

## **CHAPTER-8**

### **8.1 Inspection and maintenance of Transmission Lines**

#### **8.1.1 Inspection from ground:**

Normal patrolling of transmission line from ground is recommended to be carried out twice in a year, once in a month of April/May and again in the month of September/October and critical lines once in a month by a team of Engineer/Junior Engineer/Lineman with the help of binocular. All the possible items shall be inspected as per format-II. The condition of the various visible items shall be recorded in this format.

Once the total line is patrolled, the report of defect observed in the line is to be prepared in format III and copy sent to Executive Engineer / Superintending Engineer.

Work of minor nature which are easily accessible, such as shortage of members, tightening of nuts & bolts and providing of step bolts can also be taken up. Safety items and T&Ps such as Hunter shoes, water bags, binoculars, torch, stick, rain coat, required spanners, nut and bolts of assorted size, step bolts etc. should also be carried by the patrolling team. Trees, shrubs, bushes etc. which infringe on the clearance are to be cut during patrolling.

In case of rectification/maintenance which is required to be done under shutdown, the Assistant Engineer in charge of the line shall prepare a program for taking shutdown/shutdowns and arrange to the same through the Executive Engineer/Superintending Engineer.

Night patrolling of the lines may also be carried out for detecting the hotspots etc. once in a year on some locations on sample basis.

#### **8.1.2 Precautions & General Instructions during patrolling**

- i. Poles, towers or structures should not be climbed up under any circumstances during normal patrol.
- ii. If any snapped conductor/earth wire is found lying on the ground, the nearby residents should be cautioned that no humans, animals, bullock carts, tractor trolleys, camel carts should be allowed to go near the snapped conductor/earth wire. The matter should be immediately reported by the patrolman to the Assistant Engineer for asking remedial measures.
- iii. Any abnormal observation should be reported to the Assistant Engineer immediately by the patrolman.

#### **8.1.3 Ground patrolling :**

The following points are to be checked and attended during patrolling :-

## General

- i. Adequacy of clearance of trees, shrubs, bushes, etc. from the line conductors is to be checked. All trees, shrubs, bushes etc. which infringe on the clearances are to be cut. Small bush growth, shrubs and trees whose height is not expected to rise beyond 3 meters may be allowed to remain. Grass growth on the boundary walls ( Dola ) of farms which can grow to a height such as to infringe on the clearance should be cut. Trees outside right of way but of such height as may infringe on line clearance should be trimmed accordingly. Trees or bushes growing inside or very close to the legs of towers should be cut/removed.

The vertical clearance of conductor from trees / shrubs / bushes etc. should be checked when atmospheric temperature is high and the line is adequately loaded.

- ii. Vertical and horizontal clearances between the lowest or nearest conductor & any part of buildings/structures under construction below or adjacent to the line, etc. is to be checked and should not be less than the values given below as per IE rules 1956 :-

66 kV    132 kV    220 kV    400 kV

a) Vertical Clearance                      4.0 m    4.6 m    5.5 m    7.30

b) Horizontal clearance                    2.3 m    2.9 m    3.8 m    5.60

(on the basis of maximum deflection due to wind pressure) In case the clearances are less than those given above action should be taken to stop all such new constructions works.

- iii. Ground clearance infringement due to construction of roads, ditches and channels or due to earth and refuge dumped near or under the line or due to shifting sand dunes should be checked and arrangements made such that the minimum ground clearances given below are maintained as per IE rules 1956.

a.        66 kV lines - 5.5 m

b.        132 kV lines - 6.1 m

c.        220 kV lines - 7.0 m

d.        400 kV lines - 8.8 m

- iv. Clearance of lowest conductor from power lines or telecommunication lines should be checked, if necessary, by the-odolite. The following are the minimum clearances, as per Rule 87 IER 1956.

a.        From 400 kV lines - 5.49 m

b.        From 220 kV lines - 4.58 m

c.        From 132 kV lines - 3.05 m

d.        From 66 kV lines - 2.44 m

Contact concerned authority for maintaining required clearance.

### 8.1.4 Tower

- i. Check the backfilling of the foundation of tower. Also check that the earth around the tower footing has not sunk or got eroded or water logged or is in any way causing danger to the tower footing or exposing the foundation. Take remedial measures to restore tower footing including provision of revetment if necessary.

- ii. The earth around the tower footing should not be above the concrete level. i.e., above the chimney so as to cause damage to the tower leg. The excess earth should be removed.
- iii. Check that the concrete of the chimney is not cracked or the coping is not damaged. Take measures to rectify the defect.
- iv. For tower locations provided with revetment, check that the retaining wall is neither broken nor is in danger of failing. Take remedial measures.
- v. Check that the earthing on the tower leg is intact. If damaged, repair is to be undertaken and if missing, then it should be replaced. Measure the Earth Resistance of each Tower.
- vi. Check that all the tower members are intact and in place and not damaged due to any reason. All missing and damaged members are to be replaced at the earliest. Check that the nuts & bolts are not loose or missing. Nuts & bolts found loose or missing should be immediately tightened. replaced.
- vii. Check that the numberings on the tower and markings on the danger plates or phase plates are readable. Take remedial measures.
- viii. Check that the galvanizing or painting of the tower members is in proper condition. Take remedial measures to restore galvanizing or painting to good condition.
- ix. Check that there is no corrosion of any part of the tower. Immediate measures should be taken to rectify the defect.
- x. Check that the anti climbing devices and barbed wire are fixed and in place. If missing or damaged or incomplete, take suitable action.
- xi. Check that there are no bird nests on the tower or cross arms. Remove which are existing.
- xii. In the case of H Poles, TPS structures, four pole structures or fabricated cut point structures, check the fixing of the guys and their foundations. Any shortcomings (Loose/disconnected) should be rectified. If missing, arrange for replacement.

### **8.1.5 Insulators & Hardware**

- i. Check that the insulators have not flashed over or have got chipped. Note down details and arrange replacement.
- ii. Check that the arcing horns are not loose or touching the conductor or missing. Arrange rectification.
- iii. Check that the vibration dampers are not damaged. Arrange replacement. Also check that the vibration dampers are in their proper position i.e. they have not shifted along the conductor/earth wire and away from the tower.

The following are the recommended distances:

1. ACSR Moose –	Suspension Tower	- 1.35 M
	Tension Tower ( 2 nos. )	- 1.35 & 2.70 M
2. ACSR Panther		- 1.14 M
3. ACSR Zebra		- 1.45 M
4. 7/3.15 mm E/W		- 0.63 M
5. 7/3.66 mm E/W		- 0.65 M & 1.3 M
5. 7/4.00 mm E/W		- 0.68 M

(Clarification: In case of suspension towers, the distance is from the center of the suspension clamp. In case of bolted type tension hardware, the distance is from the end of the clamp. In the case of compression type tension hardware, the distance is from the end of the aluminum / steel portion ). In the case of Bates damper, check that P.G. clamps and the conductor are in their proper place. Arrange to attend shortcomings, if any.

- iv. QCheck that the armor rods are not damaged and that they are not damaging the conductor. Arrange replacement/rectification.
- v. Check the jumpers at tension points. There should not be any damage to the conductor or the P.G. clamps or the compressed ends. Arrange rectification/replacement.
- vi. Check that the tension clamps/suspension clamps of the conductor & earth wire are not damaged/rusted. In case of earth wire, check that the earth wire has not become free from the suspension clamps and is lying on some tower member.
- vii. In the case of tension towers check with binoculars that the pins of the D-shackles of the hardwares have not worn out. Arrange replacement, if necessary.
- viii. Check that the earth bond provided on the suspension and tension hardware of earth wire is intact and connected to the tower. Arrange rectification/replacement.

#### **8.1.6 Conductor & Earth wire (Between towers)**

- i. Check for visible damages like cut strands, deposits, burn marks, corrosion etc. Take remedial measures.
- ii. Check that the conductor/earth wire has not moved out of mid span joints.

#### **8.1.7 Schedule of inspection & maintenance activities :**

There is a need to decide the frequency of carrying out inspection of various items with and without shut down. The schedule for maintenance and attending the defects noticed during normal patrolling is also given for guidance at format-I.

#### **8.1.8 Fault inspection of line :**

Apart from the normal inspection of the line, detailed inspection of the line is required to be carried out in case of occurring of fault of minor/major nature. This includes the failure of

towers, conductors/ earth wire and insulators/hardware etc. The fault inspection report shall be prepared as per format V.

### 8.1.9 Inspection/check report for major maintenance work :

It is utmost important that required inspection/testing/checks are carried out during maintenance work and also after completion of maintenance activities so as to ensure smooth charging of line. This check list including testing details is indicated in format VI.

While replacing the insulators, it should be ensured that the mechanically as well as electrically healthy insulators should only be used. The insulators should be meggered at ground using 5 kV megger and their IR value should be above 1000 Mega ohms under dry condition. The results may be recorded as per format VI.

Carryout scanning through through thermovision camera of Lines which are critical  
On Line cleaning of insulators for lines Passing through polluted /fog affected area.

## 8.2 SCHEDULE AND FORMATS

### 8.2.1 MAINTENANCE SCHEDULES OF TRANSMISSION LINES

Format-I

<i>Sl.No.</i>	<i>Name of the activity</i>	<i>Frequency</i>	<i>Nature</i>
A	Ground inspection by lineman/team	Half yearly (Pre-monsoon+ after monsoon)	Non S/D
B	Inspection of critical line/critical Section	Annually	Non S/D
C	Thermo-vision scanning of critical lines/critical locations (spacer-dampers/jumpers/Insulators)	Annually	Non S/D
D	Punctured Insulator Detection of critical location	Annually	Non S/D
E	Attending of defects	Annually	Non S/D
1	Foundation-backfilling/soil erosion	Immediately	Non S/D
2	Attending of crack of chimney	Immediately	Non S/D
3	Replacement of Danger/number /Phase/Circuit plate	Within 3 months	Non S/D
4	Replacement of missing/damaged tower components	Immediately	Non S/D
5	Trimming/cutting of trees which do not require S/D	Immediately	Non S/D
6	Trimming/Cutting of trees which require S/D	Immediately	S/D
7	Replacement of broken/damaged insulator in normal area (two or less/string)	Yearly	HLM or S/D
8	Replacement of broken/damaged insulator in normal area (three/string)	Immediately	HLM or S/D
9	Replacement of broken/damaged insulator in normal area (more than three/string)	Immediately	S/D
10	Replacement of broken/damaged insulator in polluted area (two/string)	Immediately	HLM or S/D
11	Cleaning of insulators in polluted area a. Critical pollution	Half yearly (after-monsoon & pre	S/D S/D

	b. Normal pollution	winter) Yearly	
12	Attending of damage to conductor by temporary method	Half yearly	HLM or S/D
13	Attending of damage to conductor by permanent method	Yearly	S/D
14.	Attending of failed spacer-dampers a. Causing conductor damage b. Hanging/dislocated spacer-dampers	Half yearly Yearly	HLM or S/D
15	Attending of hot spots	Immediately	HLM or S/D
16	Temp .measures for land slide/sinking of foundation	Immediately	Non S/D
17	Tightening of B&N/Anchor bolts	Immediately	Non S/D or HLM
18	Re-fixing of vibration dampers of conductor/earthwire	Yearly	S/D or HLM
19	Measurement of tower footing resistance Normal locations / Critical locations	Once in two year / Yearly	Non S/D Non S/D

HLM - Hot Line Maintenance

Criteria for critical lines :

1. No. of failures in past
2. Affected by natural reasons i.e. pollution/flood/land slides etc.
3. Evacuation lines for power projects
4. Inter region lines

**8.2.2 Format - II**

Name of Sub-Division  
 :  
 Name of the line  
 :  
 Member of Team ( Lineman/Jen/Executive )  
 :  
 Date of Patrolling  
 :

Name of  
 Division :

	Location	1	2	3	continued
	Span	1_2	2_ 3	3	as reqd.
1)	Clearance of line conductors from trees, shrubs, bushes, etc.				
2)	Vertical & horizontal clearance of neighboring buildings & structures under construction.				
3)	Ground clearance from roads, ditches, channels, earth, refuge dump, shifting sand dunes.				
4)	Clearances from power lines & telecommunication lines.				
5)	Tower foundation free from erosion, water logging or sinking.				
6)	Earth around tower footing below concrete level.				
7)	Concrete of chimney or coping.				
8)	Retaining valve of revetment & general condition of revetment				
9)	Earthing of tower leg.				

- 10) Tower members and nuts & bolts.
- 11) Number plates, phase plates & danger plates.
- 12) Galvanising / painting.
- 13) Anti-climbing devices & barbed wire.
- 14) Bird nests.
- 15) G  
u  
y  
s.
- 16) Insulator s.
- 17) Arching horns.
- 18) Vibration dampers.
- 19) Armour rods.
- 20) Jumpers.
- 21) Suspension/Tension clamps.
- 22) Pins of D-shackles of tension hardwares.
- 23) Earth bond.
- 24) Conduct or.
- 25) Earth wire.

Signature & Date

:



8.2.3 Format - III

Name of Sub-Division :  
 Name of the line :  
 Member of Team ( Lineman/Jen/Executive ) :  
 Date of Patrolling :

Name of Division :

Details of Defects / Shortcomings and their Rectification

Loc. No. or Span	Nature of defects or shortcomings	Remedial action to be taken	Remedial action taken	Reason for not taking remedial action	Remarks
1	2	3	4	5	6

8.2.4 INSPECTION REPORT OF LINE DECLARED FAULT

Format-IV

NAME OF CIRCLE / DIVISION :  
NAME OF LINE :  
MEMBER OF TEAM (LINEMAN/JE/EXECUTIVE) :  
DATE OF PATROLLING :  
FAULT LOCATOR READING (ON/OFF LINE) :

*LINE DECLARED FAULTY INSPECTION REPORT*

S.NO.	LOCATION		PHASE	DESCRIPTION OF FAULT
	FROM	TO		

Signature & Date :

## 8.2.5 INSPECTION REPORT FOR MAJOR MAINTENANCE/BREAKDOWN WORKS

*Format V*

NAME OF REGION :  
 NAME OF LINE :  
 MEMBER OF TEAM (LINEMAN/JE/EXECUTIVE) :  
 DATE OF PATROLLING :

TYPE OF MAINTENANCE	DESCRIPTION		STATUS
Insulator Replacement	1	Whether IR value of insulators checked in stores	Yes / No
	2	Check all bolts & pins for their correct sizes, all nuts, lock nuts, washers and split pins are fitted correctly	
	3	Check verticality of insulator string (for susp. Tower), in good condition with correct number of insulators in string	
	4	Check conductor clamps ensuring that all nuts and spring washers are fitted and clamp has no signs of cracking	
Collapse of tower/conductor replacement	1	Check point no.1,2,3 and 4 above for Insulator replacement	
	2	Check damper positions are correct	
	3	From tower, visually check spacers in adjacent spans	
	4	Check ACD, Step bolts, correct plates and no damaged steel work.	

*Signature & Date*

### 8.2.6 IR VALUE AND OTHER DETAILS OF INSULATORS

Format - VI

Name of Region Area/Zone :  
Name of Line :  
Members of Team (Lineman/JE/Executive) :  
Date of activity :  
Make and Sl.No.of megger used :  
Location No/Phase :

Sl.No.	Batch No.	Manufacturer	IR Value in Mega Ohms	Remarks
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				

Signature & date :

## **8.3 PROBABLE CAUSES OF FAILURE OF THE TRANSMISSION LINE COMPONENTS**

### **8.3.1 Introduction**

In the power system, transmission lines play a very vital role in transmission of power. For a healthy/reliable power system, it is desirable that there are minimum power break-downs/outages on the transmission lines. For avoiding break-down on the lines planned preventive maintenance is considered to be absolutely necessary. This aspect not only reduces the outage period of the transmission lines but also helps avoiding lot of inconvenience to the consumers etc. and bring economy to the concerned utility/undertaking. While considerable emphasis has already been laid for carrying out proper maintenance of the transmission lines, it still becomes very important to know the causes leading to failure of the transmission line components.

EHV transmission lines has a number of components which are affected by environmental problems like corrosion, pollution, lightening, normal wear and tear etc. Instances of damage carried out during strikes and civil disobedience, damage of insulators during shooting practices, theft of tower members etc. could also affect the line performance.

In this chapter, probable causes of failure/damage of transmission line components mentioned as under have been brought out :-

- A. Insulators and Hardware fittings.
- B. Conductor and Conductor Accessories
- C. Earth wire and Earth wire Accessories
- D. Tower, Nuts and Bolts
- E. Tower foundation
- F. Tower Earthing

It is observed that the break-down (s) occur due to various reasons such as lack of knowledge of flash over on disc insulators, snapping of conductor from the mid span joints, dead end compression type clamps, breakage of conductor under suspension points. Some-times , jumpers also snap due to loose nuts and bolts on dead end compression type clamps etc.

### **8.3.2 Probable Causes of Damage of Insulators and Hardware Fittings**

The insulator strings comprising of insulator discs and hardware fittings are provided for supporting and anchoring the conductors to the towers and insulating the live conductors from the ground.

Hardware fittings comprise of suspension clamps, dead-end compression type clamps, corona control rings, arcing horns etc. With the passage of time, there can be any type of deterioration in hardware fittings due to poor quality of material, sparking and rusting of clamps etc. Some times, split pins of hardwares/security clips of disc. insulators are also found broken or missing on these fittings.

**A. Disc Insulators**

1. Poor quality of disc insulators & hardware fittings (Cap., pin, security clip, etc.) used on the transmission lines.
2. Insulators exposed to industrial pollution (brick kilns, chemical industries, cement factories, fertilizer plants, etc.) and coastal pollution (salt sea fog) are likely to get contaminated because of smoke/ chemical / salt deposit etc. from time to time. Such locations/towers are vulnerable for flashing over of disc insulators particularly during foggy weather.
3. In case earthing of tower is not proper, back flashover due to lightning strokes, direct lightning strokes or switching over voltages will not get discharged effectively and disc insulators are likely to get flashed over leading to fault online. Accordingly, the earth resistance of towers must be ensured within permissible limits.
4. Excessive vibrations on conductor.
5. Dropping of birds/ refuse/ defecation by birds on insulators where bird's guards are not provided.
6. Throwing of stones missiles, shooting practices etc, by miscreants or children on insulators.
7. Poor I.R. values of disc insulators due to ageing.
8. Failure of security clips of disc insulators.
9. Looseness of arcing horn rods of the insulators string and missing/dropping of arcing horns and grading rings from the insulator string.
10. Damage due to blasting in nearby quarries, road formation cutting in hills or practice firing in nearby firing range.
11. Falling of trees etc. on disc insulator string.
12. Dropping of long wires/big bones of dead animals etc. by vultures/birds on the disc insulators.
13. Improper handling of insulator disc/ insulator strings during transportation and erection of the insulator string causing damages in the cemented portion of the cap and pin.
14. Improper quality of cement and cementing process during fixing of cap and pin on the shell.

**B) Hardware Fittings**

1. Poor quality of hardware fittings used on the lines e.g. forging, casting, galvanizing, mechanical strength etc.
2. Deterioration/failure of corona control rings, split pins, other accessories with the passage of time.
3. Excessive vibration on line.
4. Loose fittings.

### **8.3.3 Probable Causes of Failure of Conductor and Conductor Accessories**

Conductor and conductor accessories form vital components in a transmission line. The conductor is the main current carrying component of a transmission line installation. In EHV transmission lines, ACSR and Aluminum Alloy conductors are generally used. In transmission lines of voltage rating up to 220kV, single ACSR or Aluminum Alloy conductor and in transmission lines of voltage rating 400kV and above, twin or quad ACSR or Aluminum Alloy Conductors are used. Conventional lines with ACSR conductors are operated up to a maximum temperature of 75C and Aluminum Alloy conductor up to a maximum temperature of 85C.

Conductor accessories comprise of mid span joint, repair sleeve, vibration dampers, spacers, spacer dampers, armour rods, etc. These components can fail due to premature ageing, incorrect design (vibration system design, clamping arrangement and bolt tightening torque, mechanical strength etc.), poor quality of material, sparking and rusting of components, loosening/breaking of split pins, bolts and nuts, etc.

#### **A. Conductor**

1. Loose fittings on conductor i.e. vibration dampers, spacers/spacer dampers, straight through joints, dead end clamps, repair sleeves etc.
2. Failure of hanger cleats, looseness/failure of nut-bolts attached to hardware fittings and due to cracks in hardware fittings etc.
3. Snapping/dropping of conductor due to lightning stroke causing failure/decaping of disc. Insulators due to high earth resistance etc.
4. Excessive vibration causing wear and tear/damage of conductor.
5. Looseness between aluminium and steel portions of compressed joints (straight and dead end joints) causing air gap and thus breakage of conductor.
6. Falling of big trees on the conductor/disc insulator strings.
7. Throwing of chain/wire etc. on the conductor by the miscreants and hitting by crane booms/hoist and other such machinery etc.
8. Failure of disc insulators due to poor quality/ageing and due to failure of split pins etc.

9. Loosening of performed armor rods due to poor quality of material, vibrations and improper installation etc.
10. Hitting by flying objects Aeroplane / Helicopters GI sheets etc. during storms, blasting etc.
11. Sparking/arcng corona at the conductor surface due to scratches, wear and tear caused during stringing of conductor, sticking of foreign material on the conductor, incorrect intra conductor bundle spacing, distorted bundle configuration etc.
12. Overheating resulting loss of strength of conductor due to over loading.
13. Bird caging of conductor causing opening of conductor at clamping points resulting in overstressing/damage of conductor.
14. Improper design of conductor i.e. incorrect lay ratio, chemical composition, incorrect procedure of wire drawing, low mechanical strength, high electrical resistance, etc.

**B. Conductor Accessories**

1. Incorrect design and poor quality of material of conductor accessories causing fatigue failure, cracking, fretting, hot spot, etc.
2. Loosening of nuts & bolts of damper due to vibration etc.
3. Poor workmanship (spring washers etc. not used with nuts & bolts); improper bolt tightening/torque.
4. Improper design of vibration system vis-à-vis environments.
5. Improper placing of vibration dampers, spacers and spacer dampers.
6. Improper compression of mid span joints, repair sleeve etc.
7. Improper application of tightening torque for clamping bolts of suspension clamps, vibration dampers, spacers/spacer dampers etc.

**8.3.4 Adverse affects of vibration**

In case vibration dampers/spacers are not provided or partly provided and not maintained properly, it adversely affects all the components of transmission line up to foundation as under :

**i. Conductor & Earth Wire :**

Life of earth wire and conductor is reduced and chances of their breakage are increased. The earth wire and conductor generally gets damaged in suspension clamps. Some-times, at hooking points conductor strands are broken.

**ii. Armor Rod :**



The armor rod loses its grip on conductor due to which there is sparking at armor rod ends.

**iii. Effect on clamps and its Nuts & Bolts :**

Due to vibration, the damper nuts and bolts get loosened and some-times its cotter split pins get broken causing slipping of conductor from the hooking point resulting into the break-down. Some-times hardware plate gets cracked due to vibrations.

**iv. Effect on Tower Members and Nuts & Bolts**

Tower as a whole with its members and bolts & nuts when exposed to severe vibrations leads to loosening of bolts and nuts thereby disturbing the load sharing which may result in overstressing of some members and cause failure. The vibrations transmitted to the foundations may cause loosening of chimney/muffing and the stub, cause rusting of stub due to seepage of water in the stub and chimney/muffing joint and cause foundation failure due to loss of bond length and effective area of reinforcement. Audible noise from the tower also increases.

**v. Effect on Insulators**

Due to vibrations, chances of breakage of disc insulators increase.

**vi. Effect on Arcing Horns.**

Due to vibrations, arcing horns get loosened and the gap is changed defeating its very purpose. The conductor side arcing horn causes sparking on the conductor due to looseness.

**vii. Effect on Jumpers**

Due to vibration, jumper start vibrating e.g. during lightening discharges and flow of fault current. Sparking develops and jumpers break. In case of crimp jumpers all nuts and bolts in the system of jumper get loosened and cause sparking further leading to jumpers failure.

**viii. Effect on Earth Wire Flexible Bonds**

Due to vibration the nuts and bolts in the earth bond fixing get loosened which causes sparking resulting in damage of earth wire copper bond

### **8.3.5 Probable Causes for Damage of Earth wire and its Accessories**

**a. Earth Wire**

Earth wire and earth wire accessories play an equally important role as conductor and conductor accessories in a transmission line. They protect conductor and insulator strings from damage due to lightning strokes. The material used for manufacture of earth wire is generally galvanized stranded steel wire. However in coastal areas,

aluminum alloy conductors are used as earth wire in place of galvanized stranded steel earth wire to prevent damage due to galvanic action from salt. Further, ACSR conductors and aluminum alloy conductors are also used as earth wire in place of galvanized stranded steel earth wire to reduce voltage induction on open overhead telephone circuits due to earth fault in the transmission lines. The earth wire is designed to operate at 53C (45C as the maximum ambient temperature +8C temperature rise due to solar radiation). In EHV transmission lines up to 220kV, single earth wire is generally used except for horizontal configuration lines where two earth wires are used. In case 400kV and above voltage lines, two earth wires are used.

Earth wire accessories comprise of mid span joint, repair sleeve (for 220kV and below voltage lines), vibration dampers, suspension clamps, tension clamps, etc. These components can fail due to premature ageing, incorrect design (vibration system design clamping arrangement and bolt tightening torque, mechanical strength etc.), poor quality of material, rusting of components, loosening/breaking of split pins, bolts and nuts, etc.

Damage to earth wire of overhead lines occurs due to the following probable reasons :

1. Improper design of earth wire i.e. incorrect lay ration, chemical composition and incorrect procedure of wire drawing, low mechanical strength, high electrical resistance, incorrect method of galvanization, etc.
2. Frequent lightning discharges and earth faults between conductor and earth wire resulting in high temperature stresses, burning and loss of mechanical strength.
3. Falling of trees on the earth wire, hitting of flying objects to the earth wire, etc.
4. Damage of earth wire near joints because of improper crimping and bad quality of material.
5. Breakage of split pins provided in suspension clams. This may cause dislodging of suspension clamp holder and the earth wire may fall.
6. Accumulation of moisture and water in suspension clamp portion holding earth wire which may cause rusting and hence damage of earthwire. The design of earthwire/suspension clamp with reference to environmental effects has to be taken care of properly.
7. Breakage of strands of earth wire, suspension clamp, dead end points etc. due to vibrations.
8. Failure due to inefficient earthing and also due to number of lightening discharges and ageing.
9. Loose flexible earth bond with the earth wire. In this case during lightening stroke(s) the earth wire may get damaged/broken.
10. Use of improper/ineffective earth wire vibration dampers etc.

**b. Earth Wire Accessories**

1. Poor quality of earth wire accessories i.e. earth wire, suspension clamps, dampers, earthing bond etc.
2. Improper design of clamps.(Not taking into account the environmental effect).
3. Incorrect application of tightening torque for clamping bolt of suspension clamps, tension clamps of bolted type and vibration dampers”.
4. Incorrect design of vibration system leading to failure of vibration dampers wherever used.

**8.3.6 Probable Causes for Failure of Towers**

The tower and hardware is the main component of a transmission line. The towers support conductors, insulator strings and earth wire. The towers mainly comprise of main legs and bracings of different configuration. The towers are fabricated out of mild and high tensile steel, hot dip galvanized bolts, nuts and spring washers.

Tower structure is a main component of transmission system. The failure/collapse of a tower can cause interruption of power supply for prolonged periods. The erection of a new tower or setting right the defective tower is quite a difficult job which may even take several days for restoration of power supply. It is, therefore, very essential to give proper weightage to the aspect not only from the point of preventive maintenance of tower but also to know the causes leading to its failure.

The tower hardware comprises of number plate, circuit plates, danger plate, a set of phase plates, anti-climbing device, earthing device, tower earthing bonds, bird guards, etc. Installation of these hardware on towers in addition to meeting statutory requirement also improves the operational performance of lines in terms of tripping of the lines due to lightning discharges, earth faults, pollution flashovers, etc.

**a. Towers**

Towers may collapse due to following reasons:-

1. Faulty detailed survey, check survey, setting of line, incorrect type of towers, etc.
2. Poor quality of tower material bolts nuts and spring washers etc.
3. Tower super structure of improper design and not meeting reliability, security and safety loads and narrow front wind loads
4. Soil erosion
5. Foundation not matching with the soil data (i.e. incorrect soil data)
6. Poor workmanship and negligent foundation casting i.e. improper setting of stub, in correct laying of reinforcement, improper fixing of foundation form work while concreting, not following the drawings properly, etc.) besides poor quality of foundation material.”
7. Not maintaining proper sum of adjacent spans, maximum and minimum span etc.
8. Missing of tower members due to theft/pilferage etc.
9. Hitting by vehicles and flying objects such as Aeroplane/helicopters

10. Damage by miscreants
11. Uplift of tower not properly compensated
12. Backfill not properly compacted
13. Eccentricity in the tower/out of verticality
14. Improper detailing of joints.

**b Bolts and Nuts**

1. Due to conductor vibrations, the tower vibrates and causes loosening of nuts and bolts.
2. While fixing nuts and bolts, some-times, washer is not provided. The nuts and bolts are not fully tightened even not punched. Such nuts and bolts get loosened due to vibrations and fall on ground.
3. The nuts and bolts break sometimes due to sparking/flashover due to improper earthing
4. Nuts and bolts may break due to over tightening
5. Some-times, if the breaking of the tower is fitted forcibly, nuts and bolts are subjected to bending and due to addition of vibrations these break and fall down.
6. Due to non-provision of washers, the nuts are subjected to uneven pressure and these break
7. If the threads of bolts go inside the hole due to reduction in diameter, the bolts can not take the force and fail.
8. Improper tack welding of bolts and nuts resulting in burning of bolt material.

**c Probable Causes for Rusting**

1. Due to deposit of dust on the roadside, cement pollution near cement factories etc. tower super structure/anti climbing devices may get rusted.
2. Due to poor quality of material used in super structure and anti climbing devices
3. Due to poor galvanizing of material
4. Due to the effect of chemical industries near the vicinity of towers
5. Heavy growth of grass & bushes, collection of chemical active soil, collection of water, etc. around the legs/stubs and honeycombing during concerting of stub causing exposure to chemicals present in sub soil water.
6. Collection of rain water due to non provision of drainage holes in the pockets formed in assembled structure

**d Probable Causes of Failure of Tower Foundation**

Foundation is the vital component of a transmission line. It serves as a base for erection of tower. The foundations for normal types of towers are of mass concrete or reinforced concrete type. Special types of foundations (well type, pile type, etc.) are used with special type of towers, river crossings, etc. The materials used for casting of

foundations are cement, coarse and fine aggregates and reinforced rods. Classification of a foundation depends on type of soil and sub soil water level. The grade of concrete (M15,M20 etc.) depends upon the loads to which the foundation is to cater.

The probable causes of failure of towers foundation are given as under :-

1. Land slide
2. Sinking of hill
3. Soil erosion
4. Faulty casting of foundation (poor concrete mix, incorrect size and laying of reinforcement bars, improper compaction and curing, etc.
5. Unequal movement of various legs of foundation due to earth quake.

**e. Causes of Erosion at the Base of Foundation/Tower Legs**

1. Due to diverted flow of rain water/flash floods.
2. Due to river/canal/nallah adjacent to the tower and possible breach etc.
3. Excavation works carried out by farmers near the tower. Also excavation done by other agencies for mining, quarrying and earthwork material for constructing roads etc.
4. Natural erosion of soil due to rain water (surficial and sub surficial flow).
5. Other causes including opening of gates of the spillways on upstream side of the tower etc.

**8.3.7 Probable Causes of Damage of Earthing Electrode and Earthing strip Etc.**

The earthing system of the transmission towers play a major role during normal working as well as during abnormal working of transmission lines. Earthing system of transmission line comprises of towers, earth wire including jumpers, earthing bonds, individual earthing electrodes of the tower and connections thereof or a set of counter poise earthing. Every tower is provided with individual earth by providing earth electrodes and connection with MS flat on one leg. The values of tower footing resistance of towers are required to be kept as low as possible but not beyond limits (Max. 10 ohms).

The probable causes for damage of earthing rods/strips are given as under :-

1. Nuts and bolts, earthing strip and earthing electrodes provided for earthing of towers get rusted/deteriorated with the passage of time and get damaged.
2. Vibrations lead to loosening of nuts and bolts used for fixing MS Flat to tower.
3. Lightening strokes and discharges can cause damage to earthing electrodes/earthing strips due to loose nuts and bolts
4. Theft of earthing material (M.S. flat used for connection, galvanized stranded steel wire used as counter poise).

## **8.4 MAINTENANCE PROCEDURES OF EHV TRANSMISSION LINES**

### **8.4.1 INTRODUCTION**

Today, RVPNL is maintaining transmission lines of Voltage class upto EHV AC 400 kV. These lines criss-cross the entire length and breadth of the Rajasthan and power is transmitted on these lines to the remotest corner. A very high degree of availability is therefore required which consequently gives break down maintenance of these elements paramount importance.

Breakdown maintenance is not a desired phenomenon. RVPNL try their utmost to carry out preventive maintenance in such a fashion so as to avoid break down maintenance to the extent possible. No amount of effort, however, is sufficient so as to ward off breakdowns altogether.

Generally, the following types of breakdowns are required to be attended to ;

- i. Tower collapse including foundation failure
- ii. Cross arms failure of tower
- iii. Earth wire failure
- iv. Jumper failure
- iv. Conductor snapping & breakages
- vi. Insulator failure
- vii. Reduction in clearance due to swing/Falling and growth of tree & branches
- viii. Hardware failure

Although there are minor/major modification in the design of towers ranging from 66kV to 400kV to take care of various parameters like number of sub conductors in a bundle, statutory clearances, live metal clearances, angle of shield and so on, the essential principle of break down maintenance of all towers/line material remain basically the same as described below :

### **8.4.2 METHODOLOGY**

Declaration of Break-down on line

After declaration that the line is faulty, following activities are carried out.

### **8.4.3 Locating the fault**

A number of methods are now available to pin point with a great deal of accuracy the location of a fault along the line. After having done so, the shift incharge is required to inform all concerned.

### **8.4.4 Patrolling and scheduling**

Patrolling is carried out and a schedule is prepared for the restoration of the line at the earliest taking in to account various factors like importance of the line (evacuation line, link line, inter regional line, grid strengthening etc.), availability of ERS, restoration on normal towers depending on the availability of spare towers and damage to the foundations, and so on. It must be mentioned here in this connection that there can not be a hard and fast rule or even a

thumb rule to determine the restoration time of a broken down line. It all depends on factors mentioned above as also many other reasons.

After getting a message of location of breakdown, a responsible engineer shall immediately visit the site. He shall inspect :

- The approach to the location and list out the activities to be carried out to clear the approach for truck, tractor & light vehicle
- Inspect the spot and list out the activities to be carried out to clear the site from bushes and other hindrances for easy handling of T&P and material required
- Inspect the failed part of the line and list out the materials and T&P required for the hob
- If some stays are to be provided the pit digging works shall be marked immediately and pit digging started.

After this but before leaving the site, he shall start approach clearance work and site clearance work immediately so that site is cleared for working as soon as gang, T&P and material reaches site. Similarly, unskilled man power required shall be arranged for the future work there itself.

Before starting, list of persons shall be prepared, sub gangs be formed activity-wise and their transportation arrangement to the site be made.

The scope of above activities will widen as per the nature of break down and controlling officer will be the best judge for planning. Similarly, meals are to be arranged at site only to avoid wastage of time. First aid and seasonal medical drugs shall be available for the maintenance of health of the workers. There should always be some vehicle available at workspot to meet any accidental exigencies and this shall be covered in the planning. Sufficient potable water arrangement and tents etc. shall be available at site depending upon the nature of work. Sufficient discharging local earthing sets shall be taken to site after due inspection for their perfect ness. Site camps for the convenience of the workers can be arranged in local Gram Panchayat halls etc. as per the facility available.

#### **8.4.5 ANTI CORROSIVE MEASURES**

It is observed that there is rusting of tower super structure, anti-climbing devices, stubs at concrete joints etc. since the transmission line passes through open fields the tower super-structure has to face all the climatic abnormalities/pollution effects due to chemical industries etc., as such tower super structure may get rusted at some specific locations.

#### **8.4.6 Preventive measures/anticorrosive measures**

1. Apply two coats of black bitumen paint of good quality on the tower stub/legs above ground level and also around the concrete muffs.
2. remove the soil from the stubs/tower legs and cut down the heavy growth of grass/bushes to avoid rusting
3. Apply red oxide and aluminum paint on the rusted tower super structure and anti climbing devices. This should be cleaned with wire brush etc. before applying the paint of the rusted structure.
4. The tower super structure and all other accessories used on the tower should be of galvanized steel for avoiding corrosion etc.

Generally, it is seen that maximum number of tower failures are due to failure of its foundations. This is due to design deficiency and not maintaining the quality of work of foundation during construction stage and wrong soil classification and sometimes due to negligence in maintenance.

- a) It is the experience that very less maintenance is possible for the foundation underground. However, following is the maintenance to be carried out for the portion above ground level, which is mostly a chimney part and muffing. The soil around chimney gets disturbed due to cultivation and various types of quarrying/digging by various departments for buildings, roads, railways, dams and for other construction purposes. Land sliding/hill sinking etc. takes place due to diverted water from nallahs, rivers etc. and other natural causes. Hence the only remedy remains to take care of all these soil erosions in time and due to necessary works such as building of retaining walls, diversions for water wherever required.
- b) Similarly, bushes should not be allowed to grow nearby foundations which cause storage of more water near foundation and if some hair cracks are there in the foundation, it causes water seepage in the concrete and results in rusting. This is practical experience observed.
- c) Similarly, soil should not be above muffing level to avoid rusting of the stub. If any cracks are there in chimney, it should be repaired by using cement slurry. In case of field where chemical fertilizers are much in use or near factories where factory water comes near the chimneys shall be given protective coating to avoid deterioration of chimney concrete.

The condition of the foundation can be assessed by non destructive methods and accordingly the foundation strengthening or repair is to be carried out as per result. If some cracks are found in chimney, the repair work is to be done. If only chimney is damaged, except healthy portion of the chimney the upper portion is to be dismantled and re-done with fresh material after observing routine procedure and precautions. If superficial cracks are there, it should be attended by grouting with cement slurry.

## **8.5 TREE CUTTING**

### **8.5.1 Introduction**

Transmission lines are erected for transmitting huge electrical power economically from generating stations to the distant thickly populated and industrial areas where it is not possible or economical to establish generating stations. The power is transmitted at High Voltage (HV) or Extra High Voltage (EHV). The lines carrying the power at Extra High Voltage, the voltage 66 KV and above viz. 66 KV, 132 KV, 220 KV, 400 KV on AC transmission are termed as the transmitting lines. The transmission lines generally pass through the lands of revenue, urban and forest authorities. There are enormous trees in these lands coming in the right of way (ROW) of the lines. For the reasons mentioned below and for maintaining the right of way as per IS 5613 tree cutting is required to be done. It is not economical to divert the transmission lines to avoid tree cutting interfering the ROW. Thus, tree cutting is essential during the line construction activity and also during maintenance of the lines.



Taking into consideration on theoretical requirement of right-of-way and transport requirement of maintenance, the following right-of-way widths are recommended :

Transmission Voltage ( kV )	Recommended Width of Right-of-Way ( M )
132	27
220	35
400	52

### 8.5.2 Reasons for tree cutting :

- i. To facilitate the work of preliminary survey, check survey and marking of tower position
- ii. To facilitate the work of stub setting
- iii. To facilitate the work of tower erection in some areas
- iv. To avoid damage to the conductor and earth wire during stringing and to have economical and speedy work ; and
- v. To clear the right to way as per IS 5613 before commissioning the lines.

### 8.5.3 Reasons for tree cutting during Maintenance of lines

#### To avoid tripping on the transmission lines :

The trees have moisture in them and because of deep roots in the soil the trees provide path for current which happens to flow when the branches of the trees come near the lines. As the distance between the trees and lines reduces there happens electrical break down through the air because of grounding by the trees. Sometimes the branches of the trees touch the lines. For such incidences protection is provided on the lines and those are operated to avoid future damage. Until the protection operates, dangerous step and Touch potentials are developed around the base of the trees which is hazardous to the persons and animals passing nearby . At the time of break down very big spark over takes place with cracking sound.

### 8.6 List of T & P and spares to be maintained by the AEn Incharge of the line :

T & P			Spares ( for every 40 kms of length )		
1.	Electronic fault locator	1 No.	1.	Conductor joint sleeve (aluminium and steel )	2 Nos.
2.	Megger 5000 Volts	1 No.	2.	Earthwire joints	2 Nos.
3.	Hydraulic joint machine for conductor joints with aluminium and steel core dyes.	1 No.	3.	Pre-fabricated armor rods	4 Sets.
4.	Binocular	1 No.	4.	Suspension insulator string with hard wire fitting and clamp	Nos.

5.	Mobile telephone ( BSNL )	1 No.	5.	Tension insulator string with hardware fitting and clamp	2 Nos.
6.	Jeep with trolley	1 No.	6.	Intermediate tower complete	1 No.
7.	Earth rod	3 Nos.	7.	Angle tower ( For 80 kms. )	1 No.
8.	Conductor cutter	1 No.			
9.	Charge line detector	1 No.			
10.	Two-way Three-way pulley with rope	1 Set			
11.	Safety belt, helmet, shoes, etc.	10 Nos.			