should be recorded in the books maintained by Operation Staff as well as on the consumer's meter card or readings register.

9.27 The ratios connected on the C.Ts, P.Ts and also other equipment like auxiliary C.Ts, summation C.Ts., etc., are all to be checked and the multiplying factor of the meter verified once again and confirmed. The M.F. should be boldly displayed in the meter box preferably inside the sealed area.

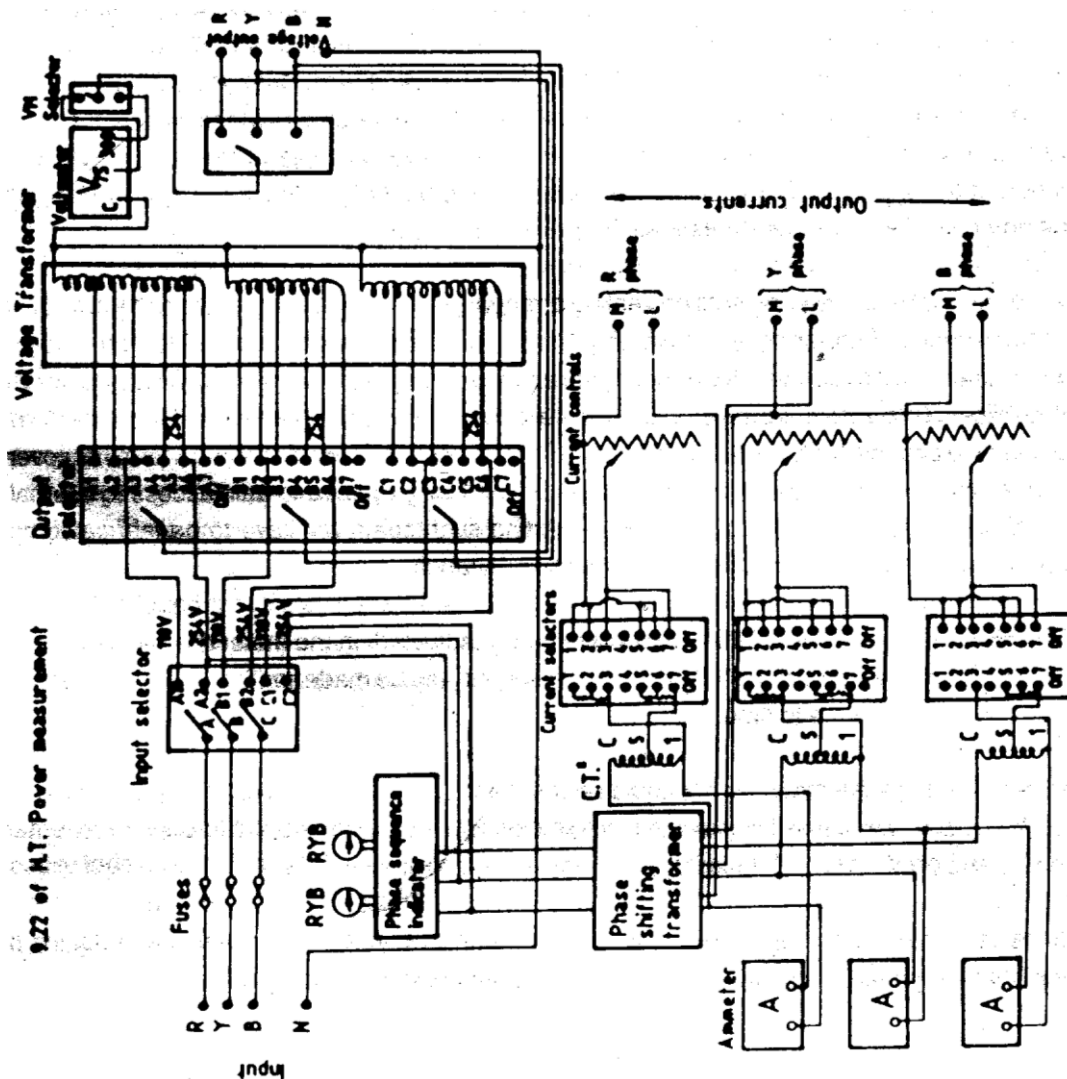
All the officers present at the time of testing including the Operation Staff have to attest the test record in the M.R.T. field book.

10.0 The above information is supplied so as to serve as an handy collection of useful information from various sources to serve as a guide for practicing Engineers-in-charge of H.T. metering at bulk consumers and to know readily the various possible wrong connections that can be given and the effects thereon on the registration by the meters.

Operating Instructions & Precautions

Kindly go through these few points before connecting the kit

1. Input Wire: Connect input as below RED-R Phase GREEN –Y Phase BLUE – B Phase BLACK – Neutral
2. Keep the input switch in current position of your supply (110 or 440)
3. Keep the output voltage switch to the rated voltages of E.S.S. & test meter.
4. Before connecting test meters check up the output voltage.
5. Current switches" have got 1A and 5A with 0.5% 0.75% each
6. 1% minimum currents are provided on current controls.
7. Keep current controls at 0.01A position while operating current switch.
8. Phase Shifter knob is fixed type and can be turned to required phase shift.



Copy of Instructions issued by APSEB in respect of High Tension Services
**GENERAL DEFECTS NOTICED IN
H.T.SERVICES**

1. Most of the H.T. Services are metered in the interior portion of the consumer's premises where the possibility for direct tapping exists. The metering structures should be as near to entrance as possible, preferably they should be accessible from outside also. It may be necessary to shift such inaccessible or outside metering structures nearer to entrance to prevent the possibility of pilferage of energy. The consumer may not agree to bear the expenditure for such shifting as the shifting is mainly intended to facilitate the departmental inspection. Even in case the expenditure has to be incurred by the Board it may be desirable to shift the structures since the cost of shifting will be very small when compared to probable loss if consumer indulges in malpractices.
2. At present sealing arrangement is not being done in many H.T. services for A.B. Switches within consumer premises. It is considered that there is great scope for the consumers to indulge in direct tapping by opening A.B. Switches. To prevent such possibility the A.B. Switch handle and all possible places where the consumer could have facility of operation of A.B. Switch should be effectively sealed with the sealing plier of A.E./Operation incharge of H.T. services. Whenever the seal is broken by the Operations staff for renewing fuses or for attending to the maintenance work an entry should be made in the records to that effect and new seal affixed with Section Officer's seal giving utmost priority. The Section Officer's seal should be replaced by the A.E.'s seal during next visit and recorded in the report as maintained for the purpose.
3. In certain types of metering sets no sealing arrangement is provided for sealing the top cover and inspection cover of metering set. In the absence of such seals there is a possibility for outside agencies to open top cover and alter the connections inside the tank which may not be known to inspecting officers till the metering set is opened in the testing laboratory. To prevent such malpractices it is necessary to provide MR.T. seals for the top cover, inspection cover, secondary terminal cover and any possible opening of metering set which could be freely opened to gain access to internal connections. The necessary arrangements for providing such seals will have to be fabricated by MR.T. organizations taking the assistance of operation branch.
4. The multiplying factor used should be prominently indicated on the meter card also. The mode of calculation to arrive at the multiplying factor should also be made available to all concerned for cross-checking from time to time.
5. In certain cases the metering set could be made inoperative by disconnecting fuses of H.T. side also. Wherever such possibility exists suitable devices should be adopted to prevent external agencies to tamper with the H.T. fuses by providing sealing arrangement.
6. In certain cases direct tapping has been resorted to by connecting incoming and outgoing terminals of metering set or the jumpers connected to metering set. In case effective insulation is provided to the terminals and jumpers such possibility could be avoided. However periodical checks may have to be done by opening the insulation to ensure malpractices are not existing.

7. In many cases metering kiosks are not provided with effective sealing arrangements. The kiosks should contain the seals of operation staff. Whenever these seals are broken an entry should be made in the register.

8. The fuses provided for the P.T. and the L.T. side appear to have been the main source for many malpractices. Instructions have been given few years ago to remove these fuses and give direct connection to the meters. Despite this still many services are having P.T. fuses. If it is found that however effective the sealing might be done there is a possibility for tampering these P.T. fuses to suppress the consumption. Hence it is necessary that all the fuses on the L.T. Side of the metering set should be removed within a period of 3 months and compliance reported. Divisional Engineer/M.R.T. and Asst. Divl. Engineer/M.R.T. are responsible for this work. They may take the assistance of the operation Staff in making structural alterations for metering arrangements.

9. In a few cases the consumption was found to be suppressed by changing the C.T. ratio and adopting different C.T. ratio for calculation. To prevent such practice it may be necessary to connect the metering set in the maximum C.T. ratio provided and the multiplying factor should be calculated without ambiguity. However, if the load of the consumer did not permit such high C.T. ratio it may be examined whether a suitable metering set could be fixed by changing metering set. Wherever there is difficulty to follow these instructions the matter may be brought to the notice of higher authorities and instructions sought.

10. If it is found that test blocks are not provided for many meters. Even in cases where such test blocks are provided they are not effectively sealed and controlled. Arrangements may be made to provide test blocks for all H.T. services to facilitate check testing of meters with consumer's load without giving interruption to the consumer. The test blocks should be effectively sealed with M.R.T. sealing pliers to prevent any possible manipulation by external agencies.

11. If it is found that Relays, Ammeters, and Voltmeters connected in the billing metering circuit are the sources for tampering. It is desirable to have a separate set of C.Ts for protection, recording load etc., instead of combining them with billing meter circuit.

SEALING PLIER

12. Each sealing plier should have a distinct serial number with suitable inscription which can be easily identified without the need for magnifying glasses. However, for finding certain differences magnifying glasses could also be used. The impression should be on both sides of the seal. It should be possible to distinguish the top side from bottom side after seal is affixed.

13. The sealing plier die should be zig-zag.
14. The sealing should be done by keeping the sealing plier perpendicular to the sealing wire. If it is done in any other manner there is possibility for slippage of seals.
15. The length of the sealing plier should be atleast 12" minimum of facilitate easy pressing to get clear impression. Whenever the impression on the sealing bits if not clear on account of wear and tear of the sealing plier necessary action may be taken on obtain fresh sealing plier by condemning the old one. The condemned sealing plier should be in the custody of D.E./M.R.T.
16. All officers in the Circle should be informed through a circular Memo. about the use of sealing pliers in the circle by various officers with inscriptions etc. so that every one would know the owner of the sealing plier with which sealing has been done during inspections. D.P.E. Organizations will have to be informed about changes of sealing plier.
17. Whenever sealing plier are lost, wide publicity should be given about the same so that its operation in other areas could be detected and culprits traced.

SEAL BITS

18. The seal bit should be serially numbered.
19. Detailed account of every seal should be maintained by the concerned including the location with respect to the meter it is used.
20. The seal bits used for H.T. meters, 3 phase meters, single phase meters should be different. In addition it may be preferable to have separate shape and size which can be easily identified from the seal bits used by operation organization.
21. The seal bits should be valuable enough to take the impression of sealing plier while having the mechanical strength to hold the sealing-wire for long period.

SEALING WIRE

22. The sealing wire used by M.R.T. organization should be distinctly different from the sealing wire used by other organization.
23. The seal wire should be cut in suitable length so that it will be adequate enough to have good sealing arrangements. The ends protruding beyond the seal bits should be trimmed to prevent any possible tampering.
24. It is not correct to put an additional seal cover one seal to the same sealing wire for observation etc. Whenever such need arises separate seal should be provided with separate sealing arrangement.
25. The sealing wire should be ductile enough to have easy maneouvability for effective sealing

while having suitable mechanical strength to withstand handling for long years,

26. In sea coast areas rust proof wire may have to be used to prevent deterioration and damage.

27. At the time of periodical testing all seals should be renewed without allowing any old sealing wire and seals to remain.

RESPONSIBILITIES OF D.P.E. ORGANISATION IN RESPECT OF H.T. SERVICES

28. The D.P.E. organization should take the assistance of Operations Staff whenever they visit H.T. services. They should also requisition the services of MR.T. organization whenever such assistance is required.

29. For surprise checks they need not inform any one.

30. A copy of the details noted during inspection of H.T. services may be handed over to Operation Staff with their recommendation to safeguard the departmental revenue in case any malpractices or defects are noticed.

31. The D.P.E. staff may circulate the proforma used during their inspection to operation and MR.T. staff so that they could also follow the same procedure during their inspections.

32. D.P.E. staff may work out the probable consumption for unit of production of different industries based on their observation of similar industries in the State. However this need not be taken as a final figure for any assessment and should serve as a guide only.

33. D.P.E. organization may also send the reports of the inspections carried out by them to operation and M.R.T. organizations in respect of H.T. Services. Whenever certain deficiencies are noted the fact should be brought to the notice to higher authorities for taking remedial action.

34. Whenever any H.T. service is kept under observation the fact should be intimated to operation and M.R.T. staff so that they may not break open the seals kept by D.P.E. staff.

35. The D.P.E staff may avail shut downs in consultation with Operation Staff as and when required for detailed examination of metering arrangements of H.T. consumers, if the same is considered necessary to safeguard the departmental revenue.

RESPONSIBILITIES OF M.R.T. AND OPERATION ORGNAISATION IN RESPECT OF H.T.

SERVICES

36. All the new H.T. services should be released in the presence of A.D.E./M.R.T. and A.D.E./Operation. Both of them should ensure that all the steps required for safeguarding the departmental revenue are taken. They will sign the test record where all the details of tests, and seals are noted.

37. Asst. Divl. Engr./Operation should inspect every H.T. service after recording monthly reading once atleast during the course of the month to take check reading and to evaluate the consumption for the period from the last reading. While doing so he would collect the production figures and compare the consumption with the output. It may be possible that certain industrialists might not voluntarily furnish the required information. In such cases a close watch may be kept through departmental agencies to ensure that the consumption is not suppressed. The Asst. Divl. Engineer/Operation should also check all sealing points during his visits and ensure that they are satisfactory. Wherever certain doubts arise which require close inspection the ADE/M.R.T. and ADE/D.P.E. may be contacted for their assistance to safeguard the departmental revenue.

38. The Asst. Engineer/A.A.E. in charge of H.T. services should also be associated with the above inspection and he may be made to feel that he is also responsible for safeguarding the departmental interests.

39. D.E./M.R.T. should inspect atleast 6 H.T. services in a month and complete the inspection of all H.T. service once in a year.

40. Divisional Engineer/Operation should inspect all H.T. services in his jurisdiction once in 6 months.

41. Asst.Engineering/M.R.T. should record complete details of seals available with meter with specific indication about their condition and impression. The entire procedure followed during testing should be recorded in chronological order along with test results. The condition of the meter before commencing the test and the details and condition of the seals before they are opened should be recorded. This test record should also be signed by Operation staff and consumer after the testing is completed in addition to M.R.T. staff. DE/MRT and ADE/MRT should review field test records and ensure that the procedures laid down are properly adhered to.

42. The Tester M.R.T. should be made responsible for the accuracy of the figures recorded in the test record.

43. The Tester's signature should be available in the test record.

44. Divisional Engineer/M.R.T. should review the consumption of all H.T. consumers every month and arrange for proper checking wherever suppression of consumption is suspected. For this purpose the Asst.Divl.Engr/Operation will have to furnish the monthly readings along with consumption to D.E./M.R.T. while sending the consumption figures for billing purposes. The ADE/Operation would also send the detailed reasons for the variation in the consumption to D.E./M.R.T. for enabling him to review the consumption.

45. The Officer affixing the seal should ensure that proper impression of the sealing plier used by him is made on the seal bit for enabling inspecting officers to verify the seals available. Wherever proper

impression is not made resealing may be done by the appropriate organization to avoid confusion and doubts in the minds of inspecting teams.

46. In addition to annual testing of H.T. meters a check test should be conducted by M.R.T. organization in the consumer's premises with consumer's load once in 6 months.

47. All the inspections and testing of M.R.T. organization should be co-ordinated with the operation staff so that all the necessary facilities for testing work and inspection will be available for the testing organization when they visit consumer's premises. Whenever periodical tests and checks are conducted the Asst.Divl.Engr./Operation may be present. In case the Asst.Divl.Engineer/Operation has other pressing works he might depute the Asst.Engineer/A.A.E. for this purpose.

48. Whenever major loads are released the Divisional Engineer/Operation and Divisional Engineer/M.R.T. should be present so that adequate precautions could be taken to safeguard the departmental revenue.

49. At present the metering arrangements made on the L.T. side of H.T. services is not being given as much importance as that of H.T. services. All such cases may also be given the same importance as other H.T. services.

50. Asst.Divl.Engr/Operation may ensure that effective sealing arrangements are made for A.B. Switches controlling the supply within the premises of H.T. Services. Similar sealing may be done in respect of kiosks and the metering room after every visit to H.T. service wherever such arrangements exist. For any reason the seal affixed by the Asst. Divl.Engr./Operation is removed an entry to that effect may be made in the registers maintained for such purpose so that the inspecting officers could take this into account when seals are found to be not existing at the time of inspection.

51. It is the responsibility of Asst.Divl.Engr./Operation and Divl.Engr./Operation to fix the metering arrangements of H.T. services in the premises of the consumer in such a way that it is accessible for inspection without much delay after entering into the premises. To the extent possible the metering structure and arrangements may be made visible from outside itself even though structure is within the premises of H.T. consumer. It is found that at present many metering structures are located in inaccessible areas for within the consumer's premises which can be approached only after the consumer produces various keys for the locks provided. All the keys for the metering arrangement should be available with the Departmental Officers and the Officers should be free to inspect the metering arrangements at any part of the day since many malpractices are found to be carried out during night when the consumers do not expect the inspecting officers to visit their premises. Even though it is not the intention of the department to inconvenience the consumer by visiting his premises during night hours it may be necessary in certain cases to make such surprise visits. For this purpose the operation Asst.Divl. Engineer and Divisional Engineer would make all necessary arrangements while fixing the location of the metering arrangements at the time of release of supply itself. In certain case where it is desirable to shift the existing location of metering structure to have the above easy access necessary expenditure could be incurred on the department side to shift such locations to a suitable place since this expenditure incurred would be amply justified in view of corresponding benefits, envisaged. All structural alternations in such cases may have to be completed within the next 6 months after obtaining the approval of competent authority and duly sanctioning the estimate and following all procedure.

52. Divisional Engineer/M.R.T. should draw up a calendar of testing of H.T. Meters and review the testing programme. He should take necessary action to prevent leakage of revenue through defective

metering, malpractices and other means.

53. The Divisional Engineer/M.R.T. should arrange for the rectification and testing of H.T. meters whenever requests are received from Asst.Divl.Engr./Operation with minimum loss of time.

54. It is the main responsibility of the M.R.T. organization for proper maintenance and upkeep of metering equipment and meters. For this purpose they would take the assistance of Operation Branch. However, this does not absolve the Operation branch of their primary responsibility. They should intimate M.R.T. organization whenever they feel that the assistance is required.

55. Divisional Engineer/M.R.T. should inspect the premises of H.T. consumer and satisfy himself that no loss of revenue has taken place whenever any report about major damage to the metering set or metering arrangement is reported. For this purpose the field officers should keep the metering set and metering arrangement in the same condition untouched till the arrival of D.E./M.R.T. party whenever major damage occurs to metering set or meters. Whenever it is possible the presence of A.D.E./D.P.E. also should be ensured before commencing inspection by D.E./M.R.T.

56. Divisional Engineer/M.R.T. will arrange to remove all the P.T. fuses on the secondary side of metering set in H.T. services and give direct connection to meters within 3 months from the date of receipt of this order. Even though these instructions were given few years ago, many H.T. services are still having P.T. fuses. Even though effective sealing is done, there is possibility to tamper the fuses if they exist. Hence it is necessary to remove them without any further loss of time.

57. The sealing plier in the control of officers should be kept in safe custody and should not be handed over to other except when they are transferred, in which case the same may be handed over to the successor. A record should be maintained of all the sealing work done with the sealing plier in a chronological order and handed over to the successor for reference and verification.

58. Proper account of seals used by officers and staff should be maintained in chronological order for verification whenever necessary.

59. The seal bits used to H.T. services should be distinctly different from the seal bits used in other services. If the serial numbers are available on the seal bits the details should be noted in the record of seals so that verification could be done whenever necessary.

60. The testing of H.T. meter should invariably be done at site with portable equipment. Wherever such test is not conducted at site the reasons may be recorded and approval from deviation may be obtained from higher Superintending Engineering having jurisdiction.

ELECTRONIC TRIVECTOR METERS

(Extract From Duke Arnics Boollet)

FUNCTIONS

Accurate registration display and transmission at all load Power factors lagging and leading on polyphase supplies of all the following electricity consumption parameters:

True Energy	kwh
True Power	KW
Apparent Energy	KVAh
Apparent Power	KVA
Reactive Energy	KVArh
Reactive Power	KVAr
Power Factor	P.F.
Frequency	Hz
Maximum Demand	KVA or KW

SYSTEMS

3 Phase 3 Wire

3 Phase 4 Wire

CURRENT RATINGS

Secondary transformer operated 5A, 1A per phase.

ACCURACY

Class 1 (1%) to BS5685 standard

Class 0.5 (0.5%) to BS5685 optional

DYNAMIC RANGE

Specified accuracy maintained full load to 2% of full load. Working range 120% of full load to 0.2% of full load.

SUPPLIES

Standard direct connected
415 V 50 hz

Voltage transformer connected
110 V 50 hz

REGISTERS AND DISPLAYS

Three counters on the front register kwh consumption on the counter and KVAh and KV Arh on the other counters. The counters may be set to register consumption in either whole units or decimal multiples or submultiples of one unit. A liquid crystal display indicates Maximum Demand information and also all line parameters.

M.D. INFORMATION

The electronic Trivector meter has the ability to store upto 5 Maximum Demands (MD), these being recorded between meter readings. The MD period can be set for either 15 or 30 minutes. Various power parameters can be displayed for individual and sum of phases via the front panel buttons. These buttons allow examination of the current and 5 previous MD's and other MD information. This information is time into current demand period together with either „predictive" or average demand this period and number of meter resets. Resets are either by a front panel key switch or via the serial link. A reset causes the latest MD to be stored in non-volatile memory – the oldest MD will be lost after 6 or more resets. Meter information is sent out over the serial link every 10 seconds. Non-volatile memory ensures that information is not lost during power failures.

MODE AND FUNCTION BUTTONS

These buttons controls the parameters displayed on the LCD. The „mode" button selects a set of parameters, „function" selects a particular parameter within a set. Repeated use of a button causes the mode of function to be displayed in a cyclic manner as shown in the table below. The exception is the Maximum Demand mode always displays the elapsed time and demand information when first selected.

<i>Mode</i>	<i>Function</i>
Maximum	1. Elapsed Demand period time, Current demand and MD (displayed as mm:ss D xxx Myyy) 2. MD at last reading („MD-1:KVA") 3. MD 2 readings ago („MD-2:KVA") 4. MD 3 readings ago („MD-3:KVA") 5. MD 4 readings ago („MD-4:KVA") 6. MD 5 readings ago („MD-5:KVA")
Maximum Demand Information.	1. Number of MD resets (readings since meter installation.
Red Phase	1. Power Factor 2. KWR 3. KVA 4. KW
Yellow Phase	As for red phase
Blue Phase	As for red phase
Sum of	1. Power Factor and KW phases 2. KWR and KVA 3. KWh and KVAh 4. Frequency and KWRh

ELECTRONIC TRIVECTOR METERS

RESET BUTTON

When operated, this button causes the following functions to be performed:

1. The MD since the last reset is displayed as:

Last MD=KVA for ten seconds after button pressed.

2. This MD is placed in non-volatile memory in the „MD atleast reading" position; the previous „last reading" becomes the value at 2" readings ago" and so on. The old 5 readings ago" value is lost.

3. Ten seconds after the button pressed, the meter resets itself and resumes normal operation.

PULSE OUTPUTS (OPTIONAL) :

Three volt-free relay pulse outputs are provided. These outputs indicate:

Relay 1 – KVAh multiples

Relay 2 – KWH multiples

Relay 3 – KVRh multiples

The „multiples" are set by the PCB switches 3 and 4 from 0.1 to 100.

SERIAL LINK (OPTIONAL)

The 3 pin DIN socket provides full duplex serial input/output capability. The data format is : 1 start bit (logic 1); 8 data bits; 1 or more stop bits (logic 0). The data rate is 300 bit/s Signal levels are +5V for logic 0, -5V for logic 1 with respect to the ground provided. Connections to the socket are as follows.

Pin 1 – Data from meter

Pin 2 – Ground

Pin 3 – Data to meter

SERIAL OUTPUT

Every ten seconds the meter outputs the following information: Meter serial number (SN); MD; KWh; KWRh; KVAh; and number of MD resets (Rsts). No carriage returns are transmitted, line feeds are used to separate the data.

SERIAL INPUT

The meter is currently set up to allow remote MD reset. To do this 2 command are required: the first unlocks the privilege protect ional; the second actually resets the format of the first command is:

s dm CU !

Where s is the source address; d the destination address; m the meter type; ii is an identification code; pppp is a password (for security)

The format of the second command is;

#s d m CR!

Where s, d, m, are as above. These can be replaced by the „universal“ address/type “@”. So for the demonstration models, the following sequence will reset the meter:

@ @ @ CU 1 0 0 4 3 D 5 !

@ @ @ C R !

These Commands will reset the meter as through the manual Reset Key had been used, as described in Section 11.

INSTALLATION

The meter installation procedure includes self test routines, performed by the microprocessor, which ensure that the meter can only be installed with the current transformers connected in the right polarity. If not-warning lights stay on until the CT"s are connected correctly.

APPLICATIONS

The electronic Trivector meters can be used for every situation where accurate measurement of any parameter of electrical energy consumption is required for tariff metering, secondary metering measurement or energy management application. They can be used just a self-contained Trivector Meter, but it can also be used to measure either locally or remotely every function of electricity consumption that could be required all within a single meter. Remote metering, local metering, portable metering, vibration insensitive and machine mounted power and energy metering are a few of the many applications.

- Tariff metering
- Energy management
- Energy auditing
- Energy accounting

- Check metering on supply meters
- Distributed electricity billing
- Machine condition monitoring
- Machine and building consumption profiles
- Maximum demand control
- Component in energy monitoring and control systems.

MECHANICAL

Enclosure	Painted Steel
Dimensions	305x225x110mm (hwxwd)
Weight	1.5 kg
Fixing	Screw brackets top and bottom

ENVIRONMENTAL

Withstands vibration, shock, temperature, humidity, transients, RF noise as per relevant ISI specifications.

(Extract from Duke Arnics)

L.T. SINGLE PHASE AND POLYPHASE METERS

1.00 CONSTRUCTIONAL FEATURES

1.01 The vital parts of an energy meter are :

(i) Main Frame, (ii) Registering Mechanism, (iii) Terminal block, (iv) Bearings, (v) Rotor, (vi) Anticreep device, (vii) Brake magnet, (viii) Electromagnet, (ix) Current coil, (x) Pressure coil, (xi) Coil formers.

1.02 Main frame which houses all the principal parts of the energy meter, is responsible for rigidity of the meter and alignment of moving parts. Hence precision machined aluminum pressure die cast construction which gives rigidity and proper alignment is to be used.

1.03 Energy register is of cyclometer type. Roller type digit wheels are used. The change over is by the help of transfer which engage the next roller.

1.04 Materials used for digit wheels and pinions are with tin lead-die cast alloy which possess good fluidity, lower coefficient of friction, high mechanical strength, stiffness, ability to withstand corrosive atmospheric conditions, ability to withstand extremes of high ambient temperatures and humidity without getting deformed.

1.05 The improvement in the technology of manufacture of materials of energy register is that new plastic materials such as Celcon/Delrin (which are acetal copolymer brands) have been developed. These materials possess a combination of mechanical and thermal resistance properties as well as superior moulding characteristics.

1.06 Terminal block terminates the current and potential leads and allows the main and load connections.

1.07 Terminal block should be designed with thicker webs and sections and with moulded inserts.

1.08 All terminals, as well as connections and terminal screws should be nickel plated.

1.09 Material used for T.B. should be non-hygroscopic and should be moulded from superior quality electrical and impact grade phenol formaldehyde (bakelite moulding powder)

1.10 Lower bearings consists of synthetic sapphire cup jewels on which revolves highly polished spherical pivots/steel ball fitted with rotor shaft.

1.11 The jewel of the meter lower bearings should be highly polished to reduce friction.

1.12 Meter bearings should be self aligning so that any minor misalignment of rotor shaft with axis of jewel assembly may not cause unequal wear of pivot/ball.

- 1.13 The bearing should be spring loaded, to prevent damage due to shock and rough handling.
- 1.14 Upper bearings consist of a highly polished hardened steel needle which guides the top part of rotor shaft.
- 1.15 Rotor materials should be of high purity aluminum having good conductivity.
- 1.16 Weight of the rotor should be as small as possible, in order to have high torque/weight ratio.
- 1.17 The two methods adopted to prevent creeping in meters are (i) by providing two holes in the disc, (ii) by attraction between a steel wire provided in the spindle and a projected vane from voltage electromagnet.
- 1.18 The best magnetic material (for brake magnet) available for meters presently is ALNICO grade.
- 1.19 ALNICO grade material possesses high connectivity which makes it immune to the effect of external magnetic fields.
- 1.20 ALNICO grade material also possesses low temperature coefficient which ensures minimum changes in meter error with variation in ambient temperature.
- 1.21 The current and potential electromagnetic cores are manufactured from low watt loss depramo grade electrical steel sheets.
- 1.22 Current coils are manufactured out of super sympathetic enameled copper wire preferably with polyester based enamels and should be of medium coating.
- 1.23 Voltage coils should be wound from polyester based medium covering super enameled copper wire.
- 1.24 By using good quality enameled wire, chances of burning out of voltage coils are reduced.
- 1.25 The voltage coil should be so designed that it should be able to absorb surge currents due to lighting and sudden fluctuation in voltage.
- 1.26 Coil formers should be of high thermal resistant and hygroscopic insulating material.
- 1.27 Voltage coils are encapsulated with non-hygroscopic material to prevent ingress of moisture which may lead to failure of insulation.

2.00 DESIGN PARAMETERS OF ENERGY METERS

2.01 The various design parameters of an energy meter are (i) Driving torque, (ii) Weight of rotor; (iii) Watt loss of pressure coil, (iv) Speed of rotation, (v) Gaps above or below rotor, (vi) Current density; (vii) Efficiency Factor, (viii) Permanence factor; (ix) Polish level of jewel and ball surfaces.

2.02 In order that calibration of meter remain the same, it is essential that, flux, Φ , of the permanent magnet (which depends on the strength of permanent magnet) and resistance, R , of eddy current paths which are induced in some part of moving system due to the placing of brake magnet (which depends on temperature changes) should remain the same.

2.03 The permanent magnet should retain the strength throughout the life of the meter.

2.04 The temperature variations should be abnormal,.

2.05 CBIP has specified that the minimum torque for S meters should be 4 gm cm and that the minimum torque for 3 meter should be 8 gm cm, when the meter is carrying basic current a upf.

2.07 Frictional torque should be reduced to minimum as frictional forces affect the speed of rotor and cause large errors.

2.07 Frictional force which is comparable to load at low loads, make the meter registration lower than actual consumption.

2.08 Frictional forces are limiting factor on the weight of the disc.

2.09 CBIP has specified weight of rotor not be exceed 18 gm.

2.10 For the meter to be more efficient, power loss in voltage coils should be least.

2.11 CBIP has specified that the active and apparent power loss in each voltage ckt of a meter at reference voltage, reference temperature and reference frequency shall not be more than 1 W and 6 VA.

2.12 For achieving low power loss in voltage coils, it is recommended to use electrolytic grade enameled copper wires.

2.13 The gauge of the copper wires is specified to be between 40 SWG and 45 SWG.

2.14 Increase in the speed of the rotor disc results in increase of driving torque as well as increase in frictional torque.

2.15 Speed of rotation of disc also has an effect on life of bearings.

2.16 CBIP has specified that speed of meter rotor shall not exceed 72 rpm for S and 50 rpm for 3 at rated maximum continuous current.

2.17 Greater the separation of Poles, greater is the chance that eddy currents will not pass between them and therefore no torque.

2.18 If the gap above or below the rotor is too small there is a chance of the disc getting stuck up.

2.19 CBIP has specified that gap above and below the disc shall not be less than 0.5 mm.

2.20 The air gap of electromagnets and permanent magnet shall be 2.2 to 2.6 mm and the air gap shall be uniform.

2.21 Current coils should be so designed that they are capable of carrying full load current continuously.

2.22 Cross section of the conductor to be used should be so designed so as to keep I^2R losses to the minimum and to enable the meter to be overloaded continuously without overheating.

2.23 CBIP has specified that cross section of the conductor used should be such that maximum current density at basic current should not exceed 1000 amps/sq.inch, i.e. 1.55 amps/mm².

2.24 CBIP has specified that at rated maximum continuous current the maximum temperature rise of the conductor should not be more than 10⁰ Cover the ambient temperature.

2.25 Efficiency factor n = permanance factor/power loss in voltage coil in watts.

2.26 Higher the power loss in voltage coil, the lower is the Efficiency factor.

2.27 Permanance factor = [Torque (gm-cm)x100] x Rotor speed (rpm).

2.28 To achieve higher efficiency torque should be more, rotor weight should be less and rotor speed should be low.

2.29 CBIP has specified that the lower bearing shall be either single jewel or double jewel with tungsten carbide ball or magnetic suspension bearing.

2.30 The synthetic sapphire cup jewel on which revolves the highly polished spherical steel ball, should be highly polished, as high polish level reduces friction.

2.31 Sapphire has a hardness of 9.

2.32 CBIP has specified that upper bearing shall be hardened and highly polished rust resisting stainless steel pin of minimum 0.5 mm dia.

2.33 Top bearing pin should be centered properly and should have proper strength so that rotor disc can move freely.

2.34 CBIP has specified polish level of jewel and ball surfaces, to be not less than 50%.

3.00 METER TESTING PROCEDURE POLYPHASE

- 3.01 All the equipment is set up on a meter test bench capable of handling 10 No. meters at one time.
- 3.02 Change over switches for power factor are provided in each phase.
- 3.03 For upf phase sequence in RYB. For 0.5 pf phase sequence is BRY.
- 3.04 The current coils of both R.B.S. meter and MUT, i.e. meter under test are connected in series, and the potential coil in parallel.
- 3.05 Performance of meter should be checked up at full load upf, full load 0.5 pt lag, 1/10 full load upf.
- 3.06 For long range meters, say 5.20 Amps, lb i.e., basic current is 5A. and I_{max} i.e. maximum current is 20 Amps.
- 3.07 The meter should start at 0.375% rated current for cyclometer type register and 0.25% of rated current for dial and pointer type registers.
- 3.08 For full load upf test, pressure coils are connected across rated supply voltage and rated full load current at upto passed through current coils.
- 3.09 The position of brake magnet is adjusted (for full load-upf test) to bring the meter speed within required limits of error.
- 3.10 The permissible errors are +2%.
- 3.11 The required calculation for evaluating the error is as follows :
- For a 3 Phase 10 Amps meter.
- Meter constant is 240 rev/KWh.
- RSS constant is 100 rev/kWh.
- $MUT \text{ constant}/RSS = 240/100 = 6.25$
- i.e. for every revolutions of MUT disc, RSS should record 2.5 revolutions.
- If this is so, then MUT has no error.
- 3.12 Revolutions in RSS can be read upto second decimal place.

3.13 There is a red mark on MUT's disc over a small length while counting the revolutions one has to select one and means where the beginning of the marking crosses the centre point or the end of the marking crosses the centre point. This is to be followed for "CLICK ON" as well as "CLICK OFF".

3.14 If suppose, corresponding to 6 revolutions of MUT (for 3 Phase, 10 Amps meter mentioned in 3.11) RSS makes 2.4 revolutions.

$$\text{Then \% error} = 2.5 - 2.4 / 2.5 \times 100 = 4\%$$

This means MUT is faster.

But RSS too has an error.

Let RSS have an error of + 0.5%

$$= \text{Net error} = +4 + 0.5 = +4.5\%$$

3.15 If suppose, corresponding to 6 revolutions of above said MUT, RSS makes 2.65 revolutions.

$$\text{Then \% error} = 2.5 - 2.65 / 2.5 \times 100 = -6\%$$

This means MUT is slower.

$$\text{RSS error} = +0.5\%$$

$$= \text{Net error} = -6 + 0.5 = -5.5\%$$

3.16 For full load, 0.5 pt lag, pressure coils are connected across rated supply voltage and rated full load current is passed through current coils at 0.5 pt lag.

3.17 Full load, 0.5 pt lag test, adjustment is made by means of loop on potential core or resistance phase loop on current electromagnet with a clamp.

3.18 1/10 full load upf; rated supply voltage is applied across pressure coils and a very low current (1/10 of full load current) is passed through the meter at upto.

3.19 Creep test: All meters are to be tested for non-registration with the voltage ckts alone energized at 10% over voltage with current ckts open.

3.20 While conducting creep test, if the meter is found to be creeping then meter is to be adjusted. After the adjustments are done, errors at 1/10 full load are to be rechecked.

3.21 The two adjustments generally provided to prevent creeping of meters are (i) an iron wire on the shaft, near to the end of the potential core (ii) two diametrically opposite holes in the disc.

3.22 Dial test is performed after full load-upf, full load 0.5pt lag, 1/10 full load upf, creep test are performed and meter adjusted to run within permissible limits of error.

3.23 During dial test, the load is to be light load at upf.

3.24 The initial reading of the meter during, dial test is usually 99997 or 99999 and the test is continued till 00000 is obtained.

3.25 By the dial test it is ensured that apart from the meter revolutions being accurate for different loads and power factors, the drive is communicated to the cyclometer and that the final registration by the meter with reference to load connected is within limits of accuracy.

3.26 After conducting the tests discussed, potential links which were kept removed, should be properly fixed.

3.27 Before proceeding with testing, it should be ensured that the disc rotates on all three phases.

3.28 Sometimes it so happens that the disc does not rotate on all three phases then the lower bearing is to be adjusted.

3.29 Sometimes it so happens that the disc rotates in two phases and does not rotate on the third phase. Then the terminal connections of that particular phase and connected coil should be checked.

3.30 If the disc stops rotating during the course of testing then lower bearing should be adjusted and all the tests should be repeated.

3.31 While putting meter cover in position after testing, it should be ensured that the gasket is tight.

4.00 TESTING OF SINGLE PHASE METERS

4.01 For obtaining upf, current coils of both RSS and MUT are connected in series to „R" phase and neutral of supply source, via loading Transformer.

4.02 For 0.5 pt lag, the loading Transformer terminals are connected across neutral and „B" Phase of supply source.

5.0 PERIODICITY AND TESTING PROCEDURES

5.01 The following periodicity of testing of meters is to be followed :

Single Phase meters – 5 Years.

Three Phase meters – 3 Years.

5.02 Permissible errors as per I.S. 722 are as follows :

<i>Single Phase meters</i>	<i>3 Phase meters</i>
upto full load +2%	upto full load $\pm 2\%$
upto 1/10 full load +2%	upto 1/10 full load $\pm 2\%$
0.5 pt full load +2%	0.5 pt full load $\pm 2\%$

5.03 Meters should be tested for no creep at 110% of rated voltage on no load.

5.04 The meters should be tested for their starting at 0.25% of rated current for meters with dial and pointer type of registers and 0.375% or rated current for cyclometer type registers.

5.05 The torque of rotating disc should be capable of driving all the digits employed on the cyclometer digit counter even at low loads.

5.06 Energy meters in service should be capable of recording 10,000 units in case of Single Phase and 1,00,000 units in case of 3 Phase meters before one complete cycle of registration is over.

6.00 CODE OF M.R.T. LABORATORY PRACTICES

6.01 New meters are received at Stores, tested at the manufacturer's premises. Wherever the tests done at works are witnessed by Board's Engineers and sealed there itself the meters can be directly issued to the field for use, by the district stores.

6.02 In case the meters are not tested as above (as in 6.01) they have to be tested at M.R.T. Lab and got sealed by A.E./M.R.T.

6.03 A.E. is the custodian of the sealing plier. It should be kept in a cash chest and the key should be with A.E. only. Under no circumstances, the plier should be taken out of M.R.T. Lab.

6.04 Before accepting any meter in the M.R.T. the seals are to be inspected and ensured as genuine.

6.05 Unless otherwise a complaint is made or any inspecting authority such as D.P.E. etc. specially requisitions for, the meters received for periodical overhaul are to be got thoroughly cleaned after cutting the seals and then tested and adjusted.

6.06 If the meter is requisitioned for or challenged by the consumer etc. the meter has to be tested in the presence of the consumer and/or the requisitioning authority such as A.D.E./D.P.E. etc.

6.07 For the challenge meters the errors before adjustment are to be taken and duly recorded. The results of the test (BA reading) are to be communicated to all concerned including billing Section, A.A.O./E.R.O.

6.08 Signatures of consumer and Board's Officers are to be obtained on the test record.

6.09 New meters received from district stores are generally sent to M.R.T. in batches of 500 Nos. or 1000 Nos. depending on the availability of space at M.R.T. Lab. The meters will be sent on T. Note.

6.10. M.R.T. will arrange testing of above new meters and the district stores on hearing from M.R.T. will arrange to take back the tested meters on T. Note.

6.11. Meters found defective, will be returned by M.R.T. on T. Note and the Stores has to arrange for rectification, as per terms and conditions of the Purchase Order, by the manufacturer.

6.12 In case the meters are rectified by M.R.T. at the request and concurrence of the manufacturer, the cost is to be recovered from the Company and this should be arranged by A.D.E./District Stores.

6.13 If the meter is found to be burnt, when receiving from field officers, it should be immediately reported to the superior officers if it is a case of deliberate burning.

6.14 Condition of seals on the meter with details of numbers and impressions is to be checked before accepting meters from field.

6.15 Meter reading available should be checked up with reference to the change slip.

6.16 All incriminating evidence of tampering like drilling of holes, breakage of glass, loosening of gaskets with scope for insertion of wires etc. to interfere with running of meter or registration are to be examined while receiving a meter.

6.17 Meter requiring rectification should be centralized at M.R.T. Lab and rectified and tested.

6.18 For all meters found burnt or damaged, M.R.T. should arrange their rectification by replacing the parts etc.

6.19 Where it is not possible or economical to rectify the meter it is to be arranged to be survey reported by M.R.T. and devaluated as scrap to stores.

6.20 Before devaluating all useful parts are to be removed and used as spares by M.R.T.

- 6.21 A register of spares retained and utilized is to be maintained by A.E./M.R.T.
- 6.22 All old meters received at M.R.T. should be got painted by M.R.T. after repair and testing and before they are delivered to the field.
- 6.23 Record of all meters received should be maintained by M.R.T. preferably field section-wise.
- 6.24 A record of all meters issued to the field is also to be maintained by M.R.T.
- 6.25 An account of seal bits indicating the seals used on the meters, meter-wise. In case of numbered seal bits, numbers are also to be noted.
- 6.26 A test record of meter testing, meter-wise duly attested by the tester is to be maintained.
- 6.27 Tester is personally responsible for the accuracy of meter.
- 6.28 Meters involved in theft of energy or referred to M.R.T. Lab. for testing in the presence of consumer, or meters challenged by the consumer are to be tested at M.R.T. Lab. on any working day and advance intimation by registered post is to be given to all concerned.
- 6.29 A record of observation of all meters referred to M.R.T. including their test results are to be maintained by A.E./M.R.T. of such testing on such dates.
- 6.30 A record of observations of all meters referred to M.R.T. including their test results to be maintained by A.E./M.R.T.
- 6.31 Copies of test reports are to be communicated to all concerned by A.E./M.R.T.
- 6.32 Only zig zag plier is to be used for sealing by M.R.T.
- 6.33 It should be ensured by A.E./M.R.T. that impressions of the seals and seal numbers are clear before issuing them to field officers.
- 6.34 It should also be ensured by A.E./M.R.T. that gaps are not available between top and bottom covers, gaskets are tight enough with no scope for any insertion, meter glass is secure and tight, meter cover is free of holes.

7.00 SUMMARISATION OF SALIENT POINTS

- 7.01 For the given accuracy class, the errors of the meters should remain within the accuracy band from say 5% of I_b to I_{max} both at upf and 0.5 pt lag, over the full life of meter. This aspect is the seal index of performance of the meter.

7.02 Friction in the counter and poor quality of bearings give rise to very high value of frictional torque. The initial compensation provided no longer remains valid.

This gives rise to slow/stuck up/stopped meters especially at low loads.

7.03 It is suggested not to resort to larger air gaps as there is a chance that eddy currents will not pass between the poles and hence no torque.

7.04 Meters with high torque fail to satisfy „sustained accuracy“ test.

7.05 Of all the frictional forces, friction in the register (cyclometer mechanism with rollers) is more detrimental.

7.06 The three undesirable damping torques in an energy meter are (i) Self damping torque due to voltage electromagnetic flux, (ii) Self damping torque due to current electromagnetic flux, (iii) Damping torque due to friction.

7.07 Self damping torque due to voltage electromagnetic flux can be eliminated by using quality laminations.

7.08 Self damping torque due to current electromagnetic flux can be eliminated by overload shunting.

7.09 Damping torque due to friction can be eliminated by proper design of registering and bearing mechanism,.

7.10 Specifications of C.B.I.P. should be adhered to.

7.11 In order that the rotor disc can move freely, top bearing pin should be centred properly and should have proper strength.

7.12 Fixing of window glass shall be such that it is dust proof and tight.

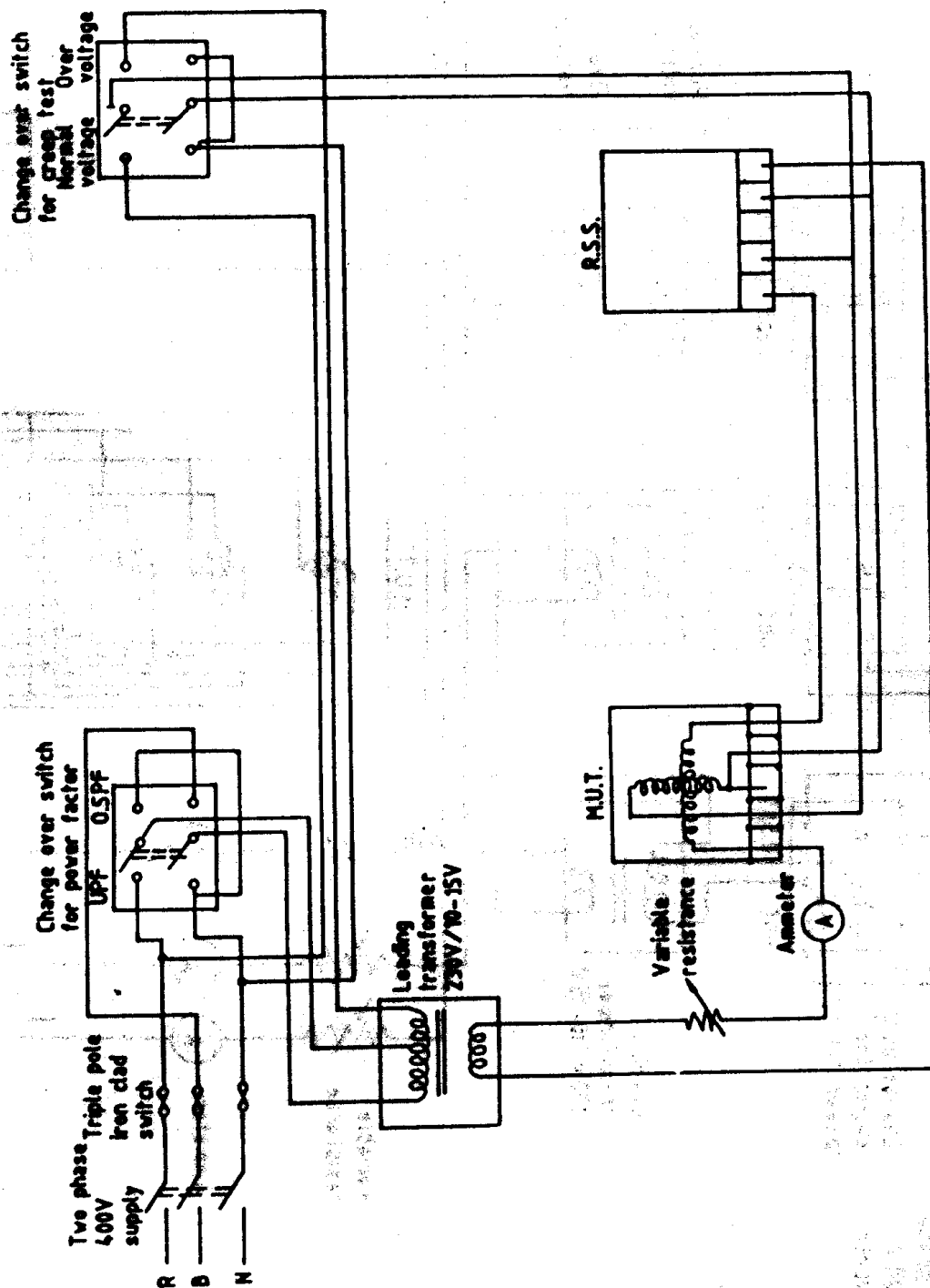
7.13 Rotor disc should be complainer so that it does not touch the brakemagnet and result in stoppage of meter.

7.14 Total frictional retardation torque can be reduced by reduced by reducing weight of worm wheel, digit wheels and transfer pinions.

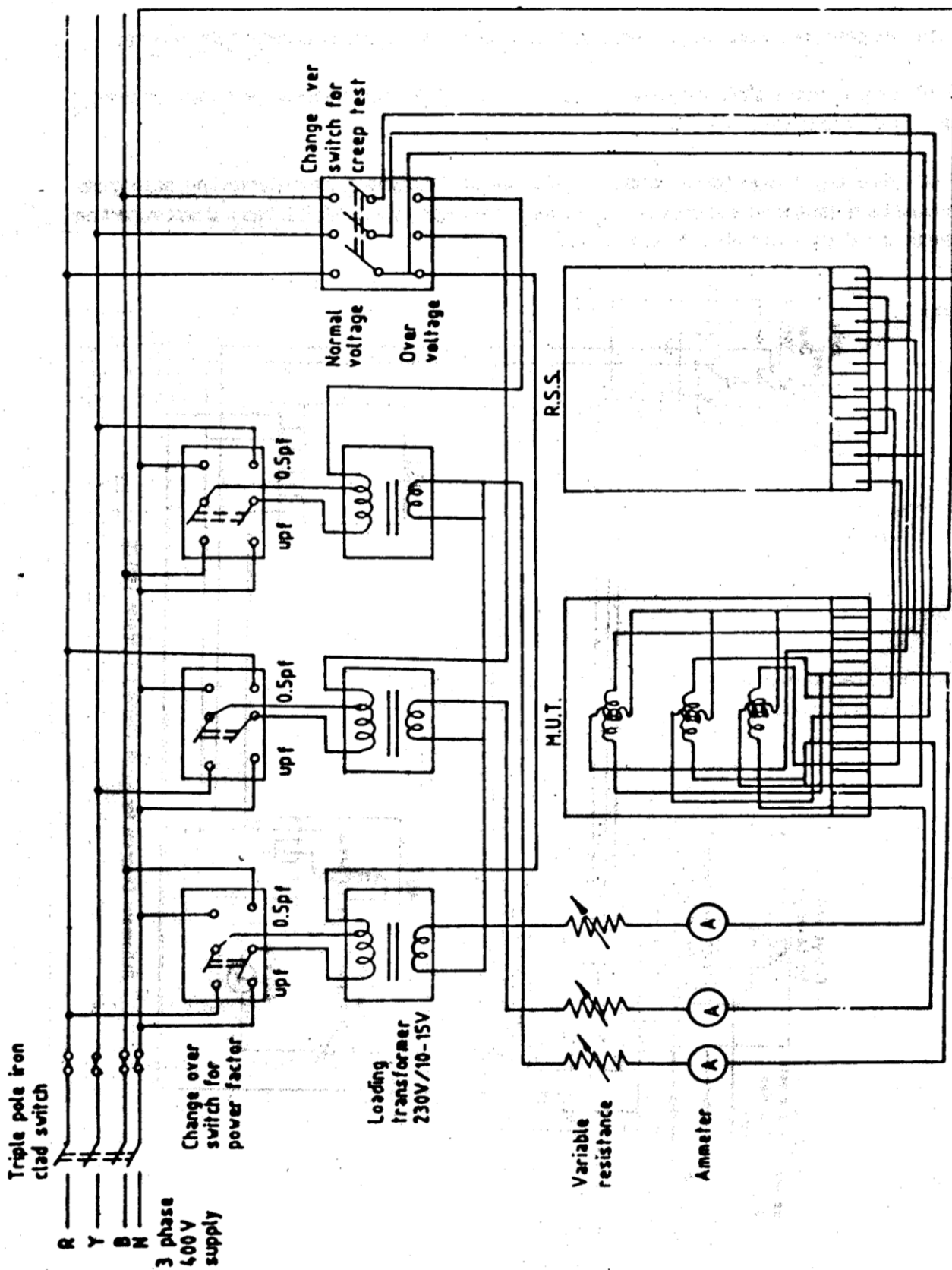
7.15 All gears shall have regular shape and free burns or irregularity to avoid tight gearings.

7.16 Digital drums shall withstand temperatures of 100° C continuously for 5 minutes without distortion or softening.

8.00 As energy meters have bearing on the revenues of the Board, the meter testing sealing etc. should be regarded as a sacred duty. Effective supervision by A.E./M.R.T. has a direct impact on the financial resources of the Board.



Schematic Diagram for Single Phase L.T. Meter Testing



Schematic Diagram for L.T. Polyphase Meter Testing

STATIC (ELECTRONIC) ENERGY METERS

Static Energy Meters are utilized now-a-days at HT Services and LT High value Industrial services. The Static energy meters are microprocessors based. The programmability of microprocessor has become a useful tool to incorporate different features like Tamper data, Import-Export, Time-of day metering, load pattern analysis, Remote meter reading etc. The availability of such meters made it possible for the Electricity Boards to evolve new metering concepts to cater to the requirements of utilities and consumers. The other important development is the advent of information technology, which now provides solution to the management and interpretation of large masses of data, handheld devices are used to gather information and transport the same to the larger computers at the utilities for Onward Processing.

The principles of measurements used in electromechanical systems and the equations governing the measurements are still the basis for processor based meters. Only difference is that, these equations are implemented with digital algorithms.

For example: single-phase active power is given by:

$$Kw = V_{rms} I_{rms} \cos$$

This can be written as

$$KW = 1/T \dots \int V I . dt$$

Where V is the instantaneous magnitude of voltage

I is the instantaneous magnitude of current and

T is the time period = 1/f

This integral measures the area under a curve obtained by voltage and current wave forms.

In discrete form, suitable for implementing with a processor based meter, this equation can be written as

$$kw = 1/N \sum_{k=1}^{k=n} V_k I_k$$

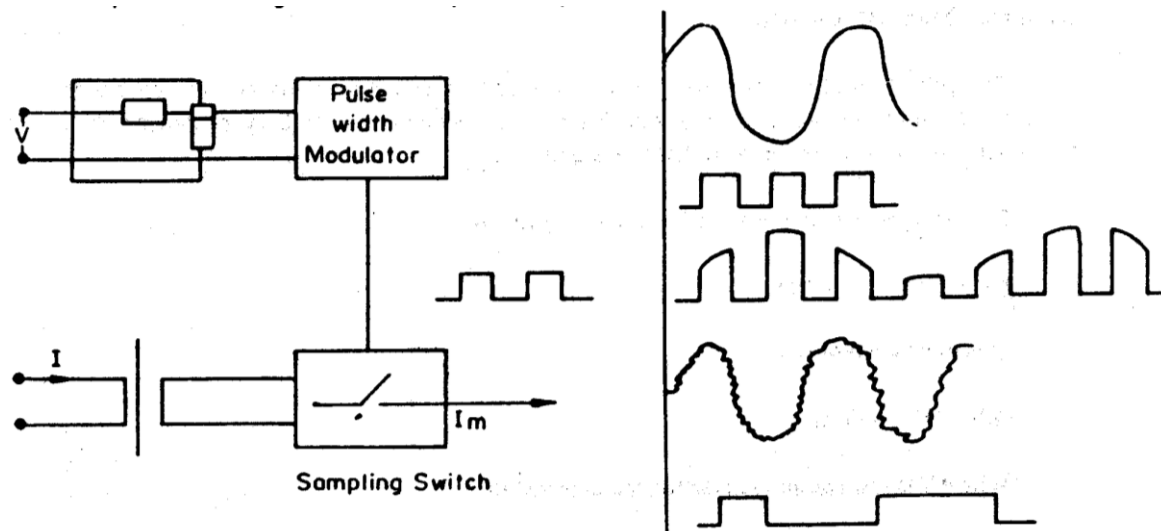
Where V_k and I_k are the sample of voltage and current taken simultaneously, n is the number of samples obtained in one period. The power is integrated over the time period to get the energy.

There are several techniques associated with solid state metering the various techniques differ mainly in the type of multipliers used. These are briefly described below.

1. Mark space amplitude Multiplier
2. Hall Multiplier
3. Analog to Digital Conversion and sampling

Mark Space Amplitude (MSA) Multiplier

In this type, multiplier voltage V is transformed in to pulses which is linear function of voltage (voltage to time conversions). These pulses are then amplitude modulated by current I . The integration of resulting signal is proportional to the energy when time energy reaches a predefined level, the integrator delivers an output pulse which is then processed, the figure illustrates a simplified block diagram of a mark-space multiplier.

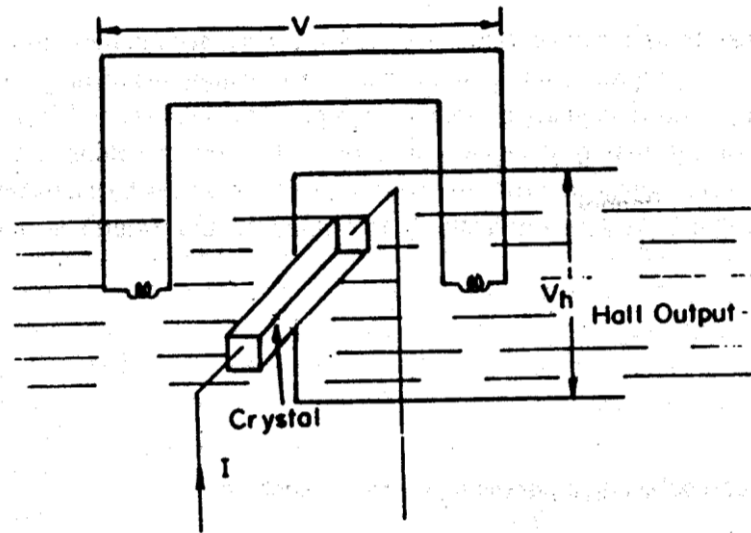


Figure

Samples are taken from the voltage to the pulse width modulator at a rate of some definite frequency. As an output, a pulse frequency is received, the mark-space ratio of which is varying according to the value of instantaneous input voltage. The voltage output signal is used to drive a sampling switch. Height of the output pulses are proportional to the instantaneous values of the current. At the output of the multiplier there is thus a signal, the pulse width of which is proportion to the voltage and height to current i.e., the average value of the signal is proportional to the electric power. The wave forms are shown in Figure 1.2. M/s Schelumberger Industries Meter use MSA Technique for measurement of energy.

Hall Multiplier

A potential difference is developed between opposite sides of current carrying conduct subject to a transverse magnetic field. This is called Hall effect and the potential difference, Hall voltage. The current carrying conductor is a semi conductor called Hall Generator. Hall voltage proportional to the product of the two input variables, current and flux.



Figure

The Hall effect is derived as a potential difference V_h which will appear across the width of a hall crystal when current, I , flows along its length as shown in figure 1.3. and placed in a magnetic field, at right angles to these two direction, then Hall output is given by:

$$V_h = \frac{KBI}{t} \quad 10$$

V_h = Hall voltage in mv

K = Hall co-efficient of conductor is $\text{Cm}^3/\text{coulomb}$

I = Current in ma

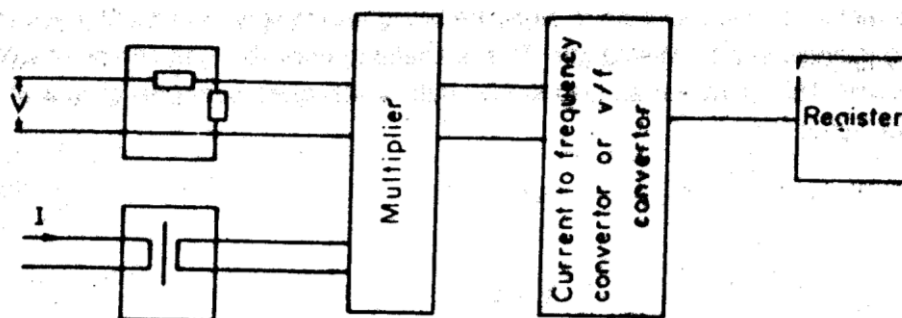
B = Flux density in Kilo causs

t = Thickness of plate in cm

M/s L&G Static meters use Hall effect principle for measuring energy.

Analog to Digital Conversion and Sampling

The simplified block diagram is shown below :



Figure

- (b) C.T. polarity reversal: The meter can also give information regarding availability of load /current. The meter can also register the non-availability of load in a particular phase compared to the other phases.
- (c) Phase Sequence Reversal: The meter can also recognize proper phase association.

The input voltage and currents are isolated from the line and sensed through internal potential and current transformers. The power supply voltages required to operate the electronics is derived from the input line voltage. The voltage and current are sampled at suitable sample frequency and converted to digital form by analog to digital converters. Then these values are fed to the microprocessor. The multiplication of both voltage and current values is done by the microprocessor and displays the energy. M/s. Duke Arnics and M/s. P.I. Industries (secure Meters) use this principle of measurements.

Static Meters

Tamper Data

The static meter can detect date pertaining to tamper such as

- (a) Missing potential: Gives the informant on regarding missing of supply to the potential coil and records the date and time of such occurrence.

Time-of-day Metering

The processor based electronic (static) meters have build-in Real-time clock. So the time available in a day i.e., 24 hours is divided into different time zones. The duration of each time zone is programmable and the user can define their time zones as per his requirements. The meter records the energy consumed in different time zones in separate registers and exhibits accordingly. This is known as Time-of-day metering. This system is very useful for utilizing the available electrical energy in an optimum way.

By revising different tariffs for peak and off-peak energies, the consumption during peak-loads can be discouraged. This helps in demand-side management by flattening the peak of the demand curve.

Load Survey Data

The static meter has the provision to store the billing and tamper data for 35 days at the specified logging interval, say 15 Mts/30 Mts. This is useful to draw the load curves of KWH & KVAH, KVA & KVAH. This is known as load survey data which gives complete picture of load pattern of that consumer.

Import/Export Metering

The static meter can measure the energy in both direction etc., the consumer acting as a load for some time and feeding into the grid for some other time. This is known as Import/Export metering.

Meter Reading Instruments

The meter reading instrument (MRI) is a simple hand held terminal used for data transfer from/to meter to/from the system-computer. MRI can be used for data transfer from HT trivector meter for analysis of data & billing. The MRI can be preloaded with meter numbers to be read and optionally the MRI can also have a bar code reader. The bar code reader will be useful to identify the serial number/identify of meter. In case of H.T. services with load survey data, MRI is very essential for transfer of data from meter to computer as the data collected is enormous and is not possible to read manually.

The MRI can also be used for LT energy meters. MRI can also be made to have a printer attached to it and a bill can be generated immediately upon reading the meter. In this case the MRI shall contain the meter serial numbers to be read and the previous reading. The entire data can be off-loaded at the end of the day.

Telemetry

Transfer of metered data through a communication network is known as telemetry. The meter shall be connected to say a telephone line at the consumer end via a Modem. At the system end also the computer is connected to the telephone via a modem. Whenever data is to be accessed by the computer, the consumer telephone number host be : dialed, and the modem connected to the telephone will connect to the meter. This type of metering system can be very useful in case of H.T. services as well as substation/services which require constant monitoring.

Prepayment Meter

Prepayment meter is essentially an energy recorded cum controller. Controller in the sense that, after the energy at credit is exhausted, the power is switched off to the consumer. In prepayment system, the meter reading, issue of bill and billing data updation is all done by the consumer himself. The meter has a card which shall contain identification number, current reading meter category type, energy to be credited on his card.

Also the computer checks.

- (i) Whether it is valid card/service
- (ii) Recognizes the category
- (iii) Takes the present reading
- (iv) Number of units credited will be encrypted

Later the consumer takes back the card and inserts the card into the meter, whereby the meter updates the units on credit. If all the units at credit are consumed the meter supply disconnects the power supply.

PREPAID METERS – A NEW CONCEPT

Introduction

Payment before use of electricity by the consumer will eliminate difficulties involved in reading of energy meters periodically, preparing bills and collection of revenue. Under this scheme, the consumer buys a specific number of units of energy as per his requirement by paying the cost in advance. The electricity metering devices (consumer's meter) have the facility to read and store the number of energy units bought by the consumer, to subtract the energy consumed by the user and to cutoff the main supply on exhausting the units.

Prepaid meters have been in existence for over a few decades in the form of coin-in-the-slot electricity meters. In these meters a coin (say one rupee) is to be inserted to obtain one unit of energy. Such meter present enormous administrative problems. Consequently the methods of implementing the pre-payment schemes have undergone a sea change. This became possible mainly because of the advances made in the field of electronics. In this paper, the latest electronic methods used for prepaid metering are presented and a scheme for implementing it in the Indian conditions is proposed.

Prepaid Meter is an Element in a Revenue Collection System – a Schematic View

Fig. 1 illustrates the use of prepaid meters as an element in a revenue collection system. It may be seen from this schematic that the previous (pay after use scheme) activities of periodic meter reading, preparation on bills, collection of revenue, monitoring of revenue and issuing disconnection notices are all replaced by just two activities, namely:

1. Vending of pre-payment device.
2. Monitoring for fraud.

For both the above activities a single computer is sufficient as described later.

3. Facilities Required in a Prepaid Meter.

Fig. 2 illustrates the Facilities required in a prepaid meter. While some of the facilities are essential, some of them are optional. The consumer buys his pre-payment device (detailed more in the later sections) from any of the EROs which are distributed geographically.

The pre-payment device contains details on :

1. Consumer number against which the pre-payment was made.
2. Number of units for which the pre-payment was made.
3. Present rate of tariff.
4. Maximum credit allowed in lieu of the deposits already made with the utility.

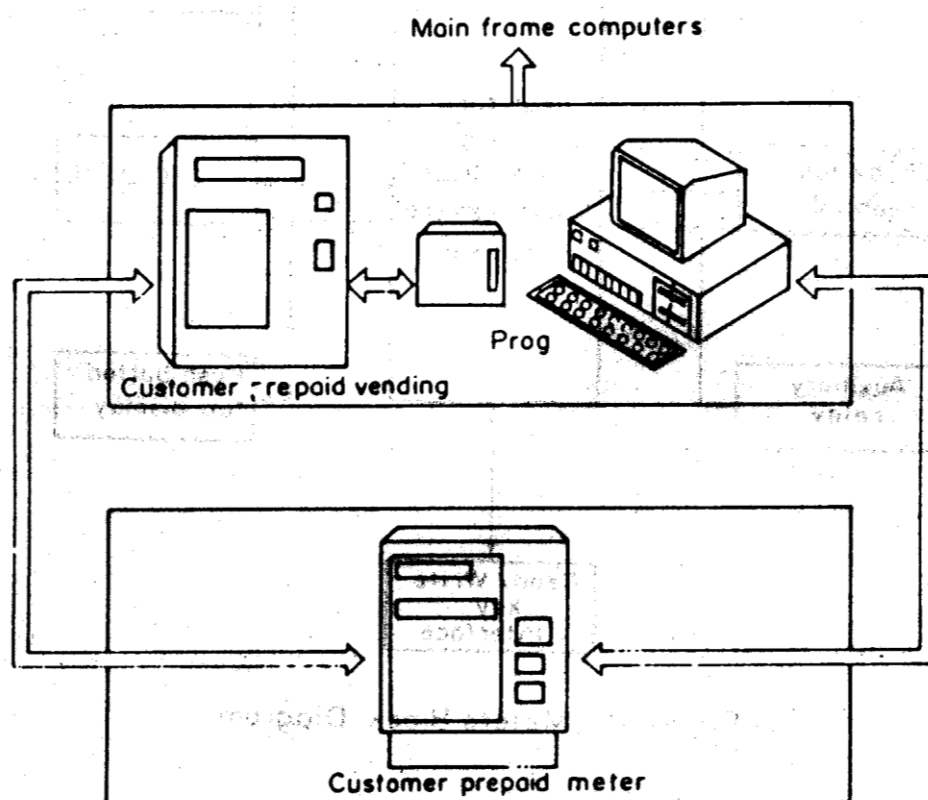


Figure 1 : Prepaid Revenue System

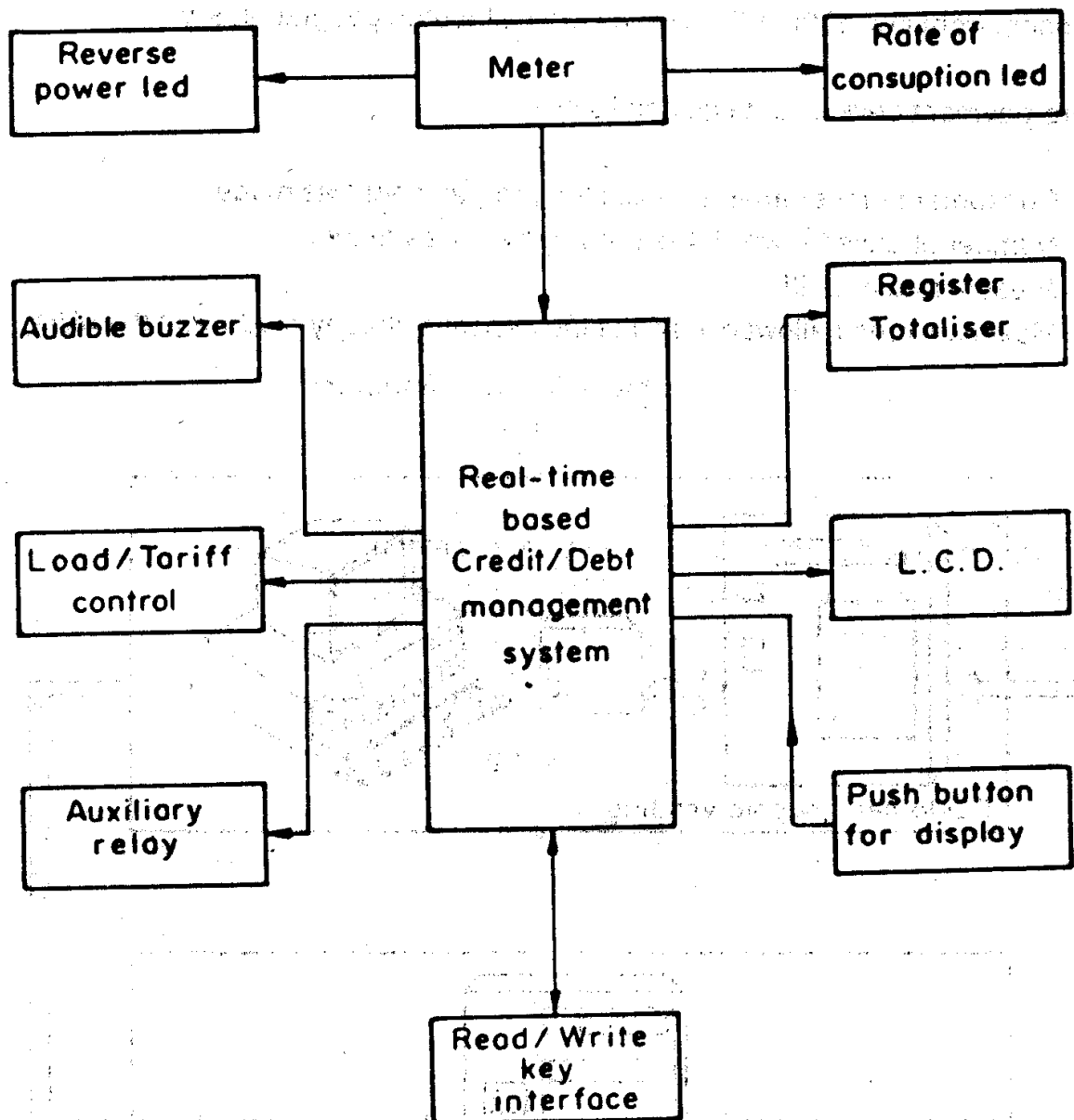


Figure 2 : Meters Block Diagram

The information on this device, when inserted into meter, will be transferred into the meter and the meter automatically cancels the pre-payment advice, so that the device may not be used again without further payments.

The meter now updates the credit available by adding the balance of the previous pre-payment advice with the current payment advice and reads backwards showing the balance amount of energy due to the consumer. When the balance is reduced to a minimum level, an audible buzzer is actuated for about ½ a minute. When the consumer ignores this warning and continues to use the electricity, when the balance reaches zero the power is automatically cut – off.

In a more sophisticated system a credit may be allowed which will be subtracted when the next payment advice is received by the meter. Also when different types of tariff (like TOD), the Real Time clock calendar takes care of the different energy rates for different timings.

Pre-Payment Methods

The old methods of pre-payment is by “coins-in-the –slot” where the consumer puts in cash or tokens bought from the utility company.

In either of the above cases, collection of revenue is conducted at the consumers premises. Administratively, it is very difficult to transfer the cash or tokens from the consumer location to the utility office. This method is highly susceptible to frauds and thefts. Also the locks on the coin meter can never be made so strong as to withstand the outside break-ins.

Fortunately, the development of electronics and its application to credit card markets have thrown in many choices to improve the pre-payment methods. Of the many methods available, the following two methods are becoming more and more popular.

1. Key type vending
2. Card type vending

The Customer Key is designed to be inserted into the meter's key receptacle which is fully isolated from the meter's electronic circuit. The key comprises an overmoulded P.C.B. Supporting a 1K bit EEPROM. The key contacts are of nickel plated copper with a gold overlay giving a life expectancy in excess of 10,000 read/write operations. A space is provided on the key for individual identification markings.

The customer key is primarily for use as a high security means of transferring credit to the customer meter. The individual customer key is personalized to that customer's particular meter and cannot be used with any other meter.

As well as being able to read and transfer meter readings from the meter back to the point-of-sale equipment, the key can be programmed with all the necessary parameters. These can be transferred to the meter along with the credit information. Without any changes to the key or the meter, the future expansion of the key system to cater for automatic key parameter updates direct from the mainframe computer via the point –of –sale equipment can easily be achieved. Key vending and programming facilities need to be fully supported by a comprehensive maintenance and after sales services.

The second system consists of customers magnetic cards available, in fixed denominations, say Rs.50,100,500. It is like a credit card and carries a magnetic code. This is simply inserted into the card slot of the meter. If the card is valid, its value is credited to the meter, its code automatically erased and visually and actually marked to prevent further use. The meter also has a facility to count the number of cards inserted and registers the total value inserted in the meter. The card can be bought from any of the registered vendors, who charge a nominal fee for the service.

The choice of any one of the above systems, depends on the following.

- A. Integrity of the vendors
- B. Security level for communication with meters and
- C. Level of monitoring for fraud.

Design Approach of Duke Arnics Towards Prepaid Metering Systems

In order to minimize the cost and also taking into the account that mechanical meters are already existing at all the places, Duke Arnics is proceeding on the following lines, in the field of prepaid metering system.

Duke Arnics proposes to use the existing electromechanical meter for metering purpose and introduce an add-on controller for conversion to a prepaid meter. The pre-payment advise will be in the form of a „SMART“ module , which is similar to a credit card.

This module contains an EEPROM, which will be loaded with the desired number of units along with the consumer code at the EROs or other commercial officers. At the time the consumer pays for the energy units. The unit module will be given to the consumer after programming the above information. He will take it to his meter controller and insert it into the slot provided on the front. The meter controller would read the contents of the memory and store in its own memory.

The control electronics circuit coupled to the energy meter constantly checks the number of energy units available in the memory. If adequate units are there, it switches on the contactor to provide power to the consumer circuit. While measuring the energy consumption, the control circuit increments a units consumed register, at the same time, decrements the „units available“ register. Once the value in the units available register reaches below a certain prefixed number, an alarm flashing light will be switched on an optional audio alarm (buzzer) can also be provided on request.

At this situation, if a unit module with more energy units is inserted, the same will be added to the already existing number of units available and the alarm will be switched off automatically. Otherwise, once all the units in „available" register are decremented to zero, the control circuit will switch the contactor off cutting out supply to the consumer circuit. The supply will be resumed only after loading units into the meter"s units available register by inserting the units module with more units.

The above design will provide a cost effective prepaid metering system. Infact, it is during the discussions with APSEB engineers that this add-on controller concept has originated.

Conclusion

The common question that is commonly asked regarding prepaid system is whether prepaid metering is relevant to Indian conditions? The prepaid meters are equally , if not more, relevant to our Indian conditions. The number of consumer are continuously increasing, making routine methods of billing more and more difficult due to sheer volume along. Added to this, the man-power costs are no longer "negligible" as it was a few years ago.

Further, introduction of these meters will eliminate the complaints regarding the billing from the most vocal sections of the society. Now the ball will always be in "their" court.

The direct benefits of these prepaid meters are improvement of financial flow to the utilities and ease of monitoring the frauds. These reasons alone justify the use of prepaid meters.

TESTING PROCEDURE FOR STATIC H.T TRIVECTOR METERS

The electronic ETVMs at the H.T.Services are tested annually for accuracy and the following procedure is followed.

- 1) Recording of parameters by Static TVR is checked through mode / function switch manually .
 - a) Voltage between each phase and neutral.
 - b) Current in each phase.
 - c) KWH,KVAH, KVARH (lag and lead)
 - d) Max. MD reached so far with time and date of occurrence.
 - e) Previous memory Data such as previous 12 months MDs with date & time of resets made.
 - f) Function of real time clock.
 - g) Date retrieval through M.R.I. for load survey and tamper date.
- 2) Measurement of voltages and currents at test block.
- 3) Calibration with consumer's load ;

The Static H.T.TVR is connected in series with the electronic reference meter (i.e. Currents in series and potentials in parallel) with consumers load and the error is evaluated. An example of error is evaluated. An example of error evaluation is discussed below.

- a) Static TVR dial constant :- 11 KV/ 110V, 100/ 5 A
- b) E.R.S.Dial constants ; 110V, Kwh meter
1000 pulses = 1 KWH
- c) Relationship for error Evaluation :-

$$\frac{\text{Static TVR}}{\text{ERS}} = \frac{\text{Meter CTR}}{\text{ERS CTR}} \frac{\text{PRT}}{\text{PTR}} = \frac{20}{1000} \frac{100}{1000}$$

Two pulses of Static TVR is equivalent 1 pulse of ERS

The ACU check is basically a reference meter with clamp on CTs of ratio 100/5A. The clamp on CTs of the ACU check are coupled to the respective phases with correct association of voltage and currents. The ACU check is programmed manually to suit the meter dial constants and CT ratio adopted. The number of revolutions of the disc per KW are arrived at. With the help of hand held click on switch the ACU check is energized for the said number of revolutions. The ACU check computes the error by in – built error computer and releases a print out .

The following information is to be programmed through key board before going for calibration to enable the ACU check printer to furnish the said data sheet together with error.

1. SI.No. of the Meter .
2. Dial constants such as revolutions per KW.
3. Meter CT Ratio.
4. Connected CT Ratio.
5. Date of Test .
6. Percentage error.

TECHNICAL SPECIFICATIONS FOR STATIC TRIVECTOR METERS :

The meter shall be made out of high quality material to ensure higher reliability and long life. It should be compact and of reliable design make it immune to vibrations and shocks in normal transportation and should be capable of with standing sever stresses likely to occur in actual service. The latest state of the art technology of surface mounting of components, etc., may be used for the purpose. The soldering if any shall be perfect without dry solders. All insulating material used in the construction of the meter shall be non-hygroscopic, non – ageing and of tested quality. All parts that are likely to develop corrosion. The construction of the meter shall be such as to be sealed independently of the terminal cover, etc. This is to ensure that the internal parts are not accessible for tempering, etc. Without breaking this seal.

Supply System :

The meters should be suitable on HV and EHV systems by using necessary CT and PTs of

Primary voltage	=	11KV to 220 KV
Secondary	=	110V for three phase 3 wire
		110/ /3 for three phase 4 wire
Primary current	=	10 A and above
Secondary current	=	5A / Amps.

The meter shall be suitable for three phase 2 element 3 wire of three phase 3 element 4 wire systems for balanced and as well as unbalanced and as well as unbalanced loads at all power factors i.e., zero –lag-unity-zero lead.

Power Supply Variation

The meter should be suitable for working satisfactory with the following supply system variations.

Voltage	=	-30% to + 20%
Frequency	=	+/- 10%
p.f. Range	=	Zero lag – unity – zero lead

However manufacturer can offer meters which can withstand higher variations.

Accuracy

Class of accuracy of meter shall be 0.55. But active and reactive measurements should have the same class of accuracy. The accuracy should not drift with time.

Apparent energy thus should have the same class of accuracy.

Measuring Parameters

The meters should be capable of measuring the following electric parameters of poly phase supplies in all the four quadrants at all power factors lagging or leading.

1. **LED test**
2. Active energy : KWH/MWH (Import & Export)
3. Reactive energy : KVARH/MVARH (lag & lead)
4. Apparent energy : KVAH/MVAH (import & Export)
5. Max. Demand with date and time : KVA/KVA (Import & Export)
6. Power factor :
7. Elapsed time & rising demand :
8. MD Resent Count :
9. Cumulative MD :
10. Display of No. of MD resets :
11. Announcing of missing potential & reversal of current;
12. Real time
13. Internal multiplying factor of CTs & PTs :
14. T.O.D. Register :

NOTE : The parameters KWH, KVARH, KVAH and max. demand shall be displayed continuously in cyclic order on the meter to enable the Board/consumer to know the above parameters at any instant

Dynamic Range : The meter shall maintain specified accuracy at 200% full load to 2% of full load.

DISPLAY

The meter shall have a minimum legible 8 digit display of liquid crystal display (LCD) of light emission diode display (LED), the minimum character. Provision shall be made to read consumption in either whole units of decimal multiples of sub-multiples of one unit. The display shall be digital type with non-destructive read out . It shall be possible to display contents of relevant display with another digit displaying legend for identification of display. The meter should have facility of auto display mode where all parameters automatically scroll with in the specified time. The no. of parameters and the scrolling period shall be field programmable. The meter should have non volatile memory, so that the registered parameters will not be affected by loss of power . A provision shall be made to read the meter parameters such as MD and consumption, etc. through the meter cover without actually opening the meter box cover. The non-volatile memory should have a minimum retention time of 12 year.

Display Resolution

1.	Voltage	=	0.1V
2.	Current	=	0.001A
3.	P.F.	=	0.001
4.	Energy	=	0.001 MWH
5.	Demand	=	0.1 KVA/KW = 0.001 MVA/MW

Maximum Demand Registration

The maximum demand is to be monitored during each demand interval set (30minutes/15 minutes as the case may be) and the maximum of these in a month shall be stored. Whenever MD is reset the maximum MD value so registered shall be stored along with date and time and source of reset. Under the current integration period, the rising demand should be displayed continuously along with the elapsed time. The registered demand and the number of time the MD is reset shall also be displayed and the information stored.

M.D. Reset

The meter should have provision of maximum demand resetting.

- a) Manually by operation of a button which is to be covered and sealing provision available for such cover.
- b) Resetting shall also be possible through a hand held terminal capable of communicating with the meter.
- c) Provision for automatic resetting at the end of certain period may be made available and it should be possible invoke this through CMRI.

Load Survey Capability

The meter should log and one or all the four parameters depending upon the Board's requirements which are selectable from KWH, Import, Export, KVRH, lag & lead and max. demand, 30 min./ 15 min. demand data for last 40/20 days in its memory and it should be possible to transfer this data on to a base computer station through DOS based hand held CMRI. The base computer shall give complete details of load survey particulars both in numeric data form and in graphic form. Necessary software for invoking the base computer station should be provided.

Time of Day Tariff/ Demand

The meter offered shall contain provisions for multiple tariff metering (Time of day metering demand) and details of the same may be indicated in the tender separately. The meter offered should have a real time clock based on a quartz crystal with a battery totally independent of power supply. The meter shall be capable of being set in to min. of 4 time zones (optionally more time zones can be offered) in 24 hours cycle to cover morning and evening on and off peak periods separately. T.O.D. register shall be provided for active energy, reactive energy (lag & lead) and demand data.

Generally TOD registers are not operated and it should be possible for the Board to invoke them through the use of a CMRI and necessary software should be loaded by the meter supplier into the Base computer station of the Board for this purpose.

Remote Read Out Facility / Communication capability

- i. The meter shall be provided with an optical communication port (such as IEC 1107 PACT port, ANSI port refer Appendix-C of CMRI specification the supplement to the CBIP technical report 88) so that it can be easily connected to a hand held meter reading instrument for data transfer or subsequently hooked to remote metering device such as modem, etc. The optical communication port shall also have sealing provision. Companies may adopt protocol of their choice but should load the software and the protocol software into the Base computer station of the board. It is the responsibility of the meter manufacturer to provide the software and all the facilities required by the A.P. State Electricity Board to use the DOS based hand held terminal for reading the meter and generating appropriate reports required by the A.P.S.E. Board.
- ii. Interface between meter and hand held meter reading instrument / CMRI : Meter optical sensor terminating in to RS.2320, 9 pin D type male connector with a flexible shielded cable of 500mm $\pm$ 10mm length with electrical circuit illustrated in Appendix-A. This cable shall be supplied by the meter manufacturer one cable for every 5 Nos. Meters shall be supplied.
- iii. Software : The following software shall be made available by each meter manufacturer whose meters are to interface with hand held meter reading instrument/CMRI.
 - a) Software to be resident in hand held terminal/ CMRI for the purpose of reading and programming the specific make (s) of static meters.
 - b) Base computer station software for accepting data from hand held terminal / CMRI, processing, generating reports and down loading instructions from the Base computer station to CMRI.
- iv. Data Security : The meter manufacturers are responsible for maintaining the security of the data extracted from the meters using manufacturer specific algorithms in the software upto down loading to the base computer station.

Terminal Arrangements

The terminals shall be marked properly on terminal block for giving external connections. A diagram of connections should be provided inside the cover of terminal block. The terminal cover shall be extended such that when it is placed in position it is not possible to approach the connections or connecting wires.

Test Terminal Block with cover

A separate TTB is to be provided. Suitable provision shall be made in the test terminal block for disconnecting the meter for testing purposes and for the purposes of testing the meter. The test terminal block shall have provision for isolating the meter from instrument transformer secondary connections. Proper arrangements for sealing of test terminal blocks cover placed such that when it is placed in position to approach the connections or connecting wires. The block shall be suitable for the meter supplied i.e., three phase 3 wire or three phase 4 wire. The extended terminal cover of test terminal block and the meter terminal block shall preferably be transparent made of good quality PVC Synthetic material so as to make the connections visible in sealed condition.

Sealing of Meter

Proper sealing arrangement should be provided on meter to make it tamper proof and avoid mishandling by un-authorized persons. Meter cover shall be provided with minimum of 2 Nos. sealing screws and meter terminal block with 2 Nos. sealing screws and one number sealing arrangement to the MD reset push button. Sealing arrangement for optical port to be used for communication to CMRI should also be provided. The meter should be designed and constructed in such a manner to make it pilfer proof once it is sealed.

Environment Aspects

Meter shall be designed and constructed to be capable of with standing all severe stresses and vibration and dust environments likely to be encountered in actual practice as the meters will be installed outdoor in boxes. The withstanding capability shall be + 60 c temperature.

If any special precautions, etc. are required as the meters are supposed to be installed in outdoor you may please specify them.

Immunity to Electro Magnetic Disturbance

The meter shall be designed in such a way that conducted or radiated electro magnetic disturbance as well as electrostatic discharge do not damage or substantially influence the meter.

Guaranteed Technical particulars

The technical particulars as specified in the CBIP/IEC/IS(where applicable) and as per the Board's requirements shall be guaranteed and a statement of Guaranteed Technical particulars in the format "schedule-F" shall be furnished along with the tender.

Temper and Fraud Protection

The meter should have features to prevent / detect common ways of tamper and fraud.

- a) Phase sequence reversal : The meter should work accurately irrespective of phase sequence of the supply. The meter must have capability to indicate availability and continuity of CT circuit. In case of shorting of one or any phases the meter shall indicate such occurrences along with date, time and duration.
- b) CT Polarity Reversal : The meter should register energy consumption correctly even though the CT polarities are reversed.
- c) Missing Potential : The meter should be capable of recording occurrences of missing potential which can happen either owing to a P.T. fuse blowing or due to internal disconnections of a potential lead.
- d) Influence quantities : The meter should work satisfactorily even under presence of influence quantities such as :
 - 1) External magnetic field
 - 2) Electro magnetic field
 - 3) Radio frequency interference
 - 4) Unbalance in load
 - 5) Vibrations, etc.
- e) The meter should register the consumption of energy even if any one of the phase is removed in three phase 3 wire system and is any of the phase or neutral is removed in three phase 4 wire system.

ERS – ELECTRONIC REFERENCE STANDARD METER

LT portable Electronic Reference standard meter for calibration and on site testing of single phase 3 phase whole current energy meters both electro-mechanical and static and 3 phase-5A/CT operated class-1 accuracy energy meters upto 120A.

This LT portable electronic reference standard meter with suitable clamp on CT'S with sustained accuracy class of 0.5 S suitable for on site testing of

- a) AC single phase 2 wire whole current, long range KWH meter of capacity(2.5-10A) and (5-20A) generally confirming and IS 13010/IS 13779 with continuous current carrying capacity upto 400% basic current suitable for operation on 240V, 50Hz A.C. supply with accuracy class-2

AND

- b) AC Three phase, 4 wire 3 element whole current type KWH meter (10-20 A) capacity generally confirming to IS 13010/1990 & IS 13779 – 1995 with continuous current carrying capacity upto 200% of basic current suitable for operation on 3 × 240V. 50Hz A.C supply with accuracy class 2 and also accuracy class I.

AC Three phase, 4 wire , 3 element CT operated KWH meter (-/5A) capacity generally confirming to IS 13010/1990 Electromechanical, IS 13779-1993 (static) & CBIP 88 with continuous current carrying capacity upto 120% of basic current suitable for operation 3 × 240 V, 50 Hz, A.C. supply with accuracy class 1.0.

- c) The accuracy of the in – built reference meter shall be 0.5 S

APPLICATION

The reference standard meters shall be portable and should be easily carried by hand. The reference standard meter shall be suitable for on site calibration of Lt single phase energy meters of class-2 accuracy and three phase Electromechanical/static long range meters / CT operated energy meters of accuracy class – I and I generally conforming to IS 13010-1990, 13779-1993, CBIP report 88. Suitable on line testing of meters without interrupting the supply at the consumers location.

The portable ERS meter shall automatically check whether the installed connections are correct and should indicate, wrong connections, if any for example reverse current, wrong phase association, etc. and also identify such wrong connection to enable correction on site.

After the connection are made reference standard meter shall display “READY” and should be able to generate necessary menu regarding details of the meter under test. After the meter under test has progressed for the set parameter the reference meter should have provision to stop in percentage. It should also indicate the energy recorded for reference.

Supply system

Voltage	:	415V Phase-Phase 230V Phase-Neutral
Current ranges	;	100A (Dynamic range 5 to 120 A)
Frequency	:	50 Hz

This portable Electronic Reference standard meter should be suitable for testing meters supplying balanced and unbalanced loads at all power factors ranging from 0 lag unity-0 lead. It should display the readings directly without any multiplying factor.

Power Supply Variations

The portable ERS meter should work satisfactorily for the following supply system variations.

i.	Voltage	:	+ 15% to – 30%
ii.	Frequency	:	$\pm 10\%$
iii.	PF	:	0 lag – UPF – 0 lead

Quantities to be tested

Active Energy : Kwh

Constructional Features

The portable Electronic reference standard meter.

- i. Should be compact and of reliable design using latest state of the art surface technology to make it immune to vibrations and shocks in normal transportation and handling. It should be housed in a neat brief case provided with a handle to make it convenient to carry to carry it around.
- ii. It should be provided with at least two meters long leads. The voltage connections shall be by insulated crocodile clips with sufficient and durable insulation so that the safety of the operator is ensured. The current shall be by clamp on type CTs with a minimum of 20mm more.
- iii. It is provided with a push button for monitoring voltage , current, pf, KW and phase sequence (forward (or) reverse)
- iv. It is provided with start / stop test push button for testing of meters.
- v. It is to confirm to degree of protection as per IS 12063 for protection against penetration of dust and water.
- vi. It is supplied with one optical head sensor for convenience of testing of the meters which generate optical pulses.
- vii. The portable calibration equipment has percentage error calculation provision and display the percentage error.

Display

The portable ERS meter has legible display of at least 6 digit bright LED/L CD electronic display. In the case of multiple values presented by a single display, it is possible to display the contents of all relevant memories. When displaying memory, the identification of each value is possible.

Automatic Connection Check

The portable ERS meter is capable of checking connection for following condition.

- i. Missing Volts
- ii. Missing current
- iii. Reverse current
- iv. Phase associations

Display Resolution

i.	Voltage	:	0.1V
II.	Current	:	0.001A
iii.	P.F.	:	0.001
iv.	Energy	:	0.00001 Kwh

Burden

Current circuit : - Less than 4VA per phase

Voltage circuit : - Less than 10VA per phase including auxiliary power supply.

Self Diagnostic Feature

Indications to show the satisfactory performance of the portable ERS meter shall be provided in the meter. It shall have capability to check its circuit for any malfunctioning. If some malfunctioning occurs it shall record or give visual indication for such malfunctioning.

The details of self diagnostic features shall be furnished by the manufacturer/ supplier in the bid.

Supply Backup

The portable ERS meter shall be independent of the requirement of any battery .

ELECTRONIC LT SINGLE PHASE METER

Features

- . Class 1.0 Accuracy as per IS 13779
- . Current Reversal indication
- . Flashing Led pulse output (with Meter Constant) for Testing purpose
- . Earth Tamper Indication
- . Class 1.0 Accuracy even on Earth Tampering and Direction Reversal
- . 6 Digit impulse counter for display of Energy.
- . Operating Frequency – 45 Hz to 55 Hz
- . Overload Capacity 400% of I_b

Optional Feature

- . Meter will Trip the load on occurrence of the tamper. Resetting is possible only by utility.

Anti Fraud Details

- . Meter functions correctly when phase and neutral connections are inter changed.
- . Meter records correct energy under reverse current connection.
- . Meter records correct energy when load is connected to earth instead of neutral.
- . Class 1.0 accuracy is maintained in all the above conditions
- . Temper indication is provided on the name plate of the meter by the way of 2 LEDs (one each for current reversal connection and earth load connection).
- . Meter to be type tested as per IS 13779 at various national laboratories.

Technical specifications

Accuracy	:	Class 1.0 as per IS 13779
Voltage Rating	:	240V (- 25% to + 20%)
Current Rating	:	5A (Others on request)
Frequency	:	50Hz $\pm$ 10%
Overload Capacity	:	400% of I_b
Starting Current	:	20 Ma (0.4% of I_b)
Registering Mechanism	:	Six digit Impulse Counter with one decimal
Pulse Rate	:	1280 Pulses/ kWh.
Enclosure	:	Sheet Steel Enclosure
Weight	:	1.5 Kg.
Mounting	:	Projection Mounting
Operating Temperature	:	0° C to 55° C

PORTABLE SPOT BILLING MACHINE

HARDWARE	Processor based with state of art technology
MEMORY	64K Program memory, Upto 128K memory
REAL TIME CLOCK	Full calendar real time clock
KEY BOARD	5 x 4 membrane Key Board matrix.
PRINTER	24 column alphanumeric compact printer
DISPLAY	16 x 2 char. Alphanumeric Bakelite LCD Display.
COMM.PORT	Variable baud rate RS – 232 port for PC interface

The layout of the area – with the location and service numbers in accordance with MRB are prepared manually and computerized. Therefore an efficient, clear route maps depicting all relevant information which makes it self-explanatory are prepared. The service connection numbers are legibly painted at the entrance each premises and on the meter board of the service connection.

The billing data like service No. name, address, category, single or poly phase, connected load, previous reading, arrears outstanding of about 100 connections loaded into the spot billing machine by connecting communication cable to the computer, and the meter reader proceeds to the field according to the relevant route map. By feeding service number, present reading and status of the meter, bill can be instantaneously generated in the very presence of the consumer himself. Simultaneously, a receipt can also be instantaneously generated on receipt of money. The tariff for different categories are programmed into the E PROM.

At the end of the day the entire data in the machine shall be down loaded into the base computer.

The battery inside the machine should be re-charged periodically.

SINGLE PHASE H.T. DISTRIBUTION SYSTEM

SINGLE PHASE H.T. DISTRIBUTION SYSTEM

1. Introduction:

The loads in rural area are predominantly pumpsets used for lift irrigation. The loads have low power factor and low load factor. Further load density is low due to dispersal of loads. The existing distribution system consists of three phase 11 KV lines and considerable size 3-phase 11 KV/433 Volts distribution transformers with lengthy L.T. Lines. The system is based on British practice and is found to be unsuitable to cater Indian Load conditions the as the line losses are high, voltage profile and reliability are unsatisfactory.

To improve quality of supply, one of the recommendations is the implementation of 'singly phase H.T. distribution system' with small capacity and singly phase distribution transformers. Under this system H.T. Line i.e., 11 KV line is extended as near the load as possible and small capacity distribution transformer. say 5, 10 and 15 KVA are erected and supply is released to the consumer through a short length of L.T. line preferably insulated over head cable popularly known as aerial bunched cable.

2. Advantages of H.T. Distribution System:

The advantages of H.T. distribution compared to conventional L.T. distribution system are indicated below:

(i) For the distribution of same power, the comparison of current losses and voltage drop for (with 100 as base) L.T. are given below:

	Single phase 6.35 KV KT distribution system	3 phase 4 wire 415V L.T. distribution system
Current Amps	11.0	100.00
Losses K.W.	8.5	100.00
Voltage drop K.V.	12.7	100.00

The consequential benefits are

- (a) Small size A.C.S.R. or aluminium alloy conductor or high conductivity steel wire can be used.

- (b) Better voltage profile.
 - (c) Reduced line losses.
- ii) Both reliability and security of supply are improved for the following reasons:
- (a) The faults on H.T. lines are far less compared to that of L.T. line.
 - (b) The faults on L.T. lines are eliminated as L.T. lines are with ABC. This in turn reduced the failure of distribution transformers.
 - (c) In the event of failure of distribution transformer which will be a rare occurrence it will effect only small number of consumers. 2 to 3 Power consumers 10 to 15 domestic consumers, whereas failure of an existing large size distribution transformer will effect a group of 40 to 50 power consumers 100 to 200 domestic consumers.

3. Design of H.T. Distribution System:

The salient design features of the system are indicated below:

The scheme envisages running 3...4 wire 11 KV line (i.e. 3 phases and one neutral) from a 33/11 KV sub-stations preferably to adjoining 33/11 KV sub-station. 11 KV single phase 2 wire branches (phase and neutral) are extended and one number 6350/-. 230-0-230 volts or 6.35 KV/240 V distribution transformer is erected to feed single phase loads. Since singly phase motor capacity is limited to 15 HP, motive power loads of above 15 HP are given by extending main line through phase converters in isolated cases.

Three ratings of single phase transformers namely 5, 10 and 15 KVA are suggested . The table below give the losses and costs of single phase transformers:

TABLE

Single Phase transformer	No load loss	Full load loss	Cost of each transformer	
			Cast resin	Oil filled
15 KVA	40 W	150 W	5,800	4,540
10 KVA	40 W	225 W	6,700	5,260
15 KVA	60 W	275 W	7,960 W	5,980

iii) The L.T. lines will be laid with aerial bunched cables (ABC) or size 16 sq.mm with a bearer wire size of 25 sq.mm. The lengths of L.T. lines has to be kept minimum to reduce L.T. losses. With the H.T. distribution system, the current carried by L.T. lines is reduced due to usage of small capacity of transformers. It is seen that the cost of line is cheaper, that the conventional L.T. 3...../4 wire line used in L.T. distribution system. The comparable cost of the ABC, ACSR, current carrying capacities and the cost per KM of line are given in the table.

TABLE

Sl. No.	Particulars ACSR	7/2.11 Sq. mm ABC	1 x 16+1x25 Sq. mm ABC	2x16+1x25
1	Current carrying capacity in Amps	115	74	88.68
2	Cost of conductor/cable per KM in Rs.	1590 per KM 3180 per 2 conductors 4770 per 3 conductors	4515 per	7555 per cable
3	Cost offline per KM	Single phase 2 wire 14,500 s... 3W 18000	14,200	17,600

The major advantages of ABC is that the fault on the L.T. lines are totally eliminated improving the quality of supply. The ABC can be run on the building facades the problem of vertical and horizontal clearance does not arise.

4. HVDS for pump sets:-

The successful implementation of H.T. single phase distribution system with its many advantages of reliability, satisfactory voltage conditions and not existent opportunity for pilferage solely depends upon availability of good quality single phase motors, because most of the rural loads are pumping load. The single phase motor chosen for the duty shall have comparable efficiency and price with that of 3 phase motors now available in the market.

There are four types of single phase motors.

- i) **Split Phase Motors:** Split phase motors are single phase induction motors and usually have a squirrel-cage motor. The stator consists of two windings, namely a main and auxiliary windings and are displaced

in space from one another by 90 electrical degrees. The difference in the winding impedances is responsible for phase displacement between the field established by the two windings. Thus a rotating magnetic field is produced in the air gap and torque is produced by the action of field on the squirrel cage rotor. A starting switch which is usually centrifugally operated, disconnects the auxiliary winding after the motor has attained approximately 70 to 80 percent of synchronous speed (wiring diagram displayed in Fig.1)

- ii) **Capacitor-Start Motors:** The capacitor start motor, is similar to the split-phase motor in design except that a capacitor is placed in series with auxiliary winding to provide the desired 90 phase displacement between the main and auxiliary fields. The auxiliary winding and its capacitor are switched out of the circuit by a starting switch, which is usually centrifugally operated as the motor nears synchronous speed.(Wiring diagram displayed in Fig.2)
 - iii) **Two-valve Capacitor Motor:** This motor has two capacitors in auxiliary winding. It starts as a capacitor start motor with start capacitor in series with the auxiliary winding. As the motor nears synchronous speed, the starting capacitor is switched out but running capacitor is brought into the circuit in series with the auxiliary winding. (Wiring diagram displayed in Fig.3). The auxiliary winding and capacitors are continued in running condition and this makes the motor operate more efficiently, with an improved power factor and slightly increased break-down torque.
 - iv) **Permanent-split Capacitor Motor:** A capacitor is permanently in series with the auxiliary winding and the auxiliary circuit remains excited both under starting and running conditions. Motor of this type designed for continuous duty have low starting torque (about 50 to 60 percent of the fully load torque) but this is adequate for the duty for pumpsets (wiring diagram displayed in Fig.4). These motors have very high P.F. generally more than 0.9. After examining the characteristics of four types of single phase motors it can be concluded that permanent split-capacitor motors are best suited for pumping loads as these motors have high power factor and the centrifugal switch which is likely to cause maintenance problem is avoided.
5. **Performance of Single Phase Motors and Comparison with Three Phase Motors:** Today in the country good quality single phase motors for 3 HP and 5 HP ratings are not available in the market. APSE Board has taken up the issue of manufacturing proto type single phase monoblock motor pumpsets with three leading manufacturers namely M/s. General Electric Company, M/s. Crompton Greaves and M/s. Kirloskar Brothers, who have evinced interest in the Project. M/s. Kirloskar Brothers and M/s. Crompton Greaves here developed 2 HP an 3 HP single phase motor pumpsets and M/s. G.E.C. 3 HP and HP single phase pumpsets. Field tests are conducted on these motors to evaluate their performance. The test results are indicated in Table-I.

Regarding efficiency it is appropriate to look for “effective efficiency” figure which is defined as the product of efficiency and power factor. The low power factor motor takes more current and in turn causes higher distribution losses. The effective efficiency of 3 phase and single phase motors are indicated below:

P.F.Efficiency

Three phase motor = $0.85 \times 0.8 = 0.68$

Single phase motor = $0.90 \times 0.75 = 0.68$

From the above it can be seen that effective efficiency of single phase motors is comparable to that of 3 phase motors.

For comparison of costs it is appropriate the total cost of electrical installation is compared. In case of three phase motors an external capacitor is required to improve the power factor, whereas this is not needed in case of single phase motors because of its inherent high power factor due to built in capacitor. The single phase motors also do not require the conventional starter as there is no single phasing of supply and a simple M.C.E. is adequate for protection of single phase motor. The comparable costs are indicated below:

TABLE

	Single Phase 3 HP	3 Phase 3 HP	Single 5HP	3 Phase 5 HP
Motor with pumpset (Mono Block)	3700	3400	5400	4900
Starter	--	500	--	550
M.C.B.	250	--	250	--
Capacitor	--	100	--	100

From the above it can be seen that difference in costs of single phase and 3 phase motors is not appreciable. With more demand and further development, the prices of single phase motor pumpsets could further come down making it cheaper than existing 3 phase motors.

6. Case Study:

A Case Study was made on the benefits that accrue on account of switch on to H.V.D.S. and the results indicate that.

The analysis of results indicated that:

- i) the single phase H.T. distribution system is 25 percent costlier than L.T. distribution system.
- ii) the power loss in single phase H.T. distribution is only 7.0 percent of L.T. distribution system.
- iii) benefits due to H.T. distribution system on account of reduction of energy losses alone is Rs.18,000/- per annum. Hence pay back period for additional capital cost is four years. If the other benefits like reduction peak power loss and improved reliability is taken into account, the pay period may not be more than a year.

8. Conclusions:

The Single phase H.T. distribution is undoubtedly superior to conventional distribution system with regard to quality of supply i.e. better voltage profile, reduced losses and better reliability. However, the capital cost will be marginally higher due to increase in the number of transformers and increase in total capacity. If the overall cost of the system is taken into account, the H.T. distribution system may be economical compared to L.T. distribution system. With regard to single phase motors required for success of H.T. distribution system, it is demonstrated that the manufacturers in the country have the technical know-how and capability to manufacture good quality single phase motors which are comparable in efficiency and price with that of 3 phase motors. It can be safely concluded that new generation of single phase motor pumpsets likely to come into the market in next few months will have better power factor, better efficiency and equal price if not cheaper than existing 3 phase motors. The modernisation of rural distribution system with introduction of single phase H.T. distribution system has to be speeded up to give better quality of supply to our farmers.

**REVIEW OF PERMANENCE OF SINGLE PHASE MOTORS - 5.9.85 & 6.5.85 TO SINGLE PHASE CSP TRANSFORMER 11 KV 230-0-230
V - 10 KVA ERECTED AT SIVALAYAM SITUATED IN CARAVAN, MEHDIPATNAM, HYDERABAD**

Sl. No. of	Make up	Rated HP of the	Voltage actuals	Amps. actual	Wattage actual	P.F. actual Mts.	Total head actual Mts.	Discharge trs/Sec.	Efficiency index	System efficiency %	Effective (P.F. X system efficiency)
1	2	3	4	5	6	7	8	9	10	11	12
1.	Crompton Graves	2 HP	216 V	11.0 A	2.19KW	0.94	10	8.10	0.76	35.52	33.39
2.	Kirloskar	2 HP	210 V	10.1 A	1.990	0.938	11	8.00	0.6332	42.64	39.99
3.	G.E.C.	3 HP	225 V	11.18A	2.304KW	0.91	11	9.909	0.5871	45.98	41.84
4.	Crompton Graves	3 HP	218 V	14.875A	2.781KW	0.84	9	10.25	0.81	33.30	27.97
5.	G.E.C.	5 HP	224 V	12.3A	2.376 KW	0.828	11	7.14	0.84	32.14	26.61
6.	G.E.C. with different impeller	5 HP	452 V	7 A	2.82 KW	0.89	13	9.9	0.66	40.90	36.40
7.	Crompton's Motor with out centri-fugal Switch	3 HP	213 V	17 A	3.3 KW	0.91	11	10.00	0.825	32.72	29.78

(A Report made in system studies cell)
HIGH VOLTAGE DISTRIBUTION SYSTEM (HVDS)

1. Introduction:

The three important problems of distribution network are

- A. Low Voltages
- B. High power losses
- C. Unauthorised direct tapping of lines

2. Factors for poor performance of LV Network

The factors contributing to this situation are

- A) Extension of supply to loads by extending LT line until the distribution transformer is fully loaded. Ignoring the voltage drop on the line the number of pumpsets that can be incident of LT line at an average span 0.2 KM and limit the maximum voltage drop to 5% are as shown below.

TABLE

S. No.	Conductor	3 HP		5 HP	
		No.	& VD	No.	% VD
1	Squirrel	4	5.08	3	5.09
2	Weasel	4	3.65	3	3.65
		5	5.58	4	6.24

Thus it can be seen that a 63 KVA transformer with 2 LT feeders with squirrel ACSR can be loaded upto 30 KVA only and 100 KVA transformer with 3 feeders can be loaded upto 45 KVA only. In other works the transformer is being loaded to 50 % of its capacity only.

- B) The results of sample study of LT lines in Hyderabad city (Urban) and Warangal district (Rural area) are shown below:

TABLE

Voltage Drop		Rural (Warangal District)		Urban (Hyderabad City)	
No.	%	No.	%	No.	%
0	3%	7	11.84	43	26.0
3	5%	8	13.56	17	10.0
5	10%	16	27.12	28	17.0
	Above 10%	28	47.86	79	47
	Total	59		167	

From the results it could be seen that 75% feeders are having voltage drop higher than 5% design limit.

- C) The removal of Off load taps on distribution transformers has resulted in bringing the voltage at consumer premises to 90% instead of statutory limit of 95%.
- D) The long LT lines stretching 1 to 2 KM provide good scope for unauthorised tappings.
- E) The power factor of the existing three phase motors is as low as 0.6 – 0.7 as they are designed to function at voltage as low as 70% of rated voltages. Unless the voltage drop on the LT line is reduced to 5%, the usage of motors with low power factor is inevitable. The usage of capacitors is totally ineffective as they are not installed and maintained. Even where it is available, its effective capacity is hardly 50% of rated capacity because of low voltages.

To over come the above problem, it was decided to introduce High Voltage Distribution System (HVDS) in APSEB in 1985.

3. **Type of HVDS:** There are two types of HVDS Phase – Neutral HVDS and Phase-Phase HVDS. The salient features of the two systems are indicated in table below. The relative merits of the two systems are discussed in detail at para-6.

Item		
Main feeder	3 Phase 4 W line with a	3 phase 3 W line continuous neutral from SS
Spur line for single phase loads	Phase-Neutral 2 wire branch	2 phase 2 wire branch
Spur line for three phase loads	2 phase and neutral 3 W branch	3 phase 3 wire branch
Transformer for single phase loads	1 No. 6350/230-0-230V transformers connected in star/open delta	

4. **Advantages of HVDS:**

The losses and voltage drop in HVDS compared to LVDS are given in table below:

Comparison of HVDS and LVDS

Sl. No.	Item	HVDS Phase-Neutral	LVDS	HVDS
1	Current	11.0	100.0	6.5
2	Voltage drop	8.7	100.0	7.5
3	Losses			
	Line Losses	5.7	100.0	2.95
	Tr. Load Losses/KVA	115.0	100.0	115.0
	Tr. No. Load Losses/KVA	138.0	100.0	138.0

The most important advantage of single phase motors is high PF (0.95 – 1.0) because of the presence of a capacitor in the circuit and the fact that motor will not run without capacitor in the circuit. In case of three phase motor the power factor is low and the external capacitor kept can be disconnected as the motor can run without capacitor also.

5. Implementation of Scheme:

Continuous neutral line is to be run from Sub-Stations for 11 KV feeders and provision of local earthing is not a desirable construction practice as it may lead to high ground to earth potential, in the even of fault and also cause interference to the adjoining communication circuits.

6. Critical Issues:

The issues on which needs critical consideration are

- A. Whether HVDS should be extended for future services or to convert existing conventional LVDS also to HVDS progressively.
- B. If HVDS is to be extended whether Phase-Phase system or phase neutral system should be adopted.
- C. How to overcome problems of integration of HVDS with the existing network? What are the changes required in the design and administrative steps are needed to implement the scheme.
- D. The need to restructure the existing distribution network and Techno-economic benefits.
- E. Policy on procurement of single phase transformers.

The issue raised above are discussed in detail

Two studies made on the advantages of HVDS compared to LVDS are shown in Annexure. First study relates to comparison of losses and cost a existing system, and the corresponding losses and cost of HVDS to meet the same loads. This study was made on a 11 KV feeder feeding 464 pumpsets. Second study relates to extension of supply to new 50 agricultural pumpsets through LVDS and HVDS. The results of two studies indicate that

- 1. The capital investment for HVDS and LVDS are approximately equal.
- 2. The losses in HVDS are hardly 20 to 30% of LVDS and voltage profile is better.

Considering all the facts change over to HVDS is inevitable to overcome the problems of LT distribution system, especially in low load density areas and where Unauthorised direct tapping of LT lines is rampant.

- B. Whether Phase-Phase system or Phase-Neutral system should be adopted.

The salient features of the two types of HVDS are described at para-3. The relative merits of the two systems are discussed below.

TABLE

Sl. No.	Item	Phase to Phase KVDS	Phase-Neutral HVDS
1	Main Line	3 Phase 3-Wire 11 KV line - The existing system can be continued as it is and there is no need for any change	3 Phase 4-Wire 11 KV line – Neutral wire has to be run all along main line which involves considerable effort and cost. But where HV and LV line are run on same supports LV neutral can be used as HV neutral.
2	Spur lines to feed single phase loads	2 Phase 11 KV line – The existing LT lines can be converted as 11 KV spur line by replacement of 2 No. LT insulator. Thus the cost of the line is marginally higher compared to phase neutral system.	Phase Neutral line – the existing LT line can be converted as 11 KV Phase-Neutral spur line by replacing 1 No. LT insulator with HT insulator.
3	Transformer	11000/230-0-230 ratio. The cost of transformer is comparatively higher as :	6350/230-0-230
		a) It requires two HV bushings in lieu of one bushing for Phase-Neutral system. b) Requires two single arrestors for voltage protection compared to one for Phase-Neutral system. c) Usage of higher size conductor on HV windings to obtain mechanical strength. d) Non-gradation of HV insulation & (HVWLV) insulation. e) Two Nos. HV fuses compared to one for Phase-Neutral system.	
4	Voltage drop	The voltage drop on Phase-Phase spur line is 116% Phase-Neutral line (with 50% current flow through ground)	
5	Line losses	The line losses of Phase-Phase spur line is 170% Phase-Neutral (with 50% current flow through ground)	
6	Grounding	The resistance between Neutral to ground on secondary side depends upon resistance of ground rod. Since the grounding is generally not good, it causes high phase to ground potential in the event of short circuit leading to transformer failure.	HV and LV Neutrals are inter connected and hence the effective resistance of secondary neutral to ground is low due to multi-grounded primary neutral.

It can be seen that Phase-Neutral system has several advantages compared to Phase-Phase system but running of continuous neutral wire is a major draw back. If

Phase-Neutral system is to be adopted, additional conductor should be taken on war footing, feeder by feeder. Considering our past experience on usage Phase-Neutral transformers, it is decided to go in for Phase-Phase system, to avoid the problem of running neutral wire.

- C. How to overcome problem of integration of HVDS with the existing network? The changes required in the design and administrative steps needed to implement the scheme?

This is the most difficult task and requires a firm commitment at all levels for decisions taken and also consumer acceptance to the new system should be built up through sustained campaign.

The important problem to be resolved and the proposed solution are discussed.

- C.1 The voltage rating of single phase motors now in service is 460V. Bureau of Indian Standards has not agreed to issue an Indian standard for single phase 460 V motors stating that 460V is non-standard voltage. The standard voltages are 240 Phase-Neutral and 415 Phase-Phase. Issuance of IS is necessary for farmers to get Bank loan for purchase of motor.

All single phase motors are double windings and the motors can be connected for 230 V or 460 V by making series or parallel arrangement. The advantage of 460 V connection is that current in LT line to the motor from transformer will be 50% and consequential lower voltage drop and line losses. Considering all the facts it is decided to adopt 240 V as voltage rating for single phase motors and order 11000/240 V single phase transformers for the following reasons:

- a) 240 V is a standard rating conforming to IS and we will be able to get an Indian standard for 240 V single phase motors.
- b) It will facilitate to go in for single winding transformers of 11000/240V and thus avoiding the problem of balancing loads on the two winding of 1100/230-0-230 V transformers.
- c) It facilitate the release of supply to single phase motors coming on the existing LT 3 Phase 4 wire system. In this case it may cause unbalance of one phase. But it may not be a very serious drawback.
- d) The comparatively higher voltage drop in LT line due to 240 V rating may not be a serious drawback because the length of LT lines is very short.

- C.2 Number of new services come up under the existing LT lines. The single phase supply may have to be extended to these services and how best it could be done has to be determined.

If the transformer has spare capacity and LT voltage drop is not higher. Single phase motor of 240 V can be connected on one of the phases. If there is no margin in transformer capacity or voltage drop is high, erect a 11KV 2 Phase line on the existing supports or on new supports and install single phase transformer and release supply.

- C.3 Should we continue to give services to 3 phase motors or insist on consumers to go in for single phase motors only.

It is better to insist all consumers to go in for single phase motors upto 10 HP. This could be done by amendment to tariffs prescribing voltages supply as single phase 240 V upto 10 HP agricultural services. The Board's right to prescribe the voltages supply is upheld by the Supreme Court and there are adequate number of manufacturers supplying single phase motors to meet the requirement.

- C.4 We have ordered 6350/230-0-230 V transformers. If single phase loads are to be released on the transformer, the field staff have to distribute the load on both the windings. It is reported that number of transformers have failed as only one winding is loaded to full capacity of the transformer.

It is better with the two winding transformers, and go in for single winding 11000/240 V transformers.

- C.5 Protection of single phase transformers, due to faults on secondary system.

With single phase transformers of 11000/240 V, the advantage of multi-grounded primary neutral will not be available. Hence it is essential to use Aerial Bunched cable for the LT lines to prevent occurrence of faults on LT line and consequential failure of transformers for 10 and 15 KVA transformers, the AB cable required is 1x16x25 or 3x16x25 for single phase and three phase loads respectively. 2x16x25 AB cable is useful for street lighting in addition to single phase. The cost of 1 KM of AB cable LT line is less than 1 KM Overhead line with bare conductor LT line. The AB system has several other advantages compared to the bare conductor system.

- C.6 How to extend 3 phase supply with single phase transformers in absence of 3 phase transformers.

With selection of 11000/240 V single winding transformers, it is not possible to release 3 phase supply with 2 No. Single transformers connected in open delta. If we connect 2 No. Single phase 11000/240 V transformers in open/delta we get 3 phase 240 V supply only. We have to use three single phase transformers connected in Delta/Star to get three phase 415 V supply.

VI - 13

The effective capacity of 2 No. Double winding transformer in open delta is 86.6% only. That is if 2 No. 10 KVA transformers are connected in open delta, the effective capacity is 17 KVA, whereas with 3 transformer we get full capacity of 30 KVA.

Pros and cons in restructuring of existing distribution network is necessary for the following reasons.

99.99% customers avail supply at 415/240 Volts thus operational performance of LV network is key to customer services.

Losses in Indian Power System are around 20% of energy and 40% demand. LV system is responsible for high loss scenario as LV line losses are 6 times target limit and 3 times maximum tolerable limit. Switchover to HVDS alone can bring losses to international norms.

Power loss for transmission of equal load in LVDS (415V) and HVDS (11000V) lines are in ratio 33:1

The voltage drop for transfer of same load on LVDS (415V) and HVDS (11000v) lines are in ratio 13:1

Maximum permissible voltdrop between DSS and customer premises is 10%. Hence compliance with IE rule. 56 on voltage drop is difficult and very expensive in LVDS whereas it is simple in HVDS.

The investigation of typical LV feeders in LVDS indicate that 75% of LV feeders have voltdrop above 5% and is cause of major losses whereas in HVDS losses on LV line are insignificant.

The current for distribution of same power by LVDS & HVDS is in ratio of 15:1 the existing conductor sizes loaded beyond economic loading limits need large scale reconductoring. It is difficult to execute and can be avoided by switch over to HVDS.

The monitoring of feeders in LVDS is difficult compared to HVDS as number of feeders to be monitored is in ratio of 60:1.

Unauthorised tapping of LV lines is simple and rampant in LVDS whereas it is very difficult in HVDS.

The work involved in restructuring distribution work are

- i) Conversion of existing low voltage lines to single phase 2 wire HV lines.
- ii) Replacement of existing three phase distribution transformers of considerable capacity with small capacity single phase transformers.
- iii) Utilisation of existing three phase motors.

Lines: The LT lines are generally of 3 Phase 4 wire construction and hence can be converted to single phase 2 wire lines without any difficult by upgrading the insulation of

one conductor and removing the additional two conductors. The released conductor can be utilised for new extensions. The net cost of this work is nil and it brings large capital credits to utility.

Transformers: The composition of the connected load of LV services is agricultural 50%, industrial 20% and others 30%. Hence, to make the distribution system energy efficient, the HVDS should cover all dispersed loads i.e., 70% to 75% of connected load. In other words, the ratio of single phase, 3 distribution transformer capacity in the distribution system should be 3:1.

- I) This would mean phase transformers are to be produced in large numbers.
- II) Replace the existing 3 Phase transformers feeding dispersed loads with single phase transformers in a phased manner.
- III) Shift the existing 3 phase transformers for feeding medium size industrial loads and concentrated loads like multi-storied building where the length of LT line is minimum.
- IV) To cannibalize the failed three phase transformers to make healthy units instead of repairing these units. The existing high failure rate of distribution transformers greatly facilitates this measure.

Utilisation of Motors: With regard to utilising 3 phase motors following alternatives are suggested.

Existing Motors are with class „A“ insulation or class „B“ insulation. Class „A“ motors have bigger frame size and can rewind with class „B“ insulation. In this case, the capacity of rewind single phase motor will be equal to that of 3 phase motor. In case of motors with class „B“ insulation, the capacity of single phase motor will be about 80% of 3 phase motors. But this may not pose a practical problem, as the consumers are in the habit of installing higher pump set than what is required for installation.

Loading of Motors: Sample motors were rewind and the results indicate that efficiency of rewind motor is equal to that of original motor and power factor is raised near to unity.

Two alternatives schemes for restructuring of existing distribution system as HVDS are proposed. Scheme I contemplates rewinding of motors. Scheme II contemplates to continue to feed three phase motors. The salient features of the two schemes are described below.

Scheme I : Single Phase Motors

Salient Features:

- Convert existing three phase four wire LV line to single phase wire HV line.
- Replace existing three phase transformers with single phase transformer.
- Rewind three phase motors for single phase operation.

Advantages:

- Cheaper compared to other schemes

Improve power factor and efficiency of motors reducing losses and avoiding investment on capacitive compensation.

Reduction in agricultural demand due to elimination of excess capacity.

Disadvantages:

Need to modify consumers equipment.

Required consumers acceptance and co-operation for implementation.

Output of rewind motor is less than original capacity for class „B“ insulated motors.

Scheme II : Three Phase Motors

Salient features:

Convert existing three phase four wire LV line to two three wire HV line.

Replace existing three phase transformer with two single phase transformers connected in star/open delta.

Advantages:

No Modification of consumers equipment required.

Implementation is easy and quick.

Disadvantages:

Schemes is comparatively costlier.

No improvement in power factor and efficiency of motors and no reduction in system capacity as existing three phase motors are continued.

What should be future procurement policy of distribution transformers?

In view of the advantages of HVDS, it may be desirable to extend HVDS for all new extensions. In respect of gradual restructure existing policy for distribution transformer described below suggested for implementation.

To procure 11000/240 V single phase transformers of 10 & 15 KVA capacity in a phased manner and progressive restructure existing LVDS in low load density areas and where pilferage by direct tapping is rampant.

Since the transformers are of 11 KV rating and can be directly used on existing system and motors are also of 240 V rating utilisation of these transformer poses no problem, as in the case of 6350/230-0-230 V transformers.

To procure 1x16+25, 2x16+25, 3x16+25, 4x16+25 AB cables for HT lines as it is cheaper than bare conductor line and is fault free.

- 1.0 The advent of pole mounted reclosures; Sectionalisers, Switched capacitor banks and Auto Voltage Boosters made it possible to modernise the existing distribution systems. The above latest additions into the family of distribution equipment have their own special features & specific application. Their usage in conjunction with each other in the appropriate form only can bring in the desired results. Many inbuilt provisions exist in each of them making them versatile.
- 1.01 The primary distribution system continue to be over head even in urban areas and these are more prone to faults which are mostly transient. A momentary interruption and automatic quick restoration of supply is the need apart from quick isolation of faulty section and introduction of auto reclosures and sectionalisers by State Electricity Boards is towards this end.
- 1.11 Similarly in order to maintain voltage profile, switched capacitor banks and auto boosters are employed and the location of these is to be optimised to derive maximum benefits.
- 1.02 It is necessary that the distribution engineer should be conversant with all the above. The intention of this chapter is to provide collection of useful information from various sources for the convenience of novices in the field so that all need not take the trouble of referring various booklets; which is difficult especially for those working at remote places where reference libraries are not available.
- 1.03 **Auto Reclosers:** These are low rupturing capacity circuit breakers which open out on faults sensed by inverse time relays with instantaneous provision and reclose a preset number of times at pre-set time intervals and get locked in open position if faults persist.
- 1.04 **Sectionalisers:** These do not interrupt fault but the line can be sectionalised into various sections using them. The faulty section gets pressed into service. These operate by sensing whether the line is ON or OFF and various types of fault detecting relays and control boxes make these adoptable for radial, loop and ring feeders etc.
- 1.05 **Switched Capacitor Banks:** These are switched on an off automatically to put them into service when needed only and avoid over compensation during light load periods. The control system is by sensing current (load).
- 1.06 **Automatic Voltage Boosters:** Essentially an auto transformer with a shunt and series winding with taps provided on the series winding and the taps are automatically selected based on voltage levels. AVBs can boost upto + 10% in steps of 2½% AVBs are also on the same principle but voltage variation is for + 10% in 32 steps of 0.625% each.

The details of each of the equipment are explained in the chapter.

2.00 AUTO RECLOSURES

The majority of faults occurring on feeders are transient in nature. Hence it is desirable to get the feeders reclosed automatically for pre-set number of times at pre-set intervals. It is also necessary that the reclosing of such feeders should be achieved without manual intervention. This will improve the reliability factor of such feeders. This aspect has been taken into consideration in latest VCBs and SF6 CBs where in auto reclosing facilities are made available.

The low rupturing capacity pole mounted auto reclosures (PMR) is self contained in all respects. It provides protection against over current and earth faults. Hence it is necessary to have CTs, which are provided underneath top cover at the bushings. It has Microprocessor controlled circuitry providing the above protection making use of over current and earth fault electronic relays. It also provides for pre-set number and type of operations. It is also possible to pre-set the duration of delay in the operation (This application is more important since in general the PMRs work in conjunction with Sectionalisers where in a definite pre-set time duration is required for Sectionalising or isolating the faulty section from rest of the healthy system).

The PRM has a solenoid to close the breaker. This is called Multistroke electromagnet. This takes power of 500 KVA for 30 milli seconds and self powered with 11 KV incoming supply. As such PMRs require 11 KV juice for closing. Line supply is tapped for the solenoid. The arrangement is such that when auto reclosure main contacts open, the solenoid coil is connected to phase – phase supply through a set of auxiliary contacts. While the auto reclosure closes, the opening springs will get charged so as to help opening at the next tripping.

PMR auto reclosures consists of a 3 Phase auto reclosure CB which is connected to a Micro processor based Electronic control unit by multi cored cable.

2.001 Battery or Power pack

The battery is made of lithium/sulphur dioxide and has a nominal life of 10 years. There are two batteries 24 volts and 12 volts and they are to be replaced when voltages fall to 21 volts or 10.5 volts respectively.

2.01 Reclosures: (2 types: Pole Mounted and Substation Operation)

The PMR Auto reclosure is intended for both pole mounted and substation operation, It consists of gas filled CB in which a rotating arc device is the means of interruption both faults and load currents.

Line current sensing is achieved by CTs mounted within the reclosure top plate. The supply from these CTs is brought out of the reclosure via a multicore cable to the control cabinet.

2.02 Electronic Control Unit: The scheme as available in Brush (S&S) make PMRs is explained below. The microprocessor based on controller unit reads the output of the three

current transformers mounted within the reclosure to provide the sensing of line current flowing through the reclosure. When the phase of residual currents exceed the pre-set values the controller initiates the specified automatic reclosing sequence i.e., a preselected series of opening and closing operations. If the fault is cleared before the end of a sequence the reclosure will remain closed and the controller, after a pre-set time resets to the start of the sequence.

2.03 The electronic control unit has several settings and mode switches to be pre-set to make it operational and they are discussed below:

2.04 **Relay settings:** They can be altered while the reclosure is in service but not during a trip sequence.

2.05 **Minimum trip restriction:** The Micro processor relay is designed for minimising its power consumption by running it in dormant mode until current reaches fault level. This is called „power-up“ point about 90% of minimum trip setting and to avoid hunting the power down is at about 70%.

It is therefore, recommended that the minimum trip current setting be atleast 160% of the rated continuous current to prevent undue drain on the battery.

2.06 **Different selective modes**

			Selection Switch	Mode
a)	IDMT (inverse) or			
b)	IDMTL (very definite minimum lag)		SW 3:8	a) OFF
c)	Superimposition of instantaneous feature			
	1 st trip	SW 7.5		
	2 nd trip	SW 7.6	Enable	ON
	3 rd trip	SW 7.7	Disable	OFF
	4 th trip	SW 7.8		

d) **Time Multiplier**
SW 3:4, SW 3:5 and SW 3:6 to OFF or ON as follows

Time Multiplier	Phase setting		
	SW 3:4	SW 3:5	SW 3:6
1.0	OFF	OFF	OFF
0.5	ON	OFF	OFF
0.4	OFF	ON	OFF
0.3	ON	ON	OFF
0.25	OFF	OFF	ON
0.2	ON	OFF	ON
0.15	OFF	ON	ON
0.1	ON	ON	ON

e) **Current Multiplier**

Red	SW 9:1	SW 9:2	SW 9:3	SW 9:4
Yellow	SW 9:5	SW 9:6	SW 9:7	SW 9:8
Blue	SW 10:1	SW 10:2	SW 10:3	SW 10:4
Tripe Setting	SW 9:1	SW 9:2	SW 9:3	SW 9:4
225%	ON ON	ON	ON	ON
200%	ON	ON	ON	OFF
175%	ON	ON	OFF	ON
150%	ON	ON	OFF	OFF
125%	ON	OFF	ON	ON
100%	ON	OFF	ON	OFF
75%	ON	OFF	OFF	OFF
0%	ON	OFF	OFF	OFF
25%	OFF	OFF	OFF	OFF

- f) The instantaneous minimum tripping current which is superimposed is adjustable by adopting a sealing factor between 1.00 and 2.4 by adjusting a switch SW 11 at the following positions.

Sealing Factor	SW 11 Position
2.4	8
2.2	7
2.0	6
1.8	5
1.6	4
1.4	3
1.2	2
1.0	1

2.07 Earth fault/spill current/residual protection

This protection again have the following selective modes.

a) IDMT/IDMTL - SW 3:7 to OFF for IDMT
to ON for IDMTL

b) Operating sequence

	1st trip SW7:5	2nd trip SW 8:6	3rd trip SW 7:7	4th trip SW 7:8
Enable	ON	OFF	ON	ON
Disable	OFF	OFF	OFF	OFF

c) The time multiples can be varied from 0.1 to 1.00 by setting switched SW 3:1 SW 3:2 and SW 3:3 as follows:

Time Multiplier	SW 3:4	Residual setting SW 3:5	SW 3
1.00	OFF	OFF	OFF
0.50	ON	OFF	OFF
0.40	OFF	ON	OFF
0.30	ON	ON	OFF
0.25	OFF	OFF	ON
0.20	ON	OFF	ON
0.15	OFF	ON	ON
0.10	ON	ON	ON

d) The trip current can be set from 10% to 90% by selecting switch positions SW 1:5 SW 1:6 SW 10:7 and SW 10:8 as ON or OF

Trip setting	SW 9:1	SW 9:2	SW 9:3	SW 9:4
90%	ON	ON	ON	ON
80%	ON	ON	ON	OFF
70%	ON	ON	OFF	ON
60%	ON	ON	OFF	OFF
50%	ON	OFF	ON	ON
40%	ON	OFF	ON	OFF
30%	ON	OFF	OFF	ON
20%	ON	OFF	OFF	OFF
10%	OFF	OFF	OFF	OFF

- e) The instantaneous setting 1.00 to 2.4 can be super imposed by selecting switch SW 12 as follows:

Sealing Factor	SW 11 Positin
2.4	8
2.2	7
2.0	6
1.8	5
1.6	4
1.4	3
1.2	2
1.0	1

2.08 There is in addition a sensitive earth fault relay SEF which has time delay setting and instantaneous setting variable as follows:

- a) SEF can be made 'enable' or 'disable' by keeping SW 13 Switch to position 2 or 1 respectively.
- b) The time delay is adustable between 0.5 and 24 Sec. by setting switches SW 7:1, SW 7:2, and SW 7:3 as 'ON' or 'OFF'.

SEF delay (Sec)	Switch setting		
	SW 7:1	SW 7:2	SW 7:3
24	OFF	OFF	OFF
10	ON	OFF	OFF
8	OFF	ON	OFF
5	ON	ON	OFF
3.5	OFF	OFF	ON
2.5	ON	OFF	ON
1.5	OFF	ON	ON
0.5	ON	ON	ON

- c) The sequence (number of trips) can be selected as 1,2,3 or 4 by setting switches SW 5:7 and SW 5:8 as ON or OFF.

Number of trip	Switch setting	
	SW 5:7	SW 5:8
4	OFF	OFF
3	ON	OFF
2	OFF	ON
1	ON	ON

- d) The SEF has also a provision by which the minimum trip current can be adjusted between 0.1 to 0.45 as sealing factor by setting switch SW 14.

Sealing Factor	SW 14 positin
0.45	8
0.4	7
0.35	6
0.3	5
0.25	4
0.2	3
0.15	2
0.1	1

- e) The instantaneous trip can be made 'enable' or 'disable' by setting switch SW 7:4 to 'ON' or 'OFF' respectively.

- 2.09 There is also a feature by which a minimum response time can be added to the instantaneous protection by adjusting switch SW 6 as follows:

Minimum Response Time (ms)	Sequence Co-ordination	SW 6
300	NO	F
250	NO	E
200	NO	D
150	NO	C
100	NO	B
No additional delay	NO	A
700	YES	9
600	YES	8
500	YES	7
400	YES	6
300	YES	5
250	YES	4
200	YES	3
150	YES	2
100	YES	1
No additional delay	YES	0

The reclose intervals for 1st, 2nd and 3rd trip can be adjusted by setting switches SW 4:1, SW 4:2, SW 4:3, SW 4:4, SW 4:5, SW 4:6, SW 4:7, SW 4:8 and SW 5:1 to OFF or ON as follows:

Reclose Interval (Sec)	Setting for 1st interval					Setting for 2nd interval			
	SW 4:1	SW 4:2	SW 4:3	SW 4:4	SW 4:5	SF 4:6	SF 4:7	SW 4:8	SW 5:1
120	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF
60	ON	OFF	OFF	ON	OFF	OFF	ON	OFF	OFF
30	OFF	ON	OFF	OFF	ON	OFF	OFF	ON	OFF
10	ON	ON	OFF	ON	ON	OFF	ON	ON	OFF
5	OFF	OFF	ON	OFF	OFF	ON	OFF	ON	ON
2	ON	OFF	ON	ON	OFF	ON	ON	OFF	ON
1	OFF	ON	ON	OFF	ON	ON	OFF	ON	ON
0.25	ON	ON	ON	ON	ON	ON	ON	ON	ON

- 2.10 The reclaim time can be adjusted by operating switches SW 5:2, SW 5:3 and SW 5:4 to OFF or ON as follows:

Reclaim Time (Sec)	SW 5:2	SW 5:3	SW 5:4
180	OFF	OFF	OFF
120	ON	OFF	OFF
60	OFF	ON	OFF
30	ON	ON	OFF
20	OFF	OFF	ON
15	ON	OFF	ON
10	OFF	ON	ON
5	ON	ON	ON

- 2.11 The total number of trips in a sequence can be adjusted to 1,2,3 or 4 by setting switches SW 5:5 and SW 5:6 to ON or OFF as follows:

Numbr of trips	Switch SW 5:5	Setting SW 5:6
4	OFF	OFF
3	ON	OFF
2	OFF	ON
1	ON	ON

3.00 SECTIONALISERS

The distribution system should be aimed at reliable supply to the consumers, if the areas affected are to be minimised and defective section should be isolated in case of permanent fault. This can be achieved by employing sectionalisers in conjunction with station auto reclose breakers.

Basically, a sectionaliser consists of 3 components they are:

- 1) A line switch called DM switch which is generally vacuum or SF6 switch for maintenance free operation.
- 2) Fault detecting or control relay box called TSR and
- 3) Voltage Transformer.

The DM switch is mounted on the line and is controlled by TSR and it is closed or opened through a solenoid. The Voltage transformer provides power source for DM switch operation and voltage detection for TSR, the sectionaliser has no time/current characteristics as in the case of relays that are used in system protection scheme, as it opens only when supply fails and recloses after a preset time of resumption of supply. No currents are interrupted by the sectionalisers as they open out only when supply fails.

Sectionalisers of Type-I and Type-II are discussed below:

3.1 Operational features of Type-I and Type-II sectionalisers

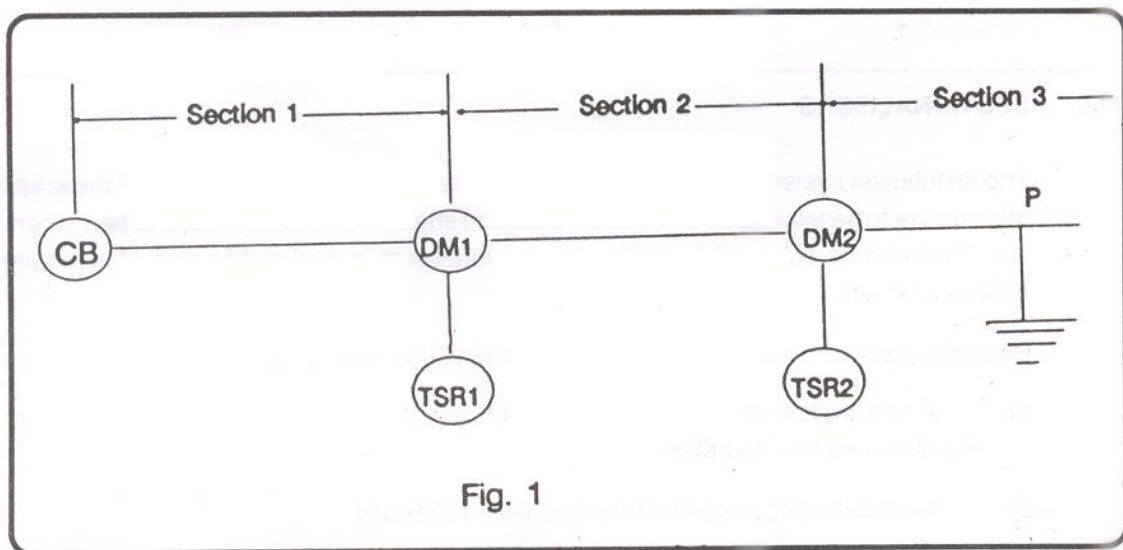
31.1 Type-I Sectionaliser: When the auto recloser CB at station closes, the control relay box TSR of sectionaliser receives voltage and it waits for a time of about 10 seconds hereinafter called „X“ time of TSR relay (which is adjustable by programming) before permitting closing of the DM switch automatically. After the Dm switch closes and an eliminating time of about 5 seconds, hereinafter called the „Y“ time of the TSR relay starts if the supply is interrupted during this „Y“ time of TSR relay, the #DM switch opens and gets locked out by TSR relay. This means the DM switch will not close even if the TSR relay receives voltage.

31.2 Type-II

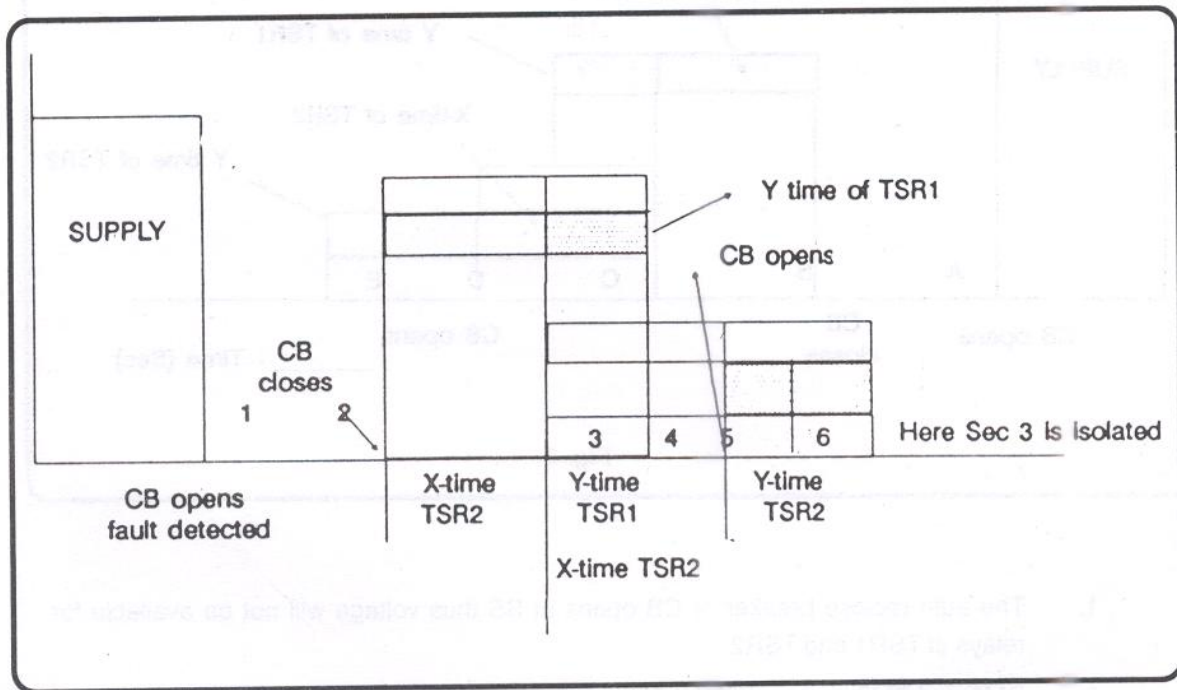
In this case, the sectionalisers count the number of interruptions and open out after a pre-set number of faulty interruptions. The main difference with Type-I is that the X time of TSR relay will not be operative. This case is dealt with in Section 3.3.

3.2 Type-I Sectionaliser:

Application to radial feeders: Consider the following figure 1 with 3 sections and with 2 sectionalisers. DM1, TSR1 and DM2, TSR2 of their components. The fault exists at point P in Section 3.



The sequence of operations for a temporary fault a P
(Figure 2)



1. The auto reclose breaker at substation open (Point 1 Refer figure 2)
2. TSR relays of DM1 and DM2 receives no voltage
3. DM1 and DM2 opens (at point 1 only)
4. The auto reclose breaker reclosures at time T1 (at point 2)
5. The TSR1 relay of DM1 receives voltage (at point 2)
6. DM1 Switch close after the lapse of „X” time of TSR1 relay at point (3)
7. The TSR2 relay of DM2 receives voltage (The X time of TSR2 and T time of TSR-1 starts at this point 3)
8. DM2 Switch closes after the lapse of „X” time of TSR2 relays at point (5)

(Here the supply to DM2 still available upto point (5) since Y time of TSR 1 was already lapsed since the fault is not in Section (1) and hence DM1 is still in closed position.

As the fault at P is temporary in nature, normal conditions are prevailed. But if the fault persists, the operations will be as follows:

For a permanent fault at point P the sequence of Operations will be as per Figure (3)

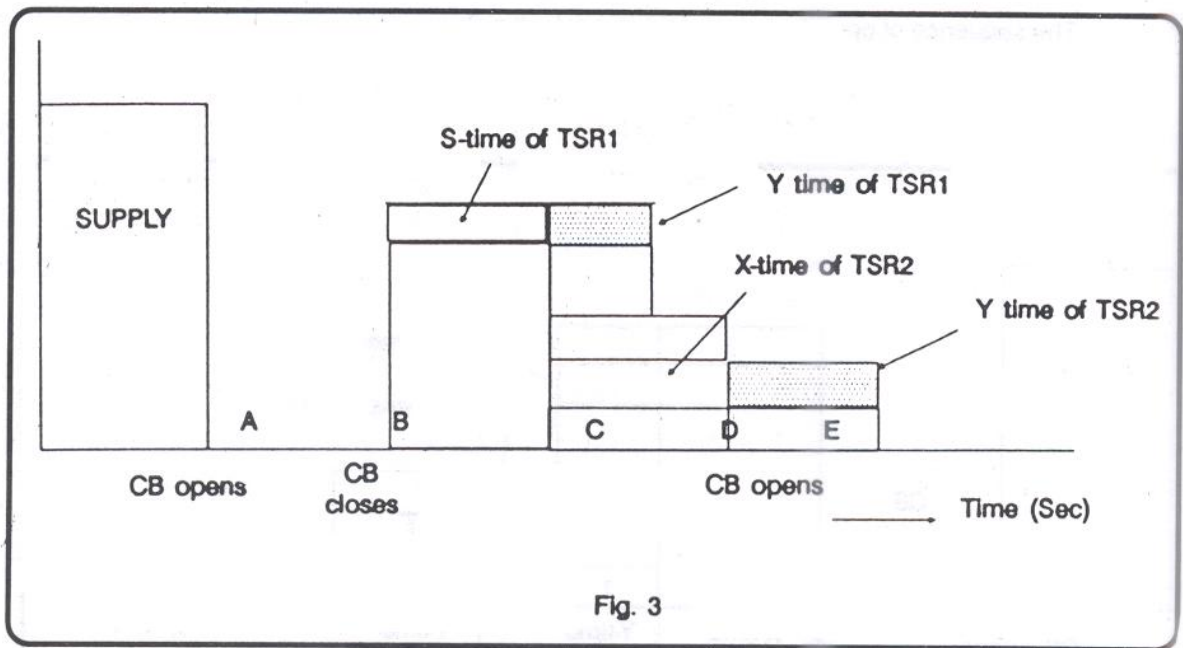


Fig. 3

1. The auto reclose breaker or CB opens at SS thus voltage will not be available for relays at TSR1 and TSR2
2. DM1 and DM2 open out (Point A)
3. The auto reclose breaker or CB reclosed after 10 seconds or at adjustable time. Thus TSR1 relay of DM1 receives voltage (Point B)
4. DM1 switch closes after 10 seconds or adjusted time of TSR1 relay (Point C)
5. The TSR2 relay of DM2 receives voltage and closes (Point D)
6. DM2 switch closes after 5 seconds but the fault is permanent nature, the circuit breaker at substation opens (Point E)
7. DM1 and DM2 opens.
8. TSR2 relay of DM2 receives no voltage and hence the DM2 sectionaliser is locked out by the TSR2 relay.
9. Section 3 has the fault and sectionalised automatically.
10. The circuit breaker at Substation is reclosed again by reclosing relay.
11. DM1 switch closes after 10 seconds or at adjusted time of TSR1 relay.
12. DM2 will not close time it is in lock out stage.
13. Supply of healthy section 1 & 2 is restored.
14. Thus the faulty section No. 3 is isolated.

The position of the sectionaliser provides clue to patrolmen to identify the fault.

3.03 Application to loop feeders:

The details of utilisation of sectionalisers is dealt with the above for radial feeder lines. These sectionalisers can be employed on loop feeder lines also using different types of auxiliary relays. Among them the following are the types available and for utilisation.

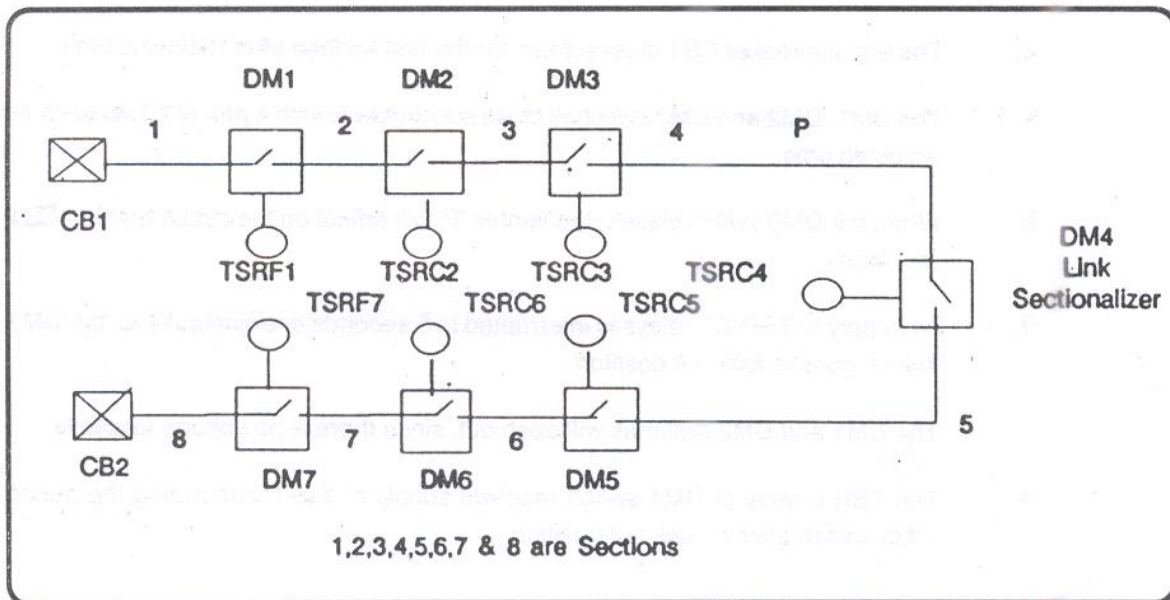
1. Relay TSR – F
2. Relay SR - L
3. Relay TSR - C

In detail the TSR-F relay are directional type. It operates only when voltage is received from sources to DM Switch. If supply fails during its starting time i.e., 5 seconds, the relay goes to lock out in open position.

This is the relay used in radial lines for all the sectionalizing switches.

The TSR-L and TSR-C relays are non directional type. These type relays can be employed in DM switch for the loop line feeders (Ring line feeders) for sectionalizing the fault. The application is detailed below:

1. Considering a line has been provided with 3 Nos. Sectionalisers in one arm connected to CB1 and 3 Nos sectionalisers in the other arm connected to CB2 as in the below sketch and a link sectionaliser.
2. The DM switches adjacent to the circuit breaker are provided with TSR-F relays.
3. The DM switch at the link point of the ring is provided with TSR-L relays.
4. All the other DM switches in the ring are provided with TSR-C relays.



Study at different conditions:

I. Normal conditions:

- a) DM7 Switch at loop point (adjacent to CB2) will be in open condition.
- b) The CB1, CB2 and all other DM switches are in closed position. Supply will be available at all section.

II. For temporary fault at point (P) location in the ring line feeder:

- 1. The circuit breaker CB1 opens. Due to fault at Point „P“ in the ring line feeder.
- 2. The TSR relays of DM1, DM2 and DM3 receives no voltage. Now TSR-L relay starts since supply fails from one side and at the same time DM1, DM2 and DM3 switches open.
- 3. Circuit breaker CB1 closes after its reclosing time.
- 4. On the expiry of 10 seconds or adjusted time, the DM1 switches closes. Accordingly, the subsequent switches close with a time gap of 10 seconds or adjusted time including DM3 switches as the fault is momentary nature, supply is restored to the entire feeder restoring normal conditions.

III. For permanent fault at Point 'P' location in the ring line feeder:

- 1. The circuit breaker CB1 opens due to fault at point „P“ in the ring line feeder.
- 2. The TSR relays of DM1, DM2 and DM3 receives no voltage.
- 3. The TSR – L relays of DM4 switch starts.
- 4. The circuit breaker CB1 closes again for the first reclose after reclosing time.
- 5. The DM1, DM2 and DM3 switches close successively with a gap of 10 seconds or adjusted time.
- 6. When the DM3 switch closes, the fault at „P“ will reflect on the circuit breaker CB1 and trips.
- 7. As supply to TSR-C3 relays is interrupted in 5 seconds or adjusted time, the DM3 switch goes to lock out position.

The DM1 and DM2 switches will open out, since there is no voltage available.

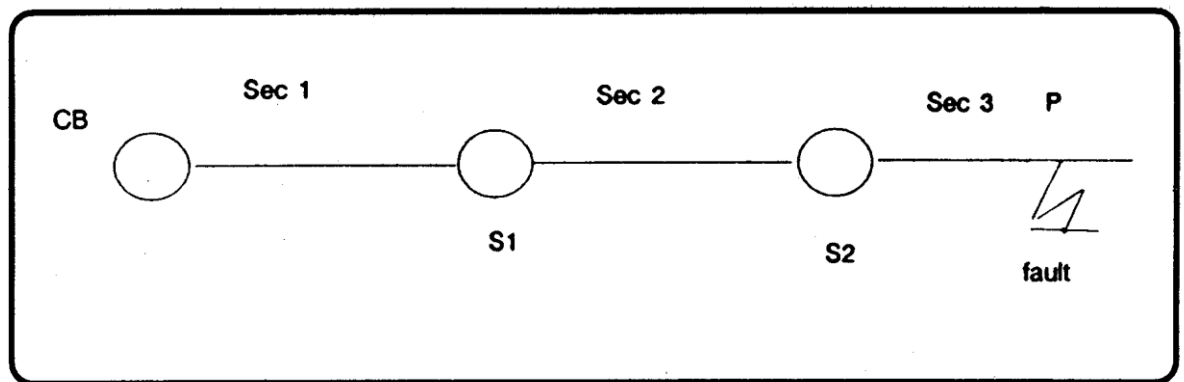
- 8. The TSR-L relay of DM4 switch receives supply of short time during the period DM3 switch goes to lock out position.

9. The circuit breaker CB1 closes again for the second reclose after reclosing time. Accordingly the DM1 and DM2 switches reclose.
10. The TSR-L relay goes to lock out position automatically.
11. The supply will be restored from circuit breaker CB2 instantaneously D5 to 8 and already the supply is available in Sections 1,2 and 3.
12. Thus determines the section 4 is faulty and will be isolated conditions as DM3 switch and DM4 switch are in lock out position.

Note: The time of TSR-L relay must be set for more than the times of (Reclosing time of CB1 and CB2 plus total times of DM switches in series from sub-station to loop point + 10 seconds extra).

- 3.3 Type 2: Sectionalising of fault sections can be achieved by sectionalisers opening on different principles of different manufacturers. The difference and variation will count on the number of faulty interruptions and open out after present number of fault interruptions.

Application:



1. S1 and S2 are two sectionalisers operating on the above principle.
2. S2 is set to open out after one fault interruptions.
3. S1 is set to open out after two fault interruptions.
4. For a fault at point „P“
 - a) Auto reclose breaker CB opens out
 - b) The Sectionaliser S2 opens out during the CB is in open position.
 - c) The CB recloses after its reclosing time, the supply will restores in section 1 determining the faulty section 3 in S2, will not close for this setting to one fault interruption.

3.4 Relative advantages of use of Type-I and Type-II Sectionalizers:

Type - I	Type - II
1. Any no. of Sectionalizers can be erected in series along radial feeders.	1. The no. of Sectionalizers is limited by reclosing speeds of the circuit breaker and the maximum no. of counts of the sectionalizers. Usual practice the tripping of CB should not exceed three.
2. The Sectionalizers can be utilised for isolating a faulty section in a ring system.	2. For a ring system the sectionalizers operate only in conjunction with reclosures in the line.
3. The no. of interruptions for any permanent fault is only two, irrespective of the location of the fault.	3. The no. of interruptions for a permanent fault depend on the location of the fault i.e. counts of sectionalizers.
4. Insulation medium of the Chamber is vacuum	4. Insulation medium of the chamber is oil which requires periodical maintenance.

- 3.5 While the State Electricity Board's have fulfilled the preliminary objective of integrating the power systems to reach the consumers, efforts are needed towards extending uninterrupted power supply to consumer's expectations.

This can be achieved only through modernisation of distribution system by providing suitable equipment leading to uninterrupted power supply.

Introduction of Automatic sectionalisers would go a long way in achieving minimum interruption time duration of powers to consumers. They are economical when compared to loss of energy consumption, during interrupted period.

4.0 CAPACITOR APPLICATIONS

4.01 Series and shunt capacitors:

They are identical in construction and only the method of connection vary their application. The series capacitors are connected in series with load carrying full load current and the same when dismantled and connected in shunt (across full line voltage) serve as shunt capacitors.

The type of usage have different applications, operation problems which are as discussed below:

Shunt Capacitors	Series Capacitors
1. Supply fixed amount of reactive power to the system at the point where they are installed. Its effect is felt in the circuit from the location towards source only.	1. Quantum of compensation is dependent on load current and instantaneous changes occur. Its effect is from its location towards load end.
2. Causes reduction in reactive power flowing in the line and causes a) Improvement of Power factor of system b) Voltage profile improvement c) decrease KVA loading on source (i.e.) generators, transformers and line upto location and thus provide additional capacity d) reduce system improvement cost per KVA	2. It is effective a) On radial feeders improve regulation, automatically. b) On tie lines; power transfers are greater. c) Specifically suitable when flickers due to repetitive load fluctuations occur.
3. The location has to be as near the load point as possible. In practice due to high compensation required it is found economical to provide group compensation on lines and at S.S.	3. As a thumb rule, best location is 1/3rd electrical impedance from source bus.
4. As fixed KVAR is supplied this may some times result in over compensation during light load periods. Switched banks, comparatively costlier becomes necessary.	4. As full load current is to pass through; the capacity (current rating) should be more than the load current.
5. As the power factor approaches unity, larger compensation is required for incremental improvement of power factor	5. As series capacitors feed faults also special protection is required.
6. Where lines are heavily loaded compensation required will be more.	6. Causes sudden rise in voltage at its location.
7. Cost is lesser comparative to series capacitor.	7. Cost of series capacitor is higher than shunt capacitor. 8. Transformers draw high transient exciting current when charged and this causes ferro resonance. Spark gap of capacitors to take care of the contingency. 9. Due to sub synchronous resonance; motors when started through series capacitors, may get locked in and continue to rotate at low speeds. This is prevented by providing resistor in parallel across capacitors or resistor in series with supply leads to motor at the time of starting.

Switched Capacitors Banks:

11KV Capacitor Banks of 1 MVAR are installed with circuit breakers and protective gear for over current, earth fault, over voltage, under voltage, and neutral displacement. We have also procured and installed 600 KVAR switched capacitor banks which have the following features.

These are pole mounted and controlled by automatic capacitor switches which switches on the units when the load current touches a pre-set value say 150 amps and cuts off during lean load periods to avoid over compensation.

The capacitor units are 6 units of 100 KVAR each and the latest revision in 3 units of 200 KVAR each.

The other design parameters are:

Rated voltage 12 KV

Rated current 200 Amps

Capacitor Switching current 4.5 KV

Rated short time current 4.5 KV

Rated making current 9 KV

BIL 75 KV

Control Supply: Those in service in APSEB require supply from a nearby distribution transformer.

The latest revision of specification by R.E.C. is for self powered units from 11 KV line and not dependent on A.C. or D.C. auxiliary supplies.

Capacitor Switch: They are suitable for Outdoor application with metallic enclosure.

These are with SF6 as interrupting medium.

A delay of 5 minutes is inbuilt between each switching operation to avoid any damage to the capacitor due to transient over voltage which may appear across in the capacitor bank. The closing is by use of solenoid.

SPECIFICATION OF CAPACITOR SWITCH

Technical Specification:

I.	a)	Application standards	:	IEC 265 or IS 9920
	b)	No. of poles	:	3 (Three)
	c)	Class	:	Outdoor Pole mounted SF 6 gas filled
	d)	Model	:	GASN 10 A - Y
	e)	Maximum capacity	:	600 KVAR
	f)	Rated Voltage	:	11 KV
	g)	Rated insulation level	:	12 KV
	h)	Rated Frequency	:	50 Hz
	i)	Rated normal current	:	200 Amps
	j)	Rated single capacity breaking current	:	50 A
	k)	Rated short time current for I	:	6 KA
	l)	Rated making current (peak value)	:	9 KA
	m)	Impulse withstand voltage (1.2*50 micro-second wave. crest)	:	
	i)	Main circuit to earth & between Poles	:	75 KV
	ii)	Across terminals in open position	:	75 KV
	n)	One minute power frequency with stand voltage	:	
	i)	Main circuit to earth & between Poles	:	28 KV
	ii)	Across terminals in open position	:	28 KV
	o)	One minute power frequency with stand on auxiliary wiring to earth.	:	2 KV

P)	Rated ratio of current Transformer :	150/5
q)	Rated control voltage :	220 V, 50 HZ
r)	Mechanical endurance :	30,000 times
s)	Electrical endurance :	30,000 times at 50 A Capacitive load current
t)	Solenoid operation Closing Opening :	2.2A to 220 V AC : 1A to 220 V AC
u)	Closing time :	0.2 seconds at the rated control voltage
v)	Opening time :	0.1 seconds at the rated control voltage

II. Climatic Conditions:

- a) The climatic conditons under which the equipment shall operate satisfactorily are as under.
- | | |
|--|------------------------------------|
| Max. temperature of air in shade : | 50° C. |
| Min. temperature of air in shade : | 3.5° C. |
| Max. humidity : | 100% |
| Average No. of thunder strom
days per annum : | 54 |
| Average annual rainfall : | 1450-3800 mm |
| Normal Tropical monsoon period: | 4 months |
| Max. wind pressure : | 150 Kg/Sq.m |
| Altitude above MSI : | Not exceeding 1000 m
above MSL. |

III. Constitutional Features:

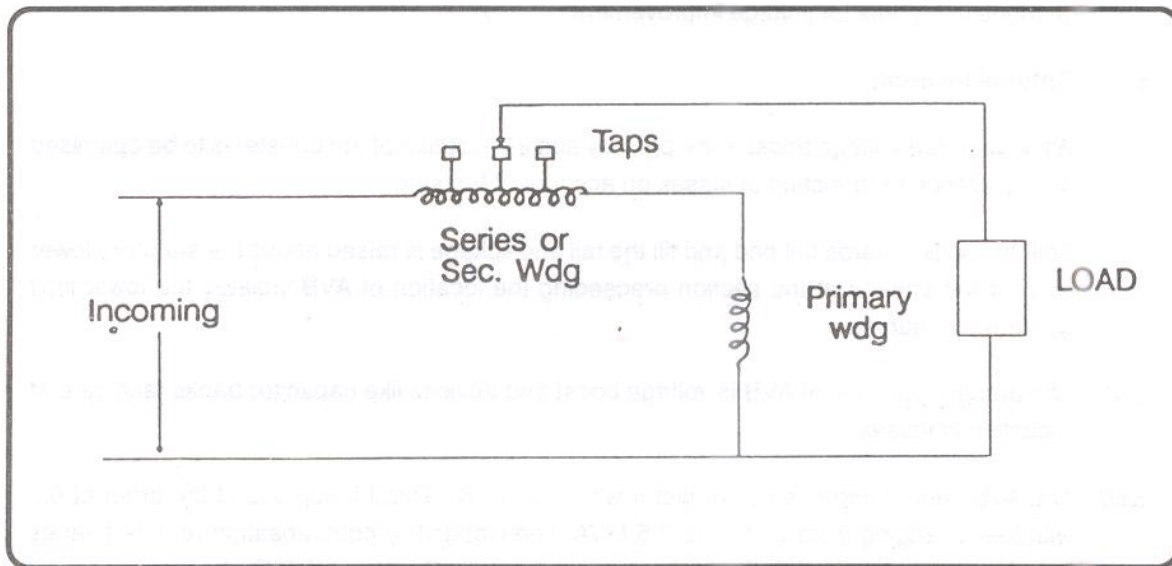
a)	Galvanisation :	Encloser and other metal parts
b)	Weight of complete SF6 capacitor switch :	58 Kgs. (approx).
c)	Degree of salinity pollution :	Upto 0.30 mg/cm2
d)	Vibration :	Under condition of 4 mm peak to peak 16.75 cycles/ Sec/hr.

5.0 AUTOMATIC VOLTAGE BOOSTERS

- 5.01 Introduction: The voltage at Consumers point of supply is to be maintained within statutory limits. This is the index for the quality of electric service provided. The equipment received power from the system operates efficiently and effectively only when the voltage at consumers point is maintained within the limits. In order to achieve the voltage control, pole mounted AVBs are used on distribution feeders.

The employment of AVBs along with switched shunt capacitor banks (SSCBs) can only give the desired objectives of loss reduction and voltage control.

PRINCIPLE OF OPERATION OF AVB



- 5.10 AVB is essentially an auto Transformer of primary winding connected in parallel with the circuit and secondary winding connected in series. Taps are provided on the series winding. The tap changing mechanism is operated by a driving motor. When a voltage is applied across the primary winding, voltage will be induced in the secondary winding due to the magnetic flux linking it. The amount of the induced voltage is controlled by means of the taps provided on the series winding. Voltage/load sensitive controls provide drive to motor which operates the tap changer. The AVBs employed in APSEB are voltage sensitive and the voltage is obtained from secondary of a P.T.

- 5.11 Rate of Booser: $\text{KVA rating of the Voltage Booser} = \frac{\text{Rated Amps of AVB} \times \text{Rated range of boost in KV}}{1000}$

Eg: For 6600 volts, 10% booser whose current carrying capacity is 100 Amps, KVA rating of booser
 $= 100 \times 6600 \times 10/100 = 66 \text{ KVA}$

5.20 **Effect of AVB:** When a booster is installed on a line. It causes a sudden voltage rise at its point of location and improves the voltage on the line beyond the location of AVB. The % voltage improvement is equal to % boost setting of AVB. The increase in voltage will cause reduction of losses in the line beyond the location of AVB.

5.21 The AVB improves the voltage as well as reduces line losses. Effect of AVB is predominant in voltage improvement as voltage boost upto 10 % can be obtained which is difficult to obtain with shunt capacitor.

5.3 With respect to loss reduction and voltage improvement in radial distribution feeders, the effect of AVB is similar to series capacitor. But, compared to series capacitors, AVBs are cheaper, easy to install and operate. Hence, AVB is preferred to series capacitor on radial distribution feeders for voltage improvement.

5.4 **Optimal location:**

While required voltage boost is the primary aim the location of the booster is to be optimised with reference to reduction of losses on account of booster.

Shift the AVB towards tail end and till the tail end voltage is raised above the statutory lower limit, or the Voltage at the section preceeding the location of AVB violates the lower limit whichever is earlier.

5.41 The primary purpose of AVB is voltage boost and devices like capacitor banks take care of reduction in losses.

5.50 The AVB cannot improve power factor which on 11 KV Rural feeders is of the order of 0.7 with loads ranging from 1 MVA to 2.5 MVA. The Capacitive compensation required varies between 300 to 800 KVAR. Fixed shunt capacitors cost Rs.60 per KVAR whereas automatic capacitor switch costs Rs.30,000. As such usage of one switched capacitor Bank per feeder a optimal location is considered enough. The optimisation approach is on the following lines.

1. Size & Location of one switched Capacitor Bank is to be deter-mined based on maximum reduction of losses.
2. Voltage profile with Capacitor bank is to be computed. If voltage variations are within limits O.K. Otherwise,
3. One AVB is to be proposed and the location is to be determined to satisfy voltage levels while minimising losses.

6.00 **CONCLUSION:**

It is the proper application of these available features that make the equipment serve the purpose for which it is intended to.

With distribution systems becoming complex due to increase in demand at unprecedented rate; employment of latest additions to the family of distribution equipment like auto reclosures, sectionalisers, autoboostrs, switched capacitor banks etc. and their optimum usage will modernise the distributions and contribute to achievement of higher reliability index.

ENERGY AUDIT

CONCEPT OF ENERGY AUDIT

The power generated at various Thermal and Hydro Power Stations is stepped upto EHV (132,220 OR 400K.V.) and transmitted to load centres. It is further stepped down to 33 K.V. for sub-transmission and to 11 K.V. or L.T. for primary and secondary distribution. Loss of energy is inevitable at each level of transformation and also during transmission of power to load centres as each element in the system offers resistance. These losses are termed as "Technical Losses". Further, commercial losses occur due to meters stuck up or burnt, meters not read, meters sluggish, unmetered services, erroneous readings and of course pilferage. The total of "Technical" and "Commercial" losses are termed as „T&D" losses in the system.

With each State Electricity Board now handling very large sums of energy to the tune of several tens of thousands of MU per year, even 1% of the losses amount to several hundreds of Crores of Rupees. A concept of „Comprehensive Energy Audit", to account for the units generated right down to units sold and the losses at each level of transmission, sub-transmission, primary distribution and to finally draw up an „Energy Balance Sheet" has come into being in the State Electricity Board.

OBJECTIVE OF ENERGY AUDIT

Identification of areas of High Technical Losses and to take steps to reduce the same.

Arrive at system improvements necessary

Obtain guidance for system planning.

Identification of areas where commercial losses are very high and to take remedial steps.

Pinpointing areas where theft of energy by direct tapping is rampant and take steps to plug up the leakages.

TECHNICAL LOSSES:

The percentage losses as existing and the corresponding achievable figures are indicated in the table below:

Sl. No.	System Element	Existing Level %	% Target Level	Max. Tolerance level %	% of Col.3 to Col.4	% of col.3 to Col.5
1	2	3	4	5	6	7
1.	Transmission System	4.50	2.00	4.00	225%	112%
2.	Sub-Transmission System	4.00	2.25	4.50	178%	89%
3.	Primary (HV) Distribution	7.00	3.00	5.00	233%	140%
4.	Secondary (LV) Distribution	7.50	1.00	2.00	750%	375%
5.	Total	23.00	8.25	15.50	279%	147%

CONSIDERATION THAT INFLUENCE TECHNICAL LOSSES:

Load density in MW/Sq. KM

Disposition of generating stations and major load.

Pattern of consumption (viz) percentage of agricultural consumption and percentage of bulk loads consumption

Ratio of consumptions at E.H.T., H.T. & L.T. levels.

Power factor of loads.

System configuration (i.e.) Ratio of lengths of lines EHT, HT & LT, Lengths of H.T. & L.T. lines per transformer, No. of transformers, No. of Voltage Transformation etc.

DIRECTOR & INDIRECT METHODS OF ENERGY AUDIT

- I) Direct Method: In this method, losses are found on the basis of difference of units sent out and received at the end of each element in the power system. The main advantage is that it is straight forward and simple. The major constraints are that it calls for metering of very high class of accuracy and the difficulty in simultaneous reading of meter. Due to employing CT & PT of very high ratios the multiplying factors are very large and any small variation will result in large discrepancy.
- II) Indirect Method: The losses are determined by simulation of the network. With the advent of powerful mini and micro computers at affordable prices and good models for simulation of T & D networks this is more popular and practical. Even in this system, metering at critical points in the system for operating parameters such as power factor, coincident fact, or load factor, loss factor and hourly load data is required for use in simulation.

LIMITATIONS

The losses arrived at can at best indicate only the range of losses but not a very accurate figure on account of the following constraints.

High cost of metering at EHT & HT points. As meters are to be connected using instrument transformers CT & PT for stepping down the primary parameters to level acceptable by meters the errors in the CT & PT together with errors in meters add up to inaccuracies. The high multiplying factors cause to magnify even small errors in registration of reading.

Simultaneous reading of all meters at every metering point is not possible unless an expensive automatic logging is provided.

Near impossibility of reading meters at all consumers at one time. Each State Electricity Board have about 10 million consumers spread over vast area. Also SEBs have different meter reading cycles such as monthly, bi-monthly, tri-monthly etc., by grouping number of services.

Assessed consumption at services with defective meters to be added up to sales.

Assessed consumption of unmetered services such as agriculture, have large bearing on arriving at the T & D losses.

ACTION TAKEN FOR ENERGY AUDIT

INTRODUCTION:

Four different actions are taken to start with:

District Wise Energy Audit: Provide the losses in each District network consisting of 132 K.V., 33 K.V., 11 K.V., AND LT systems. The losses comprise Technical and Commercial losses.

220 K.V., 132 K.V. and K.V. Lines Energy Audit: Provides the losses in each 220 K.V., 132 K.V., AND 33 K.V. lines. These losses can be taken as Technical losses only, as theft of power is very remote at these voltage levels.

11 K.V. Energy Audit: Provides the losses on each 11 K.V. feeder, consists of technical and Commercial losses.

Distribution Transformer Energy Audit: Provides the losses in the L.T. network under each distribution transformer. The losses comprise Technical and Commercial losses.

The status and action plan for performing each type of energy audit are discussed in succeeding Paras.

GAUGING OF AGRICULTURAL CONSUMPTION

Assessment made on agricultural consumption is often disputed as it is based on the estimates and also as it varies widely with cropping pattern, depth of ground water, acreage, season etc.

Hence, an attempt is made to estimate agricultural consumption by fixing meters at 10 agricultural services per Mandal and selecting the wells with different cropping, acreage, water depths etc.

It would be necessary to increase the sampling to atleast 5% of total agricultural services to get meaningful results. Perhaps, a more realistic approach may be to identify distribution transformers feeding exclusively agricultural services and provide metering to arrive at the consumption in agricultural sector district wise. To accomplish this we need to provide metering on about 5000 distribution transformers. The cost of such metering is Rs.5 crores at the rate of Rs.10,000/- per transformer.

Estimation of agricultural consumption based on sample metering at ten pilot services in each Mandal has revealed that the energy consumed in this sector is of the order of 7835 MU for 1996-97.

I) CALCULATION OF SYSTEM LOSSES

District wise import/export points are identified and energy meters are provided at each point and energy input to the system is arrived at. Monthly figures of total energy sold under each category in the district are collected and the agricultural consumption is assessed as indicated in para 230 above. The energy losses in a district are calculated. A return should be sent to Board by Superintending Engineer (Operation) every month as part of MIS.

II) CALCULATION OF ENERGY LOSSES IN THE VARIOUS ELEMENTS OF POWER SYSTEM

The following procedure may be adopted for calculation of energy losses in the various elements of power system in the District.

a) LOSSES IN E.H.T. FEEDERS AND CONNECTED EQUIPMENT

The energy exported from send end and received at the receiving end are compared every month and energy losses arrived at:

1. Energy meters should be provided at all the identified points.
2. The meter readings at the both ends should be taken on the same day every month at precisely at a fixed time.
3. The net energy sent out on 33 K.V. feeders emanating from each E.H.T. sub station are to be arrived at.
4. Also arrive the energy exported to other sub stations and areas normally fed by other areas.
5. Arrive at the total energy sent out from all the E.H.T. sub-stations.
6. Obtain total energy handled by the identified E.H.T. and H.T. feeders from the various generating stations/switch stations/sub-stations.
7. Arrive the E.H.T. line and connected equipment losses (6-5)

b) 33 K.V. FEEDER WISE AND CONNECTED EQUIPMENT LOSSES

1. Meters shall be provided for all 33 K.V. feeders emanating from E.H.T. substation (i.e.) 220 K.V. substation or 132 K.V. substation.
2. A feeder may be feeding one or more 33/11 K.V. sub station enroute. No metering need be provided on the incoming and outgoing 33 K.V. feeders of enroute substations in the first instance, if the same is not available.
3. Provide a meter on LV side of each power transformer immediately to assess the demand and energy handled by substation.
4. Provide metering for individual 11 K.V. feeders emanating from all substations.
5. The line losses for the complete 33 K.V. feeder may be evaluated as shown below.

Let a 33 K.V. feeder from E.H.T. SS feed three substations A1, A2, A3 with the following details:

Sl. No.	Name of the Sub-station	Transformer Capacity	Units sent out from 33/11 K.V. S.S i.e. sum of units sent out on all 11 K.V. feeders from the 33/11 K.V. SS or sum of units recorded on LV side of power transformers
1.	A1	2x1.5	E1
2.	A2	2x3.15	E2
3.	A3	2x5.0	E3

If there are any 33 K.V. H.T. consumers on the feeder let the consumption of the H.T. consumers be E-4.

Let the units sent out on 33 K.V. feeder at E.H.T. SS be X, the line losses on 33 K.V. feeder and the 33/11 K.V. transformers are $X - (E1 + E2 + E3 + E4)$.

The transformer losses can be estimated from the data given below:

Power transformers Capacity	No load losses Kilo watts/hour	Full load losses kilo watts/hour
0.5 MVA	3.2	6.4
1.6 MVA	3.0	16.0
3.15 MVA	4.5	23.0
5.0 MVA	6.5	34.0
8.0 MVA	8.5	50.0

Transformer losses if each transformer

= No load loss x no. of hours the transformer is in service during the month.

+ Full load copper loss x no. of hours the transformer is in service during the month x loss factor.

Loss factor = $0.8 \times (LF) + 0.2 \times LF$

Where LF is the load factor

Load Factor may be calculated as follows

$$L.F. = \frac{\text{Total units sent out of the SS in the month}}{(\text{No. of Hrs. the ss}) \times (\text{maximum demand of ss}) \text{ was in service}}$$

A monthly return for 33 K.V. feeder losses should be sent to Board by Superintending Engineer (Operation)

c) 11 K.V. FEEDER WISE AND CONNECTED EQUIPMENT LOSSES:

Energy losses in 11 K.V. system and its connected equipment can be calculated by two methods. The two methods are described.

METHOD 1

Install energy meters on all 11 K.V. feeders if not already done. Energy sent out on each of 11 K.V. feeder or a group of feeders if controlled by a single breaker may be obtained from the energy meter provided on the breaker at substation. The energy billed in respect of all services other than agricultural services distribution wise is available from billing records. The difference between the units sent out and units billed give the technical and commercial losses in the case of Urban Feeders and in respect of Rural feeders the difference between the energy sent out and billed gives the agricultural energy sales plus technical and commercial losses.

In the absence of energy meters for agricultural services, agricultural consumption has to be estimated. For this purpose, energy meters may be provided for 10 Nos. agricultural services in each Mandal selecting different types of crops if not already done. The specific energy consumption i.e., energy per horse power may be evaluated from the meter reading. The agricultural energy consumption may be computed as product of specific energy consumption and total HP of pumpsets in the Mandal. A report on the pattern of energy consumption as computed from sample metering data should be sent to the Board every month.

The important steps towards energy audit on 11 K.V. feeders are indicated below:

Provide energy meter for each 11 K.V. feeder or a group of 11 K.V. feeders controlled by a breaker at the substation.

Identify the distribution incident on the 11 K.V. feeder or group of feeders.

Identify the H.T. service incident on the feeder and their energy consumption on the current month (H.T.E.)

Obtain the energy billed distribution wise from the reports of private account agency for the current month (B1) and proceeding two months (B2, B3).

The average consumption of each distribution for non high value series, considering the three cycles ($PE = (B1 + B2 + B3)/3$)

Obtain meter readings of the meter on first day and last day of previous month (M1, M2).

The energy sent out on the feeders $ES = (M2-M1)$

Obtain the energy billed for high value services for the current month (HVE)

Obtain the total horse power of the pumpsets existing on the feeder (AHP)

Estimate the Agricultural energy sales as per the average consumption per HP arrived at based on meter readings at the pilot services (EA)

Total energy billed on the feeder.

= Private Accounting Agency Energy billed + High Value Energy billed + HT.

Energy Billed

$EB = PE + HVE + H.T.E.$

Energy losses on the feeder = Energy Sent = Energy billed – Agl. Energy Sales

$EL = ES - EB - EA$

METHOD 2

Install energy meters on all distribution transformers incident on the feeder. The energy sent out from each distribution transformer for the current month may be computed from the meter readings. The difference between the energy sent out on the feeder and sum of the energy sent out on the distribution transformers incident on the feeder gives technical and commercial losses of the feeder. This is a rigorous method but very extensive. It may be performed on one urban feeder and one rural feeder in each district. This method helps in analysis of low voltage network losses also as meters are provided on the LV side of the distribution transformer. A quarterly return on line losses of 11 K.V. feeders shall be sent to Board by Superintending Engineer (Operation).

d) LOW VOLTAGE NETWORK LOSSES:

In this case also energy losses can be calculated by two methods. In the first method, energy sent out from distribution transformer is measured by providing a energy meter. In the second method, it is estimated. The two methods are described.

METHOD 1

Meters are to be provided on LV side of distribution transformer to obtain energy sent out. Energy billed for different class of customers incident on the distribution transformer is computed from billing records. The energy sales on each distribution transformer can be automatically computed if the customer billing data base is linked upto with distribution location data base. First of all the distribution transformers will have to be given a location code No. and the procedure for coding the distribution transformer is described below:

The code number for rural area transformer consists of 9 digits. The significance of the code is indicated below:

Digit Number	Code
One and Two	District Code
Three and Four	Mandal Code
Five, Six and Seven	Village Censes Code
Eight and Nine	Sl. Number of Transformer in the Village

In the case of urban areas the code will have 12 digits

Digit Number	Code
One and Two	District Code
Three and Four	Mandal Code
Five, Six and Seven	Town Censes Code
Eight and Nine	Ward
Ten, Eleven and Twelve	Sl. Number of Transformer in the Village

Then the consumers incident on each distribution transformer have to be identified. For this purpose an additional field „Transformer location code“ is added in the consumer data base. Then the energy billed for each distribution transformer is computed automatically. The private accounting agencies have to be advised to furnish every month energy sales distribution transformer wise. The difference between the energy sent out and energy billed gives the technical and commercial losses of the LV network.

METHOD 2

In this method, energy meter is not installed and the energy sent is estimated by taking readings of current and voltage at peak load with long tester. The energy sent out is $3 \times \text{current in Amps} \times \text{Voltage (Phase – Phase)} \times \text{Load Factor} \times \text{Power Factor}$. The load factor and power factor are estimated by taking sample readings and considering load characteristics. Rest of the procedure is same as Method 1. This method does not require any additional investment and can be performed as a part of maintenance of transformer. Alternatively, the specific energy consumption for K.V.A. of transformer capacity or K.V.A of maximum demand incident on transformer is calculated and compared with the estimates obtained for distribution transformer of similar characteristics in the area.

Specific energy Consumption =

$$\frac{\text{Energy billed}}{(\text{Tong tester amps} \times 3 \times \text{voltage on LV side of DTR}) \text{ or DTR capacity}}$$

INSULATION RESISTANCE OF WINDING OF TRANSFORMERS

Rated Voltage of the winding	Minimum safe insulation resistance in Megaohms at winding temperatures of			
(1)	(2)	(3)	(4)	(5)
	30 degree C	40 degree C	50 degree C	60 degree C
66 KV and above	600	300	150	75
33 KV	500	250	155	65
6.6 KV and 11 KV	400	200	100	50
below 6.6 KV	200	100	50	25

SERVICE CONNECTIONS

S. No.	HP of 3 ohm motor	Approx. Current at 400v (amps)	Size of single core cable to be used area Sq. mm.	Capacity of 3 ohm motors to be utilised	Size of Fuse carriers for Aerial/cut outs (Amps)	Size of l.c. fuse wire SWG Aerial cutout
1.	3.0	5.0	2.5	10	19	30
2.	5.0	8.0	4.0	10	16	30
3.	7.5	12.0	6.0	10	32	28
4.	10.0	15.0	6.0	30	32	2x30
5.	12.5	19.0	10.0	30	32	23
6.	15.0	22.0	10.0	30	32	22
7.	20.0	29.0	25.0	30	63	20
8.	25.0	36.0	25.0	50	63	18
9.	30.0	42.0	25.0	50	63	18
10.	35.0	50.0	50.0	50	63	2x20
11.	40.0	56.0	50.0	100	100	2x20
12.	45.0	63.0	50.0	100	100	2x13
13.	50.0	71.0	70.0	100	100	16
14.	60.0	83.0	70.0	100	100	15
15.	70.0	98.0	95.0	100	200	14

Lighting loads (S O) in Watts :

1.	Upto 500 Watts	2.5	2.5 Amps	16	40 SWG (To)
2.	500 to 750 Watts	2.5	5 Amps	16	38 SWG (To)
3.	750 to 1250 Watts	2.5	5 Amps	16	33 SWG (To)
4.	1250 to 1750 Watts	2.5	10 Amps	16	30 SWG (To)
5.	1750 to 3900 Watts	2.5	20 Amps	32	26 SWG (To)

F.L. CURRENT OF TRANSFORMERS IN AMPS.

	K.V.A.	440 V	11000V	433 V
3 O	25	32.80	1.31	33.34
"	50	65.61	2.62	66.67
"	63	83.06	3.32	84.44
"	75	98.41	3.94	100.00
"	100	131.22	5.25	133.34
"	150	196.82	7.87	200.00
"	160	-----	8.4	213.34
"	200	262.43	10.50	266.68
"	250	328.04	13.12	333.35
"	300	393.66	15.75	400.02
"	315	-----	16.53	420.0
"	500	636.08	26.24	666.7
S O	10	21.730	1.574	-----
	15	32.60	2.36	-----

CAPACITORS TO BE INSTALLED FOR MOTORS

Sl. No.	Rating of Individual motor	KVAR rating of Capacitors various RPM of the motors			
		750 RPM	1000 RPM	1500 RPM	3000 RPM
1.	3 HP	1	1	1	1
2.	5 HP	2	2	2	2
3.	7.5 HP	3	3	3	3
4.	10 HP	4	4	4	3
5.	15 HP	6	5	5	4
6.	20 HP	8	7	6	5
7.	25 HP	9	8	7	6
8.	30 HP	10	9	8	7
9.	40 HP	13	11	10	9
10.	50 HP	15	15	12	10
11.	60 HP	20	20	16	14
12.	70 HP	24	23	19	16

**L.T. CAPACITORS TO BE
INSTALLED FOR WELDING SETS**

Rating of welding set in KVA	Capacity of Capacitor in KVAR	Rating of Welding Set in KVA	Capacity of Capacitor in KVAR
1.0	1	19.0 to 20.0	15
2.0	2	21.0	16
3.0	3	22.0	17
4.0	4	23.0	18
5.0	5	24.0 to 25.0	19
6.0 to 8.0	6	26.0	20
9.0	7	27.0	21
10.0	8	28.0 to 29.0	22
11.0 to 12.0	9	30.0	23
13.0	10	31.0	24
14.0	11	32.0	25
15.0 to 16.0	12	33.0	25
17.0	13	34.0	26
18.0	14	35.0	27

**POWER FACTORS OF SOME
COMMON TYPES OF LOADS**

Load	Power Factor
Incandescent lamps	1.00
Arc lamps used in Cinemas	0.3 to 0.7
Neon Signs	0.4 to 0.5
Fluorescent Lamps	0.6 to 0.8
Resistance Heaters	1.0
Induction heaters	0.85
Arc furnaces	0.85
Induction Furnaces	0.60
Arc Welders	0.3 to 0.4
Resistance Welders	0.65
Induction Motors	0.8

SCHEDULE OF PATROLLING OF E.H.T. LINES

1. (Approved in CE's Memo. No. SE/G O/F 11/4434/68, Dt. 10-12-68)

S. No.	Particulars of line with Voltage	Routine patrolling 50% of all the line		Test Checking of routine patrolling of 25% of lines	
		Cadre	Periodicity	Cadre	Periodicity
1.	66 KV line	Line inspector	Once in two months	ADE	Once in four months
2.	13 KV line	Line inspector	Once in two months	ADE	Once in four months
		AE/AEE	Once in six months	DEE	Once in six months
3.	220 KV line	AE/AEE	Once in two months	DEE	Once in four months
		AAE	Once in four months		
II. (Approved CE's Memo. N.T. 11/LD.CIR/1180, Dt. 12-8-68)					
4.	All poles and lines 33 KV	Wireman or Lineman	Once in two months monthly	ADE	Once in four months
5.	All poles and lines above 400V upto & including	-do-	Monthly	AAE	Once in three months
6.	All poles and line in distribution 400 V	Helper	Fortnightly	Wireman or lineman	Once in two months
7.	Telephone lines on separate poles	Helper	-do-	Lineman	Once in two months

CONVERSION TABLE AMPS Vs MVA

Reference Table MVA per Ampere

Amps	11 KV	33 KV	66 KV	132 KV	220 KV	400 KV
1	0.019	0.057	0.114	0.229	0.381	0.69
2	0.038	0.114	0.229	0.457	0.768	1.39
3	0.057	0.171	0.343	0.686	1.143	2.08
4	0.076	0.228	0.457	0.914	1.524	2.77
5	0.095	0.286	0.672	1.143	1.905	3.46
6	0.114	0.343	0.686	1.372	2.286	4.16
7	0.133	0.400	0.800	1.600	2.667	4.85
8	0.152	0.457	0.915	1.829	3.048	5.54
9	0.171	0.514	1.028	2.058	3.429	6.23
10	0.191	0.571	1.143	2.286	3.810	6.93
11	0.210	0.629	1.257	2.515	4.192	7.62
12	0.229	0.666	1.372	2.744	4.573	8.31
13	0.248	0.743	1.486	2.972	4.954	9.01
14	0.267	0.800	1.600	3.201	5.335	9.70
15	0.286	0.857	1.715	3.429	5.716	10.39
16	0.305	0.915	1.829	3.658	6.097	11.08
17	0.324	0.972	1.943	3.887	6.478	11.78
18	0.343	1.029	2.058	4.115	6.859	12.47
19	0.362	1.086	2.172	4.344	7.240	13.16
20	0.381	1.143	2.286	4.573	7.621	13.86
25	0.476	1.429	2.858	5.716	9.526	17.32
30	0.572	1.715	3.429	6.859	11.432	20.78
35	0.667	2.00	4.001	8.002	13.7	24.25
40	0.762	2.286	4.573	9.145	15.242	27.71
45	0.857	2.572	5.144	10.288	17.147	31.18
50	0.953	2.858	5.715	11.432	19.053	34.64
60	1.143	3.429	6.859	13.718	22.863	41.57
70	1.334	4.001	8.002	16.004	26.674	48.50
80	1.524	4.573	9.145	18.290	30.484	55.42
90	1.715	5.144	10.288	20.557	34.295	62.35

Reference Table Amps. per MVA

MVA	11 KV	33 KV	66 KV	132 KV	220 KV	400 KV
1	52.5	17	8.7	4.3	2.2	1.4
2	105.0	35	17.5	8.7	4.4	2.9
3	157.5	52	26.2	13.0	6.6	4.8
4	209.9	70	35.0	17.5	8.7	5.7
5	262.4	87	43.7	21.9	10.9	7.2
6	314.9	105	52.5	26.2	13.1	8.7
7	367.4	122	61.2	30.6	15.3	10.8
8	419.4	140	70.0	35.0	17.5	11.5
9	472.4	157	78.7	39.4	19.7	13.0
10	524.9	175	87.0	43.7	21.9	14.4
11	577.4	192	96.0	48.1	24.0	15.9
12	623.8	210	105.0	52.5	26.2	17.3
13	682.3	227	114.0	56.9	28.4	18.8
14	734.8	245	122.0	61.2	30.6	20.2
15	787.3	262	131.0	65.6	32.8	21.6
16	839.8	280	140.0	70.0	35.0	23.8
17	892.3	297	149.0	74.3	37.1	24.5
18	944.8	315	157.0	78.7	39.4	26.0
19	997.0	332	166.0	83.1	41.5	27.4
20	1050.0	350	175.0	87.5	43.7	28.9
25	1312.0	437.0	219.0	109.0	54.7	36.8
30	1575.0	525	262.0	131.0	65.6	43.3
35	1837.0	612	306.0	153.0	76.5	50.5
40	2099.0	700	350.0	175.0	87.5	57.7
45	2362.0	787	394.0	197.0	98.4	65.0
50	2624.0	875.0	497.0	218.0	109.3	72.2
60	3149.0	1050	525.0	262.0	131.2	86.6
70	3674.0	1225	612.0	306.0	153.0	101.0
80	4199.0	1400	700.0	350.0	175.0	115.0
90	4724.0	1575	787.0	394.0	197.0	130.0

STANDARDS TO BE MAINTAINED AT SUBSTATIONS

Voltage in KV	Clearance for equipments and rigid conductors		Phase to Phase Spacings						Arcing rod Setting			Max. Elect. Distance between LA and Tr. Bushing Terminal mm	Dia of Al Tubular bus bars inch.	Size of ACSR conduct or bus of strain bus	Bay widths	
	Phase to Phase	Phase to earth	isolators	Switches with A/c Horns	Strong Bus	Min. Clearance of live parts to ground	On Transformer bushing	On Terminal Tower	On Approach tower							
	mm	mm	mm	mm	mm	mm	mm	mm	mm							
220	3400	1700	3400	4000	4000	5500	1140	1120	1120	---		61/157	17.0			
132	1700	1020	2140	3050	3600	4600	800	735	760	43		37/168	11.0			
66	1210	760	1530	2140	2200	4600	395	330	355	24		37/110	7.6			
33	920	610	760	1220	1300	3700	"	"	"	18		Depends	4.7			
11	460	310	610	920	1330 or 920	3700	"	"	"	12		On Tr. Capacity	3.5			

CURRENT RATING OF 11 KV UG, XLPE CABLES

No. of cores & cross-sectional area of conductor	Conductor Min. No. of wires	Approx. Overall diameter	Approx. Belt weight of cable	Max. D.C. Resistance at 20 degree C	Approx. A.C. Resistance at operating Temp. 90 degrees C	Approx. Reactance at 50 c/s	Approx. Capacitance per phase	Current Rating		Short circuit rating for 1 Sec.
								Direct in Ground	In Air	
No. x Sq.mm	No.	mm	kg/km	ohm/km	ohm/km	ohm/km	uf/km	Amps.	Amps.	KA(rms)
3 x 25 rm/v	6	44	2140	1.20	1.54	0.137	0.195	93	100	2.35
3 x 35 rm/v	6	47	2420	0.868	1.11	0.130	0.215	110	120	3.29
3 x 30 rm/v	6	50	2710	0.641	0.822	0.124	0.235	130	145	4.70
3 x 70 rm/v	12	54	3150	0.443	0.568	0.117	0.265	160	180	6.58
3 x 95 rm/v	15	58	3700	0.320	0.410	0.111	0.300	190	220	8.93
3 x 120 rm/v	15	63	4280	0.253	0.325	0.107	0.330	215	255	11.3
3 x 150 rm/v	15	66	4660	0.206	0.265	0.104	0.355	240	285	14.1
3 x 185 rm/v	30	70	5330	0.164	0.211	0.101	0.385	270	330	17.4
3 x 240 rm/v	30	76	6300	0.125	0.161	0.097	0.435	315	385	22.6
3 x 300 rm/v	30	81	7260	0.100	1.130	0.095	0.475	355	440	28.2
3 x 400 rm/v	53	90	8810	0.0778	0.102	0.091	0.530	405	510	37.6
3 x 500 rm/v	53	97	10310	0.0605	0.0782	0.089	0.590	455	590	47.0

ISSUE AND RECEIPT OF LINE CLEARS - POWERS OF FIELD ENGINEERS AND SUBORDINATE STAFF

No.	Grade of Employee	Powers to issue line clear	Powers to issue line clears to one self and book himself	Powers to receive line clear from others and work himself	Special authorisation
1.	AE's and AAE's and L.Is	On all E.H.T., H.T., L.T., lines and all equipments	Same as in (3)	Same as in (3)	Authorisation by name by the DEE
2.	Lineman and L.M. Operators	a) HT S.C. lines of 33 KV and below and its equipments. There should not be any double Deck feed arrangements for the 33 KV and below S.C. lines. b) On all LT lines and equipments	Same as in (3)	Same as in (3)	Authorisation by name of the DEE on recommendation of ADE/AEE.
3.	Asst. Lineman	On all LT lines and the equipments	a) On all LT lines and equipments. b) Renewal of HG fuses of 11 KV DTR's in isolated stations. c) -do- Under guidance of higher official in urban area.	On all L.T. lines and its equipments	Authorisation by name by DEE on recommendation of ADE/AEE.
4.	Helper	Nil	Renewal of arial fuses and cut out fuses in LT services and also renew street light bulbs	Nil	Helpers of more than one year continuous experience in the cadre may be authorised by DEE or recommendation of AEE.
Authority :- Rule 212 of Safety code.					

**STANDARDS FOR PROVIDING FIRE
FIGHTING EQUIPMENT**

1. For substations 66 kv and above:

Transformers	:	One CO2 fire extinguisher of 15 lb capacity for the first 2 transformers and one for every additional transformer.
C.Bs	:	One CO2 fire extinguisher of 15 lb capacity for the first 15 lb capacity for the first 2 E.H.T.O.C.Bs, and one for every additional two breakers. In case of A.B.C.B., one for the first three and one for every additional three A.B.C.B., or less.
33 KV bus	:	One unit as above if O.B.Cs or A.B.C.Bs are in service.
11 KV bus	:	Same as above.
Control room	:	One unit of 15 lb capacity for panels.
Considering starting Transformers & panels	:	One unit as above

In addition to the above, one 50 lbs, trolley mounted CO2 fire extinguisher may be provided at all E.H.T., bus-stations.

2. For 33 KV substations:

Transformers	:	One unit of 15 lb capacity for the first two transformers and the additional unit for every additional unit for every additional two transformers or less.
O.C.Bs.	:	One unit on the incoming side bus and one on the outgoing side bus.

DISTRIBUTION TRANSFORMER FUSE RATINGS

L.T. MAINS AND CABLES

Capacity of Transformer in KVA	full load Amps 11 KV side	Current LT side	Size of T.o. fuse wire in S.W.G		Size of single core PVG A1. cable in sq. mm		Size of L.T. fuse units to be used	
			11 kv side	LT side	for mains	for feeders	for mains (Amps)	for feeders (Amps)
1. 10	---	---	---	4	25	---	---	---
2. 15	---	---	---	4	25	---	---	---
3. 25	1.31	33.4	38	20	50	1x50	3x100	3x100
						2x25		2x2x63
4. 50	2.62	66.7	33	2x20	70	1x70	3x100	3x100
						1x50+1x25		2x3x63
5. 63	3.31	84.0	33	2x13	90	1x70	3x200	3x100
						2x50		2x3x100
6. 75	3.94	100.0	33	2x1(1x14)	95	1x95	3x200	3x200
				or 3x20		1x70+1x50		2x3x100
7. 100	5.25	133.5	33	2x16	150	1x150	3x300	3x300
						1x95+1x75		3x200+3x100
8. 150/160	6.4	213.4	30	2x14	2x120	2x120	x300	6x300
				or 3x13		1x150+1x95		3x300+3x200
9. 200	10.5	236.7	28	3x14	2x150	2x130	6x130	3x300
				or 4x16		1x150+		
						1x120		
10. 250	13.12	334.4	28	4x14	3x120	1x120	9x300	9x300
						x150+1x120+1x95		6x300+3x200
11. 316	16.53	420.0	20	---	---	---	---	---
Note : 2 x 25 means 2 feeders of 25 Sq. mm Cable								

**MAXIMUM PERMISSABLE SPANS (IN METRES)
FOR TYPICAL LINES.**

Sl. No.	Particulars	75 Kg/M2 Wind Pressure	100 kg/m2 Wind Pressure
A.	33 KV lines over 9.1 M.PSCC poles with Dog/Raccon ACSR Conductor	75	75
Sl. No.	Particulars	75 Kg/M2 Windpressure 8 M.PSCC poles	100 kg/m2 Wind Pressure 8 M.PSCC poles
B. i.	11 KV lines over 8.0 M.PSCC poles with ACSR conductor a) Rabid (7/3.35) b) Weasel (7/2.59) c) Squirrel (7/2.11)	65 80 100	70 90 90
ii.	6.3 kv Single phase line over 8.0 M.PSCC poles with ACSR. Conductor (HVD System) a) Weasel (7/2.59) b) Squirrel (7/2.11)	110 110	110 110
iii.	L.T. 3o 5 wire (vertical formation) lines over 8.0 M.PSCC pole with ACSR Conductor. a) 3xRabit + 2 x Squirral b) 3xWeasel + 2 x squirral c) 5 x squirrel	54.5 65.5 67	67 67 45
iv.	L.T. 3o 4 Wire line : a) Rabbit (7/3.35) b) Weasel c) Squirrel (7/2.11)	62.5 77.5 91	66.5 82.5 100
v.	L.T.S o 3 Wire line: a) Weasel (7/2.59) b) Squirrel (7/2.11)	67 67	67 67
vi.	L.T. S o 2 wire line : a) Squirrel (7/2.11) b) Squirrel (city)	67 45	67 45

RAILWAY CROSSINGS

VERTICAL CLEARANCE: The minimum height above rail level of the lowest portion of any conductor of crossing, including guard wire, under conditions of maximum.

TABLE - 1.

Voltage	Category - A (Selection electrified on 1500 V.D.C.)		Category - B (Selection already electrified or likely to be converted for electrified on 25 KV AC System within the foreseeable future)	
	Broad, Metre and Narrow gauges		Broad, Metre and Narrow gauges	
	Inside Stn. limits (mts.)	Outside Stn. Limits (mts.)	Inside Stn. Limits (mts.)	Outside Stn. Limits (mts.)
Upto 11 KV	Only by Cable		Only by Cable	
Above 11 KV upto 33 KV	13.28	11.28	15.28	13.28
Above 33 KV upto 66 KV	13.59	11.59	15.59	13.59
Above 66 KV and below 110 KV	13.89	11.89	15.89	13.89
for 110 KV and 132 KV	14.2	12.2	16.2	14.2
for 220 KV	15.11	13.11	17.11	15.1
for 400 KV	16.63	14.63	18.63	16.63

Note : While calculating the above clearance Railways HI lines running over the 1500 V.D.C. traction structure in some sections have not been taken into consideration.

TABLE - II

For Category-C (Section not likely to be electrified in the near future)

	Broad, Metre and Narrow gauges		Broad, Metre and Narrow gauges	
	Inside Stn. limits (mts.)	Outside Stn. Limits (mts.)	Inside Stn. Limits (mts.)	Outside Stn. Limits (mts.)
Upto 11 KV	Only by Cable		Only by Cable	
Above 11 kv upto 33 kv	10.06	7.62	8.84	6.4
Above 33 kv upto 66 kv	10.36	7.92	9.15	6.71
Above 66 kv and below 110kv	10.67	8.23	9.45	7.01
for 110 kv and 132 kv	10.97	8.53	9.76	7.32
for 220 kv	11.89	9.45	10.67	8.23
for 400 kv	13.41	10.97	12.19	9.75

NOTE:

1. If the crossing is located on a meter gauge or a narrow gauge likely to be converted to Broad gauge, clearances applicable to Broad gauge shall be adopted (Section 18-3).
2. Station limits shall be taken to mean all tracks lying in the area between the outer most singals of a Railway Station (18.4)
3. U.G. cable pipe structure should be at 5 meters away from Railway power support to be located by Railway authority (Section 30-1)
4. The Spun concrete pipe encasing cable under the tracks should be laid at not less than 1 meter below the surface of formation level and upto a minimum distance of 3 meters from the centre of the nearest track on either side (Section 33-1).

Authority : Regulation for Electrical crossing of Railway Tracks 1984.

CLEARANCES AND SPACINGS

A. Clearance above ground of the lowest conductor of overhead lines including services lines.

Sl. No.	Particulars	Low & Medium Voltage (upto 460V) Mts. (ft.)	H.V. (upto 11 KV) Mts. (ft.)	H.V. (above 11 KV) upto 33 KV Mts. (ft.)	EHV above 33 KV
1.	Accross the streets	5.791 (19)	6.096 (20)	6.096 (20)	Add 0.305
2.	Along the streets	5.486 (18)	5.791 (19)	6.096 (20)	Mts. (1 ft.)
3.	Erected else where than along or across streets (Bare)	4.574 (15)	4.574 (15)	5.182 (17)	for every 33 KV or part of Voltage
4.	-do- (Insulated)	3.963 (13)	3.963 (13)	---	above 33 KV

Authority : LE Rules 77 of Indian Electricity Rules 1956.

B. Clearance from buildings (between highest/nearest point of the building to lowest conductor):-

Sl. No.	Voltage Ranges	Vertical clearance from highest point Mts. (ft.)	Horizontal Clearance from nearest points Mts. (Ft.)
1.	Low & Medium	2.44 (8)	1.22 (4)
2.	High Voltage upto 11 KV	3.66 (12)	1.22 (4)
3.	High Voltages above 11 KV upto 33 KV	3.66 (12)	1.83 (6)
4.	E.H. Voltages above 33 KV	Add 0.305 Mts. (Ft.) 33 KV or part thereof	for every additional

Authority : I.E. Rules 79 & 80 of Indian Electricity Rules 1956.

II. CLEARANCE OVER RIVERS:

- i. Non-navigable Rivers 3.05 Mts. (10') over M.F.L. to lowest Conductor
- ii. Navigable Rivers 3.05 Mts. (10') over possible tallest most of the Boats in consultation with concerned authority.

III. HORIZONTAL CLEARANCE BETWEEN LINE SUPPORT AND HIGHWAYS :

Sl. No.	Type of Road	Width of Road (Meters)	Clearance between Centre of the Road and support
1.	National Highways	11.58 (38')	7.62 (25')
2.	State Highways	9.75 (32')	6.3 (22')
3.	Major District Roads	7.32 (24')	5.49 (18')

IV. Clearance of overhead lines crossing or approaching each other :

Sl. No.	System Voltage of Existing line	High Voltages upto 66 KV KV clearance	11 KV minimum	132 KV value in	220 KV meters
1.	Low medium voltage H.V. E.H.V. upto 66 KV	2.44	2.75	3.04	4.58
2.	110 KV	2.75	2.75	3.05	4.58
3.	132 KV	3.05	3.05	3.05	4.58
4.	220 KV	4.8	4.8	4.8	4.8

Authority : I.E. Rule 87 (3) of Indian Electricity Rules 1956.

V. Clearance between power and Telecommunication lines.

Sl. No.	Particulars	Clearance between guarding wire and Tel.com line MM (Ft.)	Clearance between power and Tel.com line in MM (Ft.)
1.	Upto 11 KV	1220 (4)	1525 (5)
2.	33 KV	1220 (4)	1830 (6)
3.	66 KV	1220 (4)	2440 (8)
4.	132 KV	1830 (6)	2740 (9)
5.	220 KV	---	3050 (10)

Authority : Clause 7 & 8 on page 14-61 of Technical reference Book.

TIPS FOR PROPER MAINTENANCE OF EQUIPMENT

1. Before carrying out maintenance works on an equipment, first equipment should be isolated from the supply and grounding chain or wire. Only then, the man-in-charge should allow persons to work on it.
2. Meggering of a particular equipment. The wire megger connected to the equipment for meggering should be hanging in the air. The equipment also should be isolated from ground wires, jumpers connected to it. After the work is over, the jumpers should be reconnected and any loose connection should be checked and rectified jumpers connected to transformer bushing or breaker busbar should not be rigid. They should be flexible.
3. Every day, reading on pressure gauges connected to compressors, air flow circuits, feeding breakers etc., should be noted down and oil levels temperatures in breakers, transformers etc., should be noted.

Maintenance of Grounds in the stations is essential. Water the grounding pipes daily. Tighten the connecting bolts. Check the earth resistance at least once in a year and take corrective action if necessary.

Batteries are like the heart and DC system is like the nervous system. Maintain them well, check the level of the electrolyte everyday. Top up with distilled water if necessary. They may be charged heavily once in three months or more frequently to make up the battery voltage and specific gravity. The amount and duration of charge (limiting to the battery capacity). Should depend upon the existing condition of the battery (Voltage and specific gravity). For the lead acid battery, specific gravity should always be between 1.18 and 1.20. Voltage of individual cells should not be allowed to fall below 1.8 V.

During Pre-arrange Shut Downs... ..

1. Check for the opening and closing of breakers both manually and electrically.
2. Verify opening of the breakers for faults through relays. Check the annunciation signals.
3. Check the joints for loose contact, pitting etc.
4. Power (break downs) are mostly due to bad maintenance. Check the oil condition, insulation resistance, cooling arrangement. Buchholz relay etc., of warning.

REMEMBER undue temperature rise is a warning.

Oil Test

While collecting oil sample from an equipment through sampling cock, allow small quantity of oil to be drained out initially and then collect the oil in the bottle for testing purposes. Before conducting oil test, cool the oil sample and remove any air bubbles present.

Oil Samples taken for testing in standard testing equipment. All air bubbles should be removed by a clean stirrer.

Tests	As per I.S.S. (for New Oil)
1. Breakdown voltage KV (Dielectric strength)	50 KV (RMS)
2. Specific resistance at 27 degrees C Ohm-cm	500x10(to the power of) 12
3. Water content	50 PPM
4. Dielectric dissipation factor (Tan Delta at 9.0 degree C)	0.005
5. Neutralization Value mg of KOH/gm of oil	0.03
6. Inter facial tension N/M at 27 degree C	0.04
7. Flash Point	140 degree C
8. Sludge	0.1 Percent by Wt.

Insulation Test

Insulation resistance values should be obtained with a standard with a standard megger. The loads should be suspended air. The temperature at which the meggering is done also be noted.

Frequency of Oil and Megger tests Twice a year once before and once after monsoon

COMMON DEFECTS NOTICED AND THE CAUSE

PART	DEFECTS	CAUSES
1. Tank	a) Leakage of oil b) Deformation c) Overheating	Corrosion / mechanical damage - Gaskets worn out - Excessive internal pressure - Improper circulation of cooling oil and / or inadequate ventilation.
2. Radiators	a) Leakage of oil b) Deformation c) Overheating	Corrosion / mechanical damage - Gaskets worn out - Excessive internal pressure - Improper circulation of cooling oil and / or inadequate ventilation.
3. Conservate	a) Leakage of oil b) Deformation c) Overheating	Corrosion / mechanical damage - Gaskets worn out - Excessive internal pressure - Improper circulation of cooling oil and / or inadequate ventilation.
4. Breather	Ineffective	Inlet choked-Silacajel saturated.
5. Explosion	Glass broken	Mechanical
6. Core	a) Loose b) increased Losses c) Excess Noise	Bolts loosening up - change in characteristics due to heating-vibration of stampings
7. Winding	a) Short Circuited b) Loosening c) Insulation Brittle d) Open circuited	Overloading - Air bubbles - loss of insulation - shrinkage displacement Overheating decomposition burn out.
8. Oil	a) Discolouration b) High Acidity c) Low B.D.V. d) Sludge	Contamination - increased moisture - Decomposition chemical action with other parts.
9. Terminal Bushing	a) Breakage b) Leakage of Oil	Strain - Gasket Worn out - Loose fit.
10. Tap switch	a) Inoperative Broken lever b) Burnt Contact c) Short Circuit	Maloperation - Insulation failure - Failure of operation mechanism - overheating.

Types of faults against which Buscholz relay gives successful protection.

Visible or Audible alarm (Upper Float actuates)

1. Core bolt insulation failure
2. Short circuited core laminations
3. Bad electrical contacts
4. Local overheating
5. Loss of oil due to leakage
6. Ingress of air into the oil system

Trip circuit operates (Lower Float actuates)

1. Short circuit between phases
2. Winding earth fault
3. Winding short circuits
4. Puncture of busings

PARALLEL OPERATION OF TRANSFORMERS

The conditions that must be observed for the parallel operation fo transformers both primary and secondary side.

1. Same voltage ratio
2. Same polarity
3. Same phase sequence
4. Zero relative phase displacement

TINNED COPPER FUSE WIRE TABLE

The following Table is based on the information given in the I.E.E. Regulations 12th Edition 1950 Table 21. Approximate sizes of fuse elements composed of tinned copper wires for use in semi-enclosed fuses.

The figures are an approximate guide only the current at which the fuse will blow will depend upon the construction of the fuse holder in which the wire is used.

S.W.G.	Current rating of fuse in amperes	Approximate fusing current
1	2	3
40	1.5	3
39	2.5	4
38	3	5
37	3.5	6
36	4.5	7
35	5	8
34	5.5	9
33	6	10
32	7	11
31	8	13
30	8.5	13
29	10	16
28	12	18
27	13	23
26	14	28
25	15	30
24	17	33
23	20	38
22	24	48
21	29	58
20	34	70
19	38	81
18	45	106
17	65	135
16	73	166
15	78	197
14	102	230
13	130	295

H.G. FUSE RATINGS FOR TRANSFORMERS

Capacity of transformers in KVA (1)	HT voltage rating (2)	Size of T.C. fuse wire in S.W.G. (3)	Horn gap length in mm (inches) (4)
5000	33 KV	2 x 20	385 (15)
3000/3150	"	20	"
1500/1600	"	21	"
1000	"	22	"
750	"	23	"
500	"	26	"
500	11 KV	20	205 (8)
250	"	23	"
100	"	33	"
75	"	33	"
63	"	33	"
50	"	33	"
25	"	38	"

REGULATION CONSTANTS

Conductor Size	1.0 PF	0.9 PF	0.8 PF	0.7 PF
I. KW-KM for 33 KV 3Ø lines for 1.1% voltage drop constants (REC construction standard M-5:)				
50mm ² ACSR 7/3.35 Rabbit	16,883	12,975	11,514	10,332
80mm ² ACSR 7/4.09 mm Raccoon	25,150	17,498	14,994	13,091
100mm ² ACSR Dog (6/4.72mm + 1.51 mm)	33,405	21,248	17,714	15,512
II. KW-KM for 11 KV 3Ø lines for 1% voltage drop constants (REC construction standard A-9:)				
7/2.11 mm ACSR squirrel	706	674	640	605
7/2.59 mm ACSR weasel	1150	970	900	840
7/3.35 mm ACSR Rabbit	1920	1490	1330	1200
III. KW-KM for 415 V 3Ø lines for 1% voltage drop constants (REC construction standard B-9:)				
7/2.11 mm ACSR squirrel	1.08	0.98	0.93	0.88
7/2.59 mm ACSR weasel	1.63	1.41	1.31	1.23
7/3.35 mm ACSR Rabbit	2.72	2.18	1.96	1.78

Authority : Memo No. CEE (RE) 122/F/40B/617/82, Dt. 8.11.1982.

Method of Calculations:

$$11 \text{ KV\% regulation} = \frac{\text{KVA} - \text{Km} \times 0.8}{\text{D.F.} \times \text{Constant}} \quad (\text{Max. 8\%})$$

$$\text{L.T.\% regulation} = \frac{\text{H.P.} - \text{Mts} \times 0.746}{\text{D.F.} \times \text{Constant} \times 1000} \quad (\text{Max. 6\%})$$

I. BASIC REVENUE RETURNS W.E.F. 2-8-1996

As per B.P.Ms. No. 956, dt. 31.12.1985, Basic Revenue Return will be the Tariff Minimum.

1. Domestic	SØ - Rs.180/- per service per year.
	3Ø - Rs.1080/- per service per year
2. Non-Domestic	SØ - Rs.540/- per service per year
	3Ø - Rs.1440/- per service per year
3. L.T. Indl.	- Rs.180/- per HP per year
4. Cottage Industries	- Rs.72/- per HP per year
5. Agricultural L.T.	- No revenue return
6. Street Lights	- Rs.24/- per point per year for Municipalities/Corporations
7. General purposes	SØ - Rs.420/- per service per year
	3Ø - Rs.1200/- per service per year

II. PERCENTAGE OF REVENUE RETURNS

- Domestic-No revenue return upto two poles and Domestic Complexes.
- Non-Domestic - LT Indl. and HT Services - 12.5% above.
- Domestic (above 2 poles cottage Indl.
St. Lights, General and composite scheme - 20% above.

SIZE OF EARTH LEAD

a) For Transformer Neutral Point Earthing :

Transformer rating	Electrolytic bare copper conductor or strip	Insulated (PVC) single core Standard Aluminium	Galvanised iron conductor or strip
50 KVA or below	8 SWG	16 Sq. mm	25 mm x 3 mm
75 KVA/63 KVA	8 SWG	25 Sq. mm	40 mm x 6 mm
100 KVA	4 SWG	35 Sq. mm	40 mm x 6 mm
15 KVA / 160 KVA	2 SWG	70 Sq. mm	40 mm x 6 mm
200 KVA	25 mm x 1.5 mm	95 Sq. mm	40 mm x 6 mm
250 KVA	25 mm x 3 mm	50 Sq. mm	40 mm x 6 mm
300 KVA / 315 KVA	25 mm x 3 mm	225 Sq. mm	40 mm x 6 mm
500 KVA	25 mm x 6 mm	300 Sq. mm	50 mm x 6 mm
750 KVA	25 mm x 6 mm	300 Sq. mm	Above 500 KVA only copper/aluminium strips to be used

b) For Equipment Earthing :

(Applicable to Transformers, Motors, Generators, Switchgears, etc)

Rating 400 V.3 ph 50 cy. equipment in KVA	Size of Earth Conductor		
	Bare Copper	Aluminium PVC insulated	Galvanised iron
upto 5	14 SWG	6 Sq. mm	7/22
6 to 15	10 SWG	16 Sq. mm	8 SWG
16 to 50	10 SWG	16 Sq. mm	25 mm x 1 1/2 mm
51 to 75	8 SWG	25 Sq. mm	25 mm x 1 1/2 mm
76 to 100	6 SWG	35 Sq. mm	25 mm x 3 mm
101 to 125	4 SWG	50 Sq. mm	25 mm x 6 mm
126 to 150	2 SWG or 25 x 1 1/2 mm	70 Sq. mm	25 mm x 6 mm
151 to 200	25 x 1 1/2 mm	70 Sq. mm	38 mm x 6 mm
201 and above	25 x 3 mm	185 Sq. mm	50 mm x 6 mm

NOTE: Conductor to be protected so that no mechanical damages could be caused Earth connections for all HV equal and switchgear should not be less than 0.1 Sq. mm PVC insulated standard aluminium conductor of 2" x 1/4 G.L. strip.

CONTINUOUS CURRENT RATING OF UG CABLES
IS 692 - 1965 PILC ALUMINIUM CONDUCTOR CABLES 1.1 KV CLASS

Nominal area of conductor Sq. mm.	11 KV Cables Current rating in Amps						11 KV Cables Current rating in Amps.		
	In air		In current		In duct		3 core belted type armoured		
	Twin core	Multi core	Twin core	Multi core	Twin core	Multi core	in air	in Ground	in Duct
6	50	41	56	47	49	40			
10	70	55	75	62	62	52			
16	82	72	99	81	81	67			
25	120	100	135	110	110	92			
35	137	115	150	125	125	102	104	105	95
50	172	144	185	156	151	125	127	130	114
70	226	190	237	199	195	161	168	168	145
95	260	220	269	223	221	184	191	190	165
120	306	263	315	262	259	217	226	222	194
150	340	295	349	291	285	240	255	246	215
185	390	340	397	332	322	274	291	279	246
225	448	394	449	377	363	311	334	314	280
240	485	430	484	406	390	336	363	337	300
300	522	460	513	432	418	361	394	359	319
400	654	570	618	522	518	431	465	423	376

1. Maximum conductor temperature	In air/in ground-80 C for 1.1.70 C for 11 KV In duct 60 C for 1.1 KV 70 C for 11 KV
2. Depth of laying from ground surface	Top surface of cable 460 mm for 11 KV, 910 mm for 11 KV
3. Ambient Temperature	Air - 25 Ground - 15 C
4. Thermal resistivity of soil	120 C cm/watt.

APPROXIMATE FULL LOAD CURRENT OF TYPICAL MOTORS

H.P. of Motor	Single phase 240V	3 Phase Motor	
		400 V	415 V
0.5	2.7	0.9	0.9
1	5	1.75	1.7
2	10	3.5	3.4
3	14.5	5	4.8
4	18.2	7	6.3
5	22.8	8	7.7
6	27.3	9.5	9.2
7.5	33	11.5	11.1
10	44	15.5	14.9
15	63	21.5	20.6
20	80	28	27
30	122	42	41
40	163	57	55
50	200	68	66
60	238	83	80
70	275	95	92
80	308	106	102
90	334	115	111
100	370	128	124

USEFUL LIVES OF PLANTS

(Extracted from the Electricity (Supply) Act, 1948 and as amended upto 1968)

<u>Description of asset</u>	<u>No. of years of period</u>
A. Land owned under full title	Infinity
B. Land held under lease :	
a) for investment in the land	The period of the lease or the period remaining unexpired on the assignment of the lease.
b) for cost of cleaning	The period of the lease remaining unexpired at the date of clearing the site.
C. Asset purchased now :	
a) Plant and machinery in generating stations, including plant foundations	
i) Hydro-electric	Thirty-five
ii) Steam-electric	Twenty-five
iii) Diesel-electric	Fifteen
b) Cooling towers and circulationg water system.	Thirty
c) Hydraulic works forming part of a Hydro-electric system including	
i) dams, spilways, weirs, canals, reinforced concrete flumes and syphens.	One hundred
ii) Reinforced concrete pipelines and surge tanks, steel pipe lines, sluice gates, steel surge tanks, hydraulic control valves and other hydraulic works.	Forty
d) Buildings and civil engineering works of a permananet character, not mentioned above:	
i) Offices and showrooms	Fifty
ii) Containing thermoelectric generating plant	Thirty
iii) Containing hydro electric generating plant.	Thirty five
iv) Temporary erection such as wooden structures.	Five
v) Roads other than kucha roads	One hundred
vi) Others	Fifty
e) Transformers, transformer kiosks, substation equipment and other fixed apparatus (including plant foundations):	
i) Tranformers (including foundation) having a rating of 100 kilovolot amperes and over	Thirty Five
ii) Others	Twenty Five

f) Switchgear, including cable connections	Twenty
Switching arrestors	
i) station type	Twenty
ii) line type	Fifteen
iii) synchronous	Thirty Five
g) Batteries	Ten
h) i) Underground cables including joint boxes and disconnecting boxes.	Forty
ii) Cable duct system	Sixty
i) Overhead including supports :	
i) Lines on fabricated steel supports operating at nominal voltage higher than 66 KV	Thirty five
ii) Lines on steel supports operating at nominal voltages, higher than 132 KV but not exceeding 66KV	Thirty five
iii) Lines on steel or reinforced concrete supports.	Twenty five
iv) Lines on treated wood supports	Twenty
j) Meters	Fifteen
k) Self-propelled vehicles	Seven
l) Static machine tools	Twenty
m) Air-conditioning plant :	
i) static	Fifteen
ii) portable	Seven
n) i) Office furniture and fittings	Twenty
ii) Office equipment	Ten
iii) Internal wiring including fitting and apparatus.	Fifteen
iv) Street-light fittings	Fifteen
o) Apparatus let out on hire	
i) Other than motors	Seven
ii) Meters	Twenty
p) Communication equipment	
i) Radio and high frequency carrier system	Fifteen
ii) Telephone lines and telephones	Twenty
D. Assets purchased second hand and assets not otherwise provided for in this table.	Such reasonable period as the state Government determines in each case having regard to the nature, age and condition of the asset at the time of its acquisition by the owner.

HVDC

AN INTRODUCTION TO HVDC TRANSMISSION

One of the most exciting new technical development in electric power system in the last three decades has been “High Voltage Direct Current transmission”. From the first of HVDC links to the recent, the voltage has increased from 100 KV to 800 KV, the rated power from 20 MW to 6300 MW and the distance from 96 km to 1370 km.

Preceding and accompanying this rapid growth of Direct Current Transmission were developments in High Voltage, High power valves, in control and protection system, in DC cables and in insulation for overhead DC lines.

In India three HVDC projects are in operation.

- (i) The Rihand-Delhi HVDC transmission project having 1500 MW capacity and 500 KV DC voltage is the first commercial long distance DC transmission project in India.
- (ii) Vindhyachal 2x250 MW Back to back DC converter station which asynchronously connect the Northern and Western regions for exchange of power.
- (iii) The Nation HVDC experimental line project, which links Lower Sileru in A.P. to Barsoor in M.P. Phase 1 of this project is capable of transmitting 100 MW at 100 KV DC.

The main advantages of High Voltage Direct Current transmission are –

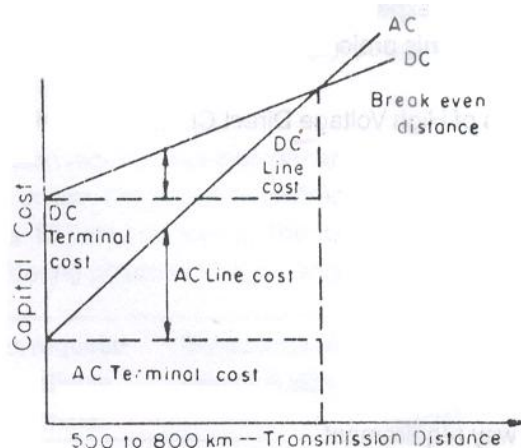
- (1) Asynchronous operation
- (2) Controllability
- (3) Stability
- (4) Reliability
- (5) Low right of way requirement
- (6) Economy on overall basis
- (7) Greater power per conductor
- (8) Simple line construction
- (9) No skin effect, charging current and less corona loss and interference
- (10) Ground return can be used
- (11) Cables can be worked at a higher voltage gradient
- (12) May inter connect AC systems of different frequencies
- (13) Low short circuit current on DC line.

Principal Applications of DC Transmission

1. For cables crossing bodies of water wider than 32 km. [Ex Sweden-Gotland link, a 20 MW, 100 KV DC single conductor submarine link to supply power to the island of Gotland.]
2. For inter connecting AC systems having different frequencies or where asynchronous operation is desired.
3. For transmitting large amounts of power over long distances by overhead lines.
4. In congested urban areas where it is difficult to acquire right of way for overhead lines and where lengths involved make AC cables impracticable.

Economic Factors

The cost per unit length of a DC is lower than that of an AC line of the same power capability with comparable reliability, but the cost of the terminal equipment of a DC line is much more than that in an AC. A graph is plotted between the cost of transmitting an amount of power by one method and the distance over which it is transmitted, below:



The vertical intercept of each curve is the cost of the terminal equipment alone. The slope of each curve is the cost per unit length of the line and of that accessory equipment which varies with length. The curve for AC transmission intersects that for DC transmission at an X axis which is the break even distance, Transmission by DC is cheaper than AC for distance above 500 km.

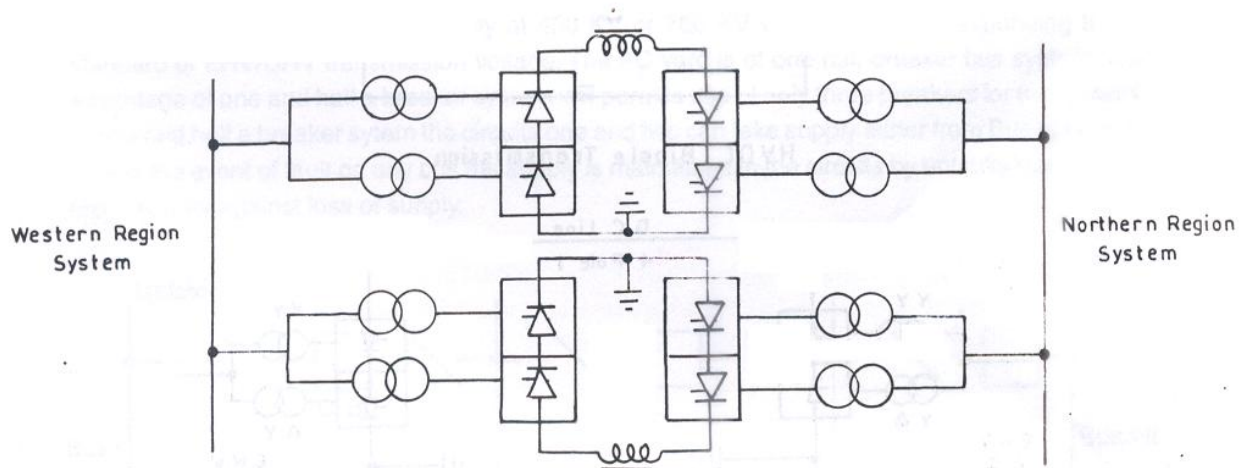
Type of DC Links

HVDC back to back link: This link is used to connect two AC grids, each AC grid can have its own load frequency control. Direction of power flow can be controlled by adjusting the characteristics of convertor valves. There is no increase in fault level and cascade trippings in the network are avoided. [Ex. Vindhyachal Back to Back HVDC link].

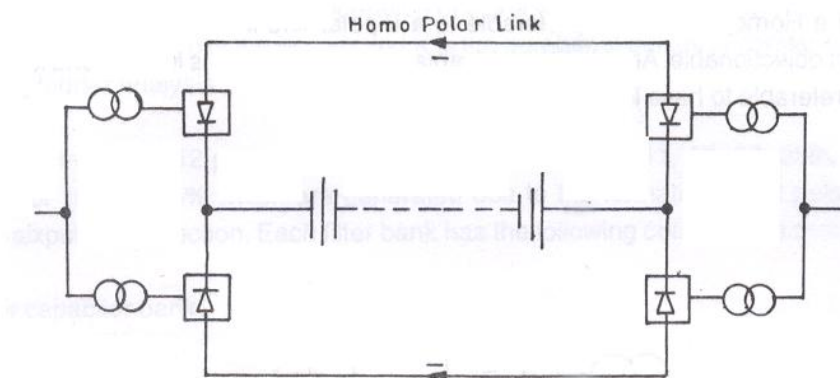
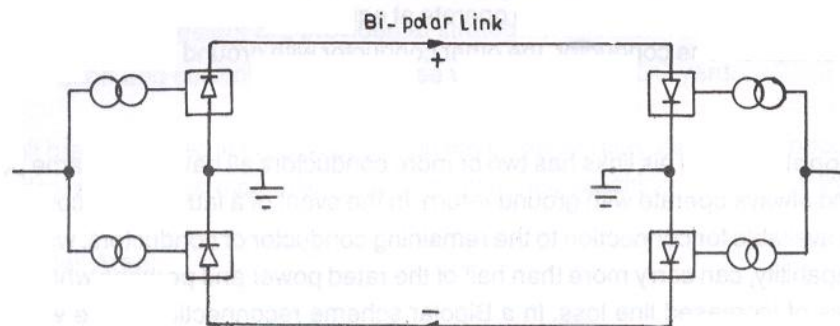
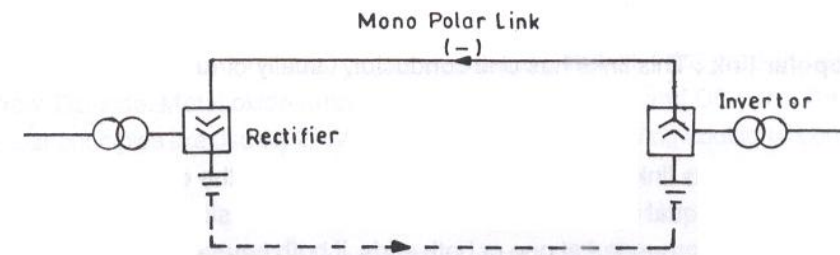
Monopolar link: This link has one conductor, usually of negative polarity, and ground or sea return.

Bipolar link: This link has two conductors one positive, the other negative. Each terminal has two convertors of equal rated voltages in series on the DC side. The neutral points (junction between convertors) are grounded at one or both ends. If both neutrals are grounded, the two poles can operate independently. Normally they operate at equal currents: then there is no ground current. In the event of a fault on one conductor, the other conductor with ground return can carry up to half the rated load.

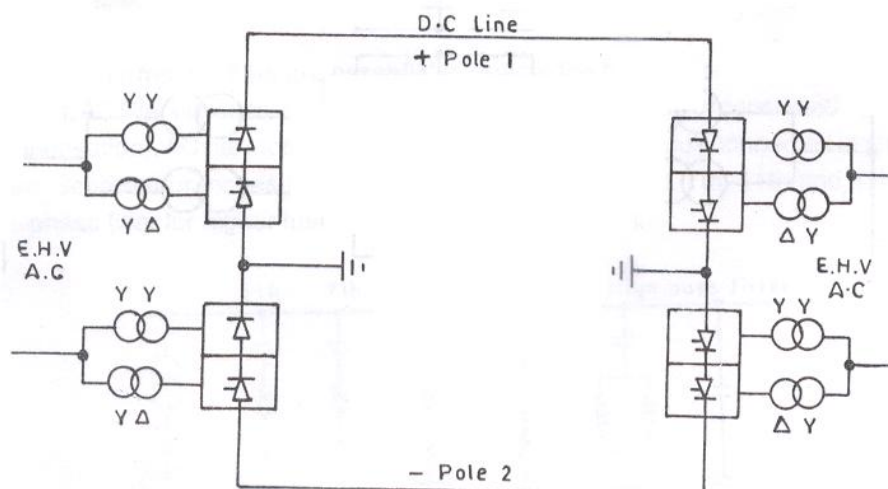
Homopolar link: This link has two or more conductors all having the same polarity, usually negative, and always operate with ground return. In the event of a fault on one conductor, the entire convertor is available for connection to the remaining conductor or conductors, which, having some over load capability, can carry more than half of the rated power and perhaps whole rated power, at the expense of increased line loss. In a Bipolar scheme reconnection of the whole convertor to one pole of the line is more complicated and is usually not feasible because of graded insulation. In this respect a Homopolar line is preferable to a Bipolar line in cases where continuous ground current is not objectionable. An additional advantage, though minor, is less corona loss and negative polarity is preferable to have less radio interference.



HVDC back to back link



HVDC Bipole Transmission



HVDC Bipole Link

Figure shows HVDC Bipolar system in which there are two poles one is negative and the other is positive. Each pole consists of one 12 pulse covnertor at both ends in which sending end will act as rectifier and receiving end will act as invertor. The 12 pulse convertor consists of two series connected 6 pulse bridges which are connected to two convertor transformers. The transformers are of Y/Y and Y/D to provide 30° phase shift for 12 pulse operation.

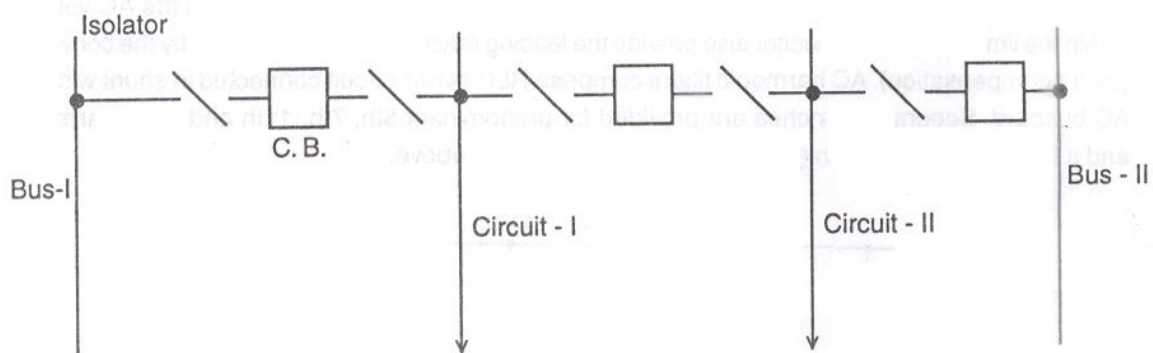
HVDC Bipolar System Layout

HVDC Rectifier and invertor station in HVDC Bipolar systems consists of following parts

1. AC switchyard
2. AC filter area
3. Convertor transformers
4. Valve hall and control room
5. DC switchyard and smoothing reactor
6. Electrical and mechanical ausiliaries

AC Switchyard

The AC switchyard is generally at 400 KV or 760 KV voltage level corresponding to the standard of EHV/UHV transmission voltage. The AC yard is of one half breaker bus system. The advantage of one and half a breaker system is it permits use of only three breakers for two circuits. In one and half a breaker system the circuits one and two can take supply either from Bus I or Bus II, thus in the event of fault on any bus the supply is maintained in the circuits by unfaulty bus. Hence, high security against loss of supply.



One and Half Breaker Scheme

The insulation coordination of the AC yard is correlated with that of DC yard and over voltages approaching from DC side. Metal oxide arrestors are used in AC yard and DC yard. The AC yard is designed in similar principles like usually EHV AC switchyards with following additional considerations:

- A large area on AC yard is covered by AC harmonic filter bank.
- More space is provided for movement of large convertor transformers and cranes.
- No. of surge arrestors are provided at strategic locations in AC yard.
- Protection and control of an enterprise with valves and DC yard.

The circuit breakers used in HVDC substation have preinsertion resistors to reduce switching over voltage and to reduce large magnetic inrush current during switching of convertor transformers.

AC Harmonic Filter Area

A large portion of the area in AC yard is covered by AC filter bank. The filters are required to filter out harmonics generated due to the operation of 3 phase AC/DC conversion which generates $kp \pm 1$ th harmonic on AC side, p is the integer and K is the number of pulses of convertor valve. This is derived using fourier analysis.

Harmonics in AC for 12 pulse system for which $K = 12$ are 1, 11, 13, 23, 25th, 5th and 7th harmonics are of 10% to 25% which are generated due to the formation of 12 pulse by series connection of sixpulse connection. Each filter bank has the following components.

AC filter capacitor bank

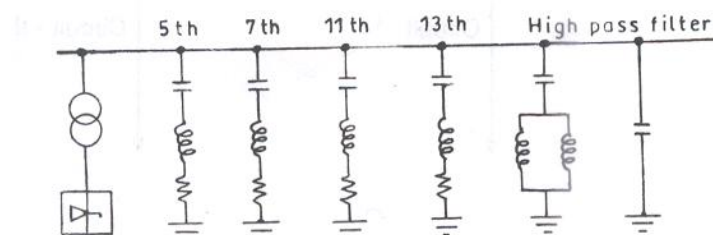
Reactor

Resistor bank

Current transformers

Circuit breakers

These AC harmonic filters are essential to reduce the harmonic content in the AC voltage within the limits. AC filter capacitor also provide the leading reactive power consumed by the convertor (shunt compensation). AC harmonic filters comprise RLC series circuit connected in shunt with the AC busbard. Separate branches are provided for predominant 5th, 7th, 11th and 13th Harmonic and a high phase filter for higher than 23rd harmonic and above.

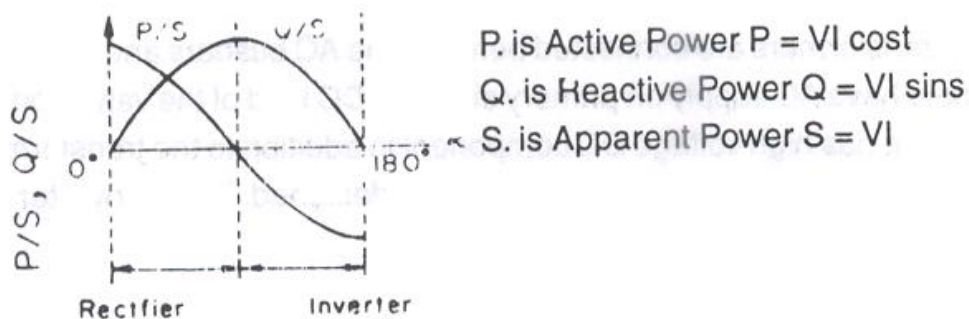


A C Harmonic Filter Circuit

Reactive power demand and compensation :- The operation of the convertor requires a certain amount of reactive power. This is due to –

- The manner of controlling HVDC convertors introduces a phase shift between the fundamentals of AC current and voltage. The magnitude of this phase shift is strongly dependant on the firing angle and in rectifier and extinction angle γ in inverter.
- The commutation process, in which the DC current is connected from one valve to another, also introduces further displacement of the AC current.

Convertor consumes reactive power both when it operates as rectifier as well as inverter. Besides the reactive power demand is also due to magnetizing current of convertor transformer. Considering normal valves of a (rectifier) firing angle and extinction angel γ (Inverter) the reactive power demand usually in the range of 50% - 60% of the transmitted active power.



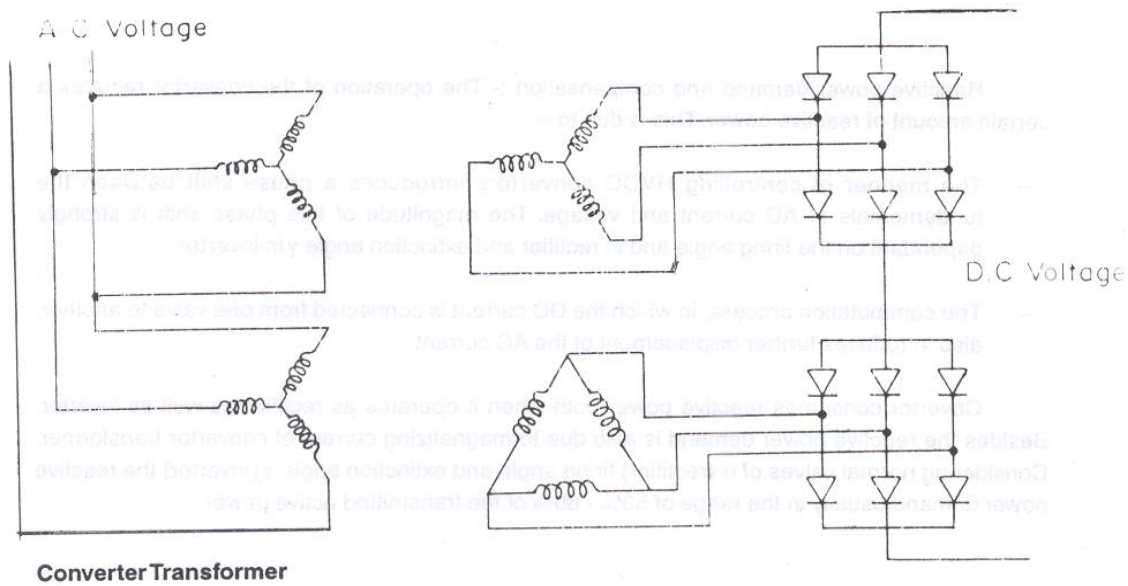
Convertor Reactive Power Demand

This reactive power in the range of 50% to 60% of the transmitted active power (each convertor station) is compensated by several ways depending on the quality of the connecting AC network. The different possibilities for suitable reactive power production are mentioned here.

- Ac filters
- Shunt capacitors
- Excessive reactive power from the AC network
- Static compensation
- Synchronous condensers

When choosing reacting power generation equipment one must consider both economic and technical aspect. The least costly solution is shunt capacitor. However, if AC network is weak a synchronous condenser is required a static compensator.

A C Voltage



Co

nverter Transformer

The converter transformers are connected between the AC busbars and the converter valves. Converter transformers have AC supply on primary side and DC load of the valves on the secondary side. The secondary side has high voltage DC component in addition to the transformed AC voltage component. Thus the insulation of windings is specially designed. The converter transformer is fitted with on load tap changers.

A twelve pulse conversion requires one star-star and star-delta transformer to create a phase different of 30° in feeding AC power. The pulsation of direct voltage in one bridge are staggered with respect to the other giving a 12 pulse converter. The following are four alternatives available for converter transformer considering phase winding arrangement:

Type	No. required for Bipole terminal	Transportation weight & size	Total project cost	Physical arrangement of transr.
1. 2 winding three phase transformer	4	Highest	Lowest	 For 0° For 30° Phase Shift
2. 3 winding single phase transformer	6	Medium	Low	 (YN) Y or Δ
3. 2 winding single phase transformers	12	Lowest	Highest	 YN (Y or Δ)
4. 3 winding 3 phase transformer	2	Highest	Medium	

The choice of convertor transformer is made after studying the complete transportation weight and project. The best choice of convertor transformer is considered as 3 winding single phase transformer.

Valve Hall and Control Room

The valve hall and control room are located between AC yard and DC yard. The valve hall houses quadruple thyristor valves, air core reactors, terminal bushings associated bus bars and surge arrestor. The control room building houses control panels for AC yard, DC yard and valves etc. in Bipolar HVDC substation there are two valve halls, each valve hall houses three quadruple valves. The control room is in between two valve halls. The valve hall is provided with uniform earthing mat in the flooring and uniform earthed screen in the wall and the roof. The screen protects the control circuits from the electromagnetic interference produced by the operation of thyristor valves. The valve hall is provided with air conditioning system. The temperature inside the valve hall is high due to valve losses and the lowest temperature of valve hall maintained is 10°C and the highest temperature of valve hall maintained is 55°C.

The control room houses the following control panels:

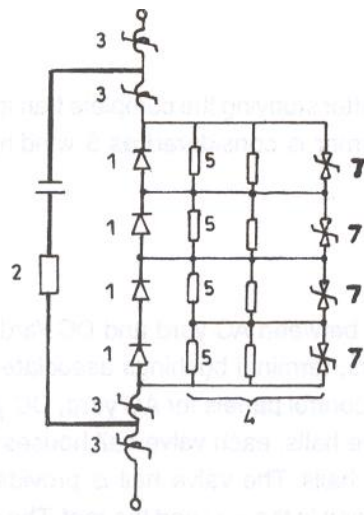
- protection, metering and control panels for AC yard, DC yard and convertor transformers.
- control panels for valves
- PLC communication and tele control panels etc.
- monitoring panels.

The auxiliary switchgear, low voltage switchgear, DC supply systems is generally installed in a separate floor of the control room building. The convertor valves are either supported on the valve hall floor on insulator columns or are under hung from the roof by means of insulators.

Thyristor Valves

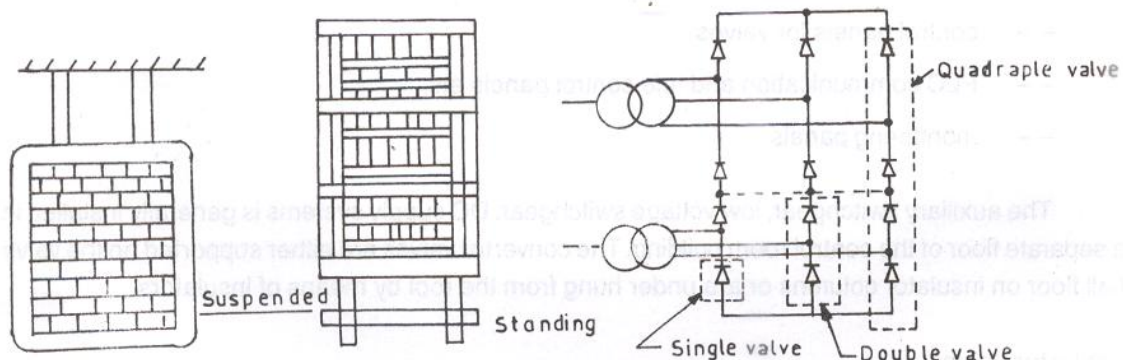
Since the individual thyristors has a limited voltage ratings nearly 7 KV, several thyristors are connected in series to achieve desired rated voltage. The assembly formed is called a thyristor valve. A thyristor valve for an HVDC convertor comprises of the following:

- Several thyristors connected in series to achieve the required insulation level. Each thyristor has its associated thyristor control unit.
- Snubber (voltage grading) circuit for equal distribution of voltage across thyristors and protection of thyristors in the string.
- Cooling system to removal heat from the cathode silicon wager. In HVDC system pure deionised water is circulated in a closed cycle to remove heat from heat sinks.



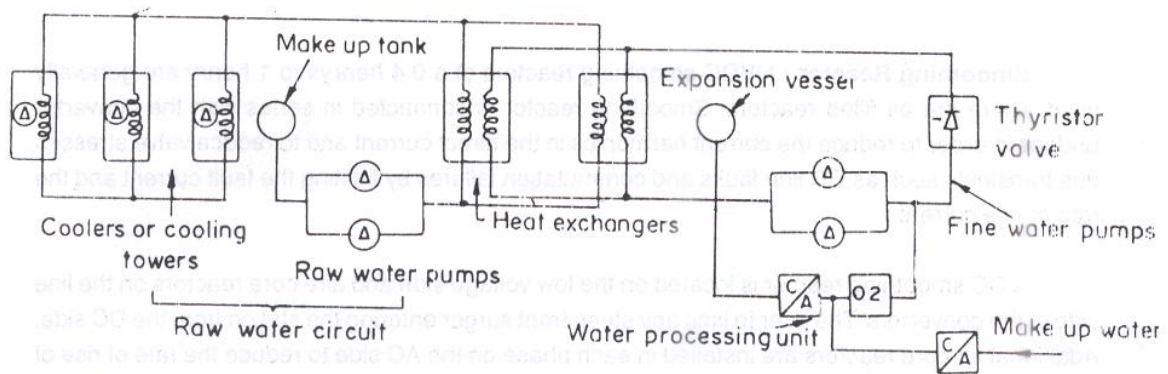
1. Thyristor
2. RC circuit across branch
3. Saturable Reactor
4. Voltage Grading and Protective circuit (Snubber Circuit)
5. R.C. Circuit
6. Surge arrester
7. Controlled Avalanche Diode

A valve is made up of stacking four valve modules in a vertical formation is called a quadruple valve. The valve is supported on porcelain insulator parts or is suspended vertically from the roof by means of glass fibre reinforced plastic rods.



A typical Bipolar twelve pulse converter substation has two valve halls, one for each pole. Each valve hall houses three quadruple valves.

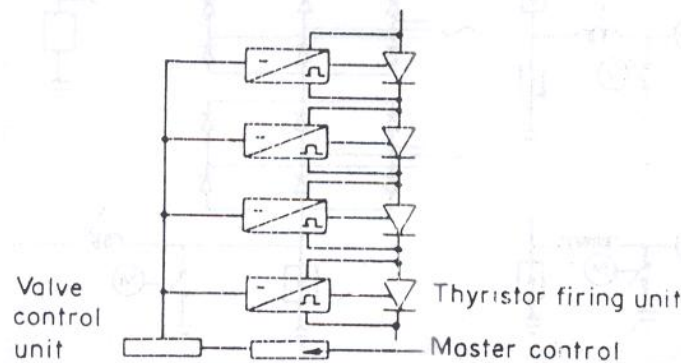
The active part of thyristor is a semi conductor mono crystalline silicon wafer with a thickness of half a milli meter and an area in the range 8 to 60 cm². The wafer has been treated to obtain P-N-P-N with desired current and voltage properties. The junction temp. with stand capability is 100° to 125°C. the water cooled wafer has 45 cm² area and a threshold voltage drop of 0.8 to 1.0 V. the thyristors are mounted on heat sinks. The modules are cooled in parallel with two cooling circuits in each module giving equal coolings. As the water should be insulating a special water processing unit is installed to deionise the water to limit the amount of oxygen in the water. The valve losses are about 0.5 percent of DC power transfer.



Cooling System for Water Cooled Thyristor Valve

Triggering of Thyristors

A thyristor needs positive pulse at the gate to start conducting. Such triggering pulses are necessary for each thyristor and for each cycle of the AC wave throughout the service life. In normal control applications, the triggering pulses from control panel to the thyristor gate are via insulated copper control cables. In case of HVDC valve this method is not suitable because individual thyristors are at higher potential and galvanic connection between high potential and control devices at nearly ground potential is not practicable. This problem is solved by using optical firing for triggering the thyristors.



Optical Firing System

In Optical firing system the electrical pulses at the source are converted to light signal and transmitted through fibre optical cables and then converted to electrical signal units in the thyristor control unit for triggering the thyristors.

DC Yard

The DC yard has the following essential equipment:-

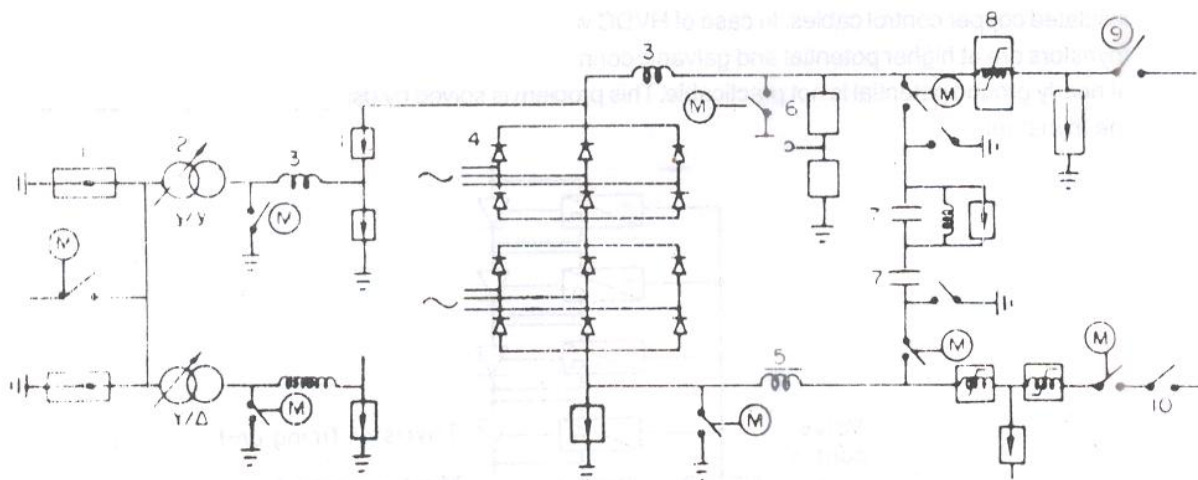
- DC smoothing reactor
- DC filters
- DC busbars and isolators, earthing switches, current transducers, voltage dividers, surge arrestors.
- Switchgear for switching from ground return to the metallic return.

Smoothing Reactor: HVDC smoothing reactors of a 0.4 henrys to 1 henry are generally used. There are oil filled reactors. Smoothing reactor is connected in series with the convertor bridges in order to reduce the current harmonics in the direct current and to reduce valve stresses due transients such as DC line faults and commutation failures by limiting the fault current and the rate of rise current.

A DC smoothing reactor is located on the low voltage side and air core reactors on the line side of the convertors. The later to limit any steep front surger entering the station from the DC side. Additional air core reactors are installed in each phase on the AC side to reduce the rate of rise of current during thyristor turn on.

DC Harmonic Filters

Using Fourier analysis we can evaluate the harmonicas on DC side for 12 pulse connector which is " Kp ", p is the integer and K is the pulse number. For 12 pulse system the harmonics generated on DC side are 0, 12, 24, etc. a high pulse DC filter turned to 12th harmonic is usually provided on DC side.



Single Line Dia of Single Pole Giving Details of DC Yard

1. Surge arrestor	6. Direct voltage measuring device
2. Converter trfr.	7. DC filter
3. Air core reactor	8. Current measuring transducer
4. Thyristor valve	9. DC line
5. Smoothing reactor	10. Electrode line

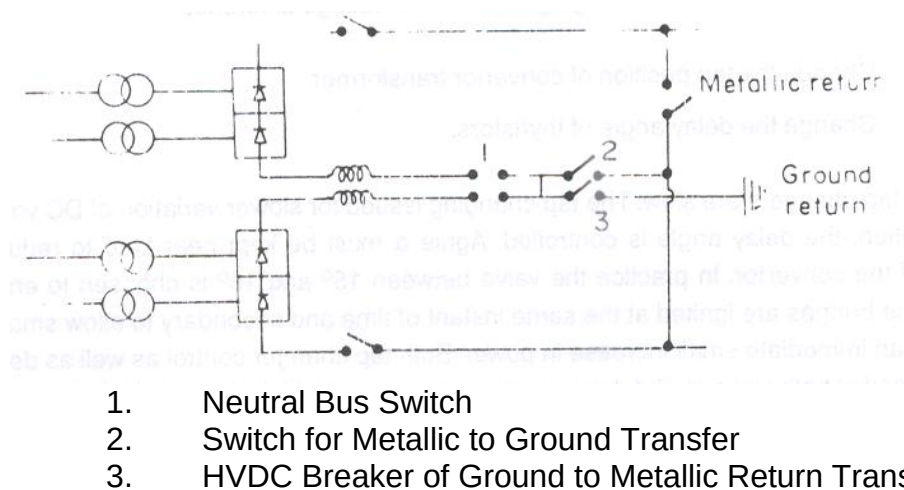
The measuring equipment i.e. a voltage divider, current measuring transducer and current transformer, provide the necessary input signals for the control and protection circuits.

Earth Return

In monopolar configuration, the return path is usually through earth or sea. Earth return or sea return reduces the cost of transmission system.

In Bipolar system the normal power flow is through pole conductors and only negligible out of balance current flow through earth. The mid points of convertors at both ends are earthed. In monopolar the return is through earth. The earth electrode station is usually built 10 to 25 km from main HVDC substation to avoid galvanic corrosion of pipes, foundation structures, cable theatres, earthing material due to cathodic corrosion.

The connection between mid point of convertor valve and a distant earth electrode is an electrode line. Electrode line is insulated from earth and connected to the earth electrode.



DC circuit breaking is difficult due to non-availability of current zero in the DC. Hence links do not have any provision of DC circuit breakers. HVDC links do not have parallel lines and T off lines due to lack of HVDC circuit breaker. HVDC circuit breaker using artificial current zero is produced by discharging a precharged capacitor bank through the breaker contacts has been developed but it is complex and not economical.

Metallic Return: In the case of fault on a pole the power transfer taken place in Monopolar mode using ground return in addition to this the line of the pole which is out of order can be used for return path. This type of current return is called Metallic return.

Electrical and Mechanical Auxiliaries

1. Cooling water system for convertor valves
2. Ventilation and air conditioning system for valve hall, control room etc.
3. Auxiliary low voltage DC supply for protection and control.
4. Auxiliary low voltage and medium high voltage AC supply for auxiliaries.
5. Station lighting system
6. Fire fighting system
7. Internal telephone system
8. Power line carrier communication system (PLCC)

Control of A HVDC Link

In a direct current control of the HVDC link, the transmitted current is given by

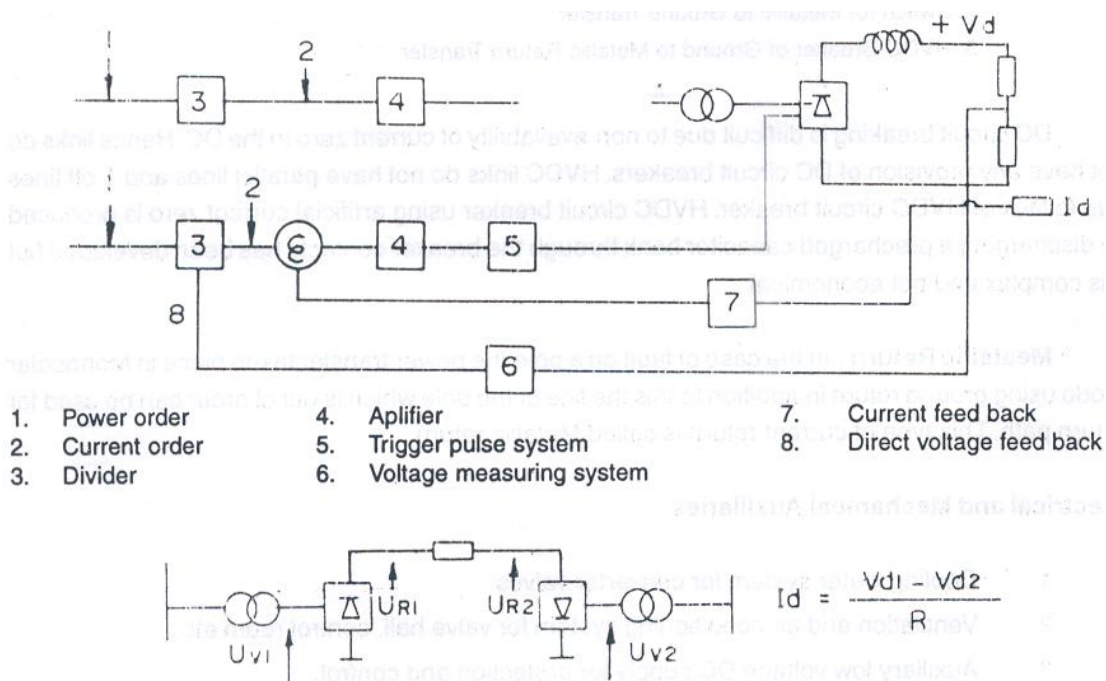
$$I_d = \frac{V_{d1} - V_{d2}}{R}$$

I_d is changed by changing the difference between V_{d1} and V_{d2} .

The methods available for changing the terminal voltage difference:

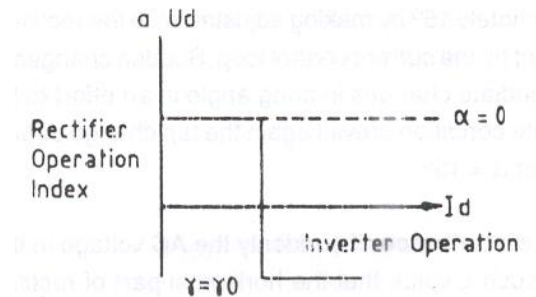
1. Change the tap position of convertor transformer.
2. Change the delay angle of thyristors.

The tap changers are slow. The tap changing is used for slower variation of DC voltage. For rapid variation, the delay angle is controlled. Angle α must be kept near zero to reduce KVA demand of the convertor. In practice the angle between 15° and 18° is chosen to ensure that valves of the bridges are ignited at the same instant of time and secondary to allow small voltage margin for an immediate small increase in power. Both tap changer control as well as delay angle control is used at both stations. But delay angle control is used initially for rapid variation of voltages. This is followed by tap changer control. The fig. Gives basic control system of control in HVDC.



Each convertor has a closed loop current control system. The input controlling parameter to this system is called current order. Thus, the convertor tries to adjust the DC voltage until there is no difference between current order and current response (DC current) or the maximum voltage is reached when fixing at minimum delay angle.

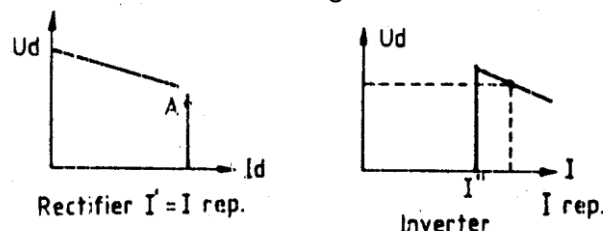
On the other hand if the current response is larger than the current order the direct voltage is correspondingly decreased. The decreasing action is limited when fixing at the least permitted commutation margin in inverter operation.



Ud / ID Characteristics of the Converter

By giving the two convertors different current orders, the convertor with highest current order will output a positive voltage and the other a negative voltage. Thus the convertor with highest current order will operate as rectifier and the other as inverter.

Further, the converter which can create the highest voltage will also control the current. Normally the control angle may be smaller in rectifier ($\alpha = \alpha_{\min}$) than in Inverter ($\gamma = \gamma_{\min}$) and the rectifier will control the current. The other convertor, consequently normally the inverter, controls the DC voltage with constant control angle $\gamma = \gamma_{\min}$. In simple words the terminal with the highest voltage limit will control the current, and the terminal with the lowest voltage limit will determine the voltage.



Normal Operation Rectifier Controls the Current

Normal Operation

In practice the controls are adjusted so that under normal conditions the rectifier controls the current and the inverter controls the voltage. This is arranged in the following way.

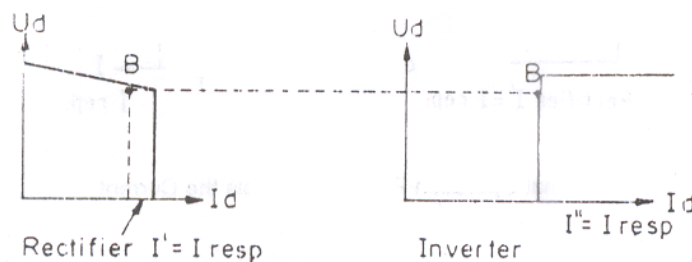
Both terminals are basically given the same current order. the power director is then established by applying a small additional negative current order to the converter which is intended to be run as an inverter. The effective current order will thus lower for this converter, which according to the foregoing will operate as inverter. The negative current order contribution is called the "current margin" and is an important feature for the operation of an HVDC link.

In fact that the current order of the inverter is lower than that of the rectifier means that the inverter is forced to fire at the highest permitted firing angle. For this mode of operation the control system keeps the margin of commutation' constant, i.e. at $y=y_0$ and accordingly the inverter defines the voltage on the DC line. The direct voltage is kept at the desired reference in the inverter by adjustments of tap changers of the converter transformers. In the rectifier the firing angle is measured and maintained at approximately 15° by making adjustment to the rectifier transformer tap changers. The current is kept constant by the current control loop. Sudden changes in transmission parameters will of course lead to immediate changes in firing angle in an effort to keep the transmitted power constant when steady state condition prevail again the tap change control will bring the firing angle back to within the region of $\alpha = 15^\circ$

Operation during disturbance: If suddenly the AC voltage in the rectifier drops, then also the DC voltage drops to such a value that the horizontal part of rectifier V_d/I_d characteristics fall below that of the inverter.

In the inverter the AC voltage still is normal and the current will decrease. When the current has dropped to a value equal to the current order to the inverter, the inverter will start to reduce its voltage by increasing its γ so as to maintain this current level. The inverter takes over control of the current and the inverter voltage will be reduced to a value equal to the voltage which is defined by the rectifier with reduced V_d and working at $(\alpha = \alpha_{\min})$.

The current will now be less than the original current transmitted between the terminals by an amount equal to the current margin. The firing angle of the rectifier will be at its extreme minimum since this terminal is trying to increase the DC voltage so as to increase DC current, whereas in the inverter the firing angle has now been decreased in order to control current. This new point B is shown in figure below for the case of inverter controlling the current.



Inverter controls the current

HVDC back to back station is similar to HVDC Bipole station. The only differences are in back to back station. Both rectifier and inverter stations are at one place and there is no DC line between these two and earth electrode station is not required as the distance between rectifier and inverter is nothing.

SCADA
(Supervisory Control & Data Acquisition)

RESMAC
(Remote Substation Monitoring & Control)

SUB-STATION AUTOMATION SCADA AND RESMAC

8.1.00 INTRODUCTION

8.1.01 With phenomenal growth of demand for electric power; the Power distribution networks are undergoing rapid expansion and becoming more and more complex making study of security, reliability and load management difficult without implementing sophisticated automation of data logging as well as control and operation

8.1.02 Benefits of Telemetry

- (i) Improve speed of restoration, especially in remote areas.
- (ii) The ability to transfer load between primary sub-stations at times of peak load to avoid replacing overloaded transformers, etc. and under fault conditions.
- (iii) The reduction of system losses by switching out primary sub-stations, lines and cables at times of low loads.
- (iv) The ability to carry out planned load shedding when supply is restricted due to either lack of generation and/or failure of major circuits.
- (v) To have reduced plant margins with faster response to system changes.
- (vi) By having the ability to accurately monitor the network and transfer loads at times of peak and/or under fault conditions, major capital savings can be made by deferring reinforcement works.
- (vii) By using the telemetry circuits established for the telecontrol/SCADA system to operate, it would be possible to pass messages from the central control room to substations, particularly manned as fuse off call centers and similarly return messages could be sent back to the control room.

8.1.03 Benefits of Telecontrol

- (i) To ensure that the system is run in the most effective way so as to maximize the use of existing assets and to defer the costs of reinforcement
- (ii) To co-ordinate system outages for routine planned work and faults so as to avoid overloading plant and minimize the loss of supply
- (iii) To act as safety Co-coordinator for staff working on the system.
- (iv) To carry out mathematic studies of the system to calculate load laws and fault level of various running conditions to ensure that plant is not overstressed.
- (v) The efficient management of loss reduction whereby at times of light loading, plant should be switched out.

8.1.04 Substation Monitoring Equipment forms the fundamental and essential building block in any Distribution Automation System, as it is required to furnish continuously information pertaining to the electrical parameters like active and reactive powers, bus voltage, etc.

8.1.05 With increasing trend towards Distribution Automation there is a growing need to modernize the Sub-station Monitoring equipment. At present the existing sub-stations have local data monitoring facility in the form of conventional electromechanical devices for monitoring the electrical parameters and the parameters are recorded manually. With the advent of microprocessor based systems dedicated data loggers connected with conventional measurements transducers have gained popularity. As Distribution Automation demands the data availability at a centralized location for effective network Co-ordination, the Sub-station Monitoring Equipment should be capable of transferring the error-free data with high efficiency at regular intervals, in addition to the existing local monitoring.

8.1.06 The data loggers alone are not adequate to meet these requirements and it is necessary to use a Remote Terminal Unit (RTU) along with this equipment to carry out the desired functions. As the configuration of a separate data logger and a separate RTU poses problems of compatibility besides the high costs, it will be useful to orient a system design which will integrate these functions into a single unit.

8.2.00 A PROJECT

8.2.101 Example

In the month of February, 1990; a joint project BHEL (R&D) and APSEB was first thought of for development of such a system for Indira Park Sub-Station in the City and a team of four Engineers from A.P.S.E.B. and three from B.H.E.L. (R&D) worked hand in hand and finally brought out a prototype by October, 1990. Brief description of the main design consideration of the system is given below.

8.2.02 The following are the consideration which go into the design of the system:

- (i) the system should be cost effective so as to be within reasonable cost limits for use even in small sub-stations.
- (ii) the system should be easily upgradeable to accommodate any future expansion for the substation.
- (iii) The system should be easily upgradeable from a local data acquisition system to an RTU for telecontrol applications.
- (iv) The system should have automatic data and event logging so that critical data is not lost due to operator shortcomings.
- (v) The system should be designed to be able to function in the substation environment for continuous operation.

8.3.00 COST EFFECTIVE DESIGN

8.3.01 The presently known measurement devices employ transducers which convert the AC signals from the CTs and PTs to the DC signal proportional to the measured value for respective parameters. An individual transducer will have to be used for each of the parameters to be measured and the cost of the transducers contribute significantly to the system cost. Therefore methods by which the cost of the system can be significantly reduced by employing different measurement techniques were thought of.

8.3.02 The technique employed puts to effective application the power of the microprocessor in conjunction with a 32 bit floating point arithmetic co-processor as a cost effective replacement for the transducers.

8.3.03 This method uses sinusoidal signals of voltage and current from the field PTs and CTs respectively which are further stepped down individually by auxiliary transformers, to the voltage levels acceptable by the microprocessors. These signals after suitable signal conditioning are further multiplexed and digitized at regular sampling intervals over a cycle by the A/D converters. With the sampled values of voltage and current, the following parameters are computed over a cycle employing suitable numerical methods:

- (i) RMS voltage
- (ii) RMS current
- (iii) Active Power
- (iv) Reactive Power
- (v) Power Factor

8.3.04 As the method employs computation of parameters after multiplexing, the addition of extra channels will have a minimum increase in cost per channel measurement, as the cost of auxiliary transformers is significantly less. In contrast with the existing measurement devices, the increase in number of channels does not result in proportional increase in system cost, due to the increased number of transducers. However, the impediment is on the update rate which is normally within acceptable limits for moderate burden.

8.4.00 SYSTEM EXPANSION

8.4.01 The system design is modular in nature to accommodate any expansion in the sub station. As the various functions outlined above are not achievable by the single microprocessor, the design is based on multiple processor architecture, where each processor works in an isolated manner in achieving the functions assigned to it and at the same co-ordinates with other processors for showing the results. This concept renders modularity both in software and hardware.

8.5.00 TELECONTROL APPLICATION

8.5.01 The Sub-station Monitoring Equipment is required to function as an RTU for Distribution Management application. This necessitates a Telecontrol system which employs data transmission protocol for optimum data transfer with error correction mechanism

8.6.00 PROTOTYPE

8.6.01 The prototype Equipment for Monitoring a **33 KV**

Sub-station incorporating the design in developed and installed at Indira Park Sub-station. The system is built with in-house hardware with the Intel's 8085 microprocessor combined with 32 bit floating point arithmetic coprocessor-**AMD 9511** for carrying out numerical operations. The data is displayed in the form of mimic on a CRT terminal and a periodic logging facility is provided.

8.7.00 The salient details of SCADA SYSTEM complete are explained below.

8.7.01 Structure

The structure of the Control system is dependent upon the size of the system to be controlled and the geographic area covered. There could be one central control responsible for all voltages or one central control responsible for the 132KV and 33KV systems with 1,2 or 3 secondary controls responsible for the 11KV and L.v.systems.

8.8.00 CONTROL CENTRE LOCATION

A suitable choice for the control center location has to be made and this will depend upon (1) the availability of space in the existing sub-stations/switching stations APSEB HQ for housing the various types of equipment, as well as (2) the distances to the different sub-stations/switching stations. The space requirement is about 300 sq.m. of built up area and open space for erecting a self-supporting communication tower of 80 metre height which will have a base dimension of 10mx 10m. The coverage area possible with a 80 metre tower is about 30 kms.

8.9.00 CONTROL PROCEDURES

Control procedures and safety rules will need to be formulated to ensure safe and efficient operation of the networks.

Typical procedures are those relating to switching schedules, logging, issue of safety documentation operation of switchgear, isolation of particular pieces of plant, etc., A „Control and Operation“ manual setting out these procedure is recommended

The term „Safety Document“ refers to one of the following:

(i) **Permit-to-work**

A safety Document specifying the High Voltage apparatus which has been made safe to work and work which is to be carried out.

A permit-to-work can only be issued with the authority of the Control Engineer by a Senior Authorized Person to a competent Person. It shall be issued before any work is carried out on any apparatus or conductor and the recipient shall confirm that he understands it and is conversant with the nature and extent of work to be carried out.

(ii) **Sanction-for-test**

A sanction-for-rest can only be issued with the authority of the Control Engineer by a Senior authorized person to an Authorized person. It shall be issued before any testing is carried out and the Authorized Person shall confirm that he understands and is conversant with the nature and extent of the testing to be done.

(iii) **Limitations-of-Access**

A Safety Document defining the limits and nature of work which may be carried out when verbal instructions are not considered sufficient for the purpose and where a permit-for-work or Sanction for Test is not applicable.

A limitation-of-Access can be issued by Senior Authorized Person or an Authorized Person when it is considered necessary to have written instructions to avoid danger. Typical situations are work in proximity to high voltage conductors, work in underground chambers, plant operated by compressed air, etc.

8.10.00 SYSTEM CONFIGURATION

The SCADA network will contain the following 3 systems:

- Instrumentation Sub-system
- Telementary/Computer Sub-system
- Communication Sub-system

8.11.00 INSTRUMENTATION SUB-SYSTEM

This sub-system has to be provided in all the sub-stations for measurement and feeding of various parameters like voltage, feeder current, power, circuit breaker status and alarm conditions etc. to the sub-station telemetry equipment usually called the Remote Terminal Unit (RTU)

Analogue: Analogue parameters to be measured are:

- (i) Bus voltage and currents from all feeders input is taken from standard potential and current transformers.
- (ii) Power factor from group circuit breaker.

For all the analogue measurements, industry standard transducers giving an output of 4-20mA/1-5VDC will have to be fitted.

Status Inputs: Parameters to be monitored are

- (i) Circuit breaker status.
- (ii) Alarm-Oil alarms, Bucholz alarms, windings, Temperature alarms, Fire alarms .
- (iii) Capacitors banks.

All status inputs will require voltage free contact parameters.

- (i) Opening and closing of circuit breakers.
- (ii) Capacitor control.

8.12.00 TELEMETRY/COMPUTER SUB-SYSTEM

This sub-system consists of the following:

- (i) Control center Master computer system along with associated Man Machine Interface (MMI) , mimic panel diagram and relevant software packages for monitoring and control of all sub-stations.
- (ii) Sub-station telemetry equipment (RTU) provided at the sub-stations for data acquisition, onward transmission of collected data to the control center and carrying out telecomm ands received from the control center.

8.12.01 Control Centre Master Computer System

This will cover all the 11KV, 33KV and 220KV Stations in the HUDA areas. Collect data and information from all the sub-stations, carryout real time control of load and voltage of the sub-station and transmit the necessary information/data to load Dispatch Centre. The block schematic of a typical control center set-up is shown in Figure 3.

The main monitoring is carried out in the control center through the data acquisition equipment which does the function of periodically selecting each Sub-station through the radio-polling circuit. When the selected station sends the data burst, it will be received and passed on to the host computer, which has in its memory the schematic of each sub-station. On getting the data it will display on the monitor the schematic along with current or power data with each feeder. These data with respect to time, can also be stored in a floppy for off line analysis. Printers can be attached for taking a print out.

For supervisory control, the control center can initiate action on the return link with the sub-station to close or trip any circuit breaker. At the sub-station end, the interface is provided before the circuit breaker. The interface identifies the nature of the command and sends either power data or circuit breaker data or operates a circuit breaker depending upon the nature of the command. In case of any emergency condition, that is by way of tripping of a circuit breaker, or a local operator trying to change the status of the circuit breaker, the equipment takes the initiative and sends emergency signals alerting the control center, which interrupts its scanning, takes necessary corrective action pertaining to the sub-station and then resumes scanning.

8.12.02 Scan Rate

The Sub-station parameters to be monitored by the control center contains a mixture of analogue, non-fleeting status inputs, high priority and fleeting events. The scanning rate will depend on two factors:

Nature of the Sub-station parameters.

Type of Sub-station, i.e., 220KV or 132KV or 33KV or 11KV

While non-fleeting status inputs and analogues would require a scanning rate 2 to 3 minutes, high priority and fleeting events like circuit breaker operation, alarms etc. would require a scanning rate of the order event information is more important in 220KV and 132KV Sub-station compared to 33KV and 11KV sub-stations. The scanning rate will therefore be decide by the sub-station parameter which require the fastest scanning. As the communication link between the control center and the sub-stations is a high speed TDMA link, the cost factor involved in the choice of the scan rate would depend on the speed of the modems at the control center and the sub-stations, and this cost is insignificant. Based on the above considerations it is suggested that the control center scan rate of the sub-stations should be 5 10 secs.

12.03 Communication Interface & Modems

The host computer at the control center will have a number of lines buffers (communication ports), and each line buffer will transfer data at selectable rates of 600, 1200, 2400, 4800,9600 bits per second to a number of RTU's located at the sub-station through a modem and the associated communication channel. Data transfer from RTU to control center takes place in the return communication channel through the same line buffers and modem. The total time including call set up time and transmission time for data transfer from one sub-station to control center will be of the order of 0.5 to 1 second depending upon the total number of analogue and status Inputs to be transmitted to the control center. Now the control center scans the sub-stations through the TDMA polling circuit every 5 to 10 seconds. Therefore 100 sub-stations can share one TDMA channel. As the total number of sub-station location is 95 by the year 2004-05, the number of TDMA channels required is 10.

The host computer will require on line buffer capable of driving 10 RTU's for one communication channel. Based on the above considerations the host computer should have a minimum of 10 communication ports and 10 modems.

8.12.04 Man-Machine Interface at Control Centre

To control the Power system successfully the Operator needs to have an overall picture of the system. He has to be able to determine the state of the system exactly and be able to pinpoint the trouble area and act in response to any disturbances in time etc. The interface between the human operator and the computer called MMI is vital for the above operations. The MMI consist of following hardware and software:

- Console

Two consoles will be provided in the control center for switching and supervisory control. The consoles will have all functional capabilities including data retrieval, display and control. Typically one console will be provided for data base editing and updating. It will not have the control capability.

- Loggers
- Printers
- Plotters
- Mimic sub-system
- Software package

The host software program drives the data acquisition display and remote control equipment in real time collects the system data from all the sub-stations and displays the data on colour monitor and printer. The data is displayed in table format, trend format, alarm format and in alarm reports. Typically the system will be menu driven with extensive use made of function keys to reduce operator input. Other typical features of the host software will be:

- Combination of memory resident data base and a compiled programming languages resulting in a program that runs very fast.
- Data base maintenance on the fixed disk by an easy-to-use data base editor.

- Although a standard program, it should have the flexibility to be customized to the user's specific needs.
- User friendly; no programming required.
- Historical trend display without compression
- Control functions: PID, ON/OFF, AND, OR, NOT, SWITCH
- Control Base Editor and graphic builder
- PID Tune display
- Building of data files
- Long term archiving of data on-line recall.

8.12.05 Data Base Software

The data base software sub-system is separated into three major functions.

- The data base generation
- The data base access function
- The data base editing function.

(i) Data Base Generation Function

Data Base Generation Function describes the Characteristics of the real-time data base and the software modules which generate, initialize, and maintain that data base. The data base generation function operates to generate and initialize a complete, consistent, and secure data base for all application programming.

The primary function of the data base is to provide a structured organization to information so that system and application program needing the information have direct and efficient access to it. Within a given CPU, less frequently referenced data resides on disk storage to conserve memory space while high usage data is kept memory resident for efficient access.

(ii) Data Base Access Function

The real time data base is referenced by many functions including data acquisition, man-machine display generation, and automatic generation control, to name of a few. Therefore, data base access routines are available to applications programs to facilitate data retrieval.

(iii) Data Base Editing Function

Data Base Editing Functions allows the user to display and alter the real-time data base without the necessity for a complete data base generation and reinitialization. Editing is performed on-line using C.T. displays and keyboards entries. Three on-line facilities are provided to meet the editing requirements of the user.

- Acquisition data base edition – for display and editing of the data acquisition data base.
- Application data base editor – for display and editing of the application sub-system data bases (ACC, etc)
- Memory/disk editor – a display console implementation of selected debug package functions.

Data base utilities support the data maintenance function in moving data from one CPU or device to another utilities are provided for the following functions:

- Installing a new data base.
- Preserving a copy of the current data base.
- Copying data from the on-line to the off-line CPU.

Minimum information needed to be sloted in the Data base are:

- Network parameters
- Network Topology
- Network State
- Historical data about the Network
- Network geographical information including layout
- Operational data like permit to work, etc.

8.12.06 SCADA Software

The main functions are:

- To provide the control center with updated information on the operating conditions of the sub-stations.
- To allow efficient supervisory control of all the equipment of the Sub-stations.
- To inform control center of any change in the status of sub-station equipment, alarms, and abnormal loading conditions.

(i) Data Acquisition Part

- It will scan all the RTUs at pre-programmed intervals. It will be possible to specify the scan rate for analogue and discrete measurands. The software will also provide for the demand mode. It will be invoked automatically after failure of the RTU or the computer system.

- Obtain data from RTU"s and store it in a buffer in the memory of the on-line computer system.
- The DAS will check every analogue value against high and low limits set by the operation and will draw the attention of the operator whenever the limits are violated. This will also be recorded in the event logger.
- Status data will be transmitted from RTU"s only when there is a change or when responding to request scan.
- Status checking routine will detect any invalid breaker or status data viz neither open nor closed and shall inform the dispatcher via alarm.
- A main memory routine for converting raw data to Engineering units will be provided.
- Transmit to the RTU" all the control commands originating from control center.

(ii) Control Commands

The control center shall be provided with the supervisory control software to perform the following functions:

Switch off of switch on circuit breaker provide at the Sub-station or on a line.

The sequence of operation for execution of supervisory control commands are indicated below:

Step-1- The DAS software sends the command code and the selected point address

Step-2- The RTU checks the messages and responds with an acknowledgment or an error return. If the message is correct, the RTU will execute the control command immediately, if the RTU responds with an error return or no reply received from the RTU, the DAS will repeat Step-1. If an error is received after the second trial, the DAS software will link back to the control feed back function in the Man Machine interface software.

The DAS software will provide for error checking and error alarming statistics.

8.12.07 Application Software

(i) Load Management

This software application function shall be capable of analyzing, the data acquired from the net work in order to fulfill the objective of meeting the demand in the most optimal manner. It shall also be capable of providing the best strategy for meeting the varying demand conditions. The management of the load shall be done by exercising control over the distribution feeders which are under the purview of the SCADA system. Flexibility should be inbuilt into this application software to accommodate time to use metering of customer loads, varying maximum demand intervals, sub-station load transfer and control, and load surveys.

(ii) Reactive Power Optimization

The objective of this applications is to minimize the losses on the distribution network. The control element used by the software to achieve the objective are : scheduling of capacitor on the network; recommendations for transformer tap settings and optimal configuration of the network. In an office mode, the function shall be capable of recommending the optimal conductor size, optimal capacitor size and optimal capacitor location to achieve minimum losses. The essential factor which drives this software function is that the reactive power profile should be optimally managed to achieve minimum losses.

8.12.08 Control Centre Computer System Configuration

(i) Host Computer

- Dual Processor configuration with automatic switchover to the host standby in case of failure of working processor.
- CPU – 32 Bit.
- Main memory – 2 Mega Bytes
- Access Time – 300 nanoseconds or less
- Auxiliary memory – 240 Mega Bytes Hard Disk Drive & 100 Mega Bytes Magnetic Tape Drive.
- Communication Ports (Line Buffers) – 12
- Each line buffer should be capable of connecting upto 10 RTU's. The data transfer rate of the line buffers should be adjustable by strapping among 600, 1200m 2400, 4800, 9600 bits per second.
- CCITT/X.25 HDLC. This port is for connection to the computer system at the Main Load Dispatch Centre.
- Modems – 600/1200/2400/4800/9600 bits per second star selectable confirming to CCIT/V.23,V.26, V.27, V.29 standards.
- Interfacing – Host computer to modems
- EIARS 232C/CCITT V.24

(i) Man Machine Interface

(a) Console

- Two colour VDU monitors. Each VDU monitor should display 48 lines with 80 characters per line. The VDU should also display standard alphanumeric characters and 60 more of power system symbols for construction of single line diagram. The minimum screen size of VDU should be 50 cms with aspect ration of 2:4.

One alphanumeric key board with standard typewriter style alphanumeric keys, four button cursor control keys, backspace and delete keys and programmable function keys.

- One special function keyboard with following functions.
- Page forward, page backward, scroll up, scroll down.
- Alarm acknowledge, silent halt.
- Display freeze, display update, display recall.
- Cursor up, down, left, right, home.
- VDU copy, plot, print.
- Next tan, previous tab.
- Raise, low, open, close, execute, cancel.
- Separate keys for sub-station single line diagram selection.
- One set of cursor positioning devices.
- One set of numeric displays having 3 displays of 6 digits.
- Audible alarm with a volume control.

(b) *Logger*

Two numbers shall be provided with the following minimum characteristic:

- Speed of 250 characteristics per second
- Line length of at least 132 characters per line.
- Bi-directional printing capability of near letter quality.

(c) *Printer*

- 1 No. of the following minimum characteristics.
- Speed of 600 lines per minute.
- Line length of at least 132 characters per line.
- Capability to print 96 standard ASCII character set.

(d) *Plotter*

- 1No. of the following minimum characteristics.
- Accepting plain paper of a minimum A3 size.
- Having 8 pen holdings.
- Plotting speed of at least 20 cm/sec

(e) Mimic

- 1No. mimic board having a flat sub-system surface with dimensions of approximately 10 meters in length and 3 metres in height. There will be 15 sub-stations to be displayed on the mimic board with a maximum of 30 sub-stations.

8.12.09 Sub-station Telemetry Equipment

Remote Terminal Units (RTU) are to be provided in each of the Sub-station for acquisition of sub-station data parameters, transmitting them to the control center and for carrying out telecomm ands received from the control center. The RTU's will be rugged, intelligent and microprocessor based All activities including I/O processing, data processing and communication processing will be done using microprocessors. A typical RTU will be a self contained unit with CPU, RAM, EEROPOM, RS 323 communication ports, power supply, protective circuitry, analogue and digital I/O channels with signal conditioning. The I/O modules will be selectable to achieve the quantity and mix of I/O needs for each Sub-station. The RTU will give priority to telecomm ands from the control center over its data acquisition tasks and at the same time ensure that the background scan of all the events at the controlled sub-stations are carried out and no event is lost. A typical RTU is given in Figure 3.

8.12.10 Software Packages for RTU

RTU's have to be supplied with software packages installed for carrying out the assigned tasks. The typical software packages are:

- Operating System.
- Command Language.
- Programming Language.

(i) Operating System

Following tasks will normally be performed:

- The host and local communication tasks which handle the serial communication through the host and local ports.
- The main scan tasks which surveys all field inputs and updates the data structure according to the set up parameters associated with each channel, it also changes the output based on information in the data structure. The main scan task launches the user's program.
- Auxiliary scan task which surveys auxiliary input also carries periodic diagnostic functions.
- Initialization task is performed on power up and hardware reset. It determines what I/O modules are in place and performs hardware checks and initializes the data structure.
- Recording of certain system level errors by the error logger for further analysis.

- The non-volatile task performs writes to EEPROM.
- Watching task resets the numerous hardware watchdog timers present in the system.

(ii) Command Language

Typically this will be structural command language which is used to communicate with the RTU. It defines the syntax used to read input channels, change outputs, tailor data processing and change system parameters. The command language usually consists of commands and responses. While a command is a message sent into the RTU, a response is a message elicited from the RTU. The response will be of two kinds; a reply response resulting from successful command execution and an error response resulting from unsuccessful command execution.

(iii) Programming Language

This is a control programming language capable of reading input channels or variables, changing outputs, communicating over the serial ports and perform mathematical, or logical operations on variables, input channels and output channels. While program source code for the function oriented language can be developed from a local terminal or any other computer with just a text editor, it would be preferable that the RTU compiles source code on-board so that no additional compilers or assemblers are required, user programs can be stored in non-volatile EEPROM to protect the program from power outages. Data loading, monitoring with alarm messages, sequential control and continuous control are some of the functions implemented by the programming language.

8.12.11 Transmission and Coding System of RTU

The I/O modules interface through memory mapping to the microprocessor. Based on the need of each sub-station the I/O channels are defined and the RTU is configured accordingly. Once this is done the RTU will scan analogue and digital data without stop, convert analogue data and store the converted data in its memory for access by the control center computer. The RTU at each sub-station should be individually addressable. The electrical interface and communication format to the mail. port is usually RS 232. Command and replies usually consist of strings of ASCII coded characters in a series of fields, each field consisting of one or more ASCII characters.

8.12.12 System Diagnostics

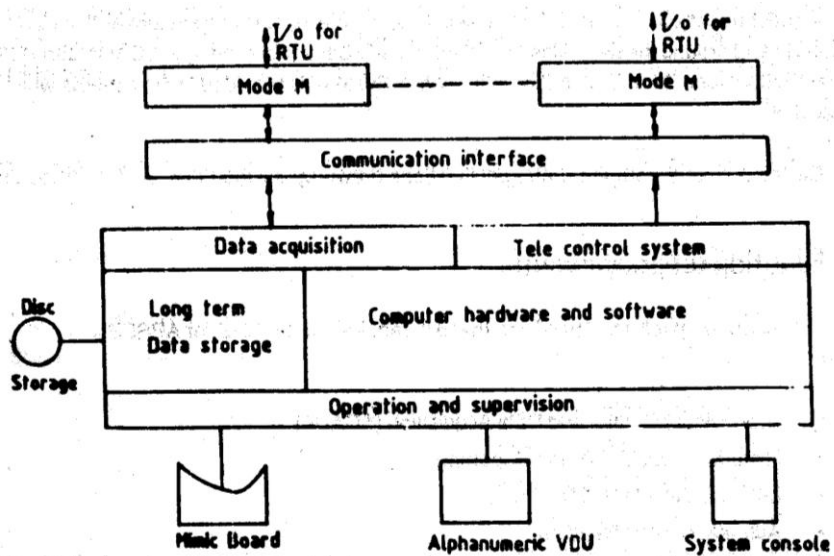
Each RTU at the sub-station will have diagnostic capabilities designed into the system at the hardware level. This provides the user with information to aid in troubleshooting and system start-up. Typical indications and diagnostics provided in the RTU are:

- PowerLED: This will be illuminated when power is applied to the based board.
- RUN LED: This indicates healthy operating system that is regularly servicing the system watchdog.

- LPAT LED: This will be illuminated if the input voltage is too low.
- Watchdog time out LED.
- Status LED: This gives a binary coded output if the system fails a software confidence test.
- Diagnostic capability at the I/O module level.
- Hardware read-back at Telecomm and output circuit for verification of data at the field connection point.
- Verification of memory and certain peripheral chips in operating system.
- Communication diagnostics to indicate activity on the Receiver and Transmitter lines for both the main and local ports.

8.12.13 RTU Configuration (Typical)

Processor	:	8088 or similar
ROM	:	128K bytes
RAM	:	64K bytes
NON VOLATILE	:	2K bytes (Expandable to 32K)
COMMUNICATION PORT	:	Main Port & Local Port RS.-232 (Configurable as DCE & DTE)
BAUD RATES	:	75-9600 bauds switch able.



Control Centre-Scada System

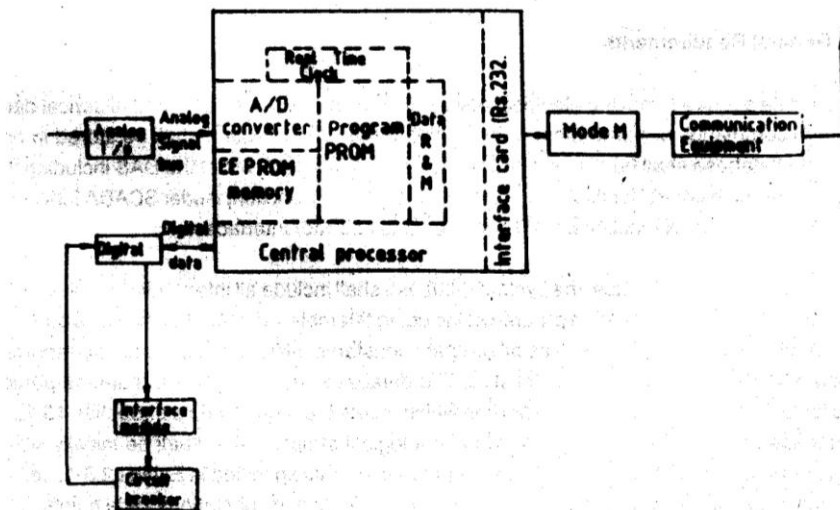


Figure 3

Sub-station-Scada

APSEB has taken a rather bold decision to automate Hyderabad system and to cover all Sub Stations in and around the twin cities of Hyderabad and Secunderabad by a „SCADA" connected to a Master Station. Also DAS (Distribution Automation System) is provided in the scheme which is under execution.

Certain extracts from the draft specifications drawn up for the purpose are reproduced below.

8.13. FUNCTIONAL REQUIREMENTS

This chapter specifies capabilities that are required of the DAS for APSEB's distribution operations:

- ✓ Supervisory Control and Data Acquisition (SCADA)
- ✓ Historical Accounting and Reporting.
- ✓ Load Control of HT Consumers.
- ✓ Automatic Meter Reading
- ✓ Feeder SCADA including fault localization, restoration of supply and load balancing.
- ✓ Integrated VoIWAR control
- ✓ Automatic Mapping and Facilities Management.
- ✓ Trouble Call Management System.

8.13.1 DATA BASE

8.13.1.1 General Requirements

All data acquired from the electrical power system, all calculated data and historical data, and all control commands or parameters to be output to the power system shall be stored in one database. The database shall be the central interface among all elements of the DAS including the SCADA functions, load control functions, automatic meter reading function, feeder SCADA functions, Integrated VoIWAR control functions, HAR accounts and operator interfaces.

As the common interface, the system database shall include all information necessary for the proper operation of all application programs, including telemetered data, data which is program calculated or operator entered, as well as all program constants, historical accounts and reporting (HAR) data, and DAS communication statistics. The database shall comprise a real-time portion optimized for fast access, and a historical portion which meets the requirements of Section 13.12.1, "HAR Database". The system database shall have a logical structure and shall be initially sized, upon delivery, to accommodate the Ultimate sizing requirements specified in Exhibit 2.3-1, i.e., no programming or system regeneration shall be required in order to add substations, data points, DAS devices, load control groups and capacitor switches, automatically read meters, etc., up to the Ultimate limits. The database may be distributed between various processors and storage devices, but it shall be of a consistent design, and data residency shall be transparent to the accessing function. Each database item shall be defined in the OAS only once; duplicate definition of the same data in various database structures is not acceptable.

8.13.1.2 Data Quality Codes

Date quality codes shall be maintained in the database, real-time and historical for points that are telemetered or calculated based on telemetered data. The required data quality codes are defined below in the order of diminishing priority. The letters in the parentheses defines the symbol that shall represent each data quality. This symbol shall be associated with the data which it represents in displays, reports and logs.

Up-to-Date (Blank) : Data has been successfully received during the latest scan.

Alarming Inhibited (I) : Alarming for the specific point has been inhibited by an operator.

Unreasonable (R) : For analog points only-the point is out of reasonability limits.

Failed (F) : The DAS failed to receive valid data for the point during the most recent scan. The last good value (old data) or calculated data based on last good values is shown.

Deactivated (D) : The operator inhibited processing of RTU data for this point. The last received value is shown.

Manually Entered (M) : The point was deactivated by an operator and data was manually 1 entered.

Uninitialized (U) : All data qualities shall be set to this value during cold startups of the DAS.

For calculated points the data quality shall be set to that of the lowest quality data involved in the calculation. As an exception, the Alarm Inhibited data quality shall not be propagated into calculated values, nor into the historical database. Instead, operands with the Alarm Inhibited data quality shall be handled as if they had an Up-to-Date data quality.

No data quality codes, including Manually Entered, shall be associated with silent data points.

8.13.1.3 Areas of Responsibility

The database shall be partitioned in such a way that it will be possible to allocate the responsibility for the operation of parts of the distribution system, and also for the management of the DAS itself, to specific operators. For this purpose it shall be possible to assign any database point, which represents a power system device, power system data, DAS equipment, etc., to one of no less than 6 Areas Of Responsibility (AOR). AOR assignments will be used primarily to allocate operational privileges to operators (see Section 4.5, "Areas of Responsibility"), and also to configure summary displays and reports for selected combinations of AORs. The following initial AORs are required:

- ✓ Distribution
- ✓ Automatic Meter Reading
- ✓ System (DAS and Radio Communications System)
- ✓ Training.

8.13.1.4 Connectivity Analysis

A connectivity analysis function shall be provided to maintain up to date the following information:

- a. Lists of all power system elements that belong to each distribution circuit. A List devices connected to a feeder shall be accessible by pointing to the circuit breaker that energizes the feeder.
- b. The circuit breaker which currently connects each circuit element to a substation bus.
- c. All circuit segments that belong to each substation, i.e., the circuit segments that are energized from the substation breaker or breakers.

Connectivity analysis shall automatically be performed" upon system startup, restart, or failover, and also when any pertinent switching device changes state. In this case the connectivity analysis may be performed only for the affected circuits. The di5tribution network is supposed to always be in a radial configuration. If a closed circuit is detected between two feeder breakers, then an alarm shall be generated and the old connectivity information shall be retained.

The connectivity information developed by this function shall be used for the display of circuit connectivity; see Section 4.1.7. The connectivity information, as well as the topological information on which it is based, shall be accessible and available for use by future distribution automation functions developed by APSEB.

8.13.2 RTU DATA ACQUISITION

The master station will finally operated with both substation RTUs and pole-top RTUs; see Exhibit 2.3-1 (F). The initial quantity of substation RTUs shall be furnished by the Contractor.

8.13.2.1 RTU Communications Protocol

A protocol suitable for RTU communications shall be proposed. The same protocol shall be used for the substation RTUs and the pole-top RTUs, because both types of RTUs will share the same radio frequency channels in party-line configurations. for safety reasons, each RTU of the DAS will be assigned a unique address, and therefore the number of RTU addresses supported by the protocol shall be equal and no less than the total Ultimate quantities of all the ERTUs specified in Exhibit 2.3.1 (F).

In order to facilitate the procurement of pole-top RTUs and additional RTUs from other suppliers, a widely accepted protocol is required. Protocols which comply with IEC- TC57 recommendations are preferred. If the suppliers offered protocol is a proprietary protocol, the supplier will additionally undertake to provide APSEB with the following information:

- a. Full protocol details for APSEB information under this contract.
- b. Outline protocol details, sufficient for other manufacturers to tender for additional RTU"s under any future contract.
- c. If, under any future contract, APSEB wish to procure RTU"s from a different manufacturer, the supplier under this contract, shall agree to provide (at no additional cost) full and complete current protocol details to the new manufacturer, via APSEB, under a suitable project specific non-disclosure agreement.

8.13.2.2 Data Acquisition

The master station shall make scan requests to all RTUs to the most current status and analog data. Such requests shall be made on a sequential basis for those RTUs on the same communication channels, and on a parallel basis for those RTUs on different channels. The required scan intervals are specified below.

a. Substation RTUs

Status	4 seconds
Analog	30 seconds

Reporting by exception may also be used. In this case, a forced or "integrity" scan shall be performed every 15 minutes. This shall be a complete scan in which every RTU point reports its status or value. Forced scanning is also required in the following situations:

Upto a warm on cold system startup

When any RTU is put back into service after being off-line for any reason

On manual request by operators. Such requests shall be processed at higher priority than periodic scans.

b. Pole-Top RTUs

It shall be possible to scan all points at least once every 30 minutes. This scan interval shall be programmer adjustable, to once per day. Scanning of pole-top RTUs shall be distributed over time in order to minimize the impact on the faster substation scan. To obtain information from pole-top RTUs when needed, such as after control commands are sent, operators shall be able to manually request the polling of any specific pole-top RTU. It shall be possible to issue such polling ! requests for an RTU by selecting a cursor target from any display, tabular schematic, on which data from that RTU is displayed. Manual polling requests shall be processed at a higher priority than any periodic scan activities.

8.13.2.3 Error Detection and Recovery

Each scan reply shall be immediately checked for certain basic error conditions including incorrect response. RTU data buffer overflow and invalid message security codes. Such checking is required for periodic scans as well as forced scans. All detected errors shall be recorded for maintenance purposes. Attempts shall be made to recover from the error conditions by repeating the particular data scan for a selected number of times, as defined in the database. If no more errors are detected in at least one of the retries, then the earlier error shall be considered as a recoverable error. Otherwise, it shall be considered as a non-recoverable error. Statistics shall be kept on communication activities and detected errors, and a Communication Report containing a summary of the communications statistics for each channel, shall be displayable and printed daily providing details on the total number of transmissions and the errors, by category for each hour of the day.

The detection of a non-recoverable error or the occurrence of a high number of recoverable errors (e.g., 30% programmable parameter) shall be considered as channel-failure and shall result in the suspension of scanning for the particular RTU and the creation of an alarm. The channel shall then be periodically tested to see if communications can be restored, and the RTU returned to scanning after a programmable number of consecutive good scans; appropriate alarm messages shall be generated. Operators shall also be able to manually suspend and resume scanning of an RTU. When scanning of an RTU is suspended, whether automatically or manually, all its points shall be marked as Failed (F). Manual suspension and resumption RTU scanning shall be treated as events.

The hardware and software must be designed so that data reported by RTUs will not be lost because of insufficient buffer size or insufficient time to service the reply data. If processing has not been completed for a certain data point or data group before the new data value for the same point or group are received in the next scan, an alarm shall be generated.

8.13.3 PROCESSING OF RTU DATA

The following types of data processing are required:

- Analog Data Processing
- Status Data Processing
- RTU data shall be promptly processed for each scan cycle.

8.13.3.1 Analog Data Processing

For analog data that has been received from an RTU without any error, the following functions shall be performed:

- Identification of significant changes
- Reasonability limit checking
- Data conversion to engineering units and storage in the database, in floating point format
- Alarm limit checking
- Rate-of-change checking
- AID accuracy monitoring.

8.13.3.1.1 Significant Changes

Analog data shall be processed if a significant change is detected in the raw data, i.e., if the change from the previously reported value exceeds a given dead band. If the value of an analog I point is close to zero, i.e., it differs from zero by less than the significant change dead band, the) value shall be forced to zero. It shall be possible to assign a specific significant change dead band, 1, including zero, to each analog point from any console in the Programmer Mode. When the dead band is set to zero, analog input data shall always be processed.

8.13.3.1.2 Reasonability Limit Checking

Each raw analog value which is processed shall be compared to a pair of reasonability limits, expressed in raw counts, which shall be definable on a point by point basis from an operator terminal in the Programming mode.

When the raw analog value becomes greater than the high reasonability limit or less than the low reasonability limit an alarm shall be generated. Analog data which exceeds its reasonability limit shall be flagged with the "R" (Unreasonable) data. quality symbol, and shall not be updated in the , database until it returns within the reasonability limits.

8.13.3.1.3 Data Conversion

The conversion of analog values to engineering units shall be made by assuming a linear transducer characteristics of the general form $Y = ax + b$, where a and b are the coefficients defining the scaling of the analog point.

Load Tap Changer (LTC) tap position will be reported as analog values derived from a voltage divider on the LTC device. These voltages shall be translated into, and displayed as, discrete tap positions.

Converted analog values shall be stored in the database in floating point format.

8.13.3.1.4 Checking of Alarm Limits

Every converted analog value shall be checked against three (3) sets of independent pre-defined high and low limits which can be individually specified for each point. These limits shall be, in order of severity:

- Low limits
- High limits
- Emergency limits.

Crossing of an analog limit in either direction shall result in appropriate alarm reporting. Each of the above six (three sets of high and low) alarm limits shall be treated separately, i.e., a unique alarm is required when each limit is crossed. A dead band shall be applied to each of the limits to derive the return-to-normal level, so that repeated alarming does not occur for point hovering around the limit. The dead band shall be specified in the data base for each individual point.

All analog points whose values are outside the low limits shall be included in Abnormal Summaries.

The set of alarm limit shall be shown for each point in tabular substation displays. The operators shall be able to change the limits for the substation displays; this capability shall be limited to points in AORs that are assigned to the operator.

8.13.3.1.5 Max/Min and Average Values

In order to prepare data for the historical database, the following calculation shall be performed for every telemetered analog point during the processing of data acquired from the RTUs.

- a. **Average Values** - The average value shall be calculated for every 15 minute period, synchronized with the hour.
- b. **Maximum Minimum Values** -The daily instantaneous maximum and minimum values shall be saved and the time of their occurrence shall be recorded.

Data quality codes shall be assigned to calculated values according to the rules specified for calculated points in Section 13.1.2.

8.13.3.1.6 Energy Calculations

Hourly MWh and Mvarh values shall be calculated through integration of telemetered MW and Mvar values. Integration shall be performed at the analog scan rate. Data quality codes shall be assigned to the calculated energy values according to the rules specified for calculated points in Section 13.1.2.

Energy values shall be transferred into HAR accounts at the end of each hour.

8.13.3.1.7 AID Accuracy Monitoring

Analog reference points will be included for each Analog to Digital converter (AID) in the RTUs. These precision reference points shall be scanned and used to determine the extent of inaccuracy (drift) of the AID converters. The percent inaccuracy of the AIDs in all the RTUs shall be shown in an ATU Communications Maintenance Display. If any inaccuracy is larger than a pre-set tolerance, an alarm indicating the problem and the magnitude of the inaccuracy shall be output. Deadbands for return-to-normal alarming shall be provided. Tolerance levels and dead band values shall be assignable from the operator terminals while in Programmer mode.

As part of the analog data processing, system shall adjust each analog value so as to compensate for the drift in the AID converter to which the analog point belongs.

8.13.3.2 Status Data Processing

Newly acquired status data shall be compared against the current status data in the database to determine if changes have taken place. Uncommented changes of state shall be processed as alarms and commanded changes of state as events, Points for which a normal state is defined in the database shall be included in Abnormal Summaries while they are not in their normal state. All status changes shall result in an immediate update of all displays on which the points are currently shown. The scan processing shall be designed to ensure that no change of status is lost.

For each status point, it shall be possible to define the relationship between the position of the contact input to the ATU and the state of the device. So, for instance, an open contact may represent "Closed" or "Open".

8.13.3.2.1 Reporting of Multiple Status Changes

For points designated in the database as subject to change detection, the System shall detect, identify, and alarm the following operations which may occur between two subsequent status scans.

- From close to open
- From close to open to close
- From close to open to close to open
- From open to close
- From open to close to open
- From open to close to open to close.

8.13.3.2.2 Three-State Devices

Motor-operated circuit switches are monitored by "a" and "b" contacts to indicate fully opened and fully closed positions. The software shall correctly interpret and show each switch position as being fully opened, fully closed, in-transit, or invalid.

8.13.4 PROCESSING OF NON- TELEMETERED DATA

Non-telemetered data points are required to represent data which are not derived from RTU's and are either manually entered or calculated by the System. The number of non-telemeter points is given in Exhibit 2.3.1.

Whether a point is telemetered or non-telemetered shall be transparent to accessing programs. Non-telemetered data points shall be definable in the real-time database similar to telemetered data points.

8.13.4.1 Silent Data Points

Silent (or pseudo) status and analog points represent power system data that are not monitored by RTUs. These data points will be updated by manual operator entry. Event messages shall be created for every update. Silent data shall be stored and accessed in the same manner as telemetered data.

8.13.4.2 Calculated Analog Points

A calculated analog point is a data point whose value is a function of the value of one or more other telemetered data, or calculated data points (component points). Analog data point calculations shall be performed at the frequency at which displays are updated. Alternatively, the calculations can occur whenever a significant change is detected in any analog point's component. The value of a calculated point shall be calculated by using an algebraic equation that defines that particular point. It shall be possible to use telemetered data, manually entered data, constants and other calculated data points as the component points in the definition of a calculated point. Up to thirty (30) Component points shall be definable as part of a calculated point's definition. It shall not be required to define multiple calculated points as interim steps in a calculation. Newly calculated values shall immediately be limit checked, and subject to the same processing as telemetered points.

As a minimum, the following operators shall be available for the calculations:

- The four arithmetic operators (+ -*/)
- Exponent, log (base 10), and natural log
- Trigonometric and inverse trigonometric functions
- Square root
- Maximum, minimum and average of a set of data
- Sum of the values in a set of data
- Absolute value
- Running average.

The following computational capabilities are also required:

- Definition of constants to be used in the calculations
- Reset counters and maximum or minimum values
- Structured conditional statements such as IF, THEN, ELSE with Boolean operators (AND, OR, NOT, XOR) and comparison operators (>, ~ =, <, <=) to define conditions.

- Simple programming steps, including the following:

- Conditional branch
- Unconditional branch
- Call another calculation
- Return from calculation

It should be possible to enter comments (not executed) into any calculation.

APSEB shall be able to store some frequently used algebraic equations, such as the calculation of power factor, so that a calculated point can be defined by specifying the component data points by name and referencing the desired equation.

8.13.4.3 Calculated Status Points

A calculated status point is a database point whose value is a Boolean function of the value(s) of one or more other status points, which may themselves be calculated status points. It shall be possible for the programmer to specify a Boolean equation which includes up to twenty (20) operators.

The calculated setup function will be used to make frequently needed logical analyses involving several status points and to produce conditional alarms. The frequency of calculations shall be the same as the frequency of display updates. Alternatively, status point calculations can occur whenever a component status point changes state.

As a minimum the following types of operations shall be supported:

- AND, OR, XOR
- NOT
- Structured conditional statements including IF, THEN, ELSE with Boolean operators (AND, OR, NOT, XOR) and comparison operators (>, ~ =, ..:s, <) to define conditions.

Calculated status points shall be treated the same as monitored status points with respect to alarming and alarm acknowledgement.

8.13.5 SUPERVISORY CONTROL

Operators shall be able to control power system devices via RTUs. Select before operate (SBO) control procedures apply to RTUs. For RTUs, SBO practices are required for both the operator procedure, and the communications with the RTU; an RTU shall be instructed to execute a command only after the master station verifies that the correct selection of point and control function were reported by the RTU.

A supervisory control request shall be sent to an RTU only after the controlled point was checked for proper conditions. The request shall be rejected if:

- The device is not subject to supervisory control of the type being attempted;
- The requested control operation is inhibited by a tag placed on the device;
- The point has been deactivated or the point's RTU is inactive;
- There is no match between the area-of-responsibility of the device and of the console initiating the control request;
- The operator's console is in a mode which does not permit supervisory control;
- A control request for the same device from another console is still pending (it has not yet been EXECUTED);
- A previous control command for the same device is incomplete (see Section 13.5.3; applies only to control via RTUs).

Rejection of a control request shall occur before any transmission is made to the RTU or control purposes. Rejection of a control request shall in a CRT message being issued. The point name and the reason for request refusal shall be identified in the message.

If the RTUs allow the master station to specify the duration of or act closure, it shall be possible to specify in the database either an individual contact closure period for each two-state, three-state, and incremental control device, or a minimum of eight typical contact closure periods to be used for different types of controlled devices. This would be permitted in Programming Mode only.

8.13.5.1 Control of the Two and Three State Devices

Select-Before-Operate (SBO) control shall be provided for various types of two-state and three-state devices, including:

- Substations breakers (trip/close)
- Breaker fast trip (on/off)
- Reclosers (on/off)
- Switches (open/close)
- Recloser (cutoff)
- Fault indication reset
- Motor-operated switches
- Miscellaneous devices (auto/manual, start stop, open/close, etc.)

Selection of a point for control shall be cancelled after the Executive command is initiated. The point shall also be automatically de-selected if the operator does not choose a specific control operation within a control time-out period after the point was selected, or does not issue an Execute command within the same control time-out period after the operation was chosen. A system-wide control time-out period shall be adjustable from a console in the Programming mode in the range of 10 seconds to 60 seconds.

8.13.5.2 Incremental Device Control (Jog Control)

Incremental, open loop, select-before-operate device control capabilities shall be provided to transmit incremental RAISE or LOWER commands to devices such as transformer load tap changers (LTC).

Once an Operator has selected such a device for control and has chosen a RAISE or LOWER operation, it shall be possible to execute the command any number of times without having to reselect the device or the operation. The operator shall also be able to alternate between RAISE and LOWER operations without device reselection. The device selection shall automatically be cancelled if neither an execution command nor a new operation selection was issued by the operator within a pre specified control time-out period. The control time-out period for incremental device control shall be a system wide parameter, independent of the control time-out specified in Section - 13.5.1 but adjustable in the same way.

8.13.5.3 Control Completion Check

Control completion checks are required when devices are controlled via an RTU. After the successful conclusion of the exchange of control messages with an RTU, the master station shall schedule itself to check for control completion by monitoring the status of the controlled device. If the expected change of status is not detected within a pre-set time period, a control-failed-to-complete alarm shall be generated. Each controlled power system device may have a different pre-set time period for control completion. The change of state shall be reported to the operator as soon as it is *i* detected, instead of waiting until the end of the control-completion check period. A control-failed-to-complete condition shall not cause any automatic control retry.

For pole-top RTUs, which are scanned very infrequently, a control completion verification scan shall automatically occur at the end of the time-out period.

8.13.5.4 Emergency Load Shedding (Option)

Operators should be able to shed blocks of load by tripping groups of breakers with a single command. For protection against operator errors, load shedding shall be initiated only from a special Load Shed display, and a two-step procedure is required. The operator shall first select the group, and the group 10 shall be displayed. The operator shall then be able to issue an Execute command , to initiate the load shedding for the selected group. or to cancel the selection. When execution is requested, a select-before-operate (S80) procedure shall automatically be performed to control each breaker in the group, subject to all restrictions imposed on supervisory control as described in Section 13.5.

The system shall support at least 20 groups of up to 20 breakers each.

Load shedding operations shall be recorded as events. Should the S80 procedure fail at one or more breakers in the group. a message shall be displayed and an alarm shall be generated. 80th the displayed message and the alarm shall identify each affected breaker and the reason for the failure. The displayed message(s) shall not be deleted or superseded without authorization by the system operator. Failure to control one or more breakers in a group shall not affect controlling the other breakers in the same group.

It shall also be possible to operate (trip or close) each individual breaker from the load shed display for the group.

Initiation of a block load shed operation shall automatically start a timer. After an operator entered time-out period, an alarm shall be generated to remind the operator to restore the loads. Normal breaker closing commands will be used to restore previously shed groups.

8.13.6 LOAD CONTROL

Load control of HT consumer loads is required to reduce the system peak load during the evening peak hours. Synthesis or load curves of the feeders to which the HT consumers are connected has to be performed for flattening of the load curve by shifting of the peak load to valley portions of the load curve.

Shedding/restoration of individual HT consumer loads shall be possible using a two way MARS remote radio, pole-top RTU and a vacuum switch located at the customer premises.

8.13.6.1 Operational Methodology

Load control of HT loads shall be possible either for single discrete loads or for the load groups where the loads are divided into load groups. The additional points to be considered are:

- (i) Whether the customer load is a process load requiring uninterrupted supply.
- (ii) Priority of the load/load group.
- (iii) Schedule of switching of individual loads/load groups with provision to enable/disable the load control.
- (iv) Duration of Interruption shall be divided equally between all loads/load groups.
- (v) Features of cold load pick up to avoid sudden system overloading.
- (vi) It shall be possible to invoke the load control program at predefined conditions (like peak load hours or system overloads) automatically or at the operator's request.
- (vii) Provision shall be available for generation of the control commands for switching on/off loads/load groups automatically through software program or by manual control by the operator through SCADA.

8.13.6.2 Reports/Displays

The following reports/displays are required:

- Time of load shedding/restoration of loads/load groups.
- Duration of interruption of loads/load groups.

- Summary of loads shed, total relief obtained and relief obtained on the feeders to which the HT consumers are connected indicating the name of Substation, name of „feeder and name of HT consumer.
- Real time display of active and reactive load of HT consumers along with name of substation and name of feeder to which each HT consumer is connected.
- Trending of load curves of loads/load groups with provision to display (i) hourly load curves, (ii) weekly load curves, (iii) monthly load curves.
- It shall be possible to effect load control from a user friendly display provided on the monitor giving the details of loads/load groups, priorities, present loading status and the time when the load was last switched off. Scramming of individual loads/load groups shall be possible with a single command from the display provided on the operator console. It shall be possible to control loads from any display showing the loads/load groups.

Graphical displays showing the single line diagrams of substation, feeders, HT consumer loads connected with real time display of active and reactive loads.

8.13.6.3 Alarms/Messages

- Failure of control commands to switch on/off loads/load groups.

8.13.7 AUTOMATIC METER READING

APSEB will install electronic meters at large industrial customers. These meters will be equipped with an RS-232C/RS-485 interface for communications with the DAS. Communications with the meters will be via a MARS radio channel. An industry standard protocol, to be determined later, will be used to communicate with the meters, APSEB will lend the Contractor meters for use in System development and testing.

Meters shall be read to obtain billing information, to monitor the customer's load and voltage, and for detection of attempts to tamper with the meter. The number of meters to be supported by the DAS is approximately 100 Nos. initially.

8.13.7.1 Acquisition of Billing Data

The following data shall be read monthly according to an operator-entered schedule kWh, kvar, and maximum hourly kWh demand during the billing period. The demand register shall automatically be reset after the monthly billing data was successfully read. It shall be possible to read billing data from up to five time-of-use (TOU) billing periods.

Billing data shall be available for display. The display shall show the customer name for each meter, and shall show the date and time when the displayed information was obtained. Operators shall be able to add or modify customer names and also demand the reading of billing data from any specific meter from the display.

The most recent billing data shall be available for transfer by magnetic tape or diskette to APSEB's Customer Information System in ASCII format.

8.13.7.2 Hourly Meter Readings

Selected data shall be read from the meters every hour on the hour. The following is a tentative list of data to be read; the final list will be developed during project implementation:

- a. Three-phase volts
- b. Total kWh, kvarh and power factor
- c. Date and time
- d. Meter tampering indicators.

Items "a" and "b" shall be stored in the real-time database, and shall be available for display and storing in HAR accounts.

The date and time readings shall be used to detect and alarm meter clock problems.

Detection of tampering shall be alarmed, and a "Tamper" indicator shall be set for the affected meter in the metering display. This flag shall flash until the alarm is acknowledged by an operator, and shall continue to be displayed until it is manually deleted.

8.13.7.3 Meter Management and Programming

The DAS shall issue all initialization, time synchronization, and register reset commands needed by the meters to support the specified requirements. It shall also be possible to specify time of use (TaU) periods and other necessary parameters for the meters from the metering display.

8.13.8 INTEGRATED VOLT -VAR NTROL

One of the important requirements of any distribution system is to provide a good voltage profile/voltage within acceptable limits to the consumers and minimize the distribution losses. This is achieved by supplying the required reactive power at the appropriate locations in the distribution system by installing switched shunt capacitor banks and voltage regulators on distribution feeders and controlling them remotely from DCC.

8.13.8.1 Function inputs

The following inputs are required by the function:

- Details of capacitors, voltage regulators like capacity, number of taps, their locations etc.
- Network data.

- Active and reactive loading of the feeder.
- Voltage at the monitored point.
- Maximum, minimum and current tap position of voltage regulators.

8.13.8.2 Operational Methodology

A pole top RTU with a MARS remote is installed at each voltage regulator/capacitor bank location and interfaced with it for getting input data of feeder voltage at the monitored point, reactive loading, current tap position of voltage regulators, on/off status of capacitor banks and to do switching operations of capacitors and voltage regulators.

The location and capacity of capacitors/voltage regulators shall be decided using an optimal strategy. The switching schedule of capacitor banks is to be obtained for minimal loss strategy while simultaneously satisfying the maximum in voltage constraints on the feeder. A similar method is required for determining the voltage regulator taps also. Here, the regulator tap position is placed in maximum possible position as long as the voltage at the maximum affected node will not exceed maximum voltage limit. The on/off switching commands for capacitor banks and raise/lower commands for voltage regulators shall be issued to pole top RTUs either through supervisory control automatically or through manual control by the operator. A feed back of the change in status due to control commands have to be obtained and the results have to be displayed with any alarm/event messages as required.

8.13.8.3 Displays/Reports

- The Graphical user interface for displays/reports of SCADA and all application functions shall be the standard MOTIF. The displays/reports required by the software are:
- Switching schedule of capacitors over a day.
- Schedule of taps for voltage regulators.
- Display of feeder layout along with capacitors and voltage regulators on it showing the voltage and reactive power at monitored points.
- Status of switched capacitors and tap position of voltage regulators are also to be displayed.

8.13.8.4 Alarms/Messages

The following alarms and messages are required:

- Feeder name, amount of voltage violation and its location on the feeder, if violation is expected to exist even after using all Volt/VAR sources on that feeder.
- Success/failure of control commands to operate capacitor banks and voltage regulators.

8.13.9 FEEDER SCADA INCLUDING FAULT LOCALISATION, RESTORATION OF SUPPLY AND LOAD BALANCING

For speedy fault localization and restoration of supply during outages and also to utilize the available system capacity effectively by load balancing, 11 KV distribution network control switches are provided on feeders sectionalize the feeders. These are operated by employing a pole top RTU with a MARS remote.

8.13.9.1 Fault Localization

On the occurrence of a fault on a radial distribution feeder, this function finds out the section in which the fault has occurred. The faulty section is isolated by opening the switches at both ends of the section.

8.13.9.1.1 Operational Methodology

Whenever there is any fault on a feeder, the circuit breaker (CB) for that breaker trips. Test, charging is done by closing the CB for 2 to 3 times at an interval of a few minutes, to ascertain that :: the fault is not a transient one. The last test charging is done by opening the isolator and closing the breaker to ensure that the fault is not in the breaker. Once it is ascertained that the fault is permanent and is on the feeder, the CB is charged again and the switches are closed one after another starting from the sub-station end. If the breaker is in closed position and trips before the first switch is closed, the fault is noted to be in between the substation and the first switch (i.e., in the first section). Otherwise, the fault is noted to be in the section beyond the most recently closed switch. The faulty section is isolated by opening switches at both ends of the section. Supply to the healthy sections between the substation and faulted section are restored.

Provision must be available for selecting either automatic operation of switches by a software program or operation of switches by the operator through SCADA.

8.13.9.1.2 Reports/Displays

The following reports/displays are required.

- (a) Report indicating the name of substation, name of 11 KV feeder in which fault has occurred, number of switches available on the feeder, switches operated and faulty section in a tabular form.
- (b) Report indicating the time of occurrence of fault and time at which the fault has been isolated.
- (c) Graphical display of faulted feeder with switches, highlighting the, faulted section in different colour.
- (d) Display indicating network modification according to dynamic changes.
- (e) Number of switching and the sequence of switching to identify the fault.

8.13.9.1.3 Alarms/Messages

Alarms/Messages are generated in the following cases:

- (a) Faulty section could not be located.
- (b) Alarm to alert the operator about the occurrence of fault on a feeder indicating the name of substation, name of feeder and time of occurrence of fault.
- (c) Failure of control commands to operate switches.

8.13.9.2 Feeder Reconfiguration for Service Restoration

After the faulted section of the feeder is isolated, service has to be restored for the healthy sections beyond the faulted section from the adjoining substation.

Provision must be made available for the service restoration function to be invoked automatically by the fault localization function or on operator request.

Facility must be available for selecting either automatic operation of switches by program or operation of switches by the operator through SCADA.

8.13.9.2.1 Operational Methodology

If the fault is in the last section of the feeder, then as there are no sections to be restored, the function has to terminate with an appropriate message to the operator. Otherwise, the function has to look for the number of alternative sources available for restoration.

The possibility of making use of the alternative sources for restoration must be examined taking the following into account :

- (a) Transformer capacity of the adjoining substations and the current loading status.
- (b) Present loading status of alternative feeder, conductor size, thermal limits, over current relay settings for the feeders and node voltage limits.

Out of the available alternatives. the best alternatives have to be indicated. The possible results of the function are:

- (a) No alternative sources available.
- (b) None of the alternative sources are viable i.e., restoration is not possible as the constraints cannot be satisfied.
- (c) Only partial restoration is possible. In this case, the sections for which restoration is possible and the sections for which restoration is not possible have to be indicated.

The alternate source/adjoining substation name, feeder name selected must also be indicated.

- (d) Restoration is possible for all sections beyond the faulted sections. The best alternative(s) have to be indicated.

8.13.9.2.2 Reports/Displays

- (a) Report indicating the name of substation, name of faulted feeder, number of switches available on the faulted feeder alternative sources available (names of adjoining substations and alternate feeders).
- (b) Details of Transformer capacity and present loading conditions of adjoining substations.
- (c) Present loading status of alternative feeders, conductor size, thermal limits, over current relay settings and node voltage limits.
- (d) Restoration status indicating the name of the alternate substation, alternate feeder chosen for restoration and number of switches operated for restoration. The loading status of the alternate substation after restoration is to be indicated showing the transformer loading, alternate feeder loading and its voltage profile. If a possibility exists, VolWAR control function can be invoked on the alternate feeder to improve its voltage profile.
- (e) Graphical display highlighting the Section(s) to which supply has been restored indifferent colour.
- (f) Display indicating network modification according to dynamic changes.
- (g) Number of switching and the sequence of switching to restore supply to health sections beyond the faulted section.

8.13.9.2.3 Alarms/Messages

Alarms/Messages are generated in the following cases:

- (a) Restoration is not possible to any of the affected sections.
- (b) Failure of control commands to operate switches.
- (c) Alternate sources not available.

8.13.9.3 load Balancing

The load balancing function helps in better utilization of the distribution facilities (transformer and feeder capacities). This increases the life expectancy of the equipments and also results in deferred equipment investments.

8.13.9.3.1 Function

The aim of the function is to distribute the total load of the system among the available transformers and the feeders in proportion to their operating capacities, considering the discreteness of the loads, available switching options between the feeders and permissible intermediate overloads during switching. For load balancing between transformers in the same substation having different per unit impedances operation on different taps may be required. The function should provide for this exigency. It is invoked by the operator or automatically on overloads, likely overloads, un equal loadings of the feeders and the transformers.

8.13.9.3.2 Operational Methodology

The problem of load balancing can be looked upto as an optimization problem where the objective function must reflect the following objectives:

- Minimization of feeder Transformer losses
- Load balancing among supply transformers
- Minimization of the worst voltage drop
- Minimization of service interruption frequency and duration.

A solution is then found to optimize the most critical objective among the above objectives.

The objective must be achieved by minimal number of switching operations of the switches. Provision must be available for selecting either automatic operation of switches by software program or operation of switches by the operator through SCADA.

8.13.9.3.3 Reports/Displays

The following reports/displays are required.

- Sequence of opening and closing of switches considering permissible intermediate overloads during switching.
The name of the substation and name of feeder/feeder section to which each switch belongs must be indicated.
- Guiding display, highlighting the next switch to be operated (in blink / colour options)
- Relevant diagrams for suggested switching operations indicating existing voltage profile and expected voltage profile of the reconfigured network.
- Loadings of feeders and transformers before and after reconfiguration.
- For load balancing between feeder pairs, the following have to be given:
 - (i) Peak loss (KW) and Energy loss (KWh) before reconfiguration.
 - (ii) Peak loss (KW) and Energy loss (KWh) after reconfiguration.
 - (iii) Loss reduction of the feeder pair (Peak loss and Energy loss) because of reconfiguration.
 - (iv) Voltage profile of the feeders before and after reconfiguration.

8.13.9.3.4 Alarms/Messages

Alarms/messages are generated in the following cases: r ~

- Feeder and transformer overloads I .Details of likely intermediate overloads.
- Failure of control commands to operate switches.
- Excess circulating current due to parallel operation of transformers in a substation *on* unequal tap positions.

8.13.10 AUTOMATED MAPPING AND FACILITIES MANAGEMENT (AM/FM)

The displays available to the DCC operator from the SCADA system are representative schematics like single line diagrams of electrical network, tables etc. The operator has very little information about the geographical location of various field devices like distribution transformers, capacitor banks, distribution network control switches etc. For trouble call shooting, it is very difficult for the operator to dispatch crew to the problematic area. This problem can be overcome with Automated Mapping (AM) function, which gives the operator latest geographical maps with the electric network merged on this.

In case of routine field device maintenance like re-laying of underground cables, erection of overhead lines etc., the operator has to rely on oral instructions from crew staff. The availability of a database of all such information helps in attending to the maintenance activities more efficiently. The FM function addresses this problem by having such databases and supporting related queries.

8.13.10.1 Function

The function of AM/FM is to have an integrated display of the geographical maps and single line schematics of the electrical distribution network, to facilitate the following:

- Display of dynamic information of various devices like status, analog values etc.
 - Facility to automatically indicate the status of any element on network.
 - Facility to import scanned maps in standard formats like DXF etc.
 - On-line modification of the geographical and network maps with the help of the map editor.
 - To provide various map functions like layering of map information zooming, scrolling and panning.
 - To extract the historical data of the devices from the database.
 - Facility for multiple users to access the facility database.
 - Facility for plotting
 - Given a device, to display/edit various data characteristics of that device viz. make, capacity etc.
- ##### **8.13.10.2 Function Inputs**
- Geographical maps in standard formats
 - Network schematics
 - Static and operational data of devices

8.13.10.3 Reports/Displays

- Plots of Geographical layouts and Single line diagrams. :
- Reports of required information of various devices like status, analog values etc. in any format.
- Integrated display of though geographical maps and single line schematics of the electrical distribution network.
- Display of data attributes of selected device.

8.13.11 TROUBLE CALL MANAGEMENT SYSTEM (TCMS)

The outage of supply reported by the consumers will be collected at Fuse off call centers. It is proposed to analyze the reasons for outage reported by the consumer/consumers and take recalculation to restore supply speedily using this function. For instance when outage of supply is reported by a large number of customers in one area, it may be probable to trace the reason to blowing off of a sectional fuse a distribution transformer. By maintaining data base of customers connected to each transformer or feeder, such an analysis could be made easily. By connecting up all the fuse off call centers to DCC, the operator at DCC will be able to make such an analysis and send rectification gangs for speedy restoration. This function helps to reduce losses due to long interruptions and improve customer relations.

8.13.11.1 Function

Input to the function is the Trouble calls from the customers/SCADA. Based on this information, the TCM software should identify the problematic device and pass this information to the operators on duty for repair. Meanwhile an alternate feed has to be arranged to the customers by eliminating the faulty portion of the network from the total network. Accordingly the database has to be changed dynamically.

8.13.11.2 Databases

Trouble Call Management System is built around two data bases, available in a Host System, the connectivity data base and the consumer information data base. Identification of consumers on every circuit is done by TCMS using these two data bases. Hence TCMS can associate a consumer who reports a problem with a particular feeder, lateral and Distribution Transformer. The data base shall be any industry standard RDBMS, preferably oracle.

8.13.11.3 Reports/Displays

The Graphical User Interface for Reports/Displays shall be based on the standard MOTIF.

The reports/displays required by the software are:

- (a) Call entry form for entering the consumer name/identifier, nature of trouble call reported and time of outage.

- (b) Call analysis report.
- (c) Call incidence report showing the distribution transformer to which the consumer is connected.
- (d) Case sheet for entering details of outage device.
- (e) Status messages for calls.
- (f) Restoration data status.
- (g) Call back list to inform consumers after restoration.
- (h) Outage data report for MIS.
- (i) Device status report at any time.
- (j) Display of entire network on the monitor.
- (k) Highlighting the problematic device as soon as analysis is over.
- (l) Network modification according to dynamic changes.

8.13.12 HISTORICAL ACCOUNTING AND REPORTING (HAR)

A Historical Accounting and Reporting (HAR) function is required to save and analyze historical data and to generate reports.

8.13.12.1 HAR Data base

A single (redundant) HAR database shall be maintained in the DAS. It shall be the sole source of data for generating DAS reports. APSEB considers it a big advantage for the HAR database to be based on a commercially available relational database product, preferably Oracle.

The HAR database shall be built on the concept of accounts. Each account shall include a set of values which are periodically copied from a point in the real-time database. It shall be possible to specify the periodicity at which data is copied into the account, and the total number of samples it holds. An account could, for example, include hourly MW or Mvar reading from a certain meter for a period of three months, or periodic snapshots of the voltage on a bus. HAR data shall be available for DAS users for the current month and three previous months.

Data, analog with its quality code, shall be transferred into HAR accounts. As an exception, all Alaram Inhibited (I) codes shall be translated into Up-to-Date (Blank) codes. All data quality requirements of Section 13.1.2. apply to the HARdatabase and shall be followed for manual entry of data and for calculated accounts.

Required accounts are specified in Section 13.12.6. The HAR database shall be sized to accommodate these accounts for the Ultimate point counts.

8.13.12.2 Management of HAR Accounts

It shall be possible to establish an HAR account for any point in the DAS database, including data that is derived from other HAR accounts. Procedures are required to :

- (a) Select data points for accounting.
- (b) Define calculated values for accounting.
- (c) Specify time periods at which the ~data is to be saved in HAR. As a minimum, data-saving Intervals of 15, 30 and 60 minutes synchronized with the hour are required, as well as daily and monthly (shortly after midnight) data-savings periods.
- (d) Specify the size of the account, expressed in the period for which data is saved, or alternatively in the number of account entries.
- (e) Edit account data.
- (f) Delete an account.

Dispatcher oriented procedure are required for the HAR management functions described above.

8.13.12.3 HAR Calculations

It shall be possible to define calculated HAR accounts based on any other HAR account(s). Calculations shall be definable via interactive CRT procedures. Each such calculated account shall be defined by a series of calculation steps wherein each step defines the operation to be performed and the associated operands. Operands shall be logically acetified; internal data IDs and offsets shall not be required. As a minimum, the calculation capabilities for arithmetic calculations specified in Section 13.4.2 "Calculated Analog Points", are required. The capability to calculate sums of values across a group of HAR accounts is specifically required. A calculated account shall have all the attributes of any other HAR account. Any account, including calculated accounts, shall be usable as an input for calculating other accounts. It shall be possible to calculate an account from shorter time frame accounts, e.g., calculate a daily account from hourly accounts or a monthly account from daily accounts.

8.13.12.4 Viewing and Editing of Accounts

An operator shall be able to view and edit any HAR account on his terminal. The operator shall, however, not be allowed to override calculated values. Operator-entered values shall be flagged with the Manually Entered (M) data quality indicator. When historical values are changed, calculated values which depend on them shall automatically be updated. As an alternative the operator can be required to manually demand data recalculation, but in this case a conspicuous message indicating the need to do so shall be displayed until the recalculation is performed.

8.13.12.5 Exporting and Archiving of HAR Data

It shall be possible to copy HAR data in a format which is suitable for import into a database or spreadsheet on an external computer. An intermediate file format which is supported by several commercially available databases and spreadsheets is required. The intermediate format shall be subject to approval by APSEB.

The HAR database and archival files shall be structured to facilitate transfer of data for one calendar month at a time. Data transfers shall be by category (such as operational data, radio communication statistics, etc.) and sub category, as defined by APSEB, but not by individual accounts. Operator procedures, based on screen selection of the data to transfer and the destination storage device, are greatly preferred over procedures which require programming skills.

8.13.12.6 Required Accounts Categories

8.13.12.6.1 Operational Accounts

The HAR accounts described below shall be set up by the Contractor for all analog points in the system, including MW, Mvar and volts. Other accounts shall be set up as needed to generate data for required reports.

- (a) The 15-minute average values calculated as per Section 13.3.1.5a.
- (b) The hourly energy values calculated as per Section 13.3.1.6.
- (c) The daily maximum/minimum values collected as per Section 13.3.1.5b.

Additional accounts shall be set up if needed to supply data to any of the required reports.

8.13.12.6.2 Radio Communication System Accounts

APSES will monitor the operation of the Radio Communication System described in Section 1.1.4. RTUs may be used to monitor all radio equipment at the sites of the backbone TDMA radios and repeaters, and remote MARS radios may also be monitored. Alternatively, RTU communications data may be available from optional communications maintenance functions specified in Sections 13.13. All data from the Radio Communications System shall be stored by HAR every hour on the hour. The list of monitored data will be compiled after Contract award.

8.13.12.7 Report Requirements

8.13.12.7.1 Creation of Reports

A Report Editor is required to allow easy interactive CRT creation, modification, and deletion of reports. Any account data store in the HAR database shall be eligible for inclusion in any or all reports. Report definition shall include the following:

- Format (e.g. layout, background title)
- Selecting whether or not data quality shall be shown
- Data definitions
- Definitions of calculations
- Printout periodicity (on demand, time of day, day/time of week, day/time of month)

- Assignment of printers.

When reports are printed on the laser printers it shall be possible to specify the “portrait” or “Landscape” printing modes, and to support scalable fonts. On other printers it shall be possible to create reports which are 80 columns wide which use standard paper and 132 columns wide which use wide paper.

It shall be possible to concatenate separately reports to be printed out together.

8.13.12.7.2 Printing and Viewing of Reports

A report shall be automatically printed at the time periods which were specified when the reports was created. In addition, an operation shall able to demand the printout of any report at any time. An operator shall also be able to select any report for viewing on a terminal, and to page through multi-page reports.

Printing of reports shall start at the top of a new page. However, if the printer is already at the top of the page, a new top of the page command shall not be issued. Under no circumstances, including system failover, shall the printing of a report be omitted. Once started, a report shall not be interrupted until it is completed, unless cancelled by the operator. Multiage output may be interrupted on page boundaries if the printer is serving its primary task and is simultaneously backing up another printer’s function. Each page of multiple page report shall have a specially designed header for that report, identifying pertinent data including time and date. At no time shall a page or printed output contain any information other than for that report.

If the designated printer is unavailable, the report shall automatically be routed to an operator-specified backup device. If no backup printer is available, the report shall be spooled to bulk storage until a printer becomes available. at which time the report shall automatically by printed.

8.13.12.8 Required Reports

The reports described below shall be included by the Contractor in the delivered system.

8.13.12.8.1 Daily Power Distribution Report

By substation, this report shall include the daily minimum and maximum readings, with the time of occurrence for:

- Three phase amps for each circuit.
- MW and Mvar for each circuit
- One phase voltage for each bus
- MW, Mvar, and tap position for each transformer
- A limited number of amp and voltage readings telemetered from feeders (if pole-top RTUs are installed).

8.13.12.8.2 System Maintenance Reports

System maintenance reports prepared by the Contractor shall include:

- (a) RTU Communications Report: This report shall provide hourly communications statistics by communication channel and by RTU. It shall be designed to enable a technician to monitor the performance of the communication channels and to identify problems associated with specific channels and specific times of day, in order to facilitate reliable communications. The scope of the report shall be for the month to date. It shall be automatically printed at the end of each month and any time on operator demand from the operator terminals.
- (b) DAS Performance Report: Reports on utilization of system resources and statistics on equipment errors and failures.

8.13.13 COMMUNICATIONS MAINTENANCE FUNCTIONS (OPTION)

The Radio Communications System described in Section 1.1.4 will be equipped with remote testing and adjustment capabilities, so that it can be operated from DCC. The Contractor shall integrate Communications Management System software, diagnostic and maintenance functions (which may be furnished by the supplier of the communications system) and their user interfaces, into the DAS so that communications maintenance can be performed from the DAS operator terminals.

8.14.0 COMMUNICATION OPTION FOR DAS & SCADA

8.14.01 Distribution Automation

Today distribution automation means differently to different utilities., This has arisen because automation of various functions of distribution system like distribution substation control, load management, feeder SCAD etc. are at different stages, in the various utilities. IEEE has defined distribution automation system (DAS) as "A system that enable and electric utility to remotely monitor, coordinate & operate distribution components, in a real time mode from remote location."

8.14.02 A good data communication system to transmit the control commands & data between DCC & large number of devices remotely located on the distribution network is a prerequisite for the good performance of Distribution Automation System (DAS). The communication requirements of each DAS is unique, depending upon the DA functions selected for implementation. A wide range of communication technologies are available to perform the tasks of DAS. The choice of communication technology has also big impact on the cost of DAS. Selecting an appropriate communication system for DAS calls for understanding of

- Communication requirements of DAS and the technologies suitable for it.
- The communication technologies available for DAS and their relative merits to perform DA.

- Communication system requirements are
- Expandability
- Flexibility
- Reliability
- Two way communication
- Meet Data requirements

8.14.03 Communication System chosen should be able to cater to the needs to the following in a district.

- 20 Bulk Substations (EHV Substations)
- 200 Distribution Sub Station (33/11 KV Substations)
- 10,000 Distribution Transformers
- 200,000 Pump sets
- Range of 150 Km viz. distance from control center to farthest point.

8.14.04 The communication technologies suitable for DAS are:

- Public telephone communications
- Power line communications
- Radio communications

1. Public Telephone Communications :Two types of telephone communications available are Dial up and dedicated or leased telephone lines. It is a two way communication system. A data rate of 1200 to 2400 BPS with dial up telephone line & data rate of 4800 to 9600 BPS with leased telephone line can be achieved. The reliability of communication varies greatly.

The public telephone system in India, does not have adequate coverage & not reliable enough for DAS applications.

2. Power line communication (PLC) : The main advantage of using the power network as a communication medium is that the network is completely by the utility. It reaches any point on the network and automatically extends to the newly added network elements.

8.14.05 Three PLC technologies are applicable for DAS.

- Ripple control
- Distribution line carrier
- TWACS or Systems based on zero crossing techniques

In the Indian power networks the distribution line joints are made manually using binding wire and the quality of joint is not very good. This will cause serious problems of signal for propagation. A maximum baud rate of 1,200 B~S will be achieved with this Power Line ~ Communication. Hence PLC technology IS considered not suitable for Indian networks at the present stage.

8.14.06 Radio Communication: Radio communications system are usually owned by the utility, and their operation is independent of the conditions of the power system. Many data channels, including high speed channels, can be supported, as well as voice communications. The following radio technologies are available.

- Ultra High Frequency (UHF) Point-to-Point Radio operates either in 400 or 900 MHz band. It is suitable for backbone communication networks. It requires line of sight.
- Time Division Multiple Access (TDMA) Radio operates in 2 GHz band. It is also suitable for backbone communication network. It requires line of sight.
- Very Small Aperture Terminal (VSAT) operates in extended C Band. Suitable for backbone communication network. Line of sight is not required.
- Ultra High Frequency (UHF) Radio System operates in 154 MHz band. Suitable for one way control of load control switches. It also requires line of sight.

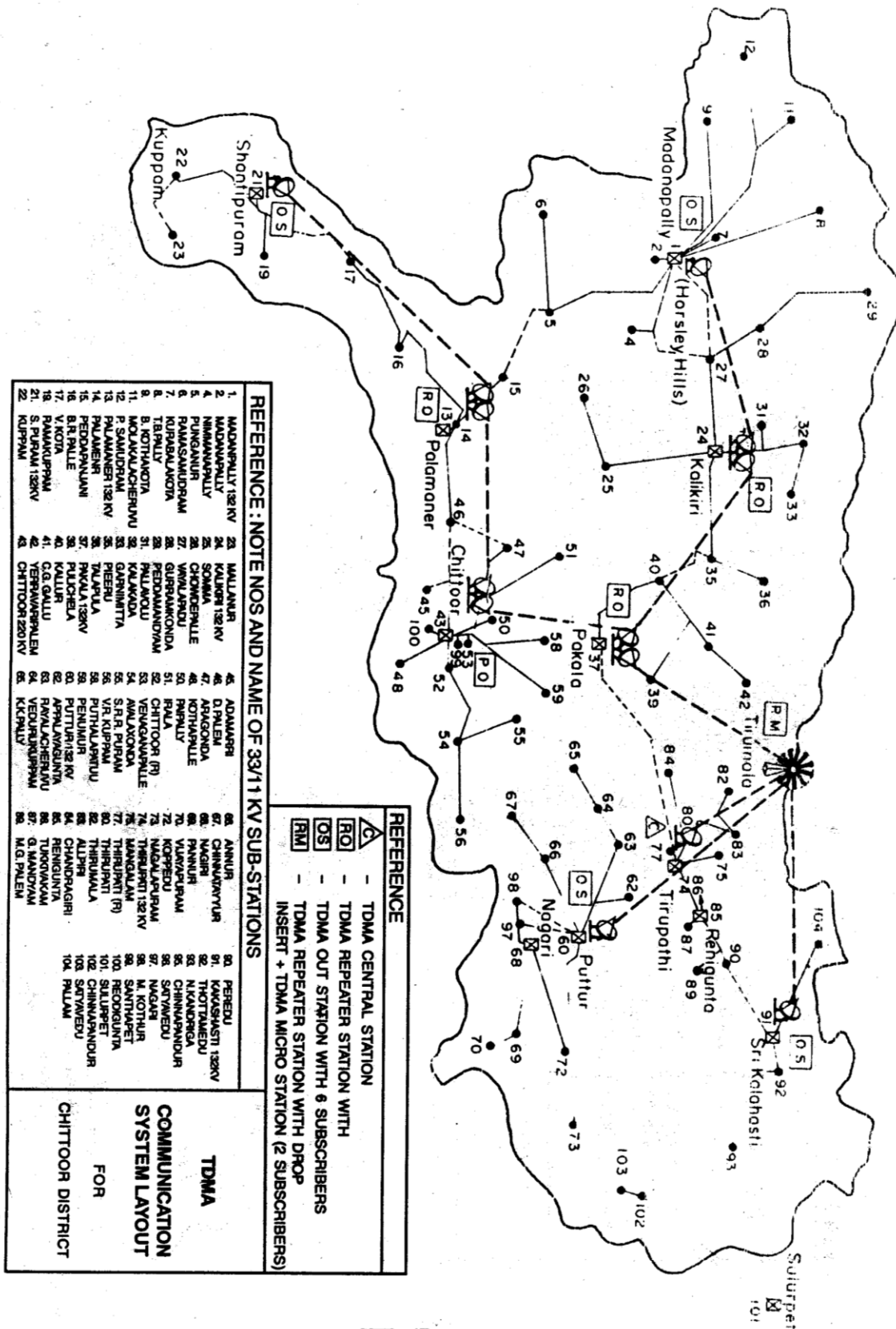
8.14.07 System configuration based on various combinations of Radio technologies will be as follows:

Considering one DAS system for districts, the farthest points are about 150 KM from the DCC. The service area was divided into a set of areas 30 KM radius. The center of each area was designated as nodal point. One of these nodal points is at the DCC.

The nodal points will be interconnected by a TDMA system for backbone network, with TDMA central station at DCC and TDMA outstation at each nodal point. TDMA has the advantage of providing 64 KBPS data rate and high quality voice communication. TDMA repeater stations will be providing 64 KBPS data rate and high quality voice communication. TDMA repeater stations will be provided at suitable locations where line of sight cannot be guaranteed.

MARS master radio will be installed in each nodal point for communication with RTUs in substation, at distribution transformers, and other required points in the distribution network. Substation RTUs will be scanned periodically, and others probably once an hour, and on demand by a DAS operator. Though radio frequencies- in the 400 MHz band are easier to obtain and provide better coverage, operation in the 900 MHz band was chosen because robust and non-conspicuous short "stick" antennas can be used. This makes radio equipment installed in exposed locations less prone to vandalism by customers opposed to load control. The MARS master stations will be suitably interfaced to the TDMA outstations and the data collected at the TDMA outstations will be transmitted to the central station.

One-way VHF radio will be used for load control because low cost load control switches are available for this technology. VHF radio switches can also be used for capacitor control on the distribution network, in view of more expensive RTUs with remote MARS radios, if monitoring is not essential at the capacitor banks.



EXTRACTS FROM APSEB MANUAL

EXTRACTS FROM APSEB MANUAL

A. CLASSIFICATION OF REVENUE RECEIPTS

102. SOURCES OF REVENUE:

The revenue of the Electricity Board is derived from power supplied under the following heads:

1. Industrial power such as mills and factories. H.T., L.T.,
2. Power to Railways.
3. Agricultural Power .
4. Domestic, Non-domestic, Commercial and General purpose power.
5. Local bodies.
6. Power to Government Departments.
7. Special Contracts including temporary supply.

103 MISCELANEOUS RECEIPTS:

Revenue incidental to sale of power such as customer charges, Re-sealing charges, Application, Registration fees, disconnection and reconnection fees, centages on service connections, fuse of calls, surcharges for belated payments, testing fees, sale of pamphlets, fees for changing meters, minimum charges for unconnected services, etc., are grouped under Miscellaneous Receipts. Receipts of the nature of hire of tools and plant, hire of electrical equipment, rent on buildings, sale of materials, interest on hire purchase loan repayments, centages on stores, lapsed deposits, inspection bungalow fees, etc., are also grouped under this head.

104 CLASSIFICATION:

Detailed classification and the Departmental Account Numbers are given in the Appendix-II.

B) General Rules governing supply of power.

105 TERMS AND CONDITIONS OF SUPPLY:

The rules regulating the Terms and conditions, and general information for the supply of electricity energy are given in the Appendix-VII,.

SERVICE CONNECTIONS FOR SUPPLY OF L.T.ENERGY

106. REQUISITION FOR SUPPLY OF POWER:

Requisition for supply or additional supply of Electricity should be made in the prescribed form obtainable free of cost from the local office of the Board at least two months in advance of the date of requirement of supply. The requisition should be made by the owner or occupier of the premises for which supply is required and should indicate his full name and address and also produce commencement report of internal wiring installation from a licensed electrical contractor through whom the wiring will be carried out. Registration of application shall be written up in the register of A' form and should be maintained in the office of the section officer.

Note 1. An intending consumer, who is not the owner of the premises he occupies, should produce a consent letter in the form prescribed by the Board from the owner of the premises for availing supply.

Note 2. If the owner is not available or if he refuses to give consent letter, the intending consumer should produce proof of his being in lawful occupation of the premises and also execute an indemnity Bond in the form prescribed by the Board indemnifying the Board against any losses on account of dispute arising out of effecting service connection the occupant (vide Annexure I).

Note 3. If supply to any type of service connection in a land owned by a Department other than Electricity board is applied for, the intending consumer shall produce a No Objection Certificate from the officer, who is authorised by that Department to issue such certificate. The intending consumer should execute an indemnity bond in the form prescribed by the Board (vide Annexure I).

107. ACCEPTANCE:

The acceptance or otherwise will be notified to the consumer by the section officer in charge of the Distribution. Service connection will be given if the premises are within economic reach of the distributing main. The Board will arrange to bring the supplying main to the street pole nearest to the consumer's premises, if such an extension is remunerative according to departmental standards.

Note 1. The section officer shall inspect the localities in person as early as possible, and advise the consumer as to how best his installation work shall be carried out and the conditions under which power could be supplied.

Note 2. In no case, should the department undertake to execute electrical works for private individuals or private bodies except under special conditions.

Note 3. Where extensions are required, the proposals shall be dealt with promptly as laid down.

108. SANCTION OF ESTIMATES

When a service is to be given either on completion of an extension or otherwise, the service connection estimate shall be prepared and sanctioned up to 5 K.W. by the section officer and above 5 KW by the Assistant Divisional Engineer duly providing meter only on Board side and other materials such as service wire, GI Wire, GI pipe, I.C. cutout and Meter Board etc., shall be supplied by the consumer except in the case of Agricultural services. No service connection charges need be collected from the consumer except in the case of Agricultural services. In case of agricultural services, the service connection estimate shall be prepared as per the cost data communicated by the Board every year and the service line shall be terminated on the Terminal pole and the consumer shall pay the service connection charges as per the rules in force. The section officer should intimate the consumers other than agriculture in the prescribed preformed (vide Annexure-III) to pay the deposits and keep ready the service wire etc.

109. (a) DEPOSITS:

The section officer should then obtain from the consumers the deposit of Development charges; Consumption Deposit for all category of service except in the case of Agricultural services in the form of crossed Demand Drafts and also an agreement where ever necessary.

In case of Agricultural services, service connection charges, Consumption deposit and an agreement should be collected.

(b) The deposits shall be in the form of crossed Demand drafts and will not be accepted in cash. The consumption deposit Demand Draft shall be drawn in favor of Assistant Accounts Officer. All other deposits shall be in favour of Divisional Engineer concerned. The section officer should issue temporary receipt for all the deposits obtained.

(c) The amount of consumption deposits shall generally be regulated as indicated in clause No.28 of Terms and Conditions of supply as amended from time to time.

110. WORK ORDER APPLICATION (W.O.A)

In case of domestic, non-domestic. Commercial and general purpose services with a connected load of 7.5.KW or less W.O.A. in the prescribed perform a vide (Annexure-IV) should be sent to Assistant Divisional Engineer at least once in a fortnight in the simplified W.O.A. format for a group of consumers who have paid the required deposits as on the date of applying the APSEB-64) should be sent to Assistant Divisional Engineer by the section officer.

111. ISSUE OF WORK ORDER:

The Assistant Divisional Engineer is empowered to issue service connection work orders irrespective of the work order amount. The work order shall be issued within 3 days in the prescribed Performa (vide Annexure-V) for the simplified work order application and for other work order applications in the prescribed Performa.

Note 1. Service Connection works shall be executed on separate work orders, even though the provision for service connections is included in the extension. Thus an estimate for distribution schemes which should be split up, during execution, into two parts, viz., extension proper and service connection. The work falling under extension proper, should be executed by the staff in charge of the construction of the extension, while the service connection work should be executed only by the operation and maintenance staff, after receipt of the deposits, agreements, Demand Drafts from the consumers.

In the case of Agricultural services all lines up to the well including the terminal pole for supply to one or more wells come under extension proper. The connection to the meter from the terminal pole with pipe and PVSC wire, board, etc., comes under the service connection.

Note 2. Copies of work orders supported by the estimates accompanied by a detailed report, necessary sketches, application etc., should be sent to the Divisional Office as and when the work order are issued by the Assistant Divisional Engineer.

Note 3. Monthly return of work orders issued should be sent by Assistant Divisional Engineers to the Division Office of the system to reach by the first of the month.

Note 4. All service connection works shall normally be executed by the consumer as per the standards fixed by the Board from time to time.

Note 5. When a single phase service is converted into three phase supply, two thirds of the labours charges incurred by the Department with respect to three phase supply will be debited to capital and the balance one third to operation and maintenance towards the original debit so that the capital may not be over estimated or inflated.

Note 6. Simplified work order should not be issued, if, more than two work orders pending for closure.

112. COMMENCEMENT OF WORK AND INITIAL ACCOUNTS:

The work should commence only when the consumer's wiring is completed and after issuer of work order which should exhibit separately materials and lab our as estimated. The initial accounts of the work should be maintained on the back of the work order by the Distribution Engineer and continued on a separate sheet if necessary. The initial account should show the estimated quantity of material and lab our in the horizontal columns. The requisitions should be Noted in the vertical column vide instructions on the work order.

113. SOUND CONSTRUCTION :

It is essential that a service line is well and truly designed and constructed in the first instance. The service line laid for by the consumer becomes the property of the Board and no further debit can be raised against the consumer on account of replacements by costlier materials found necessary during maintenance unless the replacements can be ascribed to increased connected load.

Note: The service line materials are the property of the department as long as the line is a service line, immediately there is no further use for the service line – under the rare circumstances as the premises are demolished or so completely altered as to necessitate a different service line – and the line is actually dismantled at the request of the owner, the ownership of the line materials lies with the Board.

114. The service connections shall be regulated in accordance with the requirements of the Indian Electricity Act and the rules there under, the license and the agreement with the consumers.

Note (1) Except where earthed concentric wiring is used, all conductors in consumer's premises should be insulated either by being carried inaccessibly on insulators or by using insulated cables (vide section 34 (1) of Act and Rules 41 and 49) Unless the neutral conductor is fully insulated on consumer's premises, there would be possible danger by contact to human life as also damage by leakage to communication circuits and reinforced concrete structures.

(2) In all service connection, the following instructions should receive special attention so that the requirements of Rule 51 of the Indian Electricity Rules, 1956 may be satisfied:-

(a) In the departmental portion of fuse on the phase wire and a link on the neutral wire would be provided in the meter board.

(b) The consumer's side should be thoroughly examined to see that there is no switch or fuse on the neutral wire, or tapping from the incoming service connection wire.

(c) Single phase service connection estimates should provide for only one single pole cut out and one link.

(3) In all poly phase services whether agricultural, domestic or industrial a main switch near the point of origin of the consumer's installation should be provided by the consumer as required by Rule 60 (b) of the Indian Electricity Rules, 1956 No supply should be given unless this switch is provided.

(4) In respect of supply of electric energy to a consumer under different tariffs, separate connections should be insisted upon.

115. USE OF CONSUMERS MATERIALS:

Consumers are permitted to supply materials except meter for erecting service lines and to execute them by their registered electrical contractors. In special cases and for recorded reasons, consumer's meters can be used, if they are purchased from the list of companies approved by the Board.

116. TESTING CONSUMER'S INSTALLATION :

Except under very special circumstances the services should not be given till the installation in the consumer's premises is tested and found all right. Temporary wires and fitting and 'Dead Ends' must not be permitted in the installation and no part of the consumer's work must be left incomplete. The first test and inspection will be carried out free of charge but should any further test or inspection be necessitated by faults or by noncompliance of conditions of supply, the consumer should pay testing charges, as prescribed by the Board from time to time, in advance for subsequent test or inspection.

117. When the installation satisfied the test, the test report in APSEB form 18 in respect of L.T. services for Domestic, Non – Domestic/Commercial and general purpose categories, the consumer shall be required to affix a special adhesive stamp of Rs. 100/- on the L.T. Test report (Original) at the time of release of service by the authorized officer, should be obtained and sent by the section officer to the Electricity Revenue Office on the on the date service is connected and a folio should be opened in the meter reading register of that locality. A white meter card in A.P.S.E. Board Form 23(a) should be placed in the Meter Board. The initial meter reading should be noted in white card, Meter reading register, and also in the test report. The white meter card and meter reading register should contain full information regarding consumers name, premises, connected load, meter number, date of connection class of tariff, all which should be attested by the distribution engineer at the time of their opening.

- Note:
1. Meter cards are also required in the case of flat rate consumers.
 2. No fee will be charged for the inspection by the departmental officer for the alteration.
 3. Testing important power installations should be done by the Section Officer under his personal supervision although small lighting installations can be tested by Line Inspector.
 4. In the case of temporary electrical installations in places of public resort like exhibitions, shows, entertainments, fairs, etc., the person or party applying for temporary installations might be asked to obtain and produce permission from the Assistant Electrical Inspector to Government where one hundred or more persons are likely ordinarily to be assembled and where the use of energy at a rate exceeding two hundred and fifty watts.
 5. A return of services connected in the prescribed format should be sent in duplicate by Section Officer to Electric city **IX - 6** Revenue Office by 5th of succeeding month.

118. CLOSING OF WORK ORDERS:

Within six weeks from the date of giving service or earlier the completed work order should be closed and sent to Division Office. In case of simplified work order issued for general purpose/domestic/commercial/non – domestic/services with a connected load of 7.5 KW or less, the work order should be closed in the prescribed preformed (vide Annexure – VI) within a maximum period of two weeks. The work order should be sent with a detailed bill of materials drawn, support by requisitions and devaluation numbers.

- NOTE:**
- 1) The certificate regarding devaluation of materials should be furnished.
 - 2) The Asst. Divisional Engineer should check measure the work if required by the rules before sending the closed work orders to the Division Office.

119. RIGHT OF REFUSE:

The department reserves the right to refuse to give supply to any consumer assigning reasons therefor, and to discontinue the supply at any time. While doing its best to ensure the uninterrupted service, it does not in any way accept any responsibility for any inconvenience, loss or damage caused to the consumers by interruption or causes beyond the control of the Board.

- Note :**
- 1) The Board shall be at liberty to discontinue service if any fault is discovered, until such fault is set right to the satisfaction of the Board.
 - 2) Theft of fuse carriers, meters, breaking of meter-glass, etc., in consumer's premises.

The meter and the fuse carriers are the property of the Electricity Board and the consumer shall be fully responsible for the safety of the Board's property on his premises. In the event of any loss or damage caused to Board's property by any act, neglect or default of the consumer his servants or persons employed by him or due to any reason other than force-majure conditions the consumer shall compensate the Board for the cost of necessary repairs or replacements as may be indicated by the Board, within 30 days of the issue of the bill.

- 3) Delays in issue of service connection should be avoided as it will delay in accrual of revenue.
- 4) Temporary receipts issued will be confirmed by permanent receipts from the Division Office / ERO Office.

120. PROCEDURE IN THE DIVISION OFFICE:

As soon as a copy of the work order issued by the Assistant Divisional Engineer is received a folio for the consumer should be opened in the service connection cost ledger in APSEB form 41 and preliminary entries made at the top of the folio. The deposits, received from the consumer should be entered both in the register of Demand Drafts and also in the space provided therefor in the Consumer's Deposit and Advance Ledger.

As an when expenditure is incurred on work orders, it is booked in the Service Connection Cost Ledger from the relevant cash book, journal vouchers and stored requisitions. The ledger should be reviewed monthly to see that there is no avoidable delay in closing the accounts.

121. The closed work orders received on completion of works and the initial accounts are checked with the entries in the Service Connection Cost Ledger. The account in the Service Connection Cost Ledger is closed by transfer of expenditure under detailed account numbers for ~~Meters~~ and Meter Testing equipment in the construction Operation Ledger.

122. PROCEDURE IN THE ELECTRICITY REVENUE OFFICE :

On receipt of the monthly return of services connected sent by the Section Officer in duplicate in the Electricity Revenue Office, an entry should be made in the register of service connections in APSEB form 21 and a number assigned to the service connection both in the register of service connections and in the monthly return. One copy of the monthly return should be sent to section officer and another copy to PAA / in house computer for incorporating in the monthly ledger as well as in consumer master. All papers relating to the service connection excepting the agreement should be filed in a docket. The agreements should be entered in a register of agreements and kept in a separate file arranged in the order of service connection numbers and the Junior Accounts Officer of the section shall be responsible to see that all agreements are kept in safe custody.

l) a) The Board will arrange supply to a block of building owned by an individual at one point if so desired, provided all the buildings are in the same premises and not separated by a public road. The supplier will be billed by the main meter under appropriate tariff. The owner of the premises is not however entitled to recover from the tenants at rates different from that charged by the department to the consumer at the point of supply and for the purposes nor, can he give point lights at flat rates to shops on his premises. The tariffs and supply are controlled by the Board and not the consumer.

Note: There is, however no objection to two or more services being given to the same block of building; for example two or three storied building occupied by different tenants and each occupant requiring a service.

b) When a consumer (having supply to several houses and one of the houses being vacant for non-tenancy) applied to the Board for temporary disconnection of the service owing to non-tenancy of his house, the Board may comply with such request. He will be billed monthly minimum for such period of disconnection and pay the reconnection fee when the service is resumed.

c) Indiscriminate release of multiple services in the same premises, for the same category is prohibited. If any consumer applied for a second service in the same premises for the same category under a same door number / sub door number / survey field number / sub divided field number approval of the officers mentioned below is to be obtained before releasing the second service.

1)	Single phase service	:	A.D.E./Operation
2)	Three phase services and other L.T. Categories Excluding Industrial	:	D.E./Operation
3)	L.T. Industrial	:	S.E./Operation
4)	H.T. Category	:	C.E./Zone

Periodical (annual) Verification of list of consumers.

d) A list of consumers in each area should be furnished annually from ERO Office to the section officer of the Distribution who should verify within one month and certify that the list is complete. It is also permissible to verify the service by a responsible member of the ERO office in specific cases.

Note: Changes of addresses, connected load etc., should be notified to the ERO office immediately by the field.

e) The extension estimates or the schemes sanctioned should further be reviewed as soon as the execution of the work is completed and the consumers who have not yet taken power notified of their liability for the minimum; such cases should be frequently reviewed and pursued.

II) ACCOUNTABILITY FOR LAPSE AND DEFICIENCY AT L.T. SERVICES :

Accountability for each lapse for each lapse and deficiency at L.T. Services, designate the officer responsible to rectify and time limit thereof, and also the officer responsible to

ensure that the instructions are followed against each item is fixed in Annexure-J.

ANNEXURE - J

1.	2	3.	4.	5.
Sl.No.	Deficiency / lapse at a Service or in a distribution	Responsible for detection & report	Action to rectify	Officers to ensure follow up of instructions in Col.3 & Col.4
1.	Direct tappings	JLM/ALM/LM to report	AE within two days	ADE
2.	Rampant direct tappings	JLM/LM & LI	AE & ADE	DE
3.	Defective Meters stuck-up/Burnt	Meter reader to note in Meter observation register	s ph – LI 3 ph – AE - same month	ADE
4.	Repetitive (more than twice) exceptional – consumption MS/MBO/DL/RNF/NIL	Vide paras 178 & 180		
5.	No meter	Meter reader to report	LI & AE – 10 days	ADE
6.	Low consumption	Meter reader to report	s ph – LI 3 ph – AE HV-ADE – 10 days	s ph – AE 3 ph – ADE HV – DE
7.	Multiple services at same premises for same purpose	Meter reader to report	AE – one month	ADE
8.	Suspected pilferage	Meter reader to note in M.O. Register	AE & ADE – immediate	DE
9.	Seals broken or Missing	Meter reader or LM, LI & AE during checks.	s ph – AE 3 ph – ADE HV & IDL – DE – immediate	SE
10.	Meter board loose/slant or upside down	Meter reader to report	Within 15 days. AE for high value & LI for others – 10 days	ADE
11.	Meter at inconvenient or inaccessible location	Meter reader to report	AE for high value. LI for others – 10 days	ADE
12.	Wrong categorization	Meter reader to report. LM/LI & AE during checks	AE – within 10 days	ADE
13.	No top entries in MRB	AE	ADE also if not corrected (2 months)	DE
14.	No signatures of M.Rs	Meter readers	LI & AE to ensure within next cycle	ADE
15.	Tapping from in coming service wire for new services	Person who releases the service	AE (15 days)	ADE
16.	Disconnected service availing supply a) By unauthorised R.C	Meter readers	AE (two days)	ADE
	b) By unauthorized extension from other services.	Meter readers	AE (two days)	ADE
17.	Unauthorised extension to another premises.	Meter readers	AE (two days)	ADE

123. The Andhra Pradesh State Electricity Board was constituted on 1st April, 1959. Since then it has been functioning as the Principal supplier of electricity in the State of Andhra Pradesh.

The Board is charged with the statutory obligation of promoting the coordinated development of generation; supply and distribution of electricity in an efficient and economic manner. The Board is required to adjust its charges from time to time so as to enable it to carry on its operations to leave a surplus as is not less than 3 percent of the value of the fixed assets of the Board in service at the beginning of the year vide section 59 of Electricity (Supply) Act, 1948, the Electricity (Supply), Amendment Act, 1983. Hence, tariff present an important problem and if not formulated with broad technical and commercial judgement, might result in financial difficulties to the Board; however, efficiently and economically administrated in other respects. Great care and attention should therefore be paid to forming of new tariffs or to changes in the existing rates. Tariffs are liable to be increased in or about July every year or at any time during the year as may become necessary and as may be decided by the Board on account of increase in cost of generation, purchase and supply of electricity due to increase in cost of other materials and increase in salaries and wages of the staff, interest cost or increasing any other expenses. Below is given a brief description of the general tariff structure applicable to the areas supplied by the Board.

The tariffs may be divided into two main classes:

- a) High tension two part tariff for connected loads above 75 H.P. or 56 K.W. at 11 KV; 33 KV; 132KV and 220KV applicable to bulk supplies to residential colonies, industries, railways; water works and similar loads.
- b) Low tension tariff for loads of 75 H.P. or 56 K.W. and below at connected load at 230V; single phase or 415V; 3 phase is applicable to domestic; small industries; non-domestic; commercial; general purpose and agricultural consumers.

The H.T. tariffs is again sub-divided into 6 grades and L.T. tariff into 8 grades which are in force in A.P.S.E.Board.

PART D

POWER FACTOR APPARATUS

1. FOR H.T. AGRICULTURAL CONSUMERS

Every H.T.Agricultural Consumer using induction motors shall install L.T.Shunt capacitors of specified rating as given below:

Sl. No.	Rating of individual motor(H.P.)	KVAR rating of L.T.Capacitors for various RPM motors			
		750 RPM	1000 RPM	1500 RPM	3000 RPM
1.	Up to 50	15	15	12	10
2.	60	20	20	16	14
3.	75	24	23	19	16
4.	100	30	30	24	20
5.	125	39	38	31	26
6.	150	45	45	36	30
7.	200	60	60	48	40

2. FOR L.T. CONSUMERS

a) Other than welding transformers

Every L.T.Consumer using induction motors shall install L.T. Shunt Capacitors of specified rating as given below:

Sl. No.	Rating of individual motor (H.P.)	KVAR rating of L.T.Capacitors for various RPM motors			
		750 RPM	1000 RPM	1500 RPM	3000 RPM
1.	3	1	1	1	1
2.	5	2	2	2	2
3.	7.5	3	3	3	3
4.	10	4	4	4	4
5.	15	6	5	5	5
6.	20	8	7	6	5
7.	25	9	8	7	6
8.	30	10	9	8	7
9.	40	13	11	10	9
10.	50	15	15	12	10

b) Welding transformers

Sl. No.	Rating of Welding Transformer (KVA)	Rating of Capacitor in KVAR	Sl. No.	Rating of Welding Transformer (KVA)	Rating of Capacitor in KVAR
1	1	1	19	19	15
2	2	2	20	20	15
3	3	3	21	21	16
4	4	4	22	22	17
5	5	4	23	23	18
6	6	5	24	24	19
7	7	6	25	25	19
8	8	6	26	26	20
9	9	7	27	27	21
10	10	8	28	28	22
11	11	9	29	29	22
12	12	9	30	30	23
13	13	10	31	31	24
14	14	11	32	32	25
15	15	12	33	33	25
16	16	12	34	34	26
17	17	13	35	35	27
18	18	14			

NOTE:

1. If any such consumer fails to install the capacitors at all or fails to install the capacitors of required rating or the capacitors already installed are found during inspection to be damaged or become defective or ceased to function, the consumer shall be served with a notice to get the same installed/replaced/rectified or corrected within 30 days of the inspection and intimate the fact of replacement/rectification to the concerned Section Officer, (Operation) of the Board, who will inspect the capacitors again to verify their satisfactory performance.
2. In the event of failure on the part of the consumer to comply with the above notice, the Board shall levy a surcharge of 25% per month on the bill amount from the date of release of power to the service/the date from which the capacitor was defective or ceased to function till such a time the capacitor is installed/replaced/rectified or corrected provided further that such retrospective levy of surcharge shall be limited to one year from the date of inspection. The consumer aggrieved by the retrospective levy, may appeal to the concerned Superintending Engineer(Assessment), whose decision shall be final.
3. In case of the rated capacity of the welding transformer falls in between the steps of the stipulated ratings, the capacitors suitable for the next higher step shall be installed by the consumer.
4. The failure on the part of the consumer to comply with the above notice, shall be treated as violation of terms and conditions of the supply and Board reserves the right to terminate the contract and collect the sum equivalent to the minimum charges for the balance initial period of agreement.

D. AGREEMENTS FOR SUPPLY OF POWER & DEPOSITS FOR CONSUMPTION

124.AGREEMENTS:

Except in the case of domestic or commercial non-domestic and General purpose category where the application form itself serves the purpose of an agreement, separate agreements should be obtained from all consumers for the supply of power for industrial or agricultural purposes or street lights as per conditions specified for each in the form prescribed in the terms and conditions of supply vide clause No 26,27.

Agreements with the H.T.consumers are of special nature which should be obtained from all consumers for supply of power at H.T. in the form prescribed and such agreements are taken in the office of the Divisional Engineer/Operation.

125.POWER OF ACCEPTANCE

The Asst.Divisional Engineers of the board are empowered to accept the agreement for supply of power at L.T., Divisional Electrical Engineers are empowered to accept the agreements for supply of power at H.T.

126. If any special guarantee is taken, the consumer shall certify that he has clearly understood the special guarantee in respect of consumption if consumption falls below the limit. Special guaranties can be reduced when additional revenue accrues from the same feeder.

127. (a) The printing of standard forms of L.T. agreements, and H.T.Agreements shall be arranged from the Central Office.

128. If a consumer who has given an agreement for taking supply under a particular tariff, subsequently finds another tariff is more advantageous to him, his application for transfer to the new tariff may be accepted provided his minimum guarantee is not reduced.

129. In cases where the party to an agreement discovers, subsequent to his signing the agreement and prior to execution of extensions to his installation, that the capacity of the motor as per the agreement is more than his installation will stand and therefore installs a motor of lower capacity, the agreement may be altered after full examination of the case and recording reasons for such alteration, provided the remunerative nature of the extension is not affected.

130. The following instructions should normally be observed in taking agreements:-

1. Date of agreements should not be filled up at the source. This will be the date on which the accepting authority signs the same. If one consumer has more than one installation of his own, separate agreements should be taken for each service.
2. Corrections in the agreements should be attested by the consumers. Separate sheets of clauses should not be pasted. It is preferable to insert them in writing or type in the blank space of the agreement form and have them signed.

3. No variations should be made in the terms of the standard agreements without the consent of the accepting authority. In important cases, the permission of the Chief Engineer should be taken.
4. Wherever minimum guarantees are fixed, they represent only revenue by sale of power.
5. If the signatory to the agreement is not himself the owner of the well or premises a letter of consent from the owner only may be obtained as indicated in para 106.
6. As a rule, it is advantageous to take the agreements from the owners instead of from the tenants as the latter are likely to change often. Though no formal agreement need be taken in the case domestic services it does not preclude taking agreements at discretion, the period being limited to two years under the general order of the Divisional Electrical Engineer applicable to any particular area.
7. The value of stamp to be used on all agreements is Rs.100/-
8. L.T.agreements taken for service connection not included in extension, should be sent to the ERO office.
9. Agreements should be verified by the accepting authority before the service is given or as soon after as possible.
10. Copies of agreement if demanded by the consumers may be furnished in the usual stamped agreement form, the cost being borne by them. Copies of agreements are not required by the Divisional Engineers. Any special features affecting the field in an agreement which is not in the standard form should be communicated to the Divisional Electrical Engineers.
11. Requisition for supply of L.T. energy for domestic consumers will suffice. Changes in load may be Noted in the relevant records and in the case of changes in tariff rates exchange of letters may be accepted as sufficient. However revised test report may be sent to ERO in all such cases.
12. The revised form of requisition for supply may be adopted with the period of supply as two years.

Agreements on stamped paper should however be entered into with Industrial and Agricultural consumers. Changes in loads may be entered in the relevant records and the consequential change in rates or minimum will be by exchange of letters.

13. In cases involving important changes fresh agreements may be entered into. This may be by means of an addendum to the original application/ agreement signed by both the parties.
131. (1) Before the construction of service line can be commenced, the consumer (whether owner, lessee or tenant), should deposit along with the agreement, the service line charges, development charges and consumption deposit as per the clause 28 of terms and conditions of supply.
- (2) The amount of consumption deposit shall be in the form of crossed Demand Draft's and will to be accept in cash. The consumption deposit Demand Draft's shall be drawn in favour of Assistant Accounts Officer/ERO, in case of L.T. supply and Senior Accounts Officer of the Circle in case of H.T.supply, all other deposits shall be in favour of Divisional Engineer concerned.

132.THE AMOUNT OF DEPOSITS SHALL GENERALLY BE REGULATED AS FOLLOWS:

The amount consumption deposit shall generally be regulated as indicated in clause No.28 of terms and conditions of supply.

133. Register of Demand Drafts should be maintained in ERO and Divisional Engineer's office and these registers shall be reviewed monthly by Assistant Accounts Officer and Divisional Engineer respectively. The register should provide columns showing the encashment of Demand Draft's and should show the number and amount on any given date. The Registers should also be maintained in the Section Office.

E.MISCELLANEOUS AND GENERAL RULES REGARDING SERVICES:

134. (1) **UNCONNECTED SERVICES:** As soon as an extension scheme is energised and brought into operation the Assistant Divisional Engineer of the distribution system should issue notices in (A.P.S.E.Board Form 206) to the consumers who have signed power agreements and to the other prospective consumers listed in the revenue forecast of the scheme from whom application have been received. Acknowledgments for the notices, if served in person, should be taken from the consumers. If the notices are sent by post, certificate of posting should be obtained from the Post Office. A report about the energising of the lines together with the list of persons to whom notices have been sent should be sent to the ERO Office/Circle Office in case of H.T. cases simultaneously.

(2) In the ERO Office the date of energising should be Noted in the register of unconnected services (in A.P.S.E. Board Form 207) and the list of persons to whom notices have been issued checked with the names of consumers included in the schemes as per column (4) of the register. The dates of issue of notices should be recorded in column (7) of the register.

(3) This register should be reviewed completely every month by the Junior Accounts Officer to see that all items for which service connections have not been given within three months of the date of acknowledgment of notice of availability of power by the consumer are transferred to the ledger of unconnected services for levying the minimum charges with reference to the agreement.

(4) **DISMANTLING OF FEEDER LINES OF DEFAULT SERVICES AFTER TWO YEARS:** Feeder lines of default services may be dismantled after two years if there is no prospect of connection at all, after the minimum for the full period of the agreement is recovered. In cases where at the discretion of the Superintending Engineer in charge of power systems the penalty is not enforced for bone fide reasons of inability on the part of the consumer to receive supply, the approval of the Chief Engineer should be obtained for dismantling the lines of supply has not been availed for two years or if there is no prospect of connection at all.

(5) If minimum has been waived for certain portion of the agreement period, the recovery should be for the period of the agreement minus the period for which the recovery has been waived.

All amounts due to Board can be recovered as arrears of land revenue.

POWERS OF SUPERINTENDING ENGINEER TO DISMANTLE LINES

If the loss to the department by dismantling should be within the powers of the superintending Engineers to write off, the Superintending Engineers can order dismantling of lines, a copy of the directions being furnished to the Chief Engineer. The following officers are empowered to sanction estimates to dismantle service connection materials, metering, and extensions.

H.T.Services	...	Superintending Engineer
3 Phase L.T.Services	...	Divisional Engineer
1 Phase L.T.Services	...	Assistant Divisional Engineer

NOTE: If the services remain unconnected owing to exceptional draught and scarcity of water in the Wells, remission of minimum bills can be claimed on production of dryness certificates subject to the same conditions as regular services.

DISCONNECTION ETC – GENERAL RULES

135.(1) 7 DAYS NOTICE IF DISCONNECTION IS REQUIRED:

Consumer wishing to discontinue the use of electricity (Whether permanently or temporarily) shall give at least 7 (seven) days notice, in writing, to the Section Officer who will arrange to disconnect the installation on the required date. The seven days' notice will apply also to flat rate and all other services.

- NOTE: (1) Consumers should leave their correct postal address in order to facilitate correspondence after disconnection.
- (2) TEMPORARY DISCONNECTION: In cases in which agreements are taken for a minimum period, the agreement period shall be extended by the period during which temporary disconnection of service is permitted.
- (3) AT REQUEST OF TENANTS NOT DESIREBLE: Before a service is disconnected it should be ascertained whether the person who has entered into the agreement himself vacates the premises and whether his statement to that effect is really a fact. Disconnection's may not be effected at the request of tenants.
- (4) The consumer shall be liable to pay the monthly minimum charges as per the tariff conditions in force during the period of disconnection also.
- (5) The consumer shall pay all the arrears outstanding against his service and obtain ~~No duell~~ certificate from Assistant Accounts officer, ERO and Enclose the same to the disconnection notice.

- (2) PERMANENT DISCONNECTION: Whenever a service is discontinued, the Assistant Engineer should examine the case and decide whether the service is likely to be resumed in the near future by the same consumer or a new consumer, Resumption of service either by the old consumer or new consumer, if the service connection still exists, reconnection fee and arrears shall be collected. If the meter has been removed, no charge shall be made for its installation. If the service is not likely to be so resumed within the next six months, the service connection should be taken down and the materials devoluted. Services which are not likely to be resumed should be disconnected at the aerial.

(3)DISMANTLING SERICE LINES AFTER FOUR MONTHS ODISCONNECTION WHERE THERE IS NO PROSPECT OF RECONNECTION: Service lines may be dismantled after four months of disconnection where there is no prospect of reconnection. The Assistant Accounts Officer/ERO shall issue one month notice for such consumers in the fourth month. The Section officer shall dismantle the service line of such services immediately after expiry of one month notice and intimate the same to Assistant Accounts Officer/ERO. The Assistant Accounts Officer/ ERO on receipt of the information of permanent dismantlement of such services, the arrears outstanding against such services shall be adjusted from the Consumption deposit available and transfer these services to the outstanding accounts ledger.

N.B: Before an installation is reconnected after a period of six months or more the consumer shall submit a test report of the licensed Electrical Contractor.

NOTES ON L.T. AGREEMENT:

- 1) If a consumer has taken supply for the specified period of the agreement and discontinues afterwards, he is liable to give a month's notice.
- 2) If the consumer's supply is disconnected due to default before the expiry of the agreement period, the consumer is liable to the minimum charges for the un- expired portion of the agreement.

The consumer has to pay the monthly minimum for the un-expired period irrespective of the fact he has paid consumption charges for energy actually consumed which is equivalent to the charges for the agreement period at the minimum rates.

- 3) The Department can determine the agreement on request by a consumer if he is unable to take supply. The Department should make efforts for continuing rather than terminating the agreement. The consumer has however the option to the agreement by giving one month's notice after expiry of initial period of agreement. In case of defaulters, the supply is discontinued but the agreement is not terminated. Supply should be reconnected as soon as the default ceases.
- 4) AGREEMENTS – WHEN RENEWED: A default ceases as soon as arrears are paid and reconnection made. The agreement is not therefore terminated by temporary disconnection for default and the question of its renewal after reconnection does not arise.

In case of new consumers taking an existing live service, fresh agreements will be taken.

- 5) Fresh agreements are not necessary on the expiry of the minimum period specified in the existing agreements so long as the supply continues.
- 6) The above and similar interpretations shall be most liberal from a commercial point of view and discretion should be freely exercised in waiving the claims by Board in bonafide cases.

136.DISCONNECTION FOR NON PAYMENT BEFORE DUE DATE:

In the event of any bill for supply of Electricity not being paid fully on the due date, the department reserves the right to disconnect the service, after giving seven day's notice. Reconnection will be made after receipt of arrears and the fees. The arrears include not only the payment of bills rendered but also for energy consumed and payments due up to date of disconnection. In special cases the amount of bill for the month in which the reconnection is made, may be claimed along with the monthly bills.

NOTE:

- 1) Discretion should be used before disconnecting and exceptional cases of non-disconnection may be retained in service under orders of the Assistant Divisional Engineer or the Divisional Office. The Assistant Divisional Engineer should communicate their reasons forthwith to the ERO office and such discretion shall be exercised not more than once for each consumer within a period of 12 months.
- 2) If the bills for energy consumed are not received by parties within 10 days from the date of the bill to which they relate they can write to the ERO office and ask for duplicates. Non-receipt of bills shall on no account be accepted as excuse for delay in payment.
- 3) As mistakes are likely to occur now and again in the ERO Office in regard to the proper crediting of amounts received in connection with bills and thus giving room to the possibility of service being disconnected, notwithstanding payment having been made in respect thereof, the consumers are advised to produce receipts for payments or alternatively, postal Money Order receipts, etc., before the officers directed to make disconnection's for default in payments. This will avoid needless inconvenience to consumers by preventing disconnection's of service where payments have been made.

Disconnection shall be made only when the receipts are asked for but not produced.

- 4) **DISCONNECTION OF SERVICES TO GOVERNMENTS AND LOCAL BODIES:**
Ordinarily no service to a Government building should be disconnected for default in payment of dues without an intimation in writing to the head of the office in charge of the building.
- 5) The meter reading at the time of disconnection should be invariably noted in the Disconnection list and also in the MRR.

137.RECONNECTION DUE TO ALTERATIONS IN BUILDING:

In no case should fees for reconnection be charged if the consumer has paid the cost of shifting the meter board during remodeling of his premises. If the remodeling does not entail shifting of the meter board but only necessitates disconnection and reconnection, the usual disconnection and reconnection fee should be charged.

138.METERS DURING TEMPORARY DISCONNECTIONS AND RECONNECTION FEES:

During the period of temporary disconnection, the meter will remain in the consumer's premises unless the consumer requires it to be removed. However the consumer should pay monthly minimum charges as per the tariff in force during the period of temporary disconnection also.

139.REVIEW OF DISCONNECTED SERVICES:

A list of disconnected services from which materials have not been devaluated to stock and also disconnection's made from commencement and not resumed should be maintained in the ERO/Section Office. The list should be reviewed periodically and enquiries made of the field offices to ascertain whether the service will be made use of in the future.

140.FUSE OFF CALLS:

A fuse off call book in A.P.S.E.Board form 62 is maintained for each distribution or section of a distribution system.

141. Whenever a fuseman or other member of the distribution staff proceeds to attend to a fuse off call, he should take with him the fuse off call card for noting the call hour and the name of the consumer who called and after renewal of fuses, complete the card and obtain the signature of the consumer or his representative. The number of fuses renewed should be specially Noted in the card. On return to the office he should make entries in the fuse off call book.

142. (1) FUSE OFF CALLS – RATES WHEN CHARGED: Aerial fuses and cut-outs are to be renewed at the cost of the Board. Fuses replaced in consumer installation should be charged to the consumer or whenever the cause of the fusing is in the consumers' installation, unnecessary calls made by the consumers and attended to by fuseman should be charged to the consumer.

(2) CHARGES FOR RENEWING MORE THAN ONE FUSE AT A TIME: The charge to be collected shall be for each call made irrespective of the number of fuses renewed at a point of supply on a call.

- (3) Senior Officers of the Board should occasionally make discrete enquiries among consumers to ascertain when fuse off calls were last attended to in their services and verify whether the calls have been registered in the books maintained by the Section Officer.

BILLS AND PAYMENTS

143. BILLING FOR WHOLE UNITS: Billing for energy consumption of all classes should be for the whole number of units. In the meter readings, however, decimals will be shown and also the multiplying factor where it is used. The actual consumption will be the difference between the two readings or products as the case may be. When this difference includes decimals, 0.5 and above will be reckoned as one unit and rest ignored. Consumption in the first month shall be charged at rates applicable to the monthly supply and monthly consumption.

144. PAYMENTS

Consumers should be advised and persuaded to pay the bills at the ERO office and also at bill collection centers. The terms of tariff should be explained to them by revenue cashiers Meter Readers and other staff.

- 1) All bills should be paid monthly/bi-monthly as stipulated in Board's Tariff from time to time.
- 2) BILL COLLECTIONS: Revenue Cashiers should be changed from time to time if possible and where there are more than one in a locality, their jurisdictions should be changed every half year.
- 3) Technical Officers should not be normally entrusted with the duty of collecting money due from consumers nor should they be asked to act as cashiers. This is entirely the function of the ordinary collecting staff. For collecting of arrears the Revenue cashier or the officers deputed to collection work where no Revenue cashier is appointed should first be addressed through the Distribution Engineer or the Junior Accounts Officer under whose direct supervision he works for the collection of arrears. Only in important and prolonged cases of delay should the Engineers be advised to contact the consumers for collections.
- 4) Payment of annual minimum by installments at consumers request may be allowed by the Officers authorized by the Board.
- 5) O&M' staff, lower in rank than Line Inspectors should not be deputed to explain the bills or tariffs to consumers.

145.SURCHARGE:

SURCHARGE, FOR BELATED PAYMENT OF BILLS: The H.T.Consumer shall pay the Current Consumption charges within 15 days and L.T.consumers within 14 days from the date of bill failing which the consumer shall be liable to pay additional charges at the rates as prescribed by the Board from time to time and notified in the tariff notification of the Board.

NOTE:

- 1) In respect of all current consumption bills the surcharge due in a particular month should be calculated and included in the next months bill.
- 2) If the last date of payment without surcharge falls on a holiday no surcharge. need be levied if payment is made on the next working day.

146.IMPORTANT LOADS – REVIEW OF CONSUMPTION:

The Engineers in charge of distribution are expected to have personal touch with all important consumers. Sudden fall in the consumption and maximum demand in a month which cannot be ascribed to known reason should at once be investigated and the remedial action taken. Very often low consumption is due to internal defects in the meters and metering cubicles. The section Officer and Assistant Divisional Engineer who are in charge of Distribution should inspect the H.T./L.T services whenever the consumption of energy drops and report the reasons to the Central Office/ERO Office/Divisional Engineer concerned.

147.CHANGE OF LOAD

A consumer who makes any alterations either by addition or removal of any fittings or apparatus in his installation should give previous intimation to the department. The supply to the consumer is liable to be disconnected as a penalty for not giving this previous intimation vide clause VI (I) (d) of the Schedule to the Indian Electricity Act. Neglect to intimate may also lead to further action for attempted fraud. In no case will change of tariff to the advantage of the consumer be permitted with retrospective effect, if the intimation is sent after the alteration. Similarly changes to the wiring if any should be previously notified to the Section Officer.

148. IGNORANCE OF RULES: Ignorance of procedure and rules on the part of consumer does not exonerate them from the payment of fees for fuse off calls, reconnection, etc.

149. SERVICE CONNECTION NUMBER TO BE GIVEN IN ALLCORRESPONDENCE:

The number assigned to each installation (which is also painted on the meter board) should invariably be quoted in all correspondence failing which the consumer cannot expect to obtain a prompt reply.

NOTE : The consumer should be advised that

- 1) On all matters regarding fuse off calls, interruption of supply, application for service, disconnection's and reconnections, they should apply to the local section officer or to the Assistant Divisional Engineer and that,
- 2) On all matters regarding bills, refunds of service connection charges, etc., they should address the AAO/ERO of the system. Complaints should be addressed to the Divisional Engineer or Superintending Engineer.

150. RIGHT TO DISCONNECT INSTALLATIONS:

The Board reserves the right to disconnect the services not conforming to the regulations and also where power has been used, in the judgment of the Engineer of the Board, in a manner prejudicial to the interests of the Board. In such cases he shall also have the right to impose such penalty as he may decide in each case before reconnection.

151. In all matters regarding disputes, claims, penalties, etc., the decision of the Superintending Engineer shall be final and binding. The right of appeal shall however lie with the Chief Engineer.

152. MUNICIPAL TAX: Municipal tax is not livable on electrical equipment and installations nor on the cost of electric installation to house.

TESTING OF METERS, READING AND ADJUSTMENT OF BILL OF CONSUMERS

153. METERS AND RELAYS TESTING BRANCH:

In each circle a testing division is constituted and this branch undertakes testing of meters, relays, transformers and other protection equipment.

The functions of the M.R.T.Branch—

- 1) Testing the pressure or periodicity of supply as required by clause XIII to the Schedule to the Indian Electricity Act.
- 2) Periodical testing and rectification or repair, Wherever necessary of meters, relays, instruments and other equipment's in power station and sub stations.
- 3) Testing of all service meters as per a pre-arranged programme.
- 4) Testing of complaint meters either at the instance of the department or at the request of the consumer.
- 5) Testing of electrical apparatus belonging to consumers and others.

Facilities are also afforded to consumers and others for testing their electrical apparatus in the laboratory.

154. PERIODICITY OF TESTING:

In addition to the testing of suspected meters, all meters should be tested and, if necessary, adjusted, within the periods Noted below:-

	<u>Months</u>
(a) H.T.meters on both system and consumer's premises	... 12
(b) L.T.polyphase meters	... 36
(c)Other single phase meters	... 60
(d) L.T. & C.T.s meters	... 12

155. PROGRAMME: Procedure regarding testing.--- A program of periodical tests relays and meters in the System should be prepared by the M.R.T. Branch so that the several tests may be carried out at the prescribed intervals.

NOTE:-

- (1) The programme for the test of L.T.meters due for test, relays, meters, sub-staiton meters, R.S.S.meters etc., With details every year in February.
- (2) The new meters shall be tested as and when received in the stores from suppliers.

The responsibility for periodical testing of L.T.meters rests with the Territorial Assistant Divisional Engineers and the Section Officers in consultation with M.R.T. while in the case of H.T.meters and relays, etc., the responsibility for the program and completion of the periodical testing rests with the MRT itself.

156.NOTICE: In the case of complaint tests one week's notice to consumers should be given, by the Assistant Divisional Engineer in charge of distribution. This is necessary to avoid disputes with the consumers in the matter of revision of bills based on the test results. Before removing the meter for test, it should be seen that the seals are intact and the connections are in order.

157. Departmental tests, whether routine or otherwise, other than on complaint, from the consumer, which do not disclose errors beyond permissible limits, need not be reported to the Divisional Electrical Engineer or to the Unit Office. The results of such tests may be recorded in the M.R.T.Branch itself. The test results should be recorded in A.P.S.E.Board Form 9. Other test results should be sent to the Circle Office for adjustment in bills, a copy being simultaneously sent to the Divisional Engineers.

158. For testing Work carried out in the M.R.T. Work orders are necessary:-

- (a) **WORK ORDERS FOR TESTING.** Separate single work orders for the year for...
 - (i) Periodical routine tests of service sub-station meters and instruments,
 - (ii) Periodical routine test for service meters.

Frequent tests by the department, indicating executive irregularity in execution, 1 installing and upkeep, should be watched by the Divisional Engineers and reports submitted to Superintending Engineer, if any disciplinary action is called for. There will be no hesitation in enforcing recoveries of expenses of tests made from the parties responsible.

(b) The condemned meters survey-reported need not be destroyed. They may be handed over to the M.R. T. who will try to make as many serviceable meters out of them as possible. The M.R. T. Will maintain a numerical account (number of meter shells with their serial numbers entered in a register). Any cannibalized meters will be transferred to stock at a valuation to be fixed by M.R.T. the amount being credited to the work order for repair of old meters. This numerical account will be appended to the tools and plant account of M.R.T.

N.B (1) TESTING OF NEW METERS:

Testing of new meters will be done without work orders and this will be arranged for by the Assistant Divisional Engineer. The untested new meters will be sent to the M.R.T. Branch.

(2) The meter section should maintain a record of the initial readings of all meters issued from the testing laboratory or tested in site.

159. The consumers' bills should be adjusted as a result of testing of meters. The-results in such cases should invariably be furnished to the Circle Office/ERO) office by the Meter Testing Engineer with a Note that Bills require adjustment. The following orders on the subject should be carefully Noted.

- 1) **PRIMARY TEST OR SECONDARY TEST.** The meter must be considered together with its C. Ts. and P. Ts. and hence the test results should be based on the primary test. In -' practice it is possible to have recorded the errors of instrument transformers for use in testing the meter alone and in adjusting the bill amounts.
- 2) **SITE OR LABORATORY TESTS.** Any disputed meter can be removed for test after notice and the test room resultslll utilized for bill adjustments; for all small meters in dispute cases, site tests should be made if possible.
- 3) **PERIODICAL TESTS AND COMPLAINT TESTS.** Adjustment of bills based on absolute accuracy should be made only when the error of a meter is found, whether by site test or by test at Departmental Testing Room, to exceed the Statutory limits. Adjustment of bills should be made in the case of meters found recording fast or slow beyond the statutory limit during the departmental periodical tests.

- 4) METERS DEFECTS.** The meter may be :
- i) Creeping.
 - ii) Stopping (due to burning or sticking up).
 - iii) Incorrectly reading (due to inherent error or potential coil being open circuited or fuse blows off etc.
 - iv) Out of commission for a period say during test.

In term (i) creeping is an error which, at once, classifies a meter as incorrect. The meter should be readjusted at site or tested -vide paragraph 155. The Section Officer of the distribution is authorised to inspect and report the rate of creeping and if the rate of reduction is less than one revolution in 5 minutes, no adjustment in bills need be made. In other cases, the adjustment in bills is to be made on the actual rate of creeping forward or backward from date of complaint or inspection whichever is earlier. This may be done on the assumption that the creep uniformly exists throughout the 24 hours even when the load is on.

5) 1.5.5. LIMITS OF ERROR AND ADJUSTMENT IN BILLS.

- (1) Single phase meters.
- (2) Three element four wire three phase L.T. polyphase meters without maximum demand.
- (3) Three phase, two element L.T. and H.T. meters without maximum demand
Limits of error are:
 - (i) Meters with C.T.'s
 - F.L.to 1 10 F.L. U.P.F. and 0.5 P.F 2.5 percent
 - 1/20th F.L.. U.P.F. only- 2.5 percent
 - (ii) Meters without C.T.'s
 - F.L. to 1/5th load U.P.F. and 0.5 P..F-2 percent
 - 1/5 to 1/10 F.L., U.P.F. 2 percent
 - 1/20 F.L. U.P.F. -2.5 percent.
 - 1/10 F.L. 0.5 P.F. -2.5 percent

Adjustment in bills for error at average load and P.F. should be made when the meter is incorrect at anyone of the loads as per I.S.S. though the error at average load is within the limits.

Cases of average load exceeding full load capacity of the meters should be very rare and meter should not be unduly loaded or under loaded. The meter capacity should conform to the actual load in operation.

160. LIMITES OF ERROR. The meter shall not register more than 2,5 per cent above or below absolute accuracy at all loads in excess of one tenth of full load and up to full load at consumers power factor.

No meter shall register at no load,

- a) CONDITIONS OF MAXIMUM DEMAND INDICATORS. It shall not register more than 2.5 per cent above or below absolute accuracy at all loads in excess of one tenth of full l. load and upto full load at consumers' power factor.
- b) It shall not register at no load. The error is individually for unit consumption and demand indication and adjustments are to be made separately for each according as the meter is within or beyond limits.

MR. T. -ACCOUNTING

161 The M.R.T. is a service branch of the system and all periodical, routine and special tests are to be conducted by this branch, The maintenance account of M.R.T. will be borne under working expenses and this will be debited with the entire cost of the provincial establishment, together with the maintenance and operating costs of the laboratory. Being a service branch, no recoveries will be tak~ for routine and periodical tests of meters and relays done by programme nor will the cost accounts of the sub-station or distribution be debited with such service charges.

162. The following are the general instructions on the care, proper sealing and testing of meters:-

(1) SEALS:

All the H.T. meters should be sealed under the supervision of Divisional Engineer/Assistant Divisional Engineer Meters, L.T. and other meters under the supervision of Assistant Divisional Engineer/Assistant Engineer/Meters.. The sealing pair of MR T should be distinctly different from that of the field staff. The seals of the meters received from MR T should not be broken by the filed staff.

N.B: (1) The lineman. may seal cut outs of all the single phase domestic services, The line inspector may seal cut outs of all the three phase domestic services upto 5 K.W. and will single phase non-domestic services, The Section Officer may seal: cut outs of all other L. T. category services.

(2) Sealing pliers should be in the personal custody of the person to whom they are issued. They should never be lent to anyone else even of higher rank and should be kept locked when not under use. The superintending Engineer will issue for each distribution a list of authorised sealers with the type and the form of the seals and a copy of it should be carefully maintained in the distribution office.

- (3) In no circumstances should supply be given unless both the meter and the cut-outs are sealed separately as indicated above.
- (4) The sealing should be done by keeping the sealing plier perpendicular to the sealing wire. If it is done any other manner there is possibility of slippage of seal.

(2) CUT -OUT: The phase cut-outs should be mounted after the meter on one side of the meter box on the outside. They should be fixed by means of cup headed bolts with lock nuts inside the meter box. The hinges should be reverted with good heads or should be sealed by the Line Inspector or Lineman.

(3) CONNECTIONS. All cables and connections up to the supply side of the meter should be metal clad/P.V.C. pipe throughout, i.e., if the cable itself is not armored, it should be enclosed in continuous screwed piping. If flanges with running couplings are to be employed, they should be sealed by the Section Officer and the facts recorded.

(4) METERS: The lineman may seal the meter terminal covers of all single phase domestic services after he himself has made the connections and seen that all the connections are tight. The line inspector may seal the meter terminal covers of all 3 phase domestic services upto 5 K. W. and all single phase non-domestic services. The Section Officer may seal the meter terminal covers of all other L.T. categories except CT meters. In respect of L.T., C.T meters, the meter terminal covers and pilfer proof box must be sealed by the Assistant Divisional Engineer meters. However, the in coming and out going service connection cables from the pilfer proof box may be sealed by the Section Officer. The Assistant Divisional Engineer may release and seal all H.T. services up to 1000 KVA. The Divisional Engineer may release and seal all the H.T. services above 1000 KVA.

163. The following special instructions must be observed in the case of H.T. metering cubicles:-

- a) Sealing arrangements shall be done for AS switches at consumer premises.
- b) Sealing arrangements shall be provided for sealing of the top cover and inspection cover of the metering cubicles and MRT seals shall be provided for the top cover. inspection cover and secondary terminal of the metering cubicles.
- c) Multiplying factor used shall be prominently painted on the meter and meter card also
- d) Effective insulation is to be provided to the terminals of the metering cubicle
- e) The fuses provided for the P. T. on the L. T. side shall be removed and give direct connection to the meter.

- f) The metering cubicles shall be connected in the Max C.T. ratio provided so that the multiplying factor should be calculated without ambiguity.
- g) Test blocks shall be provided to the meters. The test blocks should be effectively sealed by M.R.T.
- h) It should be ensured to have a separate set of C. Ts for protection, recording load etc. instead of combining them with billing meter circuit.

164. CHECK AND INSPECTION:

Meter readers should examine all seals at the time of taking readings and bring to the notice of the Section Officer all cases of tampering with the seals. Divisional Engineer should inspect all H. T. service connections once in every six months and send a half yearly report of such inspections to the Superintending Engineer.

165. PROCEDURE FOR PROSECUTION FOR THEFT OF ENERGY:-

- 1) Theft of energy should be dealt with under sections 39 and 44 of the Indian Electricity Act as amended up to date.
- 2) The Inspecting Officer shall file a complaint to the Inspector A.P.T.S. or with territorial Station House Officer in the prescribed format vide Annexure-K.

166. TAMPERED METERS EXAMINATION:-

Ordinarily the police should record the evidence of the departmental Engineer in presenting and conducting the necessary examination in the case of offences under the Electricity act.

167. If the magisterial sentences are inadequate, the Board standing Legal adviser should be addressed to remedy matters for future cases.

168. CORRECT' METER :- Under section 26 of the Indian Electricity Act, the department is responsible for maintaining energy meters on consumers' premises correct. All meters should be maintained within permissible limits of accuracy prescribed. From the financial point of view of the department, the extreme importance of keeping the meters accurate can be gauged from the fact that the correctness of assessment of revenue in the department depends entirely on the correctness of the readings of meters.

Whenever the consumption registered by a meter arouses suspicion, arrangement should be made for testing it.

ANNEXURE- K '

From:

To:

The S.H.O., j

Police Station,
Circle

Dt. _____

Lr.No. _____

Sir,

Sub: Theft of energy by _____ of _____ Village
_____ Mandal _____
District _____ Lodging of prosecution
complaint -Regarding.

I along with _____ have inspected the premises bearing
No. _____ of _____ Village _____
Mandal _____ District on _____ at _____ hours and
found that Sri _____ S/o. was indulging in theft of energy for
_____ purpose with the following incriminating points:-

1. Tapping supply from L. T. Overhead line by means of
- 2.
- 3.

The loss sustained by the Board due to theft of energy was provisionally estimated at
Rs. _____ (Rupees: _____).

I am herewith handing over my original inspection notes and seized to materials used for theft
of energy).

I am authorised by A.P.S.E.Board to lodge the complaint with police as per Section-50 of I.E.
Act, 1910.

I, therefore, request you to register a case against the concerned who has committed theft of
energy as per Section-39 of I.E. Act, 1910 and prosecute him/her _____

Encl:

Yours faithfully,

Station : _____

Date : _____

169. CHECK OF METERING CONNECTIONS

All new meters received in stock should first be tested and calibrated and then only issued for being put into service. Before a supply is given the following points should be checked and certified by the Section Officer in the test reports of A.P.S.E. Board Form 18.

- i) Metering arrangement and connections, ! ii) Whether the meter has been tested before installation,
- ii) Whether the meter is suitable for the particular load conditions, Care should be taken to see that such meters are calibrated before hand. There is ample time in every case, since transport and erection take time. Delay in calibration leads to several complications both with the consumer and the audit and the use of untested meters should be limited to exceptional cases only.

170. Assistant Divisional Engineers are responsible to see that all meters in their jurisdiction are suitable for the load conditions and in the case of H.T. and important L.T. meters, the responsibility is for personal check in each case.

171. REGISTER OF METERS. In order to watch that meters are tested periodically a register showing the history of each meter should be maintained by the Assistant Engineer in charge of distribution. The date of last test should be entered in it in the case of L.T. meters and the special reports in the case of H.T. meters by the Assistant Divisional Engineer. The register should be reviewed monthly and arrangement made with the M.R. T. branch for testing those meters for which tests are overdue. This register should give the serial number, service connection number, name of service, tariff, meter number, date of last test, and also consumption 1 for 12 months so that it may serve the purpose of consumption register also.

172. METER READING REGISTERS:

Meter reading registers should contain the following particulars:

(1) Meter No. and make	(6) Name & Address of the
(2) Capacity	consumer with Door No.
(3) Type	(7) Contracted Load
(4) Date of Test	(8) Category of service.
(5) Whether departmental	(9) Multiplying factor.
or consumer's	(10) Nature of premises
(11) L. T. capacitor details	(12) Distribution Transformer location code number

173. DEPOSIT FOR REQUISITIONING FOR TESTING METERS

The testing fee in the form of crossed demand draft drawn in favour of Divisional Engineer/MRT as indicated in miscellaneous and general charges of tariff conditions notified by the Board from time to time for testing meters on complaint or under dispute should be handed over to Section Officer along with the requisition for testing of meters to have the meter tested departmentally. If the meter is found on test to be recording within permissible limits the deposit will be credited to Board. If, however, the error exceeds the limits, the deposit will be refunded or adjusted in the next bill and any recovery or rebate admissible on the results of the test will be included in the next bill.

174. CHANGE OF METERS:

Meters once fixed should not be changed except under the orders of the authorised Board officers who should carefully examine the necessity therefore. However, if a meter of capacity higher than what is necessary for an installation is fixed initially owing to shortage of meters of lower capacity it should be changed as soon as one of the requisite capacity is available. The actual expenditure on the changing to meters should be debited and the difference in value of the two meters credited to maintenance of the distribution system. In such cases, no fees to the change of meters shall be chargeable of the consumer. In other cases except as provided in paragraph 185 changing of meters shall be charged for at the rates in the conditions and rates of supply.

- (a) The following officers are authorised by the Board to order for changing of the meters.

I.	H.T. Services		SE/Operation
II.	H.V. Industrial Services		Divisional Engineer/Operation
III.	Three phase meters		Assistant Divisional Engineer/Operation
IV.	Single Phase meters		Section Officer

(b) Guidelines for removal and Testing of meters from the services:-

Meters with the following incriminating points are likely to be received divisions.

- i) Meters with counterfeit seals
- ii) Meters with tampered seals
- iii) Meters without seals
- iv) Meters with glass broken, but seals being intact.
- v) Meters completely burnout including seals, making it not possible to verify the seals.
- vi) Meters with seals intact, but found having tongue cleaners, palmirah leaves etc., inside when opened for testing.
- vii) Meters with small holes on the cover etc.,

Further, mere study of consumption pattern from records may not by itself conclusively prove pilferage as the same depends on so many other aspects. It is necessary to create a sense of feeling among the consumers, that the officers of the Board are very vigilant at all levels and the consumers cannot escape being caught if indulged in pilferage of energy/malpractice. In order to inculcate a sense of detection of pilferage of energy in the minds of the field officers the following guidelines duly fixing certain duties and responsibilities for the field officers and meters organizations, so far as the removal of the meters and testing is concerned, are prescribed.

1. DUTIES AND RESPONSIBILITIES OF OPERATION STAFF:-

I. DIVISIONAL ENGINEER

- a) In the case of high value services and services having meters of 3 phase 50 A and above the Divisional Engineer is responsible to order for removal of meters in writing. Before ordering such removal he shall make a study of previous consumption pattern of the consumer. He shall also conduct inspection and record his observations in an inspection Notes as is being done in the case of pilferage of energy cases. On inspection of the service and after studying the consumption pattern, if the Divisional Engineer is satisfied that the consumer has not indulged in pilferage the meter may be got changed.
- b) If meters having suspected CF seals or tampered seals with created gaps between top and bottom covers, or any other such incriminating points are observed; the following procedure should be followed to check any foul play on the part of the consumer.
 - i) If the Divisional Engineer(Operation) concerned comes across 3 phase meters with four meter body seals, he has to remove the meter body left bottom and right top (duly confirming that these two seals are alike) seals and preserve one in closed cover under attestation of the consumer or his representative or independent witness, and the other seal preserved in open cover for further examination in Meters lab. In place of the removed .seals, the inspecting officer will provide his seals and also affix paper seals to cover holes or gaps created by the consumer between top and bottom meter covers. These paper seals should be pasted using -Quick fixll solution. The paper used should be of manifold paper. The consumers signature and the inspecting officers signature should be there on the paper seals. It is advisable to have a complete coating of quick fix on every paper seal as this provides reasonably good water proof surface which protects the writings on the paper seal and the paper seal itself It is also preferable that

the writings on the paper seal are done with ball point pen before affixing the paper seal as the same is water proof A statement to this effect should be obtained on the inspection Notes from the consumer or his representative. Under no circumstance a meter with field seals shall remain in service for more than 30 days. The responsibility for the removal of such meter rests solely with the territorial Asst. Divisional Engineer. This time limit is fixed keeping in view, it may not be possible to immediately change the meter. If the consumer tampers with the TC seals or meter box seals, the same should also be seized at the time of inspection.

- ii) Similarly for meters having -3H or -2H body seals, the seals shall be removed one in open cover and the other in closed cover as discussed in (1) above with the condition laid therein.
- iii) Where the meter body is having only one seal (with other seals missing) the same shall be removed and preserved in a closed cover under attestation of the consumer or his representative or an independent witness and all the meter body sealing points sealed by the Divisional Engineer (Operation) with the condition as item (i) above.
- iv) Whenever all the meter body seals are missing the Divisional Engineer operation has to provide his check seals, and remove the meter from service within 30 days.
- iv) The territorial. Asst. Divisional Engineer will then issue a notice to the consumer or his authorized representative to witness the testing of the meter. The inspecting officer will also attend Meters lab along with the cover in which the seized seals are preserved on the day of testing of the meter. It shall carefully be seen that the consumer identifies the original attestation rendered at the time of field inspection and a Note is recorded to this effect with the signature of the consumer. The remaining seals left by the inspecting officer with the meters at the time of inspection. should be seized in sealed covers with consumer's attestation before taking up testing.
- vi) As far as possible the inspecting officer (not less than the rank of Assistant Divisional Engineer) Should be fully equipped to identify the nature of seals of the meter body in the field itself However, it is compulsory for the inspecting officer to preserve at least one of the meter body seals in a sealed envelope incase, some incriminating points are noticed in respect of seals (under attestation of the consumer, or his representative or an independent witness).

- c) Action may be taken either for booking the consumer under pilferage or otherwise: depending upon the meter test results and other data available. If still doubt persists about the C.F nature of seals, the opinion of Director, Forensic Lab (Corn) somajiguda, Hyderabad may be obtained.
- d) In case, the consumers are reluctant to attend to testing of meters at meter lab, the procedure prescribed in item (2) (d) should be followed.
- e) When a meter is removed from a service, the same should not be reinstalled without testing in meters lab.
- f) All defective meters should necessarily be sent for rectification and testing only to meter sub division. These meters should not be accepted by the operation sub-divisions equipped with testing facilities, for periodical testing.

II. ASSISTANT DIVISIONAL ENGINEER

- a) In the case of services (other than high value services) having three phase meters of less than 50 amp. Capacity the Assistant Divisional Engineer is responsible to order for removal of meters in writing. The Assistant Divisional Engineer should follow the procedure indicated under item I (a) to I (b) above.

III. ASSISTANT ENGINEER/ADDITIONAL ASSISTANT ENGINEER

- a. In the case of services having single phase meters Asst. Engineer/Additional Assistant Engineer is responsible to order for removal of meters in writing. If any incriminating points are observed at all L.T. category services excluding Industrial/Cottage Industries the Section Officer should follow the procedure indicated under. Item 1 (a) to 1 (b) above and in respect of Industrial/Cottage Industrial the incriminating points should be brought to the notice of the Assistant Divisional Engineer/Operation in writing for further instructions.

2. DUTIES AND RESPONSIBILITIES OF METERS SUB-DIVISION.

- a) The Asst. Divisional Engineer/Asst. Engineer/Addl. Asst. Engineer, Tester, meters concerned whoever is present should check personally all the seals of each and every meter before accepting them for testing. Meters having a capacity of 3 phase 50 A, and above should be personally checked by the Asst. Divisional Engineer/Meters before accepting. If meters having any incriminating points are received, the same have to be recorded in the T.Note in the presence of the operation staff without fail and his signature obtained. A copy of this T.Note should be sent to the concerned Assistant Divisional Engineer (Operation) for taking necessary action. Meters once brought to meters lab should be accepted at once and should not be sent back even though there are some incriminating points. If any meters with the incriminating points are available in the meters lab. Without making any mention of the same in the respective T .Note, the person who accepted such meters shall be taken to task.

- b) All the meters with incriminating points mentioned in para 1 should be tested in the presence of the inspecting officer, the consumer and the Asst. Divisional Engineer, Meters.
- c) The seals should not be cut off soon after accepting in the Meters lab. The seal of the meters should be cut off only just before commencing the actual testing of the meters.
- d) It is desirable for the Meters organization to set apart a fixed day or two per week for testing of those meters received having any incriminating points. Alternatively the Assistant Divisional Engineer/Meters may intimate at least one month in advance to the concerned operation Asst. Divisional Engineer about the programme of testing of such meters. This is necessary because a reasonable time has to be given to the concerned Asst. Divisional Engineer (Operation) to intimate registered consumer and the concerned inspecting officer to attend the testing. If the consumer or the inspecting officers fail to attend or to respond, to the intimation of the concerned Asst. Divisional Engineer (Operation) without satisfactory cause, in spite of giving reasonable time (at least 15 days clear notice has to be given) the meter removed from such consumers premises may be tested separate in the presence of at least 3 Officers including the Asst. Divisional Engineer/Meters and action taken accordingly. A reasonable extension of time may be granted if the consumer so desired and is unable to attend on the appointed date of testing of the Meter.
- e) It is necessary to ensure that all the meters released from M.R. T and issued to the field for prefixing in services, are not having defects, such as impressions on the seals not clear, gaps between the covers, meter glass loose, screws of the terminals not effective, holes on the meter cover etc., proper check will have to be exercised by the meters wing on these aspects, otherwise it will give rise to complaints that the meter fixed in the consumer premises is itself defective.
- f) Meter change slips should be sent to M.R.T. along with the removed meter and also to Electricity Revenue Office as and when the meters are changed.

175. LT. METERS -TESTS BY REPLACEMENT METHOD.

Meters should be sent to M. R. T. sub-division or section by the replacement method and for this purpose a stock of meters should be kept in the numerical account. No adjustment on account of the value of meters will be made when one is sent for test.

The cost of meters in other cases will be adjusted as shown below.

The cost of meters for service connections included in the extension estimates should be charged to the estimates concerned.

The cost of meters for independent service connections not included in the estimates for the extensions (i.e. meters fixed for house connections generally) should be charged to the general estimate for service connections in a year. The expenditure on this general estimate will be booked by account numbers so that it may be correctly transferred to the accounts of the distribution lines concerned in the fixed capital ledger. Meters removed from disconnected services should be credited to service connections general-meters and testing equipment and debited to Stores or Tools and Plant (rolling stock) as the case may be.

176. (1) CONSUMER'S METERS: Consumers may in special cases be allowed to have their own meters for billing purposes. One of the conditions of such an arrangement is that the meters should be tested by the department prior to being put into service and this should be done by the M.R. T. branch. Maker's certificates if produced by the consumer for his meter will not suffice as the meter would have been subject to handling over a considerable distance and by several agencies. The certificate of test in the consumer's laboratory, if any, may, however, be accepted subject to the departmental test above. The consumer's meter is the property of the Board for all purposes.

(2) When sending meters for test to the M.R. T. branch, the distribution staff should furnish the Service Connection number to which the meter relates and whether it is periodical test or due to departmental complaint or consumer's complaint.

(3) POLYPHASE METERS -NEWLY INSTALLED: Whenever a polyphase meter (H.T. or L. T.) is newly installed the person who makes the initial reading in site should take a second reading between the 7th and the 10th day of service and should report at once to the Divisional Electrical Engineer concerned if there is any cause for suspecting that the meter is not recording correctly.

(4) CREEPING: Creeping is one of the defects in a meter which renders it incorrect. The rectification of creeping meters comes under testing in the case of L. T. meters it is not possible for M.R. T. to test all creeping meters in site. The test by the local Assistant Engineer will be accepted as valid for purposes of billing. The usual rules and procedure for testing will be observed in such cases.

When creeping of meter is suspected action may be taken as follows among other items:-

- (i) To replace the 'creeping' meter by another and thus rectify the metering in the premises.
- (ii) To report working details of adjustment in bills with special reference to -
 - (a) period of adjustment
 - (b) per cent of adjustment i.e., rate of creeping.

(5) LT. METERS -DATE OF TEST TO BE RECOMMENDED AND COMMUNICATED TO CONSUMER NOT OBLIGATORY: It is not obligatory that the date of testing of L.T. meters on complaint from consumers should be, intimated to them. However, it is desirable, if a consumer so wishes, to inform him of the date of testing so that he may be present at the time of testing. In all cases, of in site tests, the date of testing should be intimated to the consumers and he should be requested to be present if he chooses.

(6) METER AT SUB-STATION. Both ammeters mounted in cubicles and ammeters mounted on feeder panels in control rooms, when such panels are also equipped with K. W. meters, when fitted with switches having an off position should be switched to the on position only when readings are required to be taken.

METER READING

177. METERS FOR RECORDING CONSUMPTION: After an installation is tested and service is given, a departmental tested meter will be installed for recording the consumption of energy.

178. METER READINGS: The meter readings shall be taken by authorised persons. The readings shall be taken monthly/bi-monthly on fixed dates and full particulars for billing purposes. These readings shall be entered in a meter reading register of that locality and shall be sent to concerned ERO by 10th of the month after due review by the Section Officer. These meter reading books will be sent to private accounting agency/in-house computer by 11th of the month for preparation of bills after due review in the Electricity Revenue Office. On receipt of the meter readings the private accounting agency/in-house computer shall furnish the exception lists indicating the meter readings not furnished, meter stuck up/burnt meters and door lock services etc., by 15th of the month to the Section Officer through Electricity revenue Office. On receipt of the exception list, from the Computer agencies the Section Officer will furnish the required details to the private accounting agency/in-house computer agency by 20th of the month. In other words meter readings in full shape will be made available with the private accounting agency/in-house computer by 20th of the month at least.

The P.A.A./In-house computer are generating reports on exceptional as shown in the Annexure M A review of exceptional reported and action thereon will rectify the same. The officer designated in Annexure-M is held responsible for ensuring that the exceptional are attend to.

179. All meter readers shall maintain separate individual registers called ~~Meter reader observation register~~ indicating the following information whenever they are visiting the premises of the consumer for taking meter readings.

- i) The condition of the meter, whether stuck up/burnt.
- ii) Whether the consumer is availing the supply under the correct category and record any change/misuse observed in this regard.
- iii) Availability of meter terminal cover, terminal cover seals and meter cover seals and their condition. Availing supply during period of disconnection etc.
- iv) These registers shall be reviewed by the Section Officers and appropriate steps taken to set right the things immediately and action taken by them shall be recorded in the register. The Asst. Divisional Engineers, Divisional Engineer/Operation and Superintending Engineer/Operation also review these registers periodically.

180. CHECK READING: In order to ensure prompt meter readings, their review ensuring proper sealings and security responsibilities are fixed as per Annexure-N:-

NOTE:(i) Meter readers should be periodically changed.

NOTE: (ii) Whenever a departmental officer of rank not less than a Section Officer inspects any metered service he should take the opportunity of noting the meter reading on the white card and attest it with dated initials. This should be transferred to the meter reading register by the meter readers even though such reading is not required for billing.

NOTE:(iii) A return of check readings should be sent to the Electricity Revenue Office monthly by the Section Officer.

181.METER READING – H.T.SERVICES:

In the case of High Tension services, the meter readings should be taken by the Divisional Engineer/Operation for the services with a contracted demand of above 1 MVA and services with contracted demand of 1 MVA and below shall be taken by the Assistant Divisional Engineer/Operation.

It is essential that the readings should be taken on the same corresponding day every month.

182. The following are instructions in readings the consumption of the power installations:-

Instruction:--

- 1) Detailed specification in reading the consumption of the meter with meter number should be given on the top of the meter card.
- 2) It should be clearly stated whether the meter belongs to the consumer or to the Board.
- 3) Multiplying constant, if any, for the units or for the maximum demand should be given in the meter card and every time meter readings are Noted, great care should be taken to multiply the readings by this constant to arrive at the correct figures. Great care should be taken to see that no arithmetical errors are committed while computing the readings.
- 4) The maximum demand pointer should be reset to zero after readings are taken, and the resetting mechanism properly sealed. The monthly resetting should be done only just after the time switch has made the contact and the driving point has come to zero. Otherwise undue force will result on the driving pointer and may cause bending and erratic action.
- 5) The meter readers (every time they go for readings) should examine whether seals on the Meters, M.D. attachments are in tact and if not the matter reported to the next higher authority.
- 6) The signature of the consumer or his representative should be obtained on the meter card at the time of noting the meter reading. This is specially necessary in the case of high-tension services and other individual or commercial establishments where it should always be possible to obtain the signature of the consumer or his representative.
- 7) The entries of technical details on the meter cards of every high tension meter and other large consumers should be checked and certified by the Divisional Engineer/Assistant Divisional Engineer/Section Officer incharge for the first time before submitting for billing.
- 8) The power factor should be calculated monthly and Noted in the meter cards corrected to decimal places in the case of H.T. services.

183. THE FOLLOWING ARE OTHER GENERAL INSTRUCTIONS:---

Meter Reading Registers:

- 1) If necessary the meter reading registers may be sorted out according to localities to enable the meter reader to take readings in the quickest possible time.
- 2) Meter reading registers are also used for street lights and flat rates.
- 3) The readings of the meters – H.T. as well as low tension – should be duly posted in the meter reading registers and meter reading registers sent on due dates to the Electricity Revenue Office/Circle Office for the purpose of billing, after due review.
- 4) The readings of the meters should be taken during test at the laboratory or site and furnished by the M.R.T. to the Central Office/ERO Office where they should be entered in the consumers' ledger and verified with the meter readings for that month.
- 5) Whenever meters are changed, a report together with the particulars of the new meter, its reading and the reading of the old meter should simultaneously be sent to the ERO by 5th of the succeeding month.

184. CHECK METERS. Check meters may be installed by H.T. consumers purely for their information and guidance. They need not be sealed by the department. The meter cards for the Board meters should indicate whether the consumer's check meter is available or not. For billing purpose the readings of the departmental meters alone will be adopted and it is open to the consumers to challenge their correctness in the usual manner.

N.B.– CHECK METER. The readings of the check meter should also be invariably taken and Noted in the departmental meter card separately (i.e., Noted in the meter card for Board meter) and sent to the Circle office along with the regular meter card. If in any month the check meter is not available the fact should be Noted in the departmental meter card. If the readings of departmental meter and check meters differ by more than 5 per cent the discrepancy should at once be investigated and the desirability of departmental meter being tested reported to the Divisional Electrical Engineer with copy to the SAO. If on test the departmental meter is found to be correct, the Divisional Electrical Engineer will advise the consumer to keep the check meter correct or consider the advisability of making it a 'complaint meter' and a report on this sent to the Circle Office so that the readings in the check meter may not be made any use of for billing purposes.

185. METER READING INACCESSIBILITY ---- When the meter is locked up or otherwise rendered inaccessible, the procedure indicated in clause 22.3.2 of the terms and conditions of supply should be strictly followed. Notice in A.P.S.E.B. Form 24 should be issued to the consumer by post or otherwise by the Section Officer.

186. CHANGE OF METERS FEES: No fees are livable for changing meters in the following cases:--

- 1) If the existing meter creeps when it is vertical and within voltage limits and the phase sequence is correct, the fact of creeping should be certified by the Section Officer.
- 2) Permanent addition of load in service.
- 3) For temporary additions to load on occasions like marriages' festivals, etc., the fees for installing higher capacity meters should be paid. As soon as the temporary load is removed by consumer, the original meter should be re-fixed free of cost.

187. METERS OF DISCONNECTED SERVICES: When a service is disconnected the meter may either be devoluted to stock or transferred to the numerical list of tools and plant intended for testing purposed. The value of meters should be credited to the general estimate for service connections and shown under the account numbers to which it was originally debited. If the meters are transferred to the numerical list of tools and plant their value should be debited to the estimate for tools and plant new supplies.

Note: (1) If a consumer prevents access for the departmental meter, action should be taken as per the terms and conditions of the supply.

F. ADVERTISEMENT AND PROPAGANDA

188. COMMERCIAL PROPAGANDA: Commercial propaganda may be carried out by the Board to educate the consumers about efficient use of electrical energy.

189. ADVERTISEMENT: Advertisement is by distribution the public, free of cost pamphlets in English and the language of the district, containing information about conservation of electrical energy.

190. HIRE OF ELECTRICAL EQUIPMENT: The following rules govern the hire of electric plant and equipment (other than used generating plant) to intended consumers of electric power.

- 1) An application for the supply on hire of electric plant and equipment should be made to the Superintending Engineer of the System, in the prescribed forms. Copies of the forms may be obtained on application from the office of the Electricity Board.
- 2) The superintending Engineer shall cause enquiry to be made as to the solvency of the consumer and if he is satisfied that the result of the enquiries is favourable, a departmental Engineer will then inspect the site or factory at the earliest opportunity to ascertain local conditions and requirements.
- 3) The consumer will be advised as to when power can be supplied with an estimate of the costs he will have to incur.

- 4) Having agreed to the estimate of costs the consumer shall be required to enter into an agreement in the prescribed form.
- 5) Where an consumer does not own the property on which it is proposed to install the plant and equipment, then it shall be necessary to obtain the landlord's consent in the prescribed form.
- 6) An initial payment will in all cases be necessary and will be based on an estimate of the cost of transporting and erecting the equipment, insuring it and placing it in a satisfactory operating condition plus 25 per cent on account of supervision expenses.
- 7) The agreement having been signed and the landlord's consent obtained, when necessary, and the advance payment made, work shall be started on the installation as soon as practicable.
- 8) After the completion of the installation a bill showing the actual cost incurred in the erection of the plant plus 25 per cent, for supervision shall be prepared and any surplus due to the consumer by reason of the advance payment made by him, shall be deducted from the hire rent due by him.
- 9) A monthly hire rent equal to 2 per cent of the cost (book value) of the plant and equipment shall be payable by the consumer every month strictly in advance. It shall include minor running repairs and replacement of parts worn out by legitimate wear and tear.
- 10) The plant and equipment will remain the property of Board unless agreed to be sold to the consumer.
- 11) Any extra work or repairs shall be undertaken by the department at cost plus 25 per cent when required.

191. A separate numerical register of tools and plant lent out on hire in A.P.S.E.Board Form 55 should be maintained in the stores section which should periodically be checked with the hire charges ledger in A.P.S.E.Board Form 68 maintained in the Circle Office to ensure that assessment of hire rent is made in all cases. When the hire agreement is terminated the Assistant Divisional Engineer in charge should see that the plant is returned to District Stores safely at the cost of the hirer through devolution. An intimation about the termination of the hire agreement should also be sent to the Circle Office.

192.HIRE LEDGER: When tools and plant or electrical equipment are lent out on hire the monthly hire charges should be worked out as per the rules in force.

An account for each hirer should be opened in the ledger in A.P.S.E.Board Form 68 and the amount of the monthly installment Noted at the top of the folio. Bills should be made out monthly in advance and the numbers and amount thereof Noted on the debit side of the ledger.

The debits during the month should then be abstracted and the total thereof credited to Miscellaneous Revenue. The recoveries of the hire charges are posted in the ledger from the cash book. At the end of the month the credits in all the accounts in Hire Charges ledger are abstracted and credited to Hire charges suspense.

N.B. Hire agreements are taken in the Divisional Office.

G. REVENUE ACCOUNTS–BILLING, COLLECTION AND BOOKS MAINTAINED.

193. Correct assessment and revenue collection from the sales power consists in seeing—

- a) **INTERNAL CHECKS ON REVENUES:** That the power generated, transmitted and delivered to various premises is correctly metered and that the instruments are kept within permissible limits of accuracy;
- b) That the meters are properly read and that such readings, being the initial record for assessment are checked by superior authority;
- c) that all services connected or which connected are brought to account for purposes of billing;
- d) that the bills for consumption of power are made out correctly in accordance with agreements and rules in force.
- e) that the bills are issued promptly on prescribed dates and that the revenue is collected, promptly remitted and brought into account immediately.
- f) and finally, that proper books of account and ledgers are maintained, reviewed and correct accounts rendered to the management as well as to consumers.

194. The following procedure from commencement to realization of revenue is prescribed; paragraphs 196 to 202 contain the percentage checks to be exercised at various stages to prevent mistakes and leakage's in assessment and collection.

195. RESPONSIBILITY OF ACCOUNTS OFFICER (REVENUE):

The Accounts Officer (Revenue) shall enforce the procedure and internal checks prescribed and report to the Superintending Engineer any neglect on the part of the officers.

a) BILLING (I.E., ASSESSMENT OF REVENUE.)

196. **METER READING REGISTERS:** The Meter Reading Register contain full information viz., service connection number, consumer's name and premises, connected load. Meter number, date of connection, tariff as per agreement etc., which shall be made available to private accounting agency/inhouse computer by 11th of the month and the required details for the exception lists shall also be made available by 20th of the month at least for issue of the bills.

197. PREPARATION OF L.T.BILLS:

- a) The private accounting agency/in house computer shall prepare and issue of bills by 20th of the month to ERO along with B.B.A.
- b) In case of stuck up and burnt meter services, computed consumption as per B.P.Ms.No.18, dated: 10-6-1996 or previous 3 months average consumption whichever is higher shall be adopted for billing by the P.P.A/in house computer.
- c) Surcharge for belated payments should be included in the next month Current Consumption charges bill.
- d) In case of wrong meter readings furnished by the meter reader, the bills shall be revised based on check reading furnished by the Section Officer duly countersigned by Assistant Divisional Engineer, wherever large amounts are withdrawn such cases may be brought to the notice of Divisional Engineer/ Assistant Accounts Officer-ERO.
- e) 3 months average consumption should be taken for billing purpose in door lock and ~~reading~~ not furnishedll cases but not as per B.P.Ms.No.18, dated:10/06/1996.
- f) In case of street light billing for minor panchayats where 250 units are free, the actual units recorded should be exhibited in the bill, and these units shall also be accounted for as ~~Units Billedll~~ invariably.
- g) The bills will be dated 1st of the succeeding month.

198. CHECK OF L.T.BILLS:

1) The billing clerk shall check whether bills are received as per B.B.A. and for all the services for which bills are due.

2) Checks to be exercised by billing Superintendent:

- i) Check bills where the amounts are more than Rs.500/- but upto Rs.1,000/- and ensure correctness.
- ii) Check bills with (-) balances, if any and ensure correctness of credit balance.
- iii) Transmit the bills with B.B.A. to the Section Officer ensuring checking of bills within 3 day of receipt of bills from private accounting agency/in house computer; duly arranging facsimile.
- iv) Keep the B.B.A. relating to revenue cashier and hand over the B.B.A. and PR book to the revenue cashier on the last working day.
- v) Supervision of work of ledger clerk under his control.
- vi) Maintains percentage checks register for the checks conducted.

- 3) Checks to be exercised by Junior Accounts Officer:
- (i) Supervision over billing superintendent and billing clerks and ensure that internal clerks are exercised by billing superintendents/clerks.
 - (ii) Check the bills where the amounts are more than Rs.1,000/- and ensure correctness.
 - (iii) Maintain a registers showing the number of services for which bills are due and bills are actually issued.
 - a) Section
 - b) No. of Bills in last group.
 - c) Add new services released of related group.
 - d) Add re-billed services.
 - e) Add section changes and other cases.
 - f) Deduct services for which billing stopped.
 - g) Deduct section changes and other cases.
 - h) Total services for which bills are due.
 - i) No. of services for which bills are issued.
 - j) Difference.
 - k) Reason for difference.
 - (iv) Ensure that bills for balance services are issued during the same month and make the difference as –NIL.
 - (v) Compile data relating to demand, section wise, and category wise and compare the consumption and demand with previous related group.
 - (a) Find out average units per service with reference to units consumed and energy charges assessed.
 - (b) Find out the average units per service with reference to units consumed and services billed under each category.
 - (vi) Maintain Percentage checks register for the checks conducted by him.

(4) Checks to be exercised by Assistant Accounts Officer/ERO

- (i) Supervision over billing superintendents, billing clerks, and junior Accounts Officer and ensure that internal checks are exercised by them.
- (ii) Check bills where the bill amount is more than Rs.5000 and ensure correctness.
- (iii) Have a analysis of section wise and category wise demand of current month and previous months (related group) and check whether average unit rates are correct and also average consumption is identical.
- (iv) Ensure that bills are received for all services including new services of related group for which bills due.

199. Bills for unconnected services and for monthly flat rate services:- Bills for unconnected services for monthly flat rate services should be made out monthly in ERO itself. These ledgers should be checked monthly by the billing superintendents to see that bills have been issued for all the items included in them.

200. PREPARATION AND CHECK OF H.T. BILLS:

The H.T. bills will be checked by the Junior Accounts Officer H.T. revenue in Circle Office. These will be issued only after examination by Senior Accounts Officer and with the signature of the Senior Accounts Officer.

201. The abstract of the Bill book and the permanent receipts will be simultaneously written up and also the bills analysis sheets consumers' summaries.

NOTE:--- (1) Any short or excess claim made in the bill should be indicated in the abstract so as to facilitate the reconciliation of the total of the bill abstract with the corresponding total in the proof sheet of consumer's ledger postings; vide paragraph 204.

(2) Over writings in bills and receipts should be scrupulously avoided.

202. REVIEW AND SUPERVISION BY THE ACCOUNTS OFFICER/REVENUE:

The Accounts Officer (Rev.) will conduct a general review of the work in connection with billing and check where the bill amount is more than Rs. 5,000/- L.T. bills and 5 per cent of the new bills and others involving changes. The facsimile signature of the Assistant Accounts Officer/ERO will then be affixed on the bill.

The check or review referred to above comprises—

- (a) check with agreement,
- (b) check with tariff,
- (c) arithmetical check, and
- (d) other checks.

203. DUTIES AND RESONSIBILITIES OF BILLING CLERKS: Each Bill Clerk is expected to maintain accounts relating to 1900 billed services per month for BI-monthly. The following are the main items required to be done by the billing clerks.

- 1) Enter the new services released in the service connection register duly assigning service connection number and ensure that there is continuation of service numbers for each distribution as per allotment of service numbers.
- 2) Enter the details of returns received from field and forward the same to Private Accounting Agency/in house computer.
- 3) Enter the details of removal of meters/dismantlement of services in the ~~Register~~ of Disconnection and connections and transfer the bill stopped services to the outstanding ledger after adjusting the security deposit available with the consumer.
- 4) Check whether all the new services released are entered in the meter reading books and readings furnished.
- 5) Check whether bills are received as per Bill Book Abstract and for all the services for which bills are due.
- 6) Compile demand for the month, section-wise and category-wise duly reconciling the services, consumption and demand with the previous month demand (related group) taking into account new services, other additons and deletions.
- 7) Maintain daily log section-wise and date-wise for the collections made during the month—cash, Cheques, RJS and arrive the total collections as on 21st and month end.
- 8) Ensure that BCRCS are handled over to Private Accounting Agency/in house computer daily.
- 9) Keep the Disconnection lists relating to disconnected services and issue one month notice for such services under disconnection beyond 3 months, in the 4th month.
- 10) Maintain register of arrears for the amounts due from Government departments, local bodies, board quarters, installments allotted etc.
- 11) Maintain consumer ledger relating to billing stopped services.
- 12) Issue form A' notices for all services covered under billed stopped services.
- 13) Issue form B' notices for all such services for which acknowledgments are received for form A' notices issued.

- 14) Write the consumption deposit register and reconcile with control figures and financial ledger with progressive balances.
- 15) Maintain the half year consumers ledgers and condensed consumer master.
- 16) Prepare Journal entry for the rectification of wrong readings, if the mistake is confirmed by the Assistant Divisional Engineer.
- 17) Prepare Journal entry for revision of demands upward/downwards on account of change of categories.
 - a) The following Officers of the Board are authorised to approve the journal entry for revision of demand upward/downward on account of wrong reading etc. or on account of change of categories.
 - i) Assistant Accounts Officer/ERO ... Upto Rs.5,000/-
 - ii) Divisional Engineer/Operation ... Above Rs.5000 and upto Rs.50,000/-
 - iii) Superintending Engineer/Operation ... Full powers

204. TOTAL ASSESSMENT: Every month the totals of ledger debits, as taken from the abstracts of proof sheets, month bills abstracts' of all bill books used in the month, bill analysis sheets, should be reconciled with each other before the trial balance are drawn up and certified by the Accountant as this ensures the correctness of the consumers, individual accounts with the billing suspense account. Revised, cancelled and supplemental bills and journal entries should be carefully taken into account and posted in the ledgers.

B. ISSUE OF BILLS AND COLLECTIONS.

205. ISSUE AND COLLECTION OF H.T.BILLS:

The H.T.bills will be issued direct from the Circle Office to respective consumers and the realisations watched.

Note:- Certificate of posting shall be obtained for the bills.

206. ISSUE AND CORRECTION OF L.T.BILLS: The L.T.bills and Bill Book Abstract should be sent to Section Officer who will check and acknowledge receipt of them.

NOTE:

- 1) L.T. bills will be dated 1st of the month and will be despatched to the field before 23rd of the preceding month.
- 2) 14 days time will be allowed for payment of bills without surcharge and by 21st of the month with surcharge. The Section Officer should arrange delivery of the bills to the consumers with in 7 days from the date of receipt of bills by through the O&M staff or contractor.

207. The payment will normally be received by the Revenue cashiers at the notified bill collection centres and also at the ERO's.

208. (a) Simultaneously with the receipt of money for bills, the Revenue Cashier will write up Bill Collector's Remittance chalan and issue the permanent receipts after dating them. The date of collection will also be Noted by him in the bills abstract.

NOTE; (1) Separate Bill Collector's Remittance Chalan should be written for each distribution and these should be enumerated in the petty cash book.

(b) The duties of the Revenue Cashiers will be:

- 1) He should know what is permanent receipt.
- 2) He should know what is a Bill Collectors Remittance Challan (B.C.R.C.)
- 3) He should know what is bill book abstract.
- 4) He should know how to write collection register in ERO counter.
- 5) He should learn detecting counterfeit Notes or coins.
- 6) He should know how to arrange currency Notes before bundling to present in the bank.
- 7) He should know how to write denomination of currency on the reverse of pay in slip.
- 8) He should know the Boards (ERO-wise) receipt account against which he has to remit into the bank.
- 9) He should know the limit upto which he can keep the cash with him when he is in rural areas collection.

- 10) Simultaneously the receipt of money for bills, the revenue cashier will write up (Bill Collectors Remittance Chalan) B.C.R.C. and issue the permanent receipt after dating them. The date of collection will also be Noted by him in the bills abstract (BBA).
- 11) Separate BCRC's should be written for each distribution and these should be enumerated in the petty cash book.
- 12) Each day's collection should be handed over to the Sub Inspector of Revenue Cashier/U.D.C.(Cash)/Accountant cash by the Revenue Cashier for safe custody and remittance duly obtaining acknowledgment on the duplicate copy of the P.C.B. when he returns late from camp.
- 13) The collections shall be remitted into the Bank daily by the Revenue Cashier subject to the condition that the un-remitted cash amount does not exceed Rs.500/- at any time. All collections at the end of the month shall be remitted to the Bank to enable the monthly collection being brought to account.
- 14) Serial Nos. of permanent receipts book, B.C.R.Cs and P.C.Bs should be checked by revenue cashiers when they receive fresh books and intimate the discrepancies and get them rectified duly attested by The Assistant Account Officer/Junior Accounts Officer concerned/Accounts Officer without fail.
- 15) Permanent receipts should not be cancelled in normal course. All cancellations should be attested by Sub-Inspector of Revenue Cashier/Junior Accounts Officer concerned/Assistant Accounts Officer without fail.
- 16) Over writings are prohibited. Corrections should be legibly attested.
- 17) Revenue cashier should be in a position to explain doubts in bills or arrears etc.
- 18) The Revenue Cashiers will also keep tariff pamphlets, conditions and rate of supply.
- 19) The revenue cashier should be extremely courteous to consumers, offer them seats wherever available, and attend to all, representations.
- 20) The Petty Cash Book (original) with remittance slip and B.C.R.Cs should be sent to the ERO the same day.
- 21) The bill collections at out stations at out stations will be periodically checked by the Sub-Inspector of Revenue Cashier/Assistant Accounts Officer.

- 22) The pages of the Petty Cash Book should be in duplicate and machine numbered serially, so that consecutive numbers may be watched by the revenue cashier at the time of receipt. For facility of reference numbers are given to the B.C.R.C.S also which should be checked by the Revenue Cashier while receiving from the ERO.
- 23) In rural areas Revenue Cashier will be sent to the several villages according to pre-arranged programme. A copy of the Revenue Cashier indicating the dates on which he will visit the several villages should be hung in the Notice Board of each of the rural section offices and village panchayat offices.
- 24) Revenue Cashier urban will deal (1800) services in urban area, and 1500 services in rural areas. There will be two revenue Cashiers in ERO counters.
- 25) Payment of bills will be received only at the notified place/Gram Panchayat Office/Section Office/Asst.Divisional Engineers office as fixed by the Assistant Accounts Officer/ERO under the instruction of Divisional Engineer/Operation.
- 26) Cheques should not be accepted by Revenue Cashiers other than those at ERO proper.

209. The collection work is to supervise by the SIRC in his jurisdiction to ensure proper accounting of collection received by the Revenue Cashier.

The following are the main items of work to be done by SIRC:

- 1) General Supervision over the work of all Revenue Cashiers in his jurisdiction to ensure proper accounting of collections received by Revenue Cashiers.
- 2) He should arrange proper tour programme of Revenue Cashiers systematically and equitably as far as possible and get it approved by the Assistant Accounts Officer/ERO. He should so arrange the programmes that the Revenue Cashier is not left with heavy cash balance un-remitted with him. Either the Revenue Cashier should hand over the cash to the E.R.O.duly obtaining acknowledgment, if his head quarters happens to be the same as that head quarters of E.R.O. or if it is other than Head quarters of ERO the Revenue Cashier should be given remittances day next to the collection programme day for remittance and then proceed to another distribution. This would not only safeguard the Revenue Collection of the A.P.State Electricity Board, the Revenue Cashier will be free not to have heavy cash balance. The SIRC is personally responsible to fix the tour programme of Revenue Cashiers keeping this above aspect in view.
- 3) Conduct surprise checks of collection centres as per pre-arranged tour programme approved by Assistant Account Officer not less than 8 to 10 centres covering all Revenue Cashier's centres.

- 4) He should train all Revenue Cashiers newly recruited in E.R.O., as well as by accompanying to the Centers in respect of writing Permanent Receipts, writing up of B.C.R.Cs and P.C.B., tallying the cash, behavior with consumers etc. Unless this is done the Revenue Cashiers should not be left to proceed straight away on camps without knowing practical duties responsibilities, and work.
- 5) Checking cash balance with reference to B.C.R.Cs and duplicate copies of receipt; in respect Bi-monthly system consumers, and Permanent Receipts on hand for monthly billing categories. Also check the entries in B.C.R.C. since last closing of Accounts with reference to duplicate copy of receipts.
- 6) Random verification of consumers receipts with the consumer and Note down the dates of collection etc., to check with E.R.O. records and whether dates on Permanent Receipts tally with the tour programme of the distributions! by the Revenue Cashiers.
- 7) Enquire with the consumers is to regular attendance of Revenue Cashier and time the spends in the collection center. Bring all the complaints to the notice of : Assistant Accounts Officer/ERa to rectify the omission or lapses of Revenue Cashier.
- 8) Checks whether items collected as per B.C.R.C. are posted in register maintained by Revenue Cashier.
- 9) Ensure proper maintenance of various registers by revenue cashiers including record of Receipt Books, B.C.R.Cs Serial Numbers, Watch register, (with serial Nos. from & to) Register P.C.B. with from and to series, and service postage.
- 10) He should maintain register showing Permanent Receipt books, B.C.R.C.S, and service postage handed over to the Revenue Cashiers and Watch their usage and serial Nos. daily from the B.C.R.Cs and P.C.Bs received with remittance slips.
- 11) Checks the totals of all the B.C. R. Cs received from Revenue Cashiers Banks (where Bank collections are in vogue) to ensure correctness of Serial Nos. and amount and also totals in the P.C.B. every day and make entries in the register of Revenue Cashiers' collections. Passes on P.C.Bs with Bank remittance slips to UDC (cash) and B.C.R.Cs to Billing Superintendents/Clerk duly taking acknowledgement, in a register.
- 12) Writes P.C.Bs for collections made by Banks based on B.C.R.Cs. received from Banks.
- 13) Verifies the list of uncollected items on 15th for consumers with reference to Blanks in Revenue Cashiers Register.

14) Accompanies the Revenue Cashiers to Bank for remittance where cash is heavy (i.e.) above Rs.5,000/-.

15) Any changes of programme of Revenue Cashiers proposed by him should be with the written approval of Assistant Accounts Officer.

16) Scrutinizes the T.A. bills of Revenue Cashiers with reference to approved tour programme and control registers.

17) Arrears persuasion, contacting the consumers and obtaining property particulars, other live services details etc. during camps.

18) Maintains registers of cancelled permanent Receipts (where pre-receipt system prevails), Register of Receipt books/B.C.R.Cs drawn issued to the Revenue Cashiers and Watches the serial Nos. and dates.

19) Ensures the supply and proper usage of cash chests/cash bags to Revenue Cashiers.

210. The bill collections at outstation will be periodically checked by the Accounts Officer (Revenue) / Asst. Accounts Officer also.

211. Ledger Posting : The Revenue ledger should be written up periodically (not later than once a week) from the cash book. The BCRCs shall be hand over to PAA/in house computer daily.

212. CHECKS ON COLLECTIONS BROUGHT TO ACCOUNT:

A trail balance of the credit postings in the ledger should be drawn up and reconciliation effected between the following :

Credit Posting (billing suspense realization account)

Totals of credit postings of ledgers.

Totals of remittance chalans for the months.

Totals of bills abstract books showing realization less un-remitted balance certified by the junior Accounts Officer.

The junior Accounts Officer should see that this reconciliation is effected before the consolidated trail balance is drawn up this ensures cross checks on the amounts realized and brought to account.

2.13 (a) DISCONNECTION NOTICES: The PAA/in house computer should issue defaulters list by 23rd of the month duly taking the credits upto 21st. The Assistant Accounts Officer/ERO to transmit the Disconnection list on the same day to the section officer duly recording the subsequent collections.

(b) Within 7 days of the date of receipt of the disconnection list, all services appearing in disconnection list should be got disconnected and operated disconnection list should be returned to Assistant Accounts Officer/ERO and sent it to PAA/in house computer for entry of fact of disconnection in the consumers master.

(c) The Junior Accounts Officer's should check the above list and verify credits for realizations in the books.

(d) All exceptional cases should be reported by the Assistant Accounts Officer/ERO to the Asst. Divisional Engineer.

NOTE:

- 1) In the case of services for which use are not paid by the due dates the department reserves the right to disconnect the service, reconnection being made only on receipts of amounts due.
- 2) The Assistant Divisional Engineer are authorized to allow not more than three days of grace at their discretion in deserving cases beyond the due date of payment.
- 3) Immediately after the lists of installations to be disconnected are received, the distribution engineer should arrange for their disconnection by deputing responsible line staff. The disconnection shall be made only after intimating the consumers and asking them to produce receipts for payments if any.
- 4) With a view to restore service immediately to a service disconnected or to avoid disconnection where payments are received in the ERO office the clerks in charges of the section should furnish a list of such cases to the distribution engineers on the same day.
- 5) Disconnections effected should be Noted in the ledgers and the list of disconnected items reviewed periodically and reported to the Divisional Electrical Engineers with a view to their reconnection.

214. (a) OUTSTANDING ACCOUNTS : The services disconnected, with arrears outstanding should be brought on to an outstanding ledger account after receiving information from the section officer, that the service lines/ Meters of the said services are dismantled and after adjusting the consumption deposit.

(b) The arrears outstanding against such services should be recovered under R'R act.

215. BOOKS MAINTAINED:

- a) The following ledgers and books are maintained in the Electricity Revenue Office in connections with the billing and assessment of revenue.
1. General Consumers' Ledger – APSEB Form 37
 2. Revenue Ledger Account - APSEB Form 37
 3. Out standing Ledger in APSEB Form (not standardized)
 4. Unconnected services Ledger (not standardized)
 5. Revenue Return.
 6. Security Deposit Register
 7. (Section – wise and Distribution-wise)
 8. Register of Disconnections and Reconnections.
 9. Group-wise service connection register.
 10. Register of RJ's
 11. Register of inputs and outputs.
 12. Register of receipt books
 13. Register of installments
 14. Register of Consumer Grievances
 15. Register of Category changes.
 16. Register of Title transfer.
- b) **REVENUE LEDGER ACCOUNT :** An account is opened for each of the various revenue heads by the account numbers.
1. When a service is disconnected for default and the service is dismantled the account in the consumer's ledger is closed by transferring the outstanding balance to the outstanding ledger. This ledger should reviewed weekly and action taken for the early recovery of the dues. There may be further billing on account of Monthly Minimum charges etc. and the debits on account of these should be posted in the ledger.
 2. The purpose of the unconnected services minimum ledger has been explained in paragraph 134.

216. REVIEW OF LEDGERS : The Junior Accounts officer shall review the consumers' ledgers accounts , the books monthly and ensure :

- a) Compliance with conditions of the agreements and conditions of supply.
- b) Enhancement of deposits in relation to average consumption.
- c) Investigation of unusually low consumption.
- d) Attention to any other items such as disconnections, surcharges, fuse-off calls, arrears, periodical minimums, etc.

217. REVIEW OF LEDGER ACCOUNTS: The Accounts officers /Revenue should examine the revenue ledgers and bills periodically with a view to satisfy:

- 1) that the ledgers are being posted then and there upto date,
- 2) but bills are prepared correctly and verified by another clerk and that initial checks are being carried out.
- 3) That prompt action is being taken towards recovery of arrears.
- 4) That timely disconnections are made.
- 5) That changes in connected load etc., are incorporate then and there.
- 6) That the ledgers are maintained in a neat and upto date condition without over writings or erasing.

218. REFUNDS OF REVENUE : A return of refunds of revenue should be sent to the superintending Engineer.

NOTE:

- 1) Refunds mean revenue actually assessed, collected, credited and refunded. Remissions, waivers, writes off, withdrawals, claims relinquished are not to be treated as refunds on the expenditure side but as reduction of revenue assessed. They should not be exhibited under Refunds.
- 2) Superintending Engineers can sanction refunds of revenue under receipts from sale of power subject to (1) that amount originally collected is in excess of the amount already due according to departmental tariffs and conditions and terms of agreement subsisting between the Board and the party to whom refund is due and (2) that the refund is subject to any departmental orders issued by the Board

H. MISCELLANEOUS REVENUE

219. In addition to sale of power and other commercial revenues, the following other receipts are realized in the department:-

1. Rents of buildings (Vide paragraph 220)
2. Rents of lands (Vide paragraph 224)

220. RENT OF BUILDINGS: All the residential buildings in the departments are intended for occupation by departmental officers and subordinates. Recoveries of rent are effected by deduction from pay bills of the officers and subordinates. In the case of provincial and O&M establishment, the amounts of rent to be recovered should also be shown in the pay bills and the deduction for the pay bills are posted in detail on the receipts side of the Cash book.

221. To enable the Drawing Office to correctly make deductions on account of rent from the pay bills of provincial establishment to check the correctness of such deductions in the pay rolls or M establishment, all officers in charge of residential buildings should furnish not later than the 10th of every month, to the Drawing Officer a statement showing the particulars regarding the names, designations, emoluments, etc., of the officials occupying quarters. Changes in the occupancy after the 15th of the month should be intimated as and when they take place.

NOTE: For the purpose of the above rule, it will be sufficient if the officers in charge of change in the completed statements once furnished. Where there are no changes the fact should be intimated to the DRAWING OFFICER.

222. RENT OF BUILDINGS TO PRIVATE PERSONS: If in any special case, a departmental building is let to person not in the service of Board, the full assessed rent must ordinarily be recovered in advance exceptional cases being dealt with as in a commercial concern.

NOTE: Sums received in advance for payment of rents of land should be credited direct to revenue.

223. A register should be maintained in the Drawing Office to show the monthly assessment, realization and balances of rents, in respect of all residential buildings. In this register the transaction relating to the recoveries should be entered for each building. Recoveries are posted in this register from the details in the revenue ledger and the journal and cash book. The total realization in a month should be agreed with corresponding total as per the Revenue Ledger.

224. REGISTER OF LANDS : For watching the recoveries on account of rent of land a simple register in A.P.S.E.Board Form 171 is maintained. Any miscellaneous properties from which revenue is anticipated may also be included in this register.

OFFICERS - DUTIES AND RESPONSIBILITIES

1. ZONAL CHIEF ENGINEER

10. The Zonal chief Engineer is the Chief Executive in the zone and is chief adviser to the board in the development and achievements of board's objectives. He is accountable to the board for all the functions. The Zonal Chief Engineer is responsible for efficient, effective, integrated and economical functioning of the organization in the zone with regard to distribution , sale of power , achieving return on assets, deployment of man power, proper utilization of materials, etc. as per policies laid down by the Board, keeping in view the long range objectives and plans. The Zonal Chief Engineer shall coordinate flow of materials to various points in the circles under his control optimizing innovatory ensuring efficient use of materials by suitable planning, indenting, watching receipts and issues, deploy man power to extract maximum output as per policies laid down by Board, maintain best Boards policies Superintending industrial relations with the employees by following Engineers of the circles under his control, guide them and closely monitor various activities with reference to transmission, distribution, consumer servicing, billing and revenue collection.

1.1 The areas to be covered are :

- a) Sale of energy and achievements of targets in release of services, revenue billing and collection of revenues, Review of stuck-up and burnt meters and ensuring prompt replacement with special emphasis on high value services . Review and ensure prompt and effective disconnections including dismantling of services which are continually under disconnection for more than 3 months as per B.P Ms No. 152, dt; 25.8.1993 and as per clause 26.10 of Terms and Conditions of supply.

Identifying area where pilferage is prevalent and taken steps to eradicate the same by arranging continues raids and prosecuting the offenders.

Ensuring review of meter readings, attending to exceptional on top priority with special emphasis on high value services.

Drawing up a programme and implementing it for quick realization of arrears of revenue.

Ensuring hindered percent collection of current month demand raised and at least 15% of the arrears in each ERO per month.

- b) Operation and maintenance of 33 KV, 11 KV, L.T Lines, Sub-stations, and Distribution and power transformers. Ensuring scheduled patrolling of lines and special patrolling consequent to tripping pre-monsoon inspections , timely tree clearances and rectification of faults for total avoidance of breakdowns. All equipment at all sub-stations to be kept in trim condition and properly maintained as per schedules. Station batteries along with all protective features are to be ensured for providing protection to line and equipment. Auxiliaries such as Franks, pumps, O.L.T.C Gears, compressors (where available) are to be in working condition always.
- c) System improvements, Review of low voltage pockets, and peck readings reached on lines and power transformers and making proposals, for enhancements, new sub-stations, installation of capacitor banks and AVBs etc. Also proposals towards reduction in system losses are to be made keeping system configuration in view.
- d) Construction works such as minor and major extensions.
- e) Rural electrification and urban extensions.
- f) Constant review of failure of equipments and follow up of repairs and also to take steps towards avoidance of failures.
- g) Conduct District – wise, Division-wise, sub-division wise, selection – wise 11 KV feeder-wise, and Distribution transformer – wise energy audit, arrive at line losses, and take remedial actions to plug the sources of losses and reduce them.
- h) Procurement of decentralized materials for works.
- i) Budgeting and budgetary control, compilation of accounts in the Zone, pre-audit.
- j) Implementing policies, objectives and programs asset up by the Board, monitoring progress there on and reporting to Board.
- k) See that accidents are avoided by reviewing al cases and ensuring that remedial actions are taken.

12. In order to achieve the above objectives, the following statutory functions are prescribed.

(a) Inspection of field offices.

- i) Inspection of each circle office once in a year.
- ii) Inspection of any one Division Office in each circle in a year selecting sub-optimal performing division.
- iii) Inspection of any one sub-division office in each circle in a year selecting sub-optimal performing sub-division.

- iv) Inspection of any one section Office in each division in a year in respect of review of meter readings, prompt operation of Disconnection lists, maintenance of distribution transformers , and power transformers, review in interruption registers, records of services, L.T. Layouts, accounting of demand Drafts, work order closing, fuse off calls registers, etc.
- v) Inspection of Electricity Revenue offices : One ERO in each Circle in a year (A critical Review of all activities) . Monthly review at his Headquarters on demand Vs. Collection and Clearance of arrears, etc.
- b) Inspection of SPM sheds :** Once in a year.
- c) Inspection of District Stores ;** Once in 6 months for disposal of unserviceable and obsolete material for general upkeep of stores and accounts etc.
- d) Inspection of Sub-Station :**
 - i) 33KV Sub-station, wherever repetitive failure of power Transformers and other major equipment occurs.
- e) Review of meter reading registers:**

L.T. High value services and all Industrial services	:	Once in a year
H.T. Services with a CMD of less than 1000 KVA	:	Half yearly.
H.T. Services with a CMD of 1000 KVA and above	:	Quarterly.
- f) Inspection of H.T Services :**
 - i) Above 4 MVA – Once in a year and whenever abnormalities in metering including failure of metering equipment are reported.
 - ii) Others : Whenever repetitive complaints are received

13. Yard Sticks :

The following yard sticks are prescribed for reasonably good performance.

a)	Distribution Transformers	:	Reducing the failure rate By 5% per annum and gradually Reduce to a minimum of 10%.
b)	L.T Revenue arrears	:	Less than one month's demand.
c)	33 KV breakdowns	:	One per year per feeder.
d)	11 KV breakdowns	:	Not more than 4 per year per feeder
e)	Equipment failures, capacitor banks power: Transformers, switch Gear	:	Nil
f)	Struck – up meters at L.T Services	:	Not exceeding 1% at any time.

g)	Burnt meters	:	Nil
h)	H.T Metering defects	:	To be rectified within 7 days.
i)	T & D Losses	:	15% over an year to start with and gradually reduce thereafter.
j)	Collection of H.T revenue	:	100% of current demand plus 15% of arrears.
k)	Collection of H.T revenue	:	100% and no arrears except those involved in litigation and installments.

II. CHIEF ENGINEER (T.L & S.S)

14. The Chief Engineer (T.L & SS) is accountable for Board for construction of Transmission lines and substations of 220 KV and below, and all responsible for operation and maintenance of EHT Substations and lines. The following working instructions are issued for effective functioning.
- a) The Chief Engineer (T.L & SS) Will be in charge of the O&M of all EHT lines and sub-station and also the construction of Transmission lines and sub-stations of 220 KV and below.
 - b) Even in respect of 400 KV lines and sub-station while the execution of lines and sub-stations will be handled by the Chief Engineer 400 KV, they should assist the Chief Engineer KV in preliminary works pertaining to their area till the lines and sub-station come up for execution.
 - c) The Chief Engineer (TL & SS) should first concentrate on the inspecting of line and substations to ensure that the preventive maintenance is being carried out as per norms. He should take immediate action whenever there is any slippage in this regard. He should inspect each EHT sub-station in a year.
 - d) The Chief Engineer (TL & SS) Circles are already getting the maintenance works done on contract in places where there are no departmental organization. The Chief Engineer (TL & SS) should review the arrangements and take necessary action so that the periodical maintenance of lines and sub-stations are carried out timely and arrangements made for attending to emergencies are effective.
 - e) At present some of the EHT sub-stations are under the control of Operation sub-division /Divisions. The Chief Engineer (TL & SS) mould ensure that these are taken over at the earliest by the respective TL & SS divisions.
 - f) The Chief Engineer (TL & SS) should review the availability of spares and T&P for the lines and sub-stations to cater to the needs of at last six months and came up with proposals to the chief Engineer (Transmission) for their procurement immediately.
 - g) The Chief Engineer (TL & SS) should arrange for pre-monsoon inspecting of all lines in order of priority as per the check lists already available and to get the defects rectified on war-footing.

- h) The Chief Engineer (TL & SS) should ensure that O&M estimates are prepared without any delay and budget proposals are sent under intimation to Chief Engineer (Transmission).
- i) The Chief Engineer/Zones should extend all the help that is needed to ensure maximum availability of lines and sub-stations equipment so that the consumers are effectively served. This should be done particularly during emergencies without any reference to the jurisdiction problems.
- j) Instructions are issued separately creating 'TASK FORCE' who will periodically round the sub-station and suggest to the superintending Engineer (TL & SS) the points on which urgent action is needed so that superintending Engineer (TL & SS), who is otherwise busy on Operational urgencies can take remedial action.
- k) The Chief Engineer (TL & SS) should give suitable instructions that the outages of lines and equipment are promptly reported to them so that they can monitor the rectification. He should inspect the spot of breakdown wherever major rectification was done, to avoid repetitive nature of such break down.
- l) The Chief Engineer (TL & SS) should be in touch with Chief Engineer (power system) and Load dispatch to ascertain the system conditions and effectively monitor the loads keeping in view of the instructions issued from time to time.
- m) Inspection of EHT sub-station in the Zone whenever major equipment failure or mal – operation of protective relay occurs.

III. SUPERINTENDING ENGINEER (ELECTRICITY SYSTEM)

15. The administration of an Electricity Supply System in a district or a profit will be in-charge of a Superintending Engineer. The Superintending Engineer is responsible to the Chief Engineer for the administration and general professional control of the entire system and of the officers of the Board sub-ordinate to him. He is also responsible for the efficient management of the undertaking as a commercial concern and in accordance with the commercial policy laid down by the Board. He will be responsible for the commercial propaganda and all other work carried out in the interests of popularizing the use of Electricity.

16. The Superintending Engineer is empowered to order transfers of Engineering Establishment upto the cadre of Assistant Divisional Engineer's and provincial Establishment Superintending Engineer will have full powers towards punishments to O&M or construction establishment for whom he is the appointing authority. The Superintending Engineer is also competent to award punishments to O&M or construction establishment to whom the Divisional Engineer is appointing authority, if Superintending Engineer has finalized the enquiry report of Divisional Enquiries/Enquiries. He shall also exercise such powers over the provincial staff as are delegated to him under the Statutory rules.

17. He will review the registers of financial irregularities and commercial work done and will bring to notice cases of incompetence or other disqualification for public duties and in like manner all instances of extraordinary zeal and ability. He will further exercise such powers of punishment, promotion, and control as are conferred on him under the statutory rules.
18. It is the duty of the Superintending Engineer to inspect the important works in his area, to satisfy himself that the system of management so efficient and economical and that the instructions of the financial branch as regards works, operation, stock and accounts are strictly observed and that the executive and administrative work of the system is satisfactorily performed.
19. He shall satisfy himself that the staff employed (Provincial as well as work charged) is actually necessary and adequate. He will exercise concurrent control with to Senior Accounts Officer and ensure that the subordinate officers watch carefully the expenditure on works, operation and maintenance expenses, growth of load and sales of electrical energy in the area under their control.
20. When submitting to the chief engineer any report, design or estimate, the superintending Engineer will invariably state his own opinion and recommendation.
21. He is responsible for the engineering features of design and the rates in estimates prepared or sanctioned by him.
22. The Superintending Engineering is responsible for reporting without delay the probability of any excess over estimates not within his powers of sanction and should arrange for prompt reason of the estimates wherever necessary.
23. In all accident cases the Superintending Engineer has to critically analyze the detailed investigation reports submitted By the Divisional Engineer/Assistant Divisional Engineer Administratively and technically in order to prevent reoccurrence of such accidents along with compensation proposals. If any within 30 days from the date of accidents the superintending engineer should immediately report to the chief engineer any serious loss of immovable property caused by any accident or unusual occurrence within his jurisdiction.
24. Immediately after work is finished the Superintending Engineer will arrange to close its account and prepare the completion report if required by the rules. In this connection it will be his duty to see that the works are not protracted for a reasonable time and the completion reports are not unduly delayed.
25. The Superintending Engineer will be in general charge of the purchase of stores and their disposal within his limited powers and subjects to stores purchase rules and instructions issued from time to time.
26. All interruptions of large works in progress or serious stoppage to Electrical power series should be reported to the chief engineer by the superintending Engineers according to the orders which may be the chief Engineer from time to time, the classes and probable durations of service interruption being explained.

27. While the senior Accounts officer of the circle will be responsible for the direct supervision of all accounting work relating to the undertaking and for all receipts and disbursements, and will be in entire and direct charge of the operating and revenue accounts of the undertaking. The Superintending Engineer will retain his general responsibility for the financial results shown and will exercise and will exercise general supervision over the senior Accounts Officers work in relation to them. The Senior Accounts Officer will also act as a general personal Assistant to the Superintending Engineer.

28. The Superintending Engineer should generally supervise and control the correct assessment and realization of such revenue as is assessed or collected in the electric system including the revenue due to the Government. The senior Accounts Officer will be responsible for the detailed assessment and collection of the revenue and shall maintain such records and accounts for the purpose as may prescribed.

Note: The Superintending Engineer will decide all cases of doubt involving technical interpretation in the matter of billing for energy supplied. If the decision involves a deviation from any rule prescribed by Board, orders of the competent authority should be taken. When metering is in dispute, however, the case will be dealt with in accordance with the provisions of the terms and conditions of supply notified by the Board from time to time.

29. The formation of the accounts and revenue office or the Circle office and the controlling organization of the system is intended for intensive and effective internal control and to relieve the Superintending Engineer off the bulk of the accounts, revenue and allied financial work, giving him the necessary help and advice for the financial administration of the system. The Superintending Engineer is however responsible for the financial administration of the system. The Superintending Engineer is however responsible for seeing that the work of the Circle office is efficiently performed and controlled by the senior Accounts Officer and that the field officers observe the instructions promptly.

30. He shall personally review the monthly Financial progress reports on the operation of the various undertakings and will comment on any marked variation in revenues and operation or maintenance expenses.

31. The Senior Accounts Officer and the Superintending Engineer should assist each other in rendering the management of departmental accounts as perfect as possible. To this end, during inspections, the Superintending Engineer or the Senior Accounts officer will examine the registers and other account and measurement books, the mode of preparation of estimates, Contractor's accounts and agreements, the system of recording plans and papers and office work generally. He is expected to communicate freely and personally with his officers and to advise them in the performance of their duties.

32. The Superintending Engineer shall review Meter Reading Registers of the following category of services and shall take immediate action to safeguard the Board revenues.

i)	L.T Services (which are not high value) Cat. II.I & VII	:	Annually each section
ii)	L.T. high value services and all industrial services	:	Half yearly
iii)	H.T services with a CMD of less than 1000 KVA	:	Quarterly and check readings for 10 services per month.
iv)	H.T Services with a CMD of 1000 KVA and above	:	Check readings for all services in one year.

33. The Superintending Engineer shall review the following exception reports generated by the Private Accounting Agency / In – house computer, if the service is repeated more than three times in a year and shall take appropriate action to safeguard the Board revenues.

- i) Disconnected services showing progressive readings.
- ii) Negative readings.
- iii) Meter stuck up (H.T and L.T)
- iv) Meter burnt
- v) Services not existing (HV)
- vi) Meter changes
- vii) Low PF in case of H.T services.
- viii) Maximum demand low or high in case of H.T Services.
- ix) Unlettered due to CT/PT or meter defects in H.T Services.

34. The Superintending Engineer shall ensure that the High Value services under disconnection for more than 4 months are dismantled after due procedure.

35. The Superintending Engineer should conduct district wise, sub-division wise, section wise, 11 KV feeder wise, and distribution transformer wise, energy audit, arrive at line losses and take remedial actions to plug the sources of losses and reduce them.

Inspection of Offices and other than offices

- a) Inspection of each Division Office. Once in a year)
- b) Inspection of Electricity Revenue Offices.. One ERO per month
- c) Inspection of SPM sheds. Once in six months
- d) Inspection 33/11 KV sub – stations . Once in a year
- e) Inspection of District Stores ... Once In Three Months

- f) Inspection of H.T. services with CMD of
- i) above 1000 KVA & upto 4 MVA. : Once in a year and whenever abnormalities in metering including failure of metering equipment are reported.
 - ii) Others : Whenever repetitive complaints are received.

IV. SUPERINTENDING ENGINEER (TL&SS)

36. The Superintending Engineering (TL & SS) will be in charge of Operation & Maintenance of all EHT lines and sub-stations of 220 KV and 132 KV.

- a) The Superintending Engineer (TL & SS) should inspect the lines & sub-stations and ensure that the preventive maintenance is being carried out as per norms.
- b) He should ensure that the EHT sub-stations under the control of operation sub-divisions are taken over at the earliest by the respective TL&SS divisions.
- c) He should review the availability of space and T&P for the lines and sub-stations to cater the needs of at least 6 months and come up with proposals to the Chief Engineer / TL & SS for their procurement immediately.
- d) He should arrange for pre-monsoon inspection of all lines in order of priority as per the check lists available and to get the defects rectified on war footing.
- e) He should ensure that Operation & Maintenance estimates are prepared without delay and budget proposals are sent to Chief Engineer/TL&SS.
- f) The Superintending Engineer (TL & SS) should test check of routine patrolling of 25% of the EHT lines once in 12 months.
- g) Inspection of :-
 - (i) EHT Lines ----- Inspection of spot of break down wherever major rectification was done to avoid repetitive nature of such break down.
 - (ii) Inspection of EHT sub-stations ---- Once in quarter

V. SENIOR ACCOUNTS OFFICER

ZONAL OFFICE :

37. The Senior Accounts Officer, Zonal Office is responsible for

- a) Preparation of Revenue and Capital Budgets of the Zone.
- b) Efficient Revenue Administration and control over expenditure.
- c) Accountability for the total revenue and expenditure.
- d) Monitoring the performance of both capital and O&M expenditure.
- e) Compilation of Accounts including annual accounts in the Zone.
- f) Review of Revenue receipts with reference to the budget estimate and review of arrears of Current Consumption charges etc.
- g) Verification of stores and materials in the Zone.

CIRCLE OFFICE :

The senior Accounts Officer will work under the overall supervision of the Superintending Engineer. It will have complete control over the Expenditure and Revenue Branches of the accounts Organization of the circle. He will function as Financial Adviser to the Superintending Engineering, both in Revenue and Expenditure matters and assist the superintending engineer to ensure the efficient working of the circle organization

The senior Accounts Officer in an operation circle will be in charge of Circle accounts (both expenditure and revenue) and will be responsible:-

i) EXPENDITURE:

- a) For the correct maintenance of accounts and rendering monthly accounts promptly to the R.A.I.A.O. and Financial Advisor & Chief Controller of Accounts under his signature.
- b) For the prompt submission of all financial returns to Board and Financial Advisor & Chief Controller of Accounts under his signature, particularly expenditure schedule, Financial progress reports and DCB Statement.
- c) The Sr. Accounts Officer will check and pass all payments exceeding Rs.30,000/-.
- d) While the Accounts Officer (Expr.) will draw cheques upto Rs.50,000/- cheques above Rs.50,000/- will be signed by the Senior Accounts Officer without limit relieving the Superintending Engineer from the responsibility of passing bills and drawing cheques.
- e) The Senior Accounts Officer will have overall control over all branches of accounts of the circle (viz). Revenue, expenditure including stores accounts.

ii) REVENUE :

- a) The Senior Accounts Officer is responsible for correct assessment and prompt realization of revenues of the circle. He should pay special attention for application of correct tariff rates to all services with a view to eliminate short billing etc. by arranging effective internal checks. He should arrange to obtain meter reading registers, test reports promptly from the field and arrange for issue of Current Consumption bills on due dates and ensure that all services are billed without default.
- b) He should ensure that H.T. bills are issued by 26th of the month for 1 MVA and above and on 1st of succeeding month for below 1 MVA services. A monthly return of bills issued shall be submitted to Financial Advisor and Chief Controller of Accounts.
- c) He will review all cases of arrears outstanding for more than one month in the case of H.T. He will review consumption of H.T. consumers monthly with reference to test reports, change of meter, connected loads and additional loads, etc. And more than two months in the case of L.T. Services.
- d) He should arrange for the review of all cases of inadequacy of consumption deposits and arrange for their prompt collections.

iii) INSPECTIONS:

The Senior Accounts Officer will inspect the Division Offices/Sub-Divisions and Sections and Electricity Revenue Offices as below.

a)	Division Offices (Only in the case of Divisions where accounts are maintained)	--	twice in a year
b)	Sub-Division and Section Offices	--	once in a year
c)	Electricity Revenue Offices	--	one ERO per month

During the course of inspections he should check whether the accounts and records are maintained on proper lines, paying particular attention to the maintenance of stores accounts.

Copies of Inspection reports should be sent to the Superintending Engineer/Financial Advisor & Chief Controller of Accounts specifically pointing out grave financial irregularities and lapses and suggest steps to be taken for early regularization of lapses and irregularities.

iv) POWERS :

The Senior Accounts Officer will have overall control of the Accounts personnel in the circle. He will be the countersigning authority for the tour and transfer T.A. bills of Assistant Accounts Officer and Accounts Officer. He will submit his tour programmes and T.A.A bills to Superintending Engineer for approval and counter signature. He will be the reporting officer in respect of Annual Appraisal reports of Accounts Officer.

The Senior Accounts Officer may purchase stationery articles not exceeding Rs.50/- in each case and incur contingent expenditure not exceeding Rs.25/- at a time.

v) GENERAL :

- a) The Senior Accounts Officer will be responsible for the reconciliation of all remittances (Revenue and Expenditure) made into the branches of the banks. He will also reconcile the cheques drawn by himself and by others of the circle. He should obtain necessary statements from the banks daily and ensure that all cheques and DDs received are brought to account. He should pay special attention to audit object, inspection reports of Accountant General and Internal Audit and arrange for their clearance very promptly.
- b) The Senior Accounts Officer should review the initial accounts of the field and ensure their correct maintenance and will watch the timely closing of work orders. He will also be responsible for preparation of the annual accounts at Circle level and for prompt submission to Audit and to Head Quarters.
- c) The Senior Accounts Officer should give prompt attention to consumers' complaints and arrange for prompt action.
- d) The Senior Accounts Officer should arrange for timely supply of adequate quantities of forms, stationery ledgers, registers, receipt books, meter reading registers etc., to all offices.
- e) The Senior Accounts Officer is responsible for seeing that the accounts of the system are not allowed to fall in arrears.

VI. ACCOUNTS OFFICER (EXPENDITURE)

38. As a quasi-commercial concern, the transactions of the Electricity Board demand an effective system of internal administrative check conducted by an Officer of the Circle Office with an intimate knowledge of its working and with better information than that which can be derived from mere compiled accounts and documents. The Accounts Officer (Expr.) is therefore, appointed in the Circle Office for controlling accounts.

39. The Accounts Officer (Expr.) shall be with sound experience of the accounts and administrative office control.

40. The Accounts Officer (Expr.) will be responsible for the direct supervision of all accounting work relating to the undertaking and for all receipts and disbursements. He will be in entire and direct charge of expenditure of the undertaking.

41. His main functions are broadly classified below :-

- i) Financial adviser to the Superintending Engineer.
- ii) Accounts and disbursing officer of the Circle Office Establishment.
- iii) Officer in charge of the internal checks of financial transactions incorporated in the accounts.

42. The Accounts Officer (Expr.) while being under the administrative control of the Superintending Engineer renders accounts to the Financial Advisor & Chief Controller of Accounts through the Superintending Engineer and should act on Financial Advisor & Chief Controller of Accounts instructions in all Audit and Accounts matters in so far as they do not interfere with commercial accounts, and principles. He shall have the status and the general powers of an Assistant Divisional Engineer in addition to other approved by competent authority.

43. He will have full administrative control over the Circle Office Accounts.

44. The duties of the Accounts Officer (Expr.) will be...

- (i) to supervise and be responsible for the maintenance of financial accounts, cost accounts, and other statistical data, other than purely technical, required by the Board;
- (ii) to supervise the office routine generally and be the financial adviser to the Superintending Engineer in all matters affecting the system;
- (iii) to supervise the work of the priced accounts of stores maintained. He will check the stock accounts including physical verification of stores wherever convenient and call for and deal with any excesses or deficits brought to light during the annual stocktaking;
- (iv) to assist and co-operate with the field officers (Divisional Engineers) in tracing and rectification of all wastages and leakages including those arising from mismanagement or negligence or oversight and report on all such items to the Superintending Engineer.
- (v) to take charge of budgetary control including the preparation of the budgets, their reconciliation with actual results and any subsequent enquiry resulting there from;
- (vi) to see that sound financial and accounts organization is maintained throughout the circle;
- (vii) to advise on the financial aspects of all important contracts;
- (viii) to safeguard against fraud; and

45. To ensure a financially sound administrative organization the following test checks may be conducted by the Accounts Officer (Expr.) in respect of facts which are incorporated in the accounts books and which form the basis for proper expenditure. The checks will include amidst other items:

Inspect of imp rest cash and petty purchases from imp rests, occasional inspection of stores where discrepancies are suspected. Such checks will preserve the moral influence and strength of the organization as a whole.

46. The Accounts Officer (Expr.) should present through the Superintending Engineer a clear analysis of the financial position of the undertaking as a whole so that the management may promptly take steps to remedy any weakness in the field organization.

47. He will be responsible for the efficient working of the various sections of the Central Office comprising, Cash, Stores, Costing, Routine, Audit and the General section dealing with the payment and Traveling Allowance bills and also the stores and Work bills. He will co-ordinate the work of various sections and satisfy himself that all the accounts, records and ledgers are maintained up to date, that all he priced ledgers of stores are correctly maintained. He shall report on all outstanding and important points to the Superintending Engineer.

48. It shall be his duty to report on all excess over estimates, deviations from the rules and assist in taking steps for regularization. He shall see that all audit requirements are met in the maintenance of accounts and shall obtain orders of the Superintending Engineer in case of difference of opinion with the Audit Department.

49. It will be his duty to satisfy himself that regulations as regards works, stock and accounts are strictly observed; to watch and compare the rates paid for work and bring to the notice of the superior officer any economies seen from the accounts to be possible.

50. He will be responsible for the correctness of the original records of cash and stores, receipts and expenditure and for submission of complete vouchers from the information supplied by the Field.

51. He shall review the ledgers and registers periodically and satisfy himself that they are maintained neatly and up-to-date.

52. He shall be responsible for the punctual rendering of the accounts of the circle as separately required by the Financial Advisor & Chief Controller of Accounts.

53. The Accounts Officer (Expr.) is responsible for seeing that the accounts of the system are not allowed to fall into arrears; but if arrears or confusion arise he shall report to the Superintending Engineer with his recommendations for such action as is needed.

54. Claims of all kinds of Circle Office Establishment except those for petty payments to be made out from imp rest will be checked in the Circle Office and paid by cheques.

NOTE:

- 1) The Accounts Officer (Expr.) will draw pay bills of all staff of the Circle Office Establishment and will be responsible for the maintenance of service books, leave accounts etc. He should see that the sanctioned scales are not exceeded without proper authority.

All traveling allowance bills will be checked and passed by him provided they are countersigned by the Controlling Officers.

- 2) All others bills exceeding Rs.2500 e.g., Bills of suppliers for stores, etc., Contractor's bills on running account upto Rs.30,000 will be checked in the Circle Office and paid by him. The check shall be with reference to the usual rules of check measurement, agreement, Local Purchase Orders and sanctioned estimates, etc.
- 3) The Accounts Officer (Expr.) should submit to the Superintending Engineer a monthly return of outstanding bills (both receipts and disbursements) delayed beyond the time limits prescribed with brief explanations for the delay and steps taken to clear the outstanding items.

55. The Accounts Officer (Expr.) of the Circle is generally responsible (under the orders of the Superintending Engineer) not only for the financial regularity of the transactions of the whole Circle but also for the maintenance of the accounts of the transactions correctly in accordance with the rules in force. He is further required to submit the accounts to the Financial Advisor & Chief Controller of Accounts.

56. The responsibilities of the check of receipts in the Board lies entirely with the departmental officers. But a test audit of the receipts of Electrical Undertakings of the Board is conducted by the Account-General

VII. ACCOUNTS OFFICERS/REVENUE:

57. All Circle offices are now being provided with Accounts Officer (Revenue) essentially to inspect, co-ordinate and report on the functioning of the Electricity Revenue offices in the Circle. While they are to assist the Superintending Engineer (Operation) and Senior Accounts Officer in the efficient functioning of the Electricity, Revenue Offices. They have an important role in keeping the Member (Accounts) and the Board through the Dy. Chief Controller of Accounts (Revenue) fully posted, without any delay, all important developments, defects, deficiencies, omissions, commissions not only in the Electricity, Revenue Offices and the private agencies, (Accounting and collection) but also in all aspects having relevance to LT.. revenue aspects of the functioning of various offices in the circle and in particular the sections whose response in the furnishing of test reports meter readings, distribution of cards/Bills, affecting disconnections, etc., has a direct impact on Board's revenue. The Accounts Officer (Revenue) should consider his basic responsibility to ensure that, in the matter of L.T. billing, collections and accounting, there is consumer satisfaction and protection of Board's interest. He should discharge the responsibility internal in by

- a) Inspection of Electricity Revenue Offices one per month and Sections (Revenue related aspects) and Revenue Cashiers, (Surprise inspections) to cover them at least in an year with a quarterly programme of inspecting with the approval of Superintending Engineer (Operation).
- b) Keep himself constantly and regularly posted with all developments in these offices, have information on the state of records, progress of collection, performance of private agencies, computerization, bottlenecks in effective collection and urgent disposal of consumer complaints and issue suitable directions through Superintending Engineer (Operation) and ensure their effective implementation.
- c) Keep the Member (Accounts), through Dy. Chief Controller of Accounts (Revenue) fully posted through returns prescribed below or any other information and company without delay any direction given by him.

The following monthly returns shall be submitted to Member (Accounts) through Dy. Chief Controller of Accounts (Revenue) by the 15th of the month.

1. Programme of inspection and dates of actual inspection done in the previous month including particulars of surprise inspection of revenue cashiers.
2. A resume of the main points noticed in these inspections as per the inspection report issued or otherwise, in respect of inspection conducted in the second proceeding month, with action taken.
3. Progress report on engaging and performance of an computerization by private accounting agencies at the end of the previous month.
4. Report on the engagement and performance of each of the private collection agencies as at the end of the previous month.
5. Spot light report on the high value, non-slab services in the proforma prescribed on receipt and registration of separate monthly list of new services released, regularly in meter reading, billing, collection, enforcement and review of Disconnection lists and exception reports.
6. Exception reports as per list enclosed on L.T. Slab-Services including in billed services.
7. Sales and Revenue return.
8. Monthly DCB provisional.
9. Consumer complaints not disposed off for over one month.
10. Reports on monthly co-ordination meetings held in the circle.
11. Any other prescribed return.
12. Shall review the working of EROs in detail at least once in 2 months and apprise the Divisional Engineer concerned with the review report with a copy to Superintending Engineer/Operation.

VIII. ASSISTANT ACCOUNTS OFFICER (CIRCLE OFFICE)

- 58.
1. The Assistant Accounts Office is appointed mainly to give relief to the Accounts Officer (Expr.). He will assist the Accounts Officer (Expr.) in all matters and will take over from the Accounts Officer (Expr.) such duties and functions and may be allotted to him by the Superintending Engineering.
 2. He is the immediate officer under Accounts Officer (Expr.) in-charge of the circle office staff, will assist the Accounts Officer (Expr.) and act under his orders in exercising administrative control over the Circle Office staff under him.
 3. He can correspond with all officers of the system direct in accounts matters and in other matters, he will act on behalf of the Superintending Engineer and Accounts Officer (Expr.) under their instructions and authority.
 4. The duties of the Assistant Accounts Officer will be -----
 - (i) to supervise, subject to general review by the Accounts Officer (Expr.) and the Superintending Engineer to be responsible for the maintenance of financial accounts, cost accounts and other statistical data required by the administration.
 - (ii) to assist the Accounts Officer (Expr.) in supervising the office routine generally.
 - (iii) to supervise the work of the priced accounts of the stores maintained
 - (iv) to assist the Accounts Officer (Expr.) in the matter of budgetary control including the preparation of the budgets, their reconciliation with actual results and any subsequent enquiry resulting there from.
 - (v) to assist the Account Officer (Expr.) in seeing that a sound financial and accounts organization is maintained throughout the system.
 - (vi) to assist the Account Officer (Expr.) in safeguarding against fraud.
 5. The Account Officer (Expr.) will be responsible for the efficient working of the various sections of the circle office comprising cash, costing, routine audit, and general section dealing with the payment, and traveling allowance bills and also the stores and work bills. The Asst. Account Officer will be responsible for the proper work of ledger section, accounts section and stores section. The Account Officer (Expr.) and the Asst. Account Officer will coordinate the work of the various sections under their control and satisfy themselves that all accounts records and legers are maintained upto date. The Assistant Account Officer will be responsible to see that all the priced ledgers of stores are correctly maintained and that all outstanding points are brought to the notice of the Account Officer (Expr.) and the Superintending Engineer.
 6. The Assistant Account Officer should bring to notice of the Account Officer (Expr.) all excesses, over estimates and deviations from the rules and regularize them by obtaining orders of competent authority.

7. The Assistant Account Officer will exercise the following powers in respect of passing of bills and payments

- (i) All work establishment rolls countersigned by the Assistant Divisional Engineers will be passed by him, provided they are covered by sanctions.
- (ii) All actual expense bills of the O&M and construction staff of Circle Office will be passed by them provided they are counter signed by the Assistant Divisional Engineer concerned.
- (iii) All imp rests will be checked and passed for payment if they are countersigned by the Assistant Divisional Engineers. The vouchers will be admitted by the Assistant Account Officer. Any violation of the departmental rules or extravagant expenditure should be reported to the Account Officer and Superintending Engineer.
- (iv) All other bills e.g., stores bills, firm's bills for articles purchased for stocks, refunds of amounts relating to L.T. Supply e.g. refund of service connection deposits, excess collections, arrears of wages etc., will be passed by him upto Rs.2500 for each bill subject to usual rules of check-measurements, L.P.Os and sanctioned estimates and check-measurement of the Assistant Divisional Engineer when required. He will draw cheques upto Rs.10,000/- in respect of all types of bills and bills of exchange upto Rs.10,000/-.
- (v) He will conduct a cent per cent check of the entries on the payments side of the cash book daily in addition to the check done by the Junior Accounts Officer. For this purpose he will be deemed to be Disbursing Officer within the meaning of paragraph 165 of Andhra Pradesh Public Works Account Code.

IX. DIVISIONAL ELECTRICAL ENGINEER

59. The technical and executive unit of the system is the division in charge of a Divisional Electrical Engineer who is responsible to the Superintending Engineer for the execution and management of all technical and field works in his jurisdiction. The Divisional Engineer is also expected to assist in the commercial work and to keep himself and the superintending Engineer informed of all commercial, industrial and rural development. He will co-operate with the Senior Accounts Officer of the System and give him all legitimate support in rendering the management of the accounts of the Division as efficient as possible. He will be responsible to see that prompt attention is paid by all this staff in complying with the instructions issued from the Circle Office on all financial and accounting matters.

60. He will generally control and will appoint and also dismiss in the case of the work charged establishments for the works in his charge.
61. The Divisional Electrical Engineer is responsible for seeing that proper measures are taken to preserve all the buildings and works in his charge. He must keep accurate plans of all Board lands borne on the registers of the Electricity Board and ensure that his subordinates are acquainted with the boundaries.
62. All lands should be demarcated, wherever that has not been done, and this work should be carried out by the subordinates of the Electricity Board in consultation with the Officers of the Revenue Department.
63. He should report immediately to the Superintending Engineer any serious loss of immovable property caused by any accident or unusual occurrence in accordance with the rules in force as required by the Andhra Pradesh Financial Code.
64. He should conduct investigation in all departmental fatal accidents within five days and send investigation report within 15 days from the date of accident to the Chief Engineer/Operation, Zonal Chief Engineer and the Superintending Engineer.
65. He is responsible for the Engineering features of designs and the rates in estimates prepared or forwarded by him.
66. He is prohibited from commencing any work, or spending any public funds without, the sanction of the competent authority or from making any other than trifling deviations from sanctioned designs in the course of execution except in the case of emergency.
67. All interruptions of works in progress or to the electric power service should be immediately reported by the Divisional Engineer to the Superintending Engineer, the causes and the probable duration of such interruptions being duly explained.
68. The Divisional Engineers are in entire charge of all the Works, Stores, etc., in their jurisdiction and to this end it is their duty to see that the administration is financially sound within their areas.
69. He should check measure all important works in his area and at least 24 works in a year and maintain a register for the purpose and produce it to Audit.
70. He should see that the initial accounts of works are properly maintained by the Assistant Divisional Electrical Engineers or Section Officers and that the works accounts are not long kept open by the Field Officers to admit of slow creeping in of discrepancies ; in the accounts.

71. The Divisional Engineer shall review Meter Reading Registers of the following category of services and shall take immediate action to safeguard the Revenues of the Board.

i)	L.T. Service (which are not high value) Cat, I, II and VII	:	Half Yearly
ii)	L.T.H.V. Services and all Industrial	:	Quarterly and check readings 40 per month.
iii)	H.T. readings 1000 KVA & below	:	Monthly and check readings of all services in one year.

72. The Divisional Engineer shall review the following exception lists generated by the PAA/In-house computer, if the services is repeated more than 3 times in a year and shall take appropriate action to safeguard the Board revenue.

- 1) Consumption too high (over 120% of month) (H.V. Services)
- 2) Consumption too low (below 80% of month) (H.V. Services)
- 3) Readings not furnished
- 4) Door lock
- 5) Disconnected services showing progressive readings (L.V. Services)
- 6) Negative readings (L.V. Services)
- 7) Comparison of consumption for similar units per HP
- 8) Meter stuck up (L.V.)
- 9) Burnt (L.V.)
- 10) Not exits (L.V.)

73. The Divisional Engineer should conduct sub-division wise, section wise, 11 KV feeder wise and distribution transformer wise, energy audit, arrive at line losses and take remedial actions to plug the sources of losses and reduce them. He should also furnish division losses to Superintending Engineer/Operation concerned.

74. The Divisional Engineer is the administrative head of the EROs. The Divisional Engineer should conduct monthly coordination meetings with ERO Staff and field officers and these meetings should be purposeful and effective and should aim at improvement of performance and increase in revenue collections of the division. The Divisional Engineer should also inspect one ERO/sub-ERO in a month to satisfy himself that the internal checks prescribed for various activities in billing, assessment of revenue, realization of revenue etc. are strictly implemented.

75. The Divisional Engineer should also inspect all the sub-division offices once in a year, 33/11 KV sub-stations once in six months. H.T. services upto 1 MVA as CMD once in six months and conduct intensive inspections by polling up all the Assistant Divisional Engineers and Section Officers of the Division for not less than two days in a month. He should also conduct detailed investigation of theft of material cases involving more than Rs.5,000/- and upto Rs.10,000/-.

X. DIVISIONAL ENGINEER (TECHNICAL)

ZONAL OFFICE

76. The following are the duties and responsibilities of the Divisional Engineer (Technical) to the Zonal Chief Engineer.
- a) Providing the information in respect of all technical matters in operation and Maintenance of system in the Zone.
 - b) Review of failure of equipment and follow up for repairs.
 - c) Review of Line losses in the Zone
 - d) Obtaining and providing necessary information in planning and formation of commercial schemes for village electrification.
 - e) Review of preparation of various schemes for village electrification.
 - f) Monitoring of execution of construction works including system improvement schemes.
 - g) Inventory control and review of stock levels.
 - h) Effective utilization of materials throughout the Zone
 - i) Procurement of materials, excluding centralized stores purchases.

Circle Office

The following are the duties and responsibilities of the Divisional Engineer (Technical) to the Superintending Engineer.

- a) The Divisional Engineer (Techl.) will look after the Technical, Commercial Purchase & Administration Wings of the office of the Superintending Engineer/Operation.
- b) The Divisional Engineer (Techl.) will effectively co-ordinate with the other Divisional Engineers in the field in respect of all important matters including replacement of all types of defective meters, monitoring, replacement and purchase of spares and repairs of all types of failed transformers in co-ordination with the Divisional Engineer / M.R.T.
- c) The District stores will be under the administrative and Technical control of the Divisional Engineer (Techl.) of operation circles where stores is situated in Circle Head quarters, and in case the stores are not situated at the Head quarters of the Operation circles, the territorial Divisional Engineers/Operation shall carry out the functions of the Divisional Engineer/Technical in order to effectively check measure, judicious control in the issue of materials. He must send all returns in respect of the Stores to the concerned, Check-measurement of Power and Distribution transformers, Meters, Switchgear, metering cubicles, C.Ts and P.Ts received in the District stores will however be done by the Divisional Engineers / M.R.T. of the respective circles.

- d) The Divisional Engineer (Techl.) Operation Circles will also exercise the Powers exercised by other field Divisional Engineers in respect of their functions.
- e) The Personnel Officer in the Central Office will also work under the administrative control of The Divisional Engineer (Techl.)
- f) He should conduct surprise checks and ensure that R & C orders notified by the Board from time to time are strictly implemented by the field Officers.

XI. DIVISIONAL ENGINEER (METERS & PROTECTION)

77. H.T. METERING :

- 1. To draw a calendar of testing of all H.T. services and see that the periodical testing of H.T. services is implemented. He, should ensure that the seasonal loads like ice factories, khandasari, sugar factories etc. are programmed for testing during the first month of the commencement of the season.
- 2. To attend personally periodical testing of meters with CMD 1000 KVA and above.
- 3. To inspect all H.T. service with a contracted demand (CMD) 1 MVA and above once in six months and H.T. services with CMD above 500 KVA but below 1 MVA once in a year and ensure that all the guidelines given by the Board from time to time for upkeep of H.T. services is implemented.
- 4. To inspect all H.T. services where metering system is reported failure and get the defective metering rectified and metering restored within 24 hours preferably but not later than a period of seven days.
- 5. To attend personally the testing and release of all new H.T. service and ensure that all the guide liens issued by the board from time to time for upkeep of H.T. services is implemented.

L.T. METERING:

- 6. To draw a calendar and ensure periodical testing of L.T. services with C.T's once in a year.
- 7. To ensure that all meters received in stores is tested as per standards
- 8. To procure required spares and arrange rectification of all sick meters.
- 9. To maintain vendor rating of all H.T. and L.T. meters.
- 10. To maintain rolling, stock of H.T. meters, L.T. meters, C.Ts, P.Ts. C.T.P.T sets.

SUB-STATIONS:

11. To ensure that all the relays in the substations are tested once in every year
12. To approve the relay settings at all 33/11 KV substations considering the fault levels and relay settings approved by Superintending Engineer/Grid Operation for upstream of the equipment.
13. To ensure testing of all meters at the substation since in six months particularly the energy meters for proper energy audit.
14. To test and commission the protective equipment of all breakers, power transformers, capacitor banks etc.
15. To test the vacuum circuit breakers with HV test kit once in a year.
16. To inspect all substations once in six months and check earth resistance, condition of station batteries and chargers etc.

XII. DIVISIONAL ENGINEER (TRANSFORMER)**78. POWER TRANSFORMER:**

1. To conduct a joint inspection of all failed power transformers, breakers, etc, and determine the extent of damages and cost of repairs.
2. To ensure that all the failed power transformers and other equipment are repaired within three months from the date of failure by pursuing with companies and headquarters.
3. To arrange movement of power transformers and replacement of power transformers at the substation. To personally attend to handling of power transformers of 5 MVA and above capacity during loading, transport and erection etc.
4. To inspect all the private power transformer repairers frequently, not less than once in two months and ensure quality of repairs.
5. To ensure that all the thermos meters of power transformers are working correctly and to arrange calibration of all the thermos meters and checking operation of buckholz relays once in a year.
6. To arrange filtration of oil whenever oil testing warrants it or at least once in 3 years.
7. To check O.L.T.C. oil condition and replace it if required.
8. To attend the oil leakages and other complaints of power transformer promptly.

DISTRIBUTORS TRANSFORMER

9. To maintain a rolling stock of failed distribution transformers and arrange for survey reporting of units which are non-repairable.
10. To ensure that failed distribution transformers are repaired within 30 days.
11. To check up repairs of distribution transformers at various contractors and SPM centers for proper quality of repairs and also check up actual works done with reference to assessments and joint inspection done by Assistant Divisional Engineers and ensure that the weights of coils replaced, work done etc.
12. To inspect all SPM centers and contract repair unit and ensure that the testing equipment is in good working condition and testing of all the required units is performed as per standards.

SUBSTATIONS

13. To investigate failure of all equipment like power transformers, breakers and capacitors banks etc. by inspecting the installation within 48 hours of failure and send a detailed investigation report to the headquarters.
14. To inspect all substations once in a quarter if the substation capacity is 8 MVA and above and once in six months for lower capacity substations and send a detailed report on the maintenance of the equipment and the substation.

XIII. ASSISTANT DIVISIONAL ENGINEER

79. An Assistant Divisional Engineers is in charge of works, operation, distribution (including commercial activities) or construction, as the case may be, in the area assigned to his charge and he is responsible to the Divisional Engineers (or Superintending Engineer, as the case may be) for the efficient discharge and management of the departmental activities in his area. He is also responsible for furnishing to the Circle Office correct information and data in respect of all financial matters, budgets, expenditure and revenue whenever called for
80. The Assistant Divisional Engineers will be responsible for seeing that the transfer reports of Section Officer are complete in all respects thorough and should ensure that the newcomer perfectly understands his duties.
81. Designs and estimates for all works proposed by him for replacements, additions or improvements will be prepared by the Section Officer and submitted to Divisional Engineers who will scrutinize and submit them complete shape to the Superintending Engineers.

Note: Subject to the rules and orders in force from time to time the Assistant Divisional Engineer is personally responsible for methodical organization of the operation, maintenance and construction works in his charge. He should see that the lorries are properly maintained and should check their proper use. The daily lorry reports shall be scrutinized by the Assistant Divisional Engineer and the lorry log statements will be certified by him.

The Assistant Divisional Engineer will submit monthly progress reports to the Divisional Engineer.

82. It will be the duty of the Assistant Divisional Engineer to regulate expenditure with economy and he should in no case exceed his budget allotments or the estimate amounts without the orders of the Superintending Engineer which should be obtained through his Divisional Engineer.
83. If any excess is seen to be unavoidable during the progress of a work he should submit details to the Divisional Engineer promptly who will make his recommendations to the Superintending Engineer for extra funds. Savings foreseen should also be dealt with in a similar manner. Copies of usual communications should be sent simultaneously to the Circle Office.
84. Accidents : He should inform all fatal accidents Department and non-departmental immediately after occurrence of accidents by means of telegram/telephone/fax to the concerned authorities. The same procedure to be followed in case of fatal accidents to Animals also. He should submit preliminary reports on all accidents departmental fatal/non-fatal, non-departmental fatal/non-fatal to the concerned authorities within 24 hours. He should also submit detailed report to C.E.I.G. Chief Engineer/Operation concerned Electrical Inspector, Superintending Engineer and Divisional Engineer/Elec. Within 72 hours (3 days) in all accidents cases mentioned in (ii) above. In departmental non-fatal cases, non-departmental fatal/non-fatal cases, he should submit within 15 days investigation reports to Chief Engineer/Operation/Zonal Chief Engineer with copies to Superintending Engineer and Divisional Engineer.
85. An Assistant Divisional Engineer will normally deal with all technical matters in regard to L.T. consumers and H.T. distribution lines, but should obtain the orders of Divisional Engineer in important matters.
86. He will check and see that the instructions from the Circle Office are complied with promptly. He should ensure prompt action being taken on consumers arrears and disconnection notices issued by the Assistant Accounts Officer/E.P.O. Any abnormal conditions (including arrears) will be reported to the Divisional Engineer who will report to the Superintending Engineer, if necessary.
87. Statutory inspection of lines : The Assistant Divisional Engineer is authorized to conduct statutory inspection of lines under Indian Electricity Rule 63 and no line should be charged without conducting inspection. The statutory inspection report should be conducted in the prescribed proforma vide Annexure – A'.

ANNEXURE – A
INSPECTION REPORT OF H.T. LINES AND I.T. LINES

1. Name of Inspection Officer and Designation :
2. Date of Inspection :
3. Name of H.T. lines :
4. If a main line S.S. for which it is taken off, if a spur line, name of main feeder and tapping pole No. :
5. Length of line :
6. Voltage of operation :
7. Mechanical Strength
 - a) Type of support :
 - b) Span :
 - c) No. of conductors carried with their sizes :
 - d) Sag Given :
8. Clearances
 - a) Maximum of Ground clearance :
 - b) Clearance to buildings near line horizontal vertical :
 - c) Clearance to Trees :
 - d) Clearance to road level :
 - e) Clearance between phase and phase :
 - f) Whether accessible to un-authorised persons without need of special device :
 - g) Clearance between H.T. and L.T. if carried on same post :
 - h) Clearance between power and guard line :
 - i) Clearance between phase and Metal part and strain point :

9. Guarding Arrangements
 - a) Is guarding provided between H.T. and L.T. carried on same poles :
 - b) Is guarding provided over :
 - c) Earthing of guard wire :
 - d) Size of guard wires – Mechanical Strength :
 - e) Are the guard wires of sufficient current carrying capacity to conduct fault currents without fusing :
10. Protection
 - a) Protection against lighting :
 - b) Earthing (Every 4th pole) :
 - c) Bridling provided at road crossings :
 - d) Any likelihood of getting charged at a higher voltages than for which it is designed :
 - e) Strength of Insulator :
 - i) Electrical :
 - ii) Mechanical :
 - f) Protection against bird faults if any needed :
 - g) Isolating switch or fuse provided :
11. General
 - i) Danger Boards :
 - ii) Any defective construction requiring to be rectified :

88. The Assistant Divisional Engineer is responsible for the general condition of the tools and plant and stores in his area and for the proper maintenance and due submission of the respective accounts by his subordinates. He shall report on all excesses or surpluses and take action on all unserviceable items and for this purpose review the condition of tools and plant and stores not less than once a year.
89. The Assistant Divisional Engineer shall review meter reading registers of the following category of services and shall take immediate action to safeguard Board's revenue.
- | | | |
|----|--|---|
| 1. | L.T. Services (which are not high value) :
Cat I, II and VII | Quarterly and 100 check
readings per month |
| 2. | L.T. High Value services :
(Cat. I, II & VII) and all industrials | Monthly and check
readings 40 per month |
| 3. | All H.T. services below 1000 KVA : | Monthly readings |
90. The Assistant Divisional Engineer should review the following exceptional lists generated by the PAA/-in-house computer, if the service is repeated more than two items in a year, and shall take appropriate action to safeguard the Board revenue.
- | | |
|-----|---|
| 1. | Consumption too high (over 120% of normal) |
| 2. | Consumption too low (below 80% of normal) |
| 3. | Reading not furnished |
| 4. | Door lock |
| 5. | Disconnected services showing progressive readings |
| 6. | Negative readings |
| 7. | Comparison of consumption for similar units per HP |
| 8. | Meter stuck up |
| 9. | Meter burnt |
| 10. | Not existing |
| 11. | Meter Changes |
| 12. | Under disconnection for more than 3 months to be dismantled |
91. a) The Assistant Divisional Engineer should conduct Section wise, 11 KV feeder-wise and distribution transformer wise, energy audit, arrive at line losses and take remedial actions to plug the sources of losses and reduce them. He should also furnish sub-division losses to the Divisional Engineer/Operation concerned.
- b) The Assistant Divisional Engineer should inspect all 33/11 KV sub-stations in his jurisdiction once in a quarter.
- c) All high value services of 35 HP and above should be inspected once in a quarter and a quarterly return shall be sent regularly before 5th of the month succeeding the quarter, to the Member (Distribution) by the Superintending Engineer/Operation.

- d) The Assistant Divisional Engineer should inspect the Section Offices once in a year.
- e) The Assistant Divisional Engineer should review A form register i.e. Pending Service Connection Register once in a month.
- f) The Assistant Divisional Engineer should ensure that sealing of AB switches of all IIT services.
- g) He should attend all Court cases on behalf of Superintending Engineer/Operation/ Board.
- h) He should conduct detailed investigation in respect of theft of material cases less than Rs.5,000/-.

XIV. ASSISTANT ENGINEER/ADDITIONAL ASSISTANT ENGINEER (SECTION OFFICER)

92. The Section Officer who may be an Assistant Engineer or Additional Assistant Engineer has to assist superior officer who is normally an Assistant Divisional Engineer in carrying out Board works. The section Officer will normally deal with all technical matters in regards to LT. Consumers, H.T. and LT.T. distribution line and connected equipment.

The Section Officer is primarily responsible for :-

- a) Prompt disposal of pending service connection applications.
- b) Taking meter readings before 10th of the month and send the meter readings registers to ERO by 11th of the month after due review, prompt replies to the exceptional lists communicated by P.A.A./In-house computer, ensuring that the meter readings in full shape are made available to P.A.A./Inhouse computer by 20th at least.
- c) Taking check readings 1% per month in case of L.T. services (which are not high value) Cat. I, II and III.
- d) Taking monthly readings for all L.T. high value services and all industrial services in his jurisdiction.
- e) Prompt action in disconnecting the services included in the defaulter list and in returning the Disconnection list.
- f) Prompt action in arranging to serve the Current Consumption charges bills to the consumers well before 1st of every month.
- g) Ensuring that accidents are avoided by providing safety appliances to all O&M staff in his jurisdiction and in case of accidents, he should report the matter immediately to the Assistant Divisional Engineer.

- h) Conduct 11 KV feeder wise and distribution transformer wise, energy audit, arrive at line losses and take remedial measures to reduce them.
- i) Prompt action in submitting the collections made through Demand Drafts towards Service Connection charges, Consumption Deposits etc. to the Division Office/ERO.
- j) Maintaining initial accounts of the work orders received.
- k) Closing the work orders promptly.
- l) Maintaining the account for the consumable drawn from Assistant Divisional Engineer.
- m) Maintenance of all general records in office as indicated in Appendix-X.
- n) To carry out maintenance of equipment and lines as per the schedule, vide Annexure B and C.
- o) Ensuring that guarding between power line and P&T lines are in existence and the following ground clearances are to be maintained for the Over Head lines as per rule 77 of Indian Electricity Rules 1956.

Ground Clearances

Location of the Line	Low & Medium Voltage	High Voltage
Across the Street	5.8 meters	6.1 meters
Along the Street	5.5 meters	5.8 meters.

Lines erected elsewhere other than the above two cases :

- a) For low, medium & high voltage lines upto and including 11,000 volts, if bare 4.6 meters
- b) For low, medium & high voltage lines upto and including 11,000 volts, if insulated 4.0 meters
- c) For high voltage lines above 11,000 volts 5.2 meters

ANNEXURE - B

SCHEDULE FOR PATROLLING OF L.T., 11 KV AND 33 KV LINES

Sl. No.	Particulars of line with voltage	Routine patrolling		Test checking of routine patrolling 25% of the lines		Responsibility of getting reports submitting (not resubmitting reports to immediate higher officer) and carrying out repair work rests with	Responsibility of checking repair work, after repairs are carried out rests with	Premonsoon Inspection		Remarks
		Cadre	Periodicity	Cadre	Periodicity			Cadre	Periodicity	
1	2	3	4	5	6	7	8	9	10	11
1.	All pole lines in distributions 400 V	J.L.M.	Fortnightly	Lineman	Once in two months	Line Inspector	Section Officer	Line Inspector or	Annually	
2.	All pole lines above 400 V upto and including 11 KV	Lineman	Monthly	Section Officer	Three months	Line Inspector	Section Officer	Section Officer	Annually	
3.	All pole lines 33 KV	Lineman	Once in two months	ADE	Once in 4 months	Section Officer	ADE	ADE	Annually	

Note:

- 1) Whenever special patrolling is done after a trip out, routine patrolling may be done after fortnight from the date of such patrol.
- 2) Premonsoon inspection of items, 1, 2 & 3 is to be taken up by staff independent of the regular O&M staff and finalised in a short time so that rectification can be carried out before the monsoon sets in. This is to be done by actual climbing up all the poles and towers.
- 3) While patrolling the instructions issued separately should be followed.
- 4) Test checking should be conducted immediately after routine patrol and large type binoculars should be used.
- 5) Whenever the Section Officer, Assistant Divisional Engineer or Divisional Electrical Engineer conducts the test check on the routine patrolling the party should consist of only the officer concerned and a peon if considered necessary and no body else shall normally accompany the party.

SCHEDULE FOR PATROLLING OF E.H.T. LINES Viz 66 KV, 132 KV and 220 KV LINES

Sl. No.	Particulars of the with voltage	Routine patrolling 50% of all the lines		Test checking of routine patrolling of 25% of line	
		Cadre	Periodicity	Cadre	Periodicity
1.	2.	3.	4.	5.	6.
1.	66 KV Line	L.M./L.I./F.M	Once in two Months	A.D.E.	Once in four Months
2.	132 KV Line	L.M./L.I./F.M	Once in two Months	A.D.E.	Once in four Months
		Section Officer	Once in Six Months	D.E. S.E.	Once in six Months Once in twelve Months
3.	220 KV Line	Section Officer	Once in two Months	D.E. S.E.	Once in six Months Once in twelve Months
		A.D.E.	Once in four Months		

Note:

- 1) Immediately after a trip out on fault, the Section Officer should arrange for special patrolling in the stretch under his jurisdiction and send a report to the Assistant Divisional Engineer and Divisional Engineer in three days.
- 2) Points which are to be seen during the patrolling are given in the Annexure – 2.
- 3) In addition to the above the Divisional Engineers should inspect all the following important points once in a year on 220 KV lines.
 - a) Tower footing resistances at the locations where flash over discs are reported.
 - b) Vertical and horizontal clearances, where the clearances are minimum and exemption is accorded for the lower clearances.
 - c) Members of the Towers at 10% of the line specially near the village side and road side.
 - d) Jungle clearance wherever thick growth is expected.
- 4) Assistant Divisional Engineers should inspect the above items on 132 KV lines at least once in six months.
- 5) Premonsoon inspection of item 2 and 3 should be arranged by the Divisional Engineer Electrical through staff independent of the regular operation and maintenance staff and should be finished in a short time so that rectification can be carried out before the monsoon sets in. this can be done by engaging additional staff.
- 6) The rectifications should be carried out by –Hot Linell Crew wherever possible.

ANNEXURE – 2

POINTS TO BE OBSERVED DURING PATROLLING OF TRANSMISSION LINES 66 KV, 132 KV AND 220 KV

- 1) Insulators :
 - a) Broken
 - b) Chipped
- 2) Condition of joints if there is any (burnt, black marks or cut stands)
- 3) Vibration Dampers :
(Items 1 to 3 may be checked by binoculars)
- 4) Tower Members: Missing members
- 5) Drainage arrangements at the locations where revetments are provided.
- 6) Clearance :
 - i) Vertical
 - ii) Horizontal
 - iii) Tree clearance

Whenever doubt arises by mere observations, this should be investigated further by making a note and taking actual measurement during shut downs.

- 7) Maintenance of roads and foot-paths specially made for patrolling
- 8) Bird nests
- 9) Conditions of guys where provided
- 10) Condition of paint in the case of painted supports.
- 11) Any Foreign material on the towers or the conductors

Note : The Section Officer should send a report after patrolling in three days to Assistant Divisional Engineer.

ANNEXURE – C

Maintenance schedule for distribution transformers :

Sl. No.	Name of the work to be carried out	Persons responsible to do the work	Persons responsible to ensure that it is done
I	Monthly items:		
	a) Maintaining Distribution Transformer yard and keeping the earth pits tidy and watering of earth pits.	Area L.M.	Area L.I.
	b) Cleaning the transformer including the bushings	Area L.M.	Area L.I.
	c) Checking up of oil level and reporting if it is low	Area L.M.	Area L.I.
	d) Checking for oil leaks and reporting	Area L.M.	Area L.I.
	e) Checking of earth connections	Area L.M.	Area L.I.
	f) Reconditioning breather to reactivating silica gel or replacement and maintaining oil seal	Area L.M.	Area L.I.
	g) Checking the L.T fuses and renewing them	Area L.M.	Area L.I.
	h) Topping up of oil where necessary	Area L.M.	Area L.I.
II.	Quarterly items:		
	a) Renewing the HS fuses	Area L.M.	Area L.I.
	b) Measurement of insulation resistance and recording HV to E, LV to earth, and HV to LV with 1000 V Muggger and recording along with temperature of the winding	L.I.	A.D.E.
	c) Measurement of load current R-ph, Y-ph, B-ph and neutral	A.E.	A.D.E.
	d) Measurement of voltages at the transformers and at tail and of L.T. feeders and noting down RY YB BR RN YN & BN	A.E.	A.D.E.
III.	Annual items		
	a) Lubricating AB switch and checking for proper operation	L.M.	L.I.
	b) Checking line and earth connections at AB Switches	L.M.	L.I.
	c) Checking line and earth for lightening arrestors	L.M.	L.I.
	d) Checking connections for HV and LV bushings including LV neutral	L.M.	L.I.
	e) Getting oil samples tested for Breakdown and acidity and recording	L.I.	A.E.
	f) Measurement of earth resistance	L.I.	A.E.

- d) For extra high voltage lines

Shall not be less than 5.2 meters plus 0.3 meter for every 33,000 volts or part thereof by which the voltage of the line exceeds 33,000 v. Provided the minimum clearance along or across the street shall not be less than 6.1 meters.

Clearance for Buildings:

Voltage of the O.H. Line	Vertical clearance when the line passes above the structure	Horizontal clearance when the line passes adjacent to the structure
Low and Medium Voltage	2.5 meters	1.2 meters
High voltage lines upto and including 33,000 V	3.7 meters	1.2 meters (upto & including 11,000 V) 2.0 meters (Above 11 KV & upto and including 33 KV)
Extra High Voltage lines	3.7 meters + 0.3 meters for every additional 33,000 volts or part thereof.	2.0 meters plus 0.3 meters for every additional 33,000 volts or part thereof.

- p) Conduct pre-monsoon inspection for both H.T and L.T lines during the month of May and rectify the defects noticed at the time of pre-monsoon inspection before commencement of monsoon. The items to be inspected during inspection are indicated in Annexure D'.
- q) contacting periodically the consumers in various locations to find out the continuity of supply, voltage conditions and allied problems connected with supply.
- r) Review of interruptions of all L.T and H.T lines, blowing of transformer section / H.G fuses and take remedial measures to avoid re-occurrence.
- s) Ensuring that stay sets are provided with guy insulators.
- t) The Section Officer should promptly attend the Breakdowns of lines and equipment and the breakdown reports on lines should be as per the Annexure E' and F'. The maintenance register of distribution transformers, power transformers, and sub-station equipment must be reviewed as per the periodical schedule. The failure of equipment must be reported to Assistant Divisional Engineer immediately so that the Assistant Divisional Engineer may submit the reports within 24 hours to the higher authorities as per the Annexure G' and H'.
93. The Section Officer should review the following exceptional lists generated by PAA/in house computer and should take prompt action to attend the same to safeguard the Board revenue.
- I) Readings:**
1. Consumption too high (over 120% or normal)
 2. Consumption too low (below 80% or normal)
 3. Readings not furnished
 4. Door lock
 5. Disconnection service showing progressive readings
 6. Negative readings
 7. Comparison of consumption for similar units per H.P.
- II) Meter Defects**
1. Stuck up
 2. Burnt
 3. Not existing
 4. Meter change
94. The Section officer should prepare the handing over report as per Appendix XIV of APSEB Manual Vol.II whenever he is transferred.

ANNEXURE – D

PRE – MONSOON INSPECTION

This is done before the onset of monsoon which is the severest operating season for the overhead lines. Inspection is done by climbing each support after making the lines dead and effectively earthing them. Defects are rectified preferably then and there to ensure a satisfactory performance during monsoon.

All the points enumerated under ground patrolling are now effectively tested, the check being visual at close quarters as well as by handling of the equipment.

Items involving special methods of inspection are enumerated below.

I. Insulators, conductors, and Fittings:

- 1) Check insulators for checks by ringing methods (with a wooden hammer), use meggar methods wherever possible. A check for defects concealed by the binding, check condition of stiffener and Armour **tape** covering in the case of Aluminum conductor pin bindings.
- 2) Check condition of the conductor within the suspension clamps by removing the conductor from the clamp by means of a chain or rope blocks in case of heavy conductors and any broken strands in the outer layer resulting from vibration will then be apparent.

Check the condition of inner layers of conductor at the suspension clamp for breaker stands due to conductor vibrations.

To do this the conductor is gripped by the suspension clamp at a point 8 or 9 inches from normal position and twist is applied by means of a special wooden level fixed to the conductor at the corresponding position on the opposite side of the normal position of the clamp. Two or three fractured Aluminum strands in the case of heavy conductors after a number of years of service would not call for immediate action, although the fact must be carefully recorded to ensure that a further check is made at the next inspection. In the case of small size conductors it is desirable to replace that section of the conductor and a new length inserted with a joint on each side of the clamp. When fractured strands are found a special examination of the vibration dampers is made on the tower affected and on those immediately adjacent, and if all are found in good order, it may be assumed that the vibration in those spans is such that additional dampers are necessary.

Inspect parallel groove clamps for signs of load contact. Take them in places. Slight burning can be dealt with by wire brushing the conductors and the grooves of the clamps, the whole being reassembled after applying an inert grease having a high melting point to the conductors and the clamps, new clamps must be fitted and, if the jumpers are long enough, the conductors may be shortened by cutting off the burned ends. Where this is not possible owing to clearances being too far reduced, one of the spares must be lowered and a new piece of conductor joined to provide a new jumper of sufficient length. If this is not possible in the time available, a short length of conductor, may as a temporary expedient, be inserted in the number itself by using two parallel groove clamps, but the work necessary to eliminate the second clamps should be undertaken.

Check condition of eye bolts, hooks, shackles, pins, links, etc., of the insulator and conductor fittings as a results of conductor swing especially on lines in exposed location running at right angles to the direction of prevailing winds, and for rust and corrosion.

Vibration dampers, Replace dampers if sagging of weights is noticed in the case of stock bridge type dampers and looseness of weights at the stacks in the case of other type of dampers. Tighten loose clamping bolts.

Conduct/Examine conductor in mid-spans for broken strands. Temporary repair can be carried put by binding with copper wind in case of copper conductor or aluminum tapes in the case of A.C.S.R. conductors. When a large number of strands are broken, or when the steel core in the case of A.C.S.R. conductor is damaged, a new length must be inserted.

Check A.C.S.R. conductor for corrosion which has spread to inner strands in the case of coastal areas due to salt spray penetrating the aluminum strands and setting up an electro cyclic action between the steel core and the aluminum in contact with it. The conductor should be replaced as early as possible in this case.

When corrosion is limited to outer strands only as is usual in industrial areas it is rarely so serious as to warrant the replacement of the conductors before the years of anticipated life have lapsed.

II. Pole mounted; Secondary Distribution sub-station:

The annual maintenance of the sub-stations may be carried out during the premonsoon inspection as per the approved schedule of maintenance.

ANNEXURE – E

ANDHRA PRADESH STATE ELECTRICITY BOARD

Preliminary Report on Breakdown:

Note :

- i) This report should be sent to the Superintending Engineer (Grid Operation), Hyderabad to his name address with a copy of Chief Engineer / Electricity (Operation), Hyderabad, in respect of all 220 KV, 132 KV and 66 KV lines within 24 hours from time of occurrence.
- ii) This is in addition to the telephone message sent to the Superintending Engineer (Grid Operation), Hyderabad immediately after the occurrence.
- iii) However in the case of breakdowns on 33 KV lines (i) and (ii) above do not apply.

1. Name of the Feeder or equipment
2. Date of occurrence
3. Time of occurrence
4. Duration of interruptions
5. Relay indications observed
6. Cause of interruptions and any special observations.
7. Other feeders or equipment affected
8. Whether alternate supply availed and if so at what time and to what extent (i.e.) the actual duration of interruption to supply during the period of breakdown to various feeders should be mentioned.

ANNEXURE – F

DETAILED REPORT OF BREAKDOWN OF 220 KV, 132 KV, 66 KV AND 33 KV LINES

1. Sketch
2. Name of the feeder and voltage
3. Location of fault and its distances from the substation
4. Type of fault
5. Date and time of occurrence
 - a) Total duration of interruption of supply and Important loads that have been affected
6. Time taken to sectionalize the fault
 - a) As per approved operating instructions
 - b) As per actual
7. c) Time taken to locate the fault
 - d) Time taken to rectify after locating the fault
 - e) Time taken to charge the lines and to restore normal conditions after rectification
8. Sl. No. of the breakdown of the feeder in the current calendar year
9. Date of patrolling last done
10. Date of pre-monsoon inspection last done
11. Whether telephone communication was available and is in order? If not, the reason
12. Whether breakdown van was readily available? If not reason
13. Did the protective relays function properly?
14. Whether conditions at the time of the breakdown and the extent to which the same contributed to the occurrence of fault and the time taken for rectification
15. Whether the fault was due to
 - a) Any defect in design or construction
 - b) Any lapse in maintenance
16. Suggestions for preventing recurrence

Note : Detailed report of breakdown of 220 KV, 132 KV, 66 KV lines is to be sent by the DE (O) within 48 hours after rectification. In the case of breakdowns on 33 KV lines this form should be sent by the D.E. or S.E. concerned within 15 days or 20 days as the case may be).

ANNEXURE - G

ANDHRA PRADESH STATE ELECTRICITY BOARD

Proforma of preliminary report on failure of transformers

At

On

I. Name Plate Particulars:

1. Date of failure
2. Place of failure
3. Make
4. Serial No.
5. Capacity
6. Voltage Ratio
7. No. of phases
8. Frequency
9. Connection Diagram
10. Type of cooling
11. Vector group
12. Taps available
13. Present Tap
14. Specification
15. Impedance volts

II. Statistics of the Transformer

1. Date of first commissioning
2. Whether 11 KV & L.T. As are provided
3. Particulars of earthing done
4. Total load connected to the transformer
5. Peak load reached so far prior to failure
6. Period from which it was at present station
7. Capacity of HG fuses used on HT & LT side in SWG
8. Capacity on main fuses used
9. Whether transformer was sick previously
10. Observations and operations carried out before

Declaring it faulty and immediately before isolating it

With meager values

11. L.P.O. particulars
12. Stores from which drawn
13. Action taken to restore normal conditions of supply
14. Whether the transformer failed within the guarantee

period.

SECTION OFFICER

ASSITANT DIVISIONAL ENGINEER

ANNEXURE – H

REPORT ON FAILURE OF EQUIPMENT OTHER THAN TRANSFORMERS

1. Name of the equipment
2. Date of failure
3. Name of the sub-station
4. Name of the Division
5. Full name plate particulars of the equipment
6. Date of first commissioning
7. Details of protection available
8. Maximum load on the equipment in amps/MVA
9. Whether conditions at the time of failure
10. Results of line patrolling if the failure is accompanied by line fault
11. Details of operations carried out before declaring the equipment faulty (The conditions immediately, before the failure and extract of log book should be furnished
12. Action taken to restore supply and normal conditions and time when they were restored
13. Is the failure within the guarantee period? If so, is the company informed immediately?
14. Probable causes of failure

SECTION OFFICER / ASST. DIVISIONAL ENGINEER

SECTION - C

GENERAL AND MISCELLANEOUS RULES

95. The following are the general instructions for the guidance of officers

- (a) Compensation for loss of property.

No public officer is entitled to compensation for loss of property caused by an accident of any kind, merely because such accidents may have happened to him while he was employed in the service of the State except to such an extent that the Board may relax the provisions of this rule

- (b) Service under Local funds etc.

Members of the Board may be deputed temporarily to work under the Local Funds or municipalities and be paid wholly from such funds under the Service Rules of A.P.S.E.Board.

- (c) Miscellaneous Rules

Persons employed in the Board shall have no personal pecuniary interest, directly or indirectly in the construction of any public work, or in the manufacture, supply or sale of materials. They are further subject to the rules laid down in the A.P.S.E.Board Conduct RulesII.

Every member of the Board whether civil or military, must consider that his pay, for the time being, or as defined in any agreement, is sole legal remuneration, and that the receipt of commission, or any consideration, directly or indirectly on account of any business or transaction in which he may be concerned on behalf of Board is prohibited Every officer of Board is bound to report to his departmental superior any infringement of this rule which may come to his knowledge.

Note : (1) An exception is, however, allowed in cases of arbitration as follows:

- a) An officer shall not act as arbitrator in any case without the sanction of his immediate superior or unless he be directed so that to act by a Court having authority to appoint an arbitrator.
- b) No public officer shall act an arbitrator in any case which is likely to come before him in any shape in virtue of any judicial or executive office which he may be holding.
- c) If an officer acts as arbitrator at the private request of disputants he shall accept no fees except as provided in A.P.S.E.Board Fundamental Rules.
- d) If he acts by appointment of a Court of Law, he may accept such fees as the Court may fix.

Note : (2) There is also no objection to an officer of the board competing for any prize offered by a Municipality for preparing for it any designs or estimates, and to his receiving the award if he competes successfully.

Note : (3) An officer of the Board called upon by Court to act as a commission to give reliable information on certain technical points of engineering, may comply with the request unless debarred by the operation of clause (2) of note I above. If he accepts the commission, he may retain such fees as are fixed by the Court.

Note : (4) General Rules of Office Procedure:

No officer or subordinate of the Board may except with the previous permission of the authority to which he is immediately subordinate, seek an interview with any officer in respect of any matter affecting him personally as a Board servant. The previous permission of the Chief Engineer should be obtained through the proper channel in the case of an interview with a Minister or a Secretary to Government.

No officer should correspond with any authority superior to the officer under whom he is immediately serving or with the Board, out of the regular course, except in a case of extreme urgency, in which case he must send copies of his communications to his immediate superior.

No anonymous communications regarding the conduct of any Board officer shall be acted upon without the permission of the Board, excepting so far as to endeavor to remove any apparently well-founded causes of complaint which do not affect the character of individuals. With the above exception, every complaint by or against any person in the Board must be received and enquired into by his superior officer.

Note : (5) Procedure in regard to Law Suits

When any officer or subordinate in the Board is personally sued in any civil court, by parties claiming from him wages or money arising out of transactions in which he is concerned only in his official capacity, and bonafide on behalf of Board, it will be necessary that he defends the suit by pleading that Board should be made the defendant as the party really interested. But when the suit is for damages in respect of an alleged wrongful act of Board officer, the party aggrieved may, as a general rule, bring the suit against such officer, and it would be no defense for the officer sued to contend that Board ought to be the defendant. The plaintiff may legally contend that he has a right to look to the party by whose act he has been aggrieved, whether he could or could not have used that party's principal. The distinction is between suits on contracts and suits for wrongs. In cases of the latter kind, it will remain with Board to determine whether it would be just and proper that the defence should be carried on at the expense of Board. This course should ordinarily be adopted only in cases where there is no reasonable doubt of the innocence of the defendant. When there is prima facie evidence that he has acted improperly, he

should be left to conduct his own defence the question of Board contributing towards the cost of the defence being subsequently considered. Whatever, be the nature of the case, failure to defend the suit, or to reply to the plaint in person or by the counsel, as the case may require, will render the officer or subordinate personally responsible.

N.B. An officer, receiving a summons to produce official documents in a Court of Law, should, provided the documents be specified, produce them to the Court unless they are unpublished official records relating to any affairs of Board, when he must refer to the next higher authority.

SECTION - D

OFFICE ROUTINE

96. The office procedure will be generally in accordance with the working instructions vide Appendix XIII.

A list of periodical returns and the registers to be maintained in the various offices is included in the Appendix X.

97. Destruction of official records : The records may be destroyed after the periods specified in, Appendix XI, unless, in any case, a record has been specially ordered to be kept for a longer period. As regards records not included in the Appendix, the sanction of the Chief Engineer should be applied for annually in the month of January. The Accountant-General should be consulted in respect of Audit records before applying to the Chief Engineer. In ordering the destruction of such records, great care should be exercised that it is confined to such as are valueless, but the following should on no account be destroyed.

- (1) Records in connection with expenditure which is within the statute of limitation.
- (2) Records in connection with expenditure on works not completed although beyond the period of limitation.
- (3) Records of experiments and observations
- (4) Records in connection with claims to service and personal matters connected with persons in the service.

In the Office of the Divisional Engineer and the Central Office of a System full details of all records destroyed from time to time should be maintained permanently.

98. Recording of plans and drawings : The Superintending Engineer of the System shall keep on record in his office the following plans or such of them as are required in his system---

- (i) Copies of all standard plans of buildings, completed plans, sections and elevations of every building under his charge, the boundaries of the ground attached to any buildings being distinctly shown.

Detailed drawings including foundations, where practicable, of all other civil works in the system as actually completed and the boundaries of the ground attached to such works.

- (ii) Accurate plans of all electrical and mechanical equipment in the system.

Maps showing distributions and the tapping arrangements including extensions to existing feeders.

- (iii) Copies of all specifications issued.
- (iv) All estimates sanctioned from year to year.

N.B.: The Divisional Engineers shall also maintain copies of the above as pertaining to their areas.

TRANSFER OF CHARGE

99. A register of incumbents of charges shall be maintained in the Circle Office showing the period of incumbency of each Board officers, or Accounts establishment The Divisional Engineer shall maintain similar incumbency registers in their offices in respect of their subordinate executive staff.

100. (1) On assuming charge, every officer shall make it his business to acquaint himself with the works and the special features of the items in his charge. The officer shall count, weight or measure selected stores in order to test the accuracy of their accounts and should minutely examine the works in progress as to their quality and as to their accordance with the sanctioned plans and estimates. He shall further go through the books, registers, and ledger accounts and report on any arrears or confusion that may come to his notice. The above area the general instructions relating to the functions of each officer. If the relieving officer fails to bring to the notice of his superior within a reasonable period (say, three months) any deficiency or defect in work, stores accounts, etc., taken over, he will be held responsible for the same so far as he was in a position to ascertain it.

(2) The relieved officer should give the relieving officer a memorandum showing all the works in hand, the orders remaining to be compiled with, and matters of importance relating to operation, maintenance, load and other items in his charge. All matters which particularly require the attention of the relieving officer should be detailed with full explanation of any peculiarity.

(3) An officer must not delay making over charge after arrival of the relieving officer; nor must he, without the permission of his immediate superior officer, leave the station before the arrival of his successor. The relieving officer will take up the expenditure of cash and stores from and for the first day of the month during which the relief took place, and submit the next monthly accounts in the same manner as if he has been in charge during the whole month. But the relieved officer remains responsible that proper explanation is forthcoming for transactions during his incumbency.

(4) Whenever the transfer of charge is prolonged so that two Board servants may be entitled to draw pay and allowances simultaneously for the same appointments (see Audit instructions under Fundamental Rule 107) the Superintending Engineer should intimate to the Board if the time taken is reasonable and the relieving officer may be considered as on duty for the period. If, however, the Superintending Engineer considers the time taken in making over and receiving charge to be excessive, the relieving officer must be treated as if he were on leave or on joining time, etc., as the case may be, for as much of the time as may be regarded as excessive.

In the case of an executive charge becoming vacant by the death or sudden departure of the officer in-charge, the next senior officer of the Board should assume charge and proceed with the normal work.

(5) It is an object of great importance to secure as far as possible continuity in procedure or practice in regard to cases and matters actually under settlement and to this end the Superintending Engineers and Accounts Officer should make special mention about such matters in their notes to successors.

N.B.: Forms of questionnaire shall be drawn up and issued with the approval of the Superintending Engineers for guidance of officers preparing transfer notes.

They should be merely taken as indicating the general lines on which transfer notices should be prepared and should not be considered to be exhaustive.

INSPECTIONS

101. The Officers of the Systems should make it a point to inspect the offices and stores of their subordinates during tours and this will help a long way to prevent the accumulation of arrears and discrepancies in stores and accounts besides fostering an impetus in the field for a sound administrative organization in each section.

This lines of inspection may be classified under the following broad outlines -----

Administration ;
Technical & Commercial ; and
Financial

Administration : Under this may be grouped seniority list of work establishments in the sections, register of works, register of returns progress reports and other similar items including files relating to accidents.

Technical & Commercial : List of drawings and plans, pole schedules of works, distribution charts, load record statements, interruptions to supply, etc., correspondence on electrical inspections and other items purely of a technical nature may be included here.

Financial : Every commitment for expenditure or revenue is an important time. All items whether purely of a technical or administrative nature ultimately leading to some financial effect, budget, revenue or expenditure, should be classified under this group and dealt with accordingly.

The following officers will be the inspecting officers in each system and the scope of their inspections will be as heretofore mentioned.

The Superintending Engineer is the Controlling Officer of each system and the following main items will be inspected by him during his tours.

Administration : The offices of the Assistant Divisional Engineers and the Section Officers will be inspected by the Superintending Engineer as and when convenient and the officer of the Divisional Electrical Engineers will be inspected not less than once a year. He will inspect whether the several registers and returns are properly maintained, whether the progress reports, interruption reports and load record statements are concurrently written up and whether the Divisional Engineers and the Assistant Divisional Engineers are exercising their checks efficiently and discharging their duties satisfactorily. He will further see that the stores are properly maintained and obsolete materials are not over stored, that not more than the required spares and tools and plant are kept in.

Technical & Commercial ; He will see that the distribution charts and plans and sketches of the transmission lines and sub-stations and other buildings are properly maintained; that the execution of operation, maintenance and construction works are properly executed as per approved designs and plans; that interruptions are properly remedied and that the sub-stations and equipments are well maintained.

He will further see that the supply to H.T. consumers is well attended to ; that their maximum demands, metering arrangements are all well-inspected periodically and that important technical matters are promptly attended to by the Assistant Divisional Engineers and the Divisional Engineers.

Financial : From the commercial point of view, the financial aspect of the undertaking is most important. The Superintending Engineer should check, wherever he consider necessary, the following points during his inspections.

That the H.T. power consumers; services are periodically inspected by the Assistant Divisional Engineers and Divisional Engineers to ensure correct recording of meters so that loss of revenue may not occur; that the maintenance staff and expenditure are kept at the minimum that the collections (wherever attached to sections) are properly watched that the initial record of accounts, work orders are regularly maintained that the imp rest accounts are correctly maintained and rendered to the Circle/Divisional Office; that no unauthorized works, though in the interest of service, are executed that the accounts returns are periodically and correctly rendered that measurement books and other initial records are properly maintained and work orders closed as expeditiously as possible. He should further check at least a few items of stores whenever convenient and ensure that the bin cards, ledgers etc., are concurrently posted and the quantitative balances agree.

Divisional Engineers – Administration : The Divisional Engineers are each incharge of one electrical division and are responsible for the entire works in their jurisdiction. They are primarily responsible for the proper administration in each division and should inspect sub-divisions in their area once in a year and ensure that the records of returns are properly maintained; that the stores required for operation, maintenance and construction for one months' requirements are stored; that the O&M establishment is kept at the minimum and has full-time work, etc.

Technical & Commercial : They will review the register of works, check-measure as many major works as possible concurrently as the works are proceeded with; satisfy that the designs and specifications are correctly followed; that deviations wherever necessary are brought to his notice for approval by competent authority. They should at least inspect once in six months all the H.T. services in their jurisdiction and report to the Superintending Engineer any important feature detected. The commercial activity of each sub-division is a main feature for the development of load and the Divisional Engineers should ensure that this item is well realized by the Assistant Divisional Engineers and sufficient progress in investigation made by them.

Financial : The Assistant Divisional Engineers are primarily responsible for all financial matters, expenditure and revenue. However the Divisional Engineers should during their inspections check the initial records of all accounts, works, stores, spares, tools and plant, imp rest accounts, measurement books, collections, petty cashbooks, etc., and take prompt action to communicate to the Superintending Engineer cases wherever negligence, or oversight would result in loss of revenue or property, unprofitable outlay, etc. They should also check the register of meters, history of services, etc. The Divisional Engineers should be primarily responsible for the spending of appropriations and see that there are no excesses or lapses.

Assistant Divisional Engineers – Administration : The Assistant Divisional Engineers are in administrative charge of each sub- division and in direct immediate control of the Section Officers and Line Inspectors in their distribution areas. They are responsible for the work and conduct of the staff in the distribution area and report to the Divisional Engineer wherever action is required. They should periodically inspect and see that the offices are well maintained, that the lines are patrolled and that diaries are maintained and important features are communicated to the Assistant Divisional Engineers without delay.

Technical & Commercial : They should inspect the various works and as many of the service connections as is possible and see that they are executed as per standard designs. They should check measure all works costing over Rs.2500 and all service connections costing over Rs.1,000/- during inspections and make a record of all such check-measurements. As many of the important power service connections as possible should be verified to see that the wiring connection, etc., are intact. All the registers pertaining to technical returns due to the Chief Engineer or Superintending Engineer should be reviewed and instructions given to the Subordinates wherever required for maintaining up-to-date records. The return of service connections connected is an important record to watch load developments and should be reviewed by the Assistant Divisional Engineer during each inspection.

Financial : The following records maintained by the field are the initial records of accounts and of great financial importance. The Assistant Divisional Engineers should see that these are properly maintained and should report all cases requiring attention and rectification to the Divisional Engineers.

- a) **Cash :** The Assistant Divisional Engineers should check the imp rest and temporary advance accounts and satisfy that the expenditure was necessary and no amount has been spent unnecessarily or to the advantage of an individual.
- b) **Stores :** Forms and stationery, service stamps and stores including spares and tools and plant are as good as cash. The records containing the numerical accounts, bin cards, stores ledger accounts should be checked in respect of a few items at least during each inspection so that the main important items may be verified completely in the course of the year and discrepancies traced and rectified without undue delay. A report should be made to the A.O. wherever losses are detected for pursuing action by the Circle Office.

- c) **Accounts** : The Assistant Divisional Engineers are responsible for appropriation, expenditure and revenue and should therefore check the initial records of works accounts maintained by the Section Office and should see that the estimates and appropriations are not exceeded or allowed to lapse; that materials drawn for one work are not utilized on another for which no appropriation is made, that the execution of works are not delayed or protracted resulting in the postponement of revenue earning stage; that the labour employed is no excessive, etc.

They will completely inspect the offices of the Section Officer's in their area once in a year and ensure that the office registers and accounts are well maintained. They will ensure that the work of the subordinates is correct and all technical and field work upto-date. They will go through the arrears list of the Section Offices as to

- (i) Correspondence with consumers ;
- (ii) Correspondence on technical matters ;
- (iii) Correspondence on accounts and pending references of superior officers (and the Circle Office) and see that they are dealt with expeditiously and issue necessary instructions as to disposals.