MAINTENANCE HANDBOOK ON LIGHTNING ARRESTER

CAMTECH/E/2008/LA/1.0

April, 2008

Centre for Advanced Maintenance TECHnology

Excellence in Maintenance

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MAINTENANCE HANDBOOK ON LIGHTNING ARRESTER
LIGHTNING ARRESTER plays an important role in ensuring safety of electrical equipments as well as working personal from Lightning surges in Traction Installations. The proper maintenance of this equipment is very essential to ensure regular power supply in OHE for smooth running of Rolling Stock in electrified sections.

This handbook contains comprehensive information about construction, maintenance, installation and testing of Lightning Arrester. It also contains new developments in the field of condition monitoring.

I am sure this handbook will prove to be very useful for our field personnel working in Traction Installations.

CAMTECH, Gwalior
Date: 29-04-2008

PRAMOD KUMAR
EXECUTIVE DIRECTOR
PREFACE

Lightning Arrester is a vital equipment of Traction substation (TSS), sub-sectioning post (SSP) and sectioning post (SP). Its proper upkeep and maintenance is necessary to ensure good reliability and trouble free service.

This handbook on maintenance of Lightning Arrester has been prepared by CAMTECH with the objective of making our maintenance personnel aware of maintenance practices as well as new developments in condition monitoring.

It is clarified that this handbook does not supersede any existing provisions laid down by RDSO or Railway Board. The handbook is for guidance only and it is not a statutory document.

I am sincerely thankful to staff and officers of Traction Installation Directorate of RDSO/ LKO for their valuable comments. I am also thankful to all field personnel who have helped us in preparing this handbook.

Technological up-gradation & learning is a continuous process. Hence feel free to write to us for any addition or modification in this handbook. We shall highly appreciate your contribution in this direction.

CAMTECH, Gwalior
Date: 28-04-2008

JAIDEEP
DIRECTOR ELECTRICAL
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CHAPTER 1

GENERAL DESCRIPTION

1.1 INTRODUCTION

The insulation requirements of switch gears are determined by transient voltages, over-voltages, surges or transients. Transients are voltage waves of magnitude higher than desirable value and these persist for a short duration and occur due to several causes, some of them are as follows:

i. Lightning
ii. Sudden changes in circuit condition
iii. Switching
iv. Resonance
v. Arching grounds
vi. Faults
vii. Traveling waves etc.

1.2 WHAT IS LIGHTNING

The clouds get charged during thunder storms and the high potential gradient causes breakdown of insulation of air producing a lightning stroke. The stroke tries to hit the earth, it is attracted by overhead lines and affects line insulators resulting in flash over or puncture. The traveling wave reaches to the substation. The insulation of equipment is also stressed.
Representative values of a lightning stroke:

Voltage - 2 x 10^8 volts.
Current - 2 x 10^4 Amps
Duration - 10^{-5} seconds.
Power - 8 x 10^5 kW

- The purpose of LA is to discharge over voltage to earth and thus prevent service interruption and damage to station equipment.

- Stations connected over head, transmission lines are exposed to over voltage generated during the under storm.

- These voltages may cause damages to station equipments.

- To protect these valuable equipments LAs are installed between line and earth near the equipments to discharge the over voltage to earth.

1.3 TECHNOLOGY TRANSITION

The technology of the over voltage protection devices (i.e., surge arresters) has undergone several changes during the last one century; i.e., since the inception period of power system. Initially, simple spark gaps were used to arrest the over voltages/ surges. Subsequently, lead oxide and electrochemical aluminium cell based devices were used. These devices are however, not hermetically sealed and hence the performance was varying depending upon the environmental conditions. During the 1930s, the
development of silicon carbide no-linear elements had resulted in the hermetically sealed silicon carbide gapped arresters. It is important to note that the silicon carbide based arresters reigned supreme till 1970. During 1970’s the development of ZnO based non-linear elements led to the development of first gapless arresters.. Refer figure 1.1 for historical progress of arrester technology.

Figure 1.1  HISTORICAL PROGRESS OF ARRESTER TECHNOLOGY
1.4 WORKING PRINCIPLE OF GAPLESS LIGHTNING ARRESTER

Zinc Oxide arrester consists of ZnO poly crystalline elements. The elements are housed in a hollow full length of porcelain insulator. The elements exhibit high non-linear voltage current characteristics. During normal voltages lightning arresters does not conduct and acts as an insulator drawing a very little leakage current. When a surge wave traveling along the overhead line comes to the arrester, the surges are absorbed by Zinc oxide elements regain its impedance (i.e. pre-breakdown condition) and ready for subsequent surge suppression.

Contrarily, in the case of silicon carbon (with gap), arrester the current continues to flow till the first cycle zero even after the passage of surge. The absence of follow-on current ensure smooth operation of the arresters. Hence the insulation of equipment connected to the line protected.

1.5 THE ADVANTAGES OF ZnO (GAPLESS) OVER THE SiC (WITH GAP ARRESTER).

- **High non-linearity in V-I characteristics:**
  
  The non linear index $\alpha$ defined as $I = KV\alpha$ is 30 to 40 for ZnO based elements while the same is < 5 in the case of SiC elements.

- **Absence of series/ spark gaps:**
  
  ZnO arresters do not constitute series gaps due to high non – linear while the series gaps are essential in the case of SiC arresters.
• **Superior performance under polluted environments**

Deposition of polluted layer on the porcelain housing of SiC arresters lead to significant increase in the internal temperature due to the presence of series gaps. The absence of series gaps in the ZnO arresters ensures better performance in the polluted conditions.

• **Absence of follow on current**

As soon as the surges are absorbed the ZnO arrester regains its impedance (i.e., pre-breakdown condition) and ready for subsequent surge suppression. Contrarily, in the case of SiC arresters the current continues to flow till the first cycle Zero even after the passage of surge. The absence of follow on current ensures smooth operation of the arresters.

• **High energy handling capability**

ZnO ceramic elements are capable of withstanding higher energies in the range of 150 jouls/ cm².

• **Longer life**

ZnO arresters have inherently better service life in the absence of series gaps and follow on current.

• **Superior protective characteristics**

Combination of high non-linearity and faster response enables the arrester to offer controlled protective characteristics.
1.6 RATING OF LIGHTNING ARRESTER

A lightning arrester is expected to discharge surge current of very large magnitude, thousands of amperes but since the time is very short in terms of microseconds the energy dissipated through the lightning arrester is small compared with what it would have been if a few amperes of power frequency current had been flown for a few cycles. Therefore, the main consideration in selecting the rating of a lightning arrester is the line to ground dynamic voltage to which the arrester may be subjected for any condition of system operation. An allowance of 5% is normally assumed; to take into account the light operating condition under no load at the far end of the line due to Ferranti effect and the sudden loss of load on water wheel generators. This means an arrester of 105% is used on a system where the line to ground voltage may reach line to line value during line to ground fault condition.

1.7 LIGHTNING ARRESTER SPECIFICATION AND TERMS

1.7.1 Impulse Ratio

Impulse ratio of a protection device is the ratio of breakdown voltage on specified impulse wave to breakdown voltage at power frequency.

1.7.2 Terminal Connectors

The line conductors, while connected to the arrester terminal, impose a load on the terminals as well as bending moment at the arrester base. Both these values to be reduced to acceptable values.
1.7.3 Short circuit forces

The arrester has to withstand forces exerted by the flow of short circuit current in the conductors and bus bars in the substation.

1.7.4 Seismic load

The application of arresters in the earthquake prone zones need to have adequate seismic with standing capacity.

1.7.5 Continuous operating voltage of an arrester

The continuous operating voltage is the designated permissible r.m.s. value of power frequency voltage than may be applied continuously between the arrester terminals.

1.7.6 Rated frequency of an arrester

The frequency of the power system on which the arrester is designed to be used.

1.7.7 Puncture (breakdown)

A disruptive discharge through a solid

1.7.8 Flash over

A disruptive discharge over a solid surface

1.7.9 Pressure relief device of an arrester

Means for relieving internal pressure in an arrester and preventing violent shattering of the housing following prolonged passage of fault current or internal flashover of the arrester.
1.7.10 Rated Voltage of the Arrester:

Maximum permissible r.m.s. voltage between the line terminal and earth terminal of the arrester.

1.7.11 Follow Current

The current which flows from connected power source through lightning arrester, following the passage of the discharge current.

1.7.12 Normal Discharge Current

Surge current which flows through the LA after the spark over expressed in crest value (Peak value) for a specified wave.

1.7.13 Discharge Current

The surge current which flows through the arrester after the spark over.

1.7.14 Power Frequency Spark Over Voltage.

r.m.s. value of power frequency 50 c/s voltage applied between the line and earth terminals of arrester and earth which causes spark over of the series gap.

1.7.15 Impulse Spark Over

Highest value of voltage attained during an impulse of given polarity, of specified wave shape applied between the line terminal and earth terminal of an arrester before the flow of discharge current.
1.7.16 Residual Voltage

The voltage that appears between the line terminals and earth of an arrester during the passage of the discharge current.

1.7.17 Rated Voltage

Maximum impulse current at which the peak discharge residual voltage is determined.

1.8 TYPES OF LIGHTNING ARRESTER

The following types are protective – against Lightning surges.
1. Rod Gap
2. Horn Gap
3. Explosion Gap or Protective tube
4. Surge Absorber
5. Lightning arrester or Surge Diverters.

1.8.1 Rod Gap

The simplest protection of line insulation, equipment, insulators and bushings is given by rod gaps or coordinating gaps. The conducting rods are provided between line terminal and earthed terminal of the insulator with an adjustable gap. The medium of gap is air. The rods are approximately 12mm, dia or square. The gap is adjusted to breakdown at about 20% below flash over voltage of insulator. The distance between arc path and insulator should be more than 1/3 of the gap length i.e. \( l_1 > 1/3 \) (Fig.1.2)
Figure 1.2 ROD GAP
1.8.2 Horn Gap

The gap between horns is less at the bottom and large at the top. An arc is produced at the bottom during high voltage surge. This arc commutes along the horn due to electromagnetic field action and heat of the arc. Thereby the length increases. The arc may blow out. Horn gap is in between 135 to 160 mm. (Fig. 1.3)

![Figure 1.3](image)

1.8.3 Expulsion gap or Protective tube

An important of the rod gap is the expulsion tube which consists of (i) a series gap (1) external to the tube which is good enough to with stand normal system voltage, thereby there is no possibility of corona or leakage current across the tube; (ii) a tube which has a fiber lining on the inner side which is a highly gas evolving material; (iii) a spark gap (2) in the tube; and (iv) an open vent at the lower end for the gases to be expelled (fig.1.4). It is desired that the breakdown voltage
of a tube must be lower than that of the insulation for which it is used. When a surge voltage is incident on the expulsion tube the series gap is spanned and arc is formed between the electrodes within the tube.

The heat of the arc vaporizes some of the organic material of the tube wall causing a high gas pressure to build up in the tube. The resulting neutral gas creates lot of turbulence within the tube and is expelled out from the open bottom vent of the tube and it extinguishes the arc at the first current zero. At this instant the rate of build up of insulation strength is greater than the RRRV. Very high currents have been interrupted using these tubes. The breakdown voltage of expulsion tubes is slightly lower than for plain rod gaps for the same spacing.

1.8.4 Surge Absorbers

A surge absorber is a device which absorbs energy contained in a traveling wave. Corona is a means of absorbing energy in the form of corona loss. A short length of cable between the equipment and the overhead line absorbs energy in the traveling wave because of its high capacitance and low inductance. Another method of absorbing energy is the use of Ferranti surge absorber which consists of an air core inductor connected in series with the line and surrounded by an earthed metallic sheet called a dissipater. The dissipater is insulated from the inductor by the air as shown in fig. 1.5.

![Figure 1.5](image-url)
The surge absorber acts like an air cored transformer whose primary is the low inductance inductor and the dissipater acts as the single turn short circuit secondary. Whenever the traveling wave is incident on the surge absorber a part of the energy contained in the wave is dissipated as heat due to transformer action and by current. Because of the series inductance, the steepness of the wave also is reduced. It is claimed that the stress in the end turns is reduced by 15% with help of surge absorber.

1.8.5 Lightning Arresters or Surge Diverters

Three classes of lightning arresters are available:

1.8.5.1 Station Type

The voltage ratings of such arrester vary from 3kV to 245kV and are designed to discharge current 10,000 amps, they are used for the protection of substation and power transformer.

Figure 1.6
1.8.5.2 Line type

The voltage ratings vary from 3kV to 123kV and can discharge current 5,000 amps. They are used for the protection of distribution transformer, small power transformer and some times small transformer.

1.8.5.3 Distribution type

The voltage ratings vary from 0.175kV to 0.660kV and an discharge current 1500 amps. They are used mainly pole mounted sub station for the protection of distribution transformer.

In this handbook we will discuss station type LA which is mostly used in switching station.
1.9 CONSTRUCTION OF STATION TYPE LA (Gapless)

1.9.1 Station Type Arresters (Gapless)

Each station type arresters contains one or more units. These units are modular in constructions so that they can be assembled one on the other depending upon the overall rating. This individual unit will have a separate name plate indicating rating and other details, if the arrester contains more than one unit.

The units are connected in series and mounted vertically. The terminal of line units is connected to the line (bus-bar or feeder etc.). The lowest terminal is connected to earth.

The construction of Zinc Oxide gapless arrester is ZnO poly crystalline elements. The elements are housed in a hollow porcelain insulator and hermetically sealed. The number and size of ZnO elements vary depending upon the system voltage and energy class requirements.

ZnO arrester have three regions

i. Pre-break down
ii. Break down/ non linear zone
iii. Upturn constitutes V-I curve
The non-linear characteristics of zinc oxide block is as shown in figure 1.8

![Figure 1.8 Voltage–Current Characteristics](image)

**A** - Bottom linear part (Ohmic region)
**B** - Knee point (Breakdown region)
**C** - Non-linear part/region
**D** - Upper linear part (Up linear region)
**O** - Working point (Continuously applied voltage)

In above figure X axis is in logarithmic scale. This special characteristic is the heart of protection technology.

Functionally the ZnO arrester acts as a near insulator drawing very little current prior to reaching breakdown or threshold voltage and act as a conductor thereafter.

The rated voltage of Zinc Oxide element is proportional to the height. The energy level increases with the increase in area of the Zinc oxide block. Hence, the minimum diameters for different energy class are as below:
Diameters (minimum)
1. Discharge class 1 - 41 +/-1mm
2. Discharge class 2 - 50 +/-2mm
3. Discharge class 3 - 62 +/-2mm
4. Discharge class 4 - 75 +/-2mm

Figure 1.9
CHAPTER 2

SELECTION, INSTALLATION & TESTING

2.1 SELECTION OF LIGHTNING ARRESTERS

Lightning arrester is located near the equipment to be protected. It is the first apparatus from the line to substation, lightning arrester are also installed near transformer terminals. The proximity of earthed objects and height of lightning arrester above earth affects the characteristics adversely. Hence separation distances should be considered.

The requirement of LA is:

a. It should take no current during normal power frequency condition. The break down strength should be above the normal power frequency voltage and permissible over voltage.

b. Transient Over voltages of value more than insulation flash over or break down level should be diverted to earth.

c. The discharge current should not damage the arresters. Lightning arrester should be in a position to absorb the energy without getting damaged.

d. The voltage across arrester during discharge (residual voltage) should not be too low nor too high.

e. Normal condition should be restored soon after the surge has been diverted.
The following procedure is recommended by standard in selection and location of LA.

Determination of maximum phase to ground power frequency voltage at the location of arrester.

This is affected by type of earthing.

- To determine the insulation withstand strength of the protected apparatus.

- Tentative selection of voltage rating and class of the arrester based on above.

- To determine the limit voltage level to be protected by the lighting arrester.

- Final selection of lighting arrester.

2.2 ABNORMAL SERVICE CONDITION

The following parameters are generally considered as abnormal service conditions for ZnO arresters.

- Ambient temperature in excess of +50°C or below -10°C & heat sources near the arrester.

- Installation at higher altitude (>1000m) locations.

- Locations where corrosive vapours or fumes and/ or explosive mixtures of dust, gases or fumes are generated continuously/ frequently.

- Excessive contamination by smoke, dirt salt spray or other conducting materials.
• Live washing of arresters.
• Nominal frequencies below 48 Hz and above 62 Hz.
• Abnormal mechanical conditions such as (i) earthquakes, (ii) vibrations, (iii) high wind velocities, (iv) high cantilever stresses and (v) high ice loads etc.

Application of arresters under the above abnormal service conditions calls for special consideration in the manufacture and hence the conditions should be brought to the attention of the arrester manufacturer.

2.3 SELECTION OF LIGHTNING ARRESTER VOLTAGE RATING

Operating voltage (COV & MCOV)

The continuous operating voltage (C.O.V.) is the normal sinusoidal power frequency voltage across the arrester terminal continuously. C.O.V. is usually estimated as nominal system voltage $\sqrt{3}$. The maximum continuous operating voltage (M.C.O.V.) is the maximum permissible value of a sinusoidal power frequency voltage which may be continuously applied between the arrester terminals. In other words, M.C.O.V. is the maximum steady state voltage which the arrester can withstand on a continuous basis under the normal operating conditions. MCOV is estimated as Max. system voltage$\sqrt{3}$. The MCOV and COV of commercial arresters usually bear a margin of 5 to 10% depending upon the manufacturer. Note that the margin is given based on the harmonic content in the system voltage.
**Rated voltage**

The rated voltage is the maximum power frequency voltage that is applied in the operating duty test for 10s (IEC:99-4). The rated voltage is usually defined based on the following relationship.

\[
\text{Rated voltage} = (\text{Max. system voltage}) \times (\text{ground fault factor})
\]

Ground fault factor
- for effectively/ solidly grounded system = 0.8
- for ineffectively grounded system = 1

As in the case of COV & MCOV estimation, the margin in the rated voltage calculation is considered based on the harmonic content in the system voltage. However in any case, the margin should not be more than 10%. Use of higher rated arrester increases the capability of the arrester to survive on the power system, but reduces the margin of protection for a specific insulation level.

The arrester selection must strike a balance between arrester survival and equipment protection. Note that the rated voltage is the reference parameter to establish the power frequency voltage versus time characteristic of the arrester (IEC 99-4).

**2.4 RECEIVING AND STORAGE OF LA**

On receipt of the unit, detailed inspection is to be carried out for any visible sign of damages.

Un-pack the units carefully, examine for breakage or other damages especially to the porcelain. A close
examination by a competent person is required to check such damages. If damages exist, inform the company as well as the carrier.

A thorough check of the parts with the packing list should be made and if shortages exist, inform the carriers as well as the company.

2.4.1 Storage

Arrester crates should be stored preferably indoors on cement floor to prevent damage to crates or water entry into arrester. For longer storage it is essential to have elevated platforms with covered sheds.

2.5 INSTALLATION

2.5.1 Preparation

• Before proceeding with the installation of the pole all the units making up the pole should be identified.
• Crane or chain pulley block, nylon ropes ‘D’ shekel and pulley etc. should be available on site.
• Remove the arrester from wooden containers and check for any visible sign of damage.
• Before installation take the insulation resistance of each unit.

2.5.2 Precaution

• The arrester should not be lifted using its line terminal.
• The maintenance or any staff should not be climbed for any reason.
• These should be handled only in upright position. Using crane or chain pulley blocks, nylon rope can be wound around the porcelain and can be used for lifting.

• The line terminal connection should be made without giving an excessive mechanical strain to the arrester.

• Position the exhaust ports of the arrester so that they are away from the nearby objects and other arrester poles.

2.5.3 Installation of Single Unit Arresters

Install the arrester on the mounting surface with the help of crane or chain pulley block wound by the nylon rope around the porcelain for lifting. Care to be taken that it is perpendicular; shimming under one or two mounting lugs or brackets of end fitting, if necessary. It is important that all brackets or lugs rest solidly on the mounting surface to avoid unnecessary stresses in the end fitting. Tighten the bolts firmly.

In case discharge counter is used, an insulating base will have to be used to isolate arrester from ground. The discharge counter is electrically connected in series with arrester and the discharge counter mounting bracket is connected to station ground.

2.5.4 Installation of Multi-Unit Arrester

The individual arrester units be erected in the exactly same order which is specified on the out line drawing. The model number of the arrester units is given on the unit name plate. The out line drawing for the spacing as also for the stacking arrangement of individual unit.
Install the insulating base on the foundation bolts as in the case of discharge counter is used. In case insulating base is not used; install the bottom unit on the mounting surface. See that the arrester is perpendicular. Shims may be used under one or two feet if necessary. It is important that all the three feet rest solidly on the foundation before the foundation bolts are drawn to avoid unnecessary stresses in the end fittings. The opening of pressure relief should be oriented so as to minimize damage to adjacent equipment by incandescent gases in the remote event of arrester failure.

Select the next unit carefully by referring to the outline drawing and bolt it securely to the insulating base or the base unit as the case may be, using shims if required. Keep the arrester perpendicular.

Complete the stacking arrangement in the same manner as above, using the proper units for the proper rating.

2.6 GRADING RINGS

For arrester of 96kV and above a grading ring is provided to ensure an equal distribution of voltage across the unit.

2.7 LINE AND GROUND CONNECTION

In case insulating base is not used connect the arrester ground to the apparatus ground and the main station ground, utilizing reliable common ground net-work of low resistance. In case insulating base and discharge counter are used. The discharge counter mounting bracket is to be connected to main station ground. The line point of the discharge counter is to be connected to ground terminal of
the arrester with a suitable lead. Suitable terminal is provided to connect the arrester to the line. Line connection should be made in such a manner that excessive mechanical stresses is placed on the arrester.

2.8 **SURGE MONITOR**

**General**

The use of modern diagnostic techniques means generally increased service reliability and cost savings for the electric power industry. It is therefore desirable to check the emendation of surge arresters at regular time intervals, by measuring the resistance component of the continuous leakage current in service without de-energizing the arrester.

**Construction**

To monitor the healthiness of the lighting arrester, each arrester shall be provided with surge monitor. Surge monitor shall be designed to record directly the number of surges handled by the lightning arrester on a cyclometric counter and also indicates the leakage current passing through the lightning arrester on an ammeter continuously. No push button shall be provided in the ammeter circuit for taking the reading of the leakage current surge monitor shall be interchangeable and suitable for outdoor service. The design of surge monitor shall be such that in the eventuality of its failure, the lightning arrester base should automatically be connected to the earth system.

For station class arrester depending on requirement on insulating bore will also be supplied for isolating the bottom of arrester from structure/ground. For this purpose a connection from the arrester bottom to the surge monitor
bushing and surge monitor body to the station ground is required to be connected.

This essentially connects the surge monitor electrically in series to the arrester in question, therefore it is advised to see that the connecting flat from arrester bottom to surge monitor bushing does not touch the structure of the grounded object (As shown in figure 2.1)

![Figure 2.1](image)

It is recommended that connections lengths from arrester bottom to the surge monitor and surge monitor to station ground should not exceed two meters each. Connections from lighting arrester base to surge monitor unit/earth terminal shall be made through a small piece of 35mm$^2$; 1100 volts grade; unarmored PVC insulated copper cable.

![Figure 2.2](image)
2.9 TESTING AND COMMISSIONING

- To take the insulation resistance of the each units, if it is within permissible limit arrester can be energized.

- Ensure all connections are made before an energization.

- If no facilities exist to check the leakage current of arrester, it may be energized after erection and the surge monitor will indicate the actual condition of the arrester.
CHAPTER 3

MAINTENANCE SCHEDULES

3.1 MONTHLY SCHEDULE

2. Clean the insulator of LA with dry cloth and check flash mark, chipping, surface cracks etc.
3. Record the number of discharges of surge counter if meter is provided.
4. Value of leakage current to be recorded if provided.

3.2 QUARTERLY SCHEDULE

1. Check all points stated in monthly maintenance schedule.
2. Check and tighten main and earth connections.
3. Check and tighten guarding rings if applicable.

3.3 HALF YEARLY SCHEDULE

1. Check all points stated in monthly, Quarterly maintenance schedule.
2. Measure the leakage current and record if leakage current monitor is provided as per specification no. TI/SPC/PSI/LCMLA/0030.
3.4 YEARLY SCHEDULE

1. Check all point stated in monthly, quarterly, half yearly.

2. Check the IR value of LA each units. The IR value for 42kV LA should be more than 1G ohm and more than 10G ohms (For LA on HV side). The meggering should be done by 2.5/5kV megger.

3. Check the earth resistance of earth connection it should not more than 0.5 ohms.

4. Records for the measurements of each LA shall be maintained including location, rating, make, serial no., date of manufacture, date of commission, date of measurement, IR value, THRC value of leakage current, total leakage current, no. of surges passed and remarks.

3.5 PRE MONSOON CHECK

Before onset of monsoon season it should be ensured for LA, no schedule maintenance work is overdue.

In addition to schedule maintenance following work may be ensured.

i. Proper cleaning of all arresters should be carried out.

ii. IR value of each unit should be checked positively to avoid any bursting or failure lightning arrester.

iii. All connection tightness should be ensured.

iv. Leakage current monitor reading should be checked, if provided.

v. Surge counter reading should also be checked, if provided.
CHAPTER 4

FAILURE, CAUSES & REMEDIAL ACTION

During seminar on maintenance of LA on 23\textsuperscript{rd} and 24\textsuperscript{th} Aug 7 the following common failure obtained.

1. Failure
   Low insulation resistance value

Causes
   - Ingress of moisture inside LA
   - Ageing of zinc oxide blocks

Remedial Action

i. Disconnect & unload LA from line carefully and kept aside.

ii. If LA consists of single unit, check the IR value of spare LA it should be found within permissible limit, replace the defective LA.

iii. If LA consists of more than one units, check the IR value of each unit dismantle low IR value unit and provide fresh unit of same make unit

iv. Check the IR value of complete LA, it shall be within permissible limit.

v. Erect the LA & take IR value again and reconnect the all connection before commissioning.
2. **Failure**

LA Burst or punctured

**Causes**

- Heavy rain and thundering

**Remedial Action**

i. Disconnect & unload the LA from line carefully and kept aside.

ii. If LA consists of single unit check the IR value of spare LA it should be found within permissible limit, replace the defective LA.

iii. If LA consists of more than one unit remove the busted or puncture unit and check the IR value of other units and provide healthy unit of same make.

iv. Check the IR value of complete assembled LA, it should be more than permissible limit.

v. Erect the LA & take the IR value again and reconnect the all connection before commissioning.
3. **Failure**

Hair cracks on porcelain portion of insulator.

**Causes**

Hitting by foreign body, Manufacturing defect

**Remedial Action**

i. Disconnect & unload the LA from line carefully and kept aside.

ii. If LA consists of single unit check the IR value of spare LA it should be found within permissible limit, replace the crack LA.

iii. If LA consists of more than one unit remove the crack unit and provide healthy unit of same make and assemble.

iv. Check the IR value of complete LA, it should be more than permissible limit.

v. Erect the LA & take the IR value again and reconnect all connection and commission.
4. Failure

Hot spot on top connector.

Causes

Loose connection

Remedial Action

1. Tighten the connection.

2. i. If LA top connection plate is repairable then repair it and LA can be used.

ii. All overheated nut & bolt should be replaced.

iii. If LA top connection plate badly overheated same LA disconnect & unload from line carefully.

iv. If LA consists of single unit, check the IR value spare LA, it should be found within permissible limit, replace the defective LA.

v. If LA consists of more than one units, remove the top unit and provide healthy top unit of same make and assembled.

vi. Check the IR value of complete LA, it should be within permissible limit.

viii. Erect the LA & take IR value again and reconnect the all connection before commissioning.
5. **Failure**

   In one case the top diaphragm burst.

**Causes**

   Manufacturing defect.

**Remedial Action**

   i. Disconnect & unload the LA from line carefully.

   ii. If LA consists of single unit check the IR value of spare LA it should be more than permissible limit, replace the defective LA.

   iii. If LA consists of more than one unit replace the defective LA and provide healthy unit of same make and assemble.

   iv. Check the IR value of complete LA, it should be more then permissible limit.

   v. Erect the LA & take the IR value again and reconnect all connection before commissioning.
CHAPTER 5
DOs AND DON’Ts

5.1 DOs

1. Before maintenance, inspection or replacement work, take shut down & earthed the concern circuit disconnect the arrester from line end as a safety precaution.

2. While erecting arrester it is to keep the vent ports away from transformer and other equipments, so as to prevent damage to them in the event of failure of arrester.

3. Damaged or unserviceable arrester should be kept away from the healthy arrester.

4. Arrester crates should be stored indoors on cement floor to prevent damage to crates or water entry into arrester.

5. Arrester crates should be kept in vertical position to prevent damage and loosening of parts inside.

6. If surge monitor is not used, then connect the bottom of arrester directly to station earth.

7. Always be certain that the ground connection is firmly made before connecting the arrester to an energized line. In case discharge counter is used, it must be connected before connecting arrester to an energized line.

8. When installing the grading rings individual care should be taken to avoid rings striking the porcelain.

9. In multi units same make units should be used.
5.2 DON’TS

1. Do not work on arrester without taking shut down in concern circuit.

2. While maintenance or installing the arrester unit. The staff should not be climbed as this may result in breakage of porcelain.

3. The chipped or cracks porcelain housing of arrester should not be installed.

4. Arrester should not be lifted by line terminal, rope may be used around the housing for lifting the arrester.

5. The arrester should not be tilted, these should be handling only in an upright position.

6. In case any abnormal sound amounting of broken. Components inside the porcelain housing is heard in any of the arrester, the arrester should not be used.

7. In multi units different make should not be used.

8. The arrester should not be used as bus support.

9. The earth terminal of the arrester should never be isolated in the event of removing of surge monitor disconnection should be by-passed by an earthing shunt.

10. Surge monitor being an sensitive instrument proper handling of the instrument is required.
CHAPTER 6
NEW DEVELOPMENTS

6.1 CONDITION MONITORING OF LA

Leakage current monitor as per RDSO specification no. TI/SPC/PSI/LCMLA/00030 may be used by the Railways for measuring the third harmonic resistive components (THRC) leakage current of LA.

A complete portable system (LCM III) for condition monitoring of live surge arrester. The system is suitable for measurement and analysis of resistive leakage current of LAs in live switch yard conditions without any need for shut down. The system is based on the measurement of 3\textsuperscript{rd} harmonic resistive current with compensation for harmonic in the system voltage shown in figure (6.1).

![Schematic diagram of leakage current monitoring equipment](image_url)

Figure: 6.1
Schematic diagram of leakage current monitoring equipment
It provides quick and reliable information about the health of the LA and allows for storing of all the measurement data in the field.

The system includes a complete set of accessories, a carrying case for safe transportation and storage of kit of accessories required for the successful operation of the system at site.

### 6.2 MEASURED PARAMETERS

- The LCM III measures and displays the following parameters in a charged switch yard.
  - Direct display of total leakage current of the LAs.
  - Direct display of third order harmonic current.
  - Direct display of resistive leakage current.
  - Direct display of corrected value of resistive leakage current referenced to 70% rated voltage and 20 deg. C.

### 6.3 BENEFITS WITH THE LCM

The LCM can monitor the condition of high voltage Surge Arresters in service. The LCM measures the resistive component of the leakage current of the Arresters. Increased resistive current indicates a higher risk of breakdown of the Arresters. The LCM offers the following benefits.

- Confident knowledge to replace surge arresters in due time before an arrester failure occurs. The LCM is the most reliable system for diagnosis of metal oxide surge arresters on the market.
• Capability to prevent costly arrester failure and possible damages to other major equipment in the neighborhoods. An important achievement is an increased safety for the maintenance staff.

• No disturbance for the normal operation of the system. The condition of surge arresters is checked without any influence on the operation of the power system.

• Assured knowledge of the condition of the surge arresters. This experience is even more important as the age of the arrester increases. It is very satisfactory also to know whether the condition of the components in the supply system is “perfect”, or not.

• Systematic information about all measured surge arrester. It is included a comprehensive data base to give all necessary information like the status of each arrester, key data of each item, numbers of measurements, time for next measurement etc.

The instrument should be used as a part of the regular maintenance program to increase the reliability of the supply. Many power utilities are using the LCM world wide since 1989 and the current number sold is more than 200 units.

The LCM is a very reliable system for field measurements. The instrument is portable and gives fast results. The method for measurements is well accepted internationally. The LCM is based on harmonic analysis of the leakage current using a principle called third harmonic with compensation. System for measurements of third harmonic resistive leakage current only, is considered very unreliable.
6.4 APPLICATION OF LCM

The LCM may be used in three different ways:

- As a portable instrument for checking the conditions of the surge arresters on a regular basis.

- To monitor the condition of an arrester during a shorter or longer period of time for instance to investigate in more detail the behaviours of an arrester which shows a leakage current higher than expected.

- Permanently installed for continuous registration in substations of big importance to the operation reliability of the system.

6.5 RECOMMENDATION

- The resistive component of the leakage current should be measured short time after the arrester installation. This measurement is the best reference (“finger print”) for comparison with future measurement.

- Measurements should be carried out regularly, especially in locations where the arresters are exposed to atmospheric pollution. Measurements are important after periods with bad weather conditions and flashovers in the network, caused by salt and/or industrial pollution. Decisions about measurements should therefore, be taken by the local staff responsible for the area and not by a centralized organization not updated on the local conditions.
• Measurements should be carried out after special fault situations in the network causing TOVs of high amplitude and/or long duration.

• In most cases the ageing causes a gradual increase of the leakage current with time. If therefore procedures for leakage current measurements are established, it will be possible to detect aged arresters and take them out of service before failures occur.

• In this respect it is also important to point out that an arrester failure is not only the question of a lost arrester, because an arrester failure may cause severe system disturbances and also cause damage to other equipment like transformer bushings etc.

• Reliable diagnostic equipment, that in an easy way can be used in service without disturbing the operation of the system, will be of great benefit to the users. The use of such equipment is recommended to be a part of the regular maintenance of the electric power systems. It is important, however, that measuring equipment based on harmonic analysis of the leakage current have features that compensate for the influence of the harmonics in the system voltage.
The followings are the sources for LCM procedure:

1. PGK Electronics  
   D/96/C, SOWBHAGYA COLONY  
   K.K.Nagar (near Bus terminus), Chennai – 6000 78  
   Tel : 24892003, E-mail; Pami@vsnl.com

2. Applied TECHNO PRODUCTS Pvt. Ltd.  
   (Principals; M/s Transi Nor As, Hornebergreien 7, N-7038, Trondheim; Norway)  
   D-14, Pamposh enclave greater kailash – 1, New Delhi – 110 048  
   Ph. – 011 – 26485134, Fax – 011 – 26224381  
   E-mail – appliedtechno@vsnl.com.
To upgrade maintenance technologies and methodologies and achieve improvement in productivity, performance of all Railway assets and manpower which inter-alia would cover reliability, availability, utilisation and

If you have any suggestions and specific comments please write to us.

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