INSPECTIONS, MAINTENANCE & TESTING PROCEDURES

EARTHING & LIGHTNING PROTECTION SYSTEMS

PREPARED BY:

LIGHTNING PROTECTION CONCEPTS

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Introduction

All earthing and lightning protection systems require some form of maintenance and testing to ensure that the relative protection systems are in tact and fully functional.

The effectiveness of the earthing and lightning protection systems depends on the installation, maintenance and testing methods used.

The testing and inspection of earthing and lightning protection systems should be in accordance with the following codes of practice:

- SANS Code 10313 : 2012
- SANS / IEC 62305 parts 1, 2, 3 and 4
- SANS 10199 : 2010

If the protection systems are not tested and maintained as per the standards, then the earthing and lightning protection systems cannot be regarded as compliant to the relevant codes of practice.

Application of Maintenance

Regular inspections are fundamental for the reliable maintenance of lightning protection systems. Regular testing is fundamental to the reliable maintenance of earth termination systems.

The objective of the inspections is to ascertain that:

- The lightning protection system conforms with the relevant codes of practice.
- All components of the lightning protection system are in good condition and capable of performing their designed functions, and that there is no visible corrosion.
- Any recent additions to the structure that could influence the effectiveness of the lightning protection system be incorporated into the LPS.

Regular testing is required for the reliable maintenance of the earth termination, down conductor, air termination and equipotential bonding of the earthing and lightning protection systems.

The objective of the test procedures are to:

- Verify if there is substantial degradation or corrosion of the below ground conductors.
- Ensure that electrical continuity between various conductive elements is still in place.

Order of Inspections

Inspections and or testing should take place as follows:

- During the construction of the structure to ensure that all cast-in and below ground items are correctly installed.
- Periodically at intervals which is determined by the type of structure to be protected. i.e. corrosion problems and the lightning protection level.
- After alterations, additions or repairs to the structure.
- When it is known that the structure has been struck by lightning.

During inspections, it is particularly important to assess the following:

- Deterioration and corrosion of air-termination elements, conductors and connections.
- Corrosion of earth electrodes.
- Earth termination system D.C. resistance value.
- Condition of connections, equipotential bonding and fixings.

LPS = Lightning Protection System
Lightning Protection Inspection Intervals

The inspector of the LPS should be provided with LPS design report (incl. LPS risk assessments), as-built drawings and test reports.

The inspector should also be provided with any previous LPS inspection and maintenance reports.

The earthing and LPS should be inspected as described earlier and on a regular basis as shown below:

MAXIMUM PERIOD BETWEEN INSPECTIONS OF A LPS

<table>
<thead>
<tr>
<th>Protection Level</th>
<th>Visual Inspection (Year)</th>
<th>Complete Inspection (year)</th>
<th>Critical Systems Complete Inspections (year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I and II</td>
<td>1</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>III and IV</td>
<td>2</td>
<td>4</td>
<td>1</td>
</tr>
</tbody>
</table>

The above inspection schedule is as per SANS / IEC 62305 Part 3. We however recommend that full inspections take place on an annual basis. Critical systems should have a visual inspection twice a year with a full inspection annually. A full inspection consists of a visual inspection as well as the earth resistance and continuity testing of the earthing and LPS.

Inspection Procedure

The purpose of the tests and inspections is to ensure that the earthing and LPS conforms to the standards in all respects.

Technical Documentation

Technical documentation should be checked for completeness, compliance with the relevant standards and agreement with the site layout as executed. The technical documents also give a good indication competency of the original designers and installers and the compliance with the standards.

Visual Inspections

Visual inspections should be made to ascertain that:
- The LPS conforms to the standard
- The LPS is in good condition
- There are no loose connections or accidental breaks in the LPS conductors
- The system is not weakened by corrosion
- Any additions or alterations to the structure are equipped with additional protection
- There is no visual evidence of damage to the LPS or SPDs
- Correct equipotential bonding has been established and any new services entering the structure are adequately bonded
- Separation distances are maintained
- All connections, above ground conductors and SPDs are fully functional

LPS = Lightning Protection System
Testing

A full site inspection of the earthing and lightning protection systems must also include a range of tests to determine the functionality of the protection systems.

Although numerous tests are required, essentially there are only two types of tests that need to be performed on the site:

Earth Resistance Tests

In order to determine the D.C. Resistance of the earth termination system, earth resistance tests are conducted. The earth termination system should be tested as a whole and individual earth electrodes where practical should be tested in isolation (i.e. disconnected from the down conductor or main earth bar).

Generally, the ‘Fall in Potential’ method of testing is applied to small and medium size earth termination systems, for larger earthing systems the ‘Tagg Method’ of testing is recommended.

Required Earthing System Resistances:
- Lightning Protection Systems = 10 Ohms or less
- Mains / Electrical Earthing Systems = 1 Ohm or less (depending on Step & Touch calculations)

Continuity Tests

In order to determine whether or not the correct internal equipotential bonding is in place numerous electrical continuity tests are required between the LPS and the various internal conductive elements of the structure.

Conducting continuity tests for the LPS elements that are not visible (cast-in items and buried items) is essential due to the fact that visual inspections are not possible. Continuity tests across the concrete steel reinforcing is also required where natural down conductors are utilised.

All continuity tests with results less than 0,20 Ohms are acceptable.

Surge Protection Devices

SPDs without a visual indicator need to be tested, preferably using the guidelines or equipment provided by the manufacturer.

LPS = Lightning Protection System

Continuity Test - FLUKE 1621  Earthing Resistance Meter GEOHM C
Earth Resistance Test Procedure

Introduction

The ‘Fall in Potential’ method of testing the D.C. Resistance of an earthing system can only be employed for small to medium sized earthing systems.

Larger earthing systems require special consideration in order to obtain accurate testing and results.

The test procedures as described below are in accordance with SANS Code 10199:2010

Test Procedure for Small & Medium Size Earthing Systems

When it is possible to carry out measurements so that $L_2$ (see Fig.1) is at least five times the largest diagonal width or depth of the earthing system then the ‘Fall in Potential’ method of testing should be utilised.

Place the potential probe $L_1$ along a straight line so that the geometric centre of the earthing system is aligned with the current probe $L_2$. Under ideal conditions $L_1 = 0.62L_2$. The D.C. Resistance should be obtained directly in Ohms.

Procedure for Large Size Earthing Systems

Constraining Conditions

Because the dimensions of many earthing systems are extremely large, it is difficult and unpractical to reach a distance $L_2$ (current probe) of at least 5X the largest diagonal width of the earthing system. The presence of underground services and structures could also affect the accuracy of the results obtained. In addition, the coupling between the voltage and the current leads would be large enough to negate the accuracy of the measurements obtained by the increased distance $L_2$.

Another problem is in determining where the centre of the equivalent hemisphere is and from which point the measurement of $L_2$ is taken.

When measuring large grid type earthing systems, the electrical centre of the grid tends to move from the Geometric Centre to a point on the grid nearer to the Current and Potential Electrodes.

The procedure for the accurate testing of large format earthing systems was devised by ‘Tagg’ and is the most practical method of determining the earth resistance of large format earthing systems.

![Diagram of Fall in Potential Method](image-url)
Tagg Method of Testing

Determine Distance L’1

- Choose a convenient starting point for the linear measurements and a suitable distance L2 for the Current Electrode.
- Insert Potential Electrode at distances L1 equal to 0.2 L2, 0.4 L2 and 0.6 L2 (see Fig.2 Tagg Method below).
- Measure the earth resistance, using each of these potential electrodes in turn. These are resistance Rx1, Rx2 and Rx3 respectively.
- Calculate the Slope variation coefficient Z where

\[ Z = \frac{Rx3 - Rx2}{Rx2 - Rx1} \]

Note: If the value of Z is greater than 2, the distance of L2 must be increased.
- Locate the value of \( \frac{L1}{L2} \) corresponding to this value of Z from the attached table.
- To determine distance L1 multiply value obtained from table by distance L2.

Determine Earth Resistance

- Insert a Potential Electrode at distance L’1 and measure the earth resistance Rx0 for the particular value of L2.
- Repeat this procedure for the two other values of L2 and for each of these values determine the true earth resistance values Rx0.
- To determine the earth resistance at the point of testing the resistance Rx is the average of the three values of Rx0.

<table>
<thead>
<tr>
<th>C</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distance to NDRP electrode (L) m</td>
<td>RX1 = 0.2L2</td>
<td>RX2 = 0.4L2</td>
<td>RX3 = 0.6L2</td>
<td>z</td>
<td>L1 / L2</td>
<td>L1</td>
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<tr>
<td>60</td>
<td>0.1690</td>
<td>0.1965</td>
<td>0.2310</td>
<td>1.2530</td>
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<tr>
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<td>0.2040</td>
<td>0.2205</td>
<td>1.1780</td>
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<td>114</td>
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<td>0.2025</td>
<td>0.2150</td>
<td>0.7570</td>
<td>0.5877</td>
<td>67.0000</td>
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