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CONDUCT OF MAINTENANCE (P950)
OPERATIONS AND MAINTENANCE MANUAL
OPERATIONS & MAINTENANCE CRITERION

TITLE: LIGHTNING PROTECTION SYSTEMS

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RECORD OF REVISIONS

Revision No.	Date	Description
0	08/ 27/ 98	Initial Issue. Replaces 3.7-600, Rev. 0. Deleted Forward, Statement of Authority, Maintenance Standard Update, 1.0 General Requirements and 2.0 LANL Maintenance Policy Documents.
1	04/ 01/ 02	This revision includes the addition of a Table of Contents, the use of Basis Statements in Sections 6 and 7, and incorporates a review of ORPS & NRC lessons learned 1/ 1/ 95 to 6/ 2000.
	04/ 17/ 02	This revision incorporates the latest format of the Criterion 101: Writer's Guide Revision 3.
	05/ 22/ 02	Inclusion of comments and changes from Maintenance Subcommittee review.
	05/ 22/ 02	Rewording of Requirement Training Section 6.2 and inclusion of AHJ per Maintenance Committee request.
	05/ 31/ 02	Inclusion of comments and changes from Maintenance Subcommittee
	07/ 16/ 02	Change in Definitions
2	07/ 21/ 02	Addition of Requirements for structures with Faraday Cage or Faraday-like Shield in explosive areas (Section 6.3)
		Incorporation of all resolved comments from PEER and POC/ FM reviews.
3	10/ 01/ 05	Added Operability and Impairment Definitions. Added requirement for Operability Determinations
4	04/ 01/ 06	Added several definitions; reorganized requirements in Sections 6 and 7; revised Appendix A to remove ML levels; incorporated a review of Lessons Learned from 6/ 2000 to 3/ 2006
5	06/ 06/ 06	Added UL certification as acceptable to demonstrate competence as a LPS inspector
6	12/ 01/ 09	Changes reflect Division reorganization Change references to reflect IMP 951-1 to P 951-1 Change all references to ISD 951-1 to P 951-1 Remove DOE 430.1B references from Section 1

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CRITERION 507
LIGHTNING PROTECTION SYSTEMS

1.0 PURPOSE

This Criterion establishes the minimum requirements and best practices for operation, inspection, and maintenance of lighting protection systems at LANL. This document addresses the requirements of P 315, *Conduct of Operations Manual, and* P 950, *Conduct of Maintenance*; by defining the minimum operations and maintenance criteria for structures, systems, and components that it covers. The criterion lists requirements that are based on codes, standards, contract commitments, lessons learned, or business case. It also lists recommendations based on industry practices, operational experience, or business case. Guidance for implementation of the requirements and recommendations is also provided.

2.0 SCOPE

This document covers the inspecting, testing, and maintaining of all lightning protection systems at scheduled intervals, in accordance with ANSI/ NFPA 780 and DOE M440.1-1. This Criterion does not address corrective maintenance actions required to repair or replace equipment.

3.0 ACRONYMS AND DEFINITIONS

3.1 Acronyms

AHJ	Authority Having Jurisdiction
CFR	Code of Federal Regulations
DOE	Department of Energy
FOD	Facility Operations Director
LANL	Los Alamos National Laboratory
MM	Maintenance Manager
MSS	Maintenance and Site Services
OM	Operations Manager
O&M	Operations and Maintenance

3.2 Definitions

Air Terminal. That component of a lightning protection system that is intended to intercept lightning flashes; lightning rod.

Approved. Acceptable to the authority having jurisdiction.

Authority Having Jurisdiction (AHJ). An organization, office, or individual responsible for enforcing the requirements of a code or standard, or for approving equipment, materials, an installation, or a procedure.

Bonding. An electrical connection between an electrically conductive object and a component of a lightning protection system that is intended to significantly reduce potential differences produced by lightning currents.

Catenary Lightning Protection System. A lightning protection system consisting of overhead wire suspended from poles connected to a grounding system via down conductors.

Explosives Facilities. A structure or defined area used for explosives storage or operation as defined by the DOE Explosives Safety Manual, DOE M440.1-1A.

"Faraday Cage or Faraday Like Shield". An LPS where the area to be protected is enclosed by a heavy metal screen, like a bird cage; or continuous metallic structure with no un-bonded metallic penetrations.

Fastener. An attachment device used to secure the conductor to the structure.

Ground Terminal. That component of a lightning protection system such as a ground rod or a counterpoise conductor that is intended to provide electrical contact with the earth.

Impaired. System deviates from applicable codes and standards however is still able to perform its intended function.

Inoperable. System deviates from applicable codes and standards and is not able to perform its intended function

Lightning Protection System (LPS). A complete system of strike termination devices, conductors, ground terminals, interconnecting conductors, surge suppression devices, and other connectors or fittings required to complete the system.

Listed. Equipment, materials, or services included in a list published by an organization that is acceptable to the authority having jurisdiction and concerned with evaluation of products or services, that maintains periodic inspection of production of listed equipment or materials or periodic evaluation of services, and whose listing states that either the equipment, material, or service meets appropriate designated standards or has been tested and found suitable for a specified purpose.

Shall. Indicates a mandatory requirement.

Should. Indicates a recommendation or that which is advised but not required.

Operable. System is in accordance with applicable codes and standards and is able to perform its intended function

Strike Termination Device. A component of a lightning protection system that intercepts lightning flashes and connects them to a path to ground. Strike termination devices include air terminals, metal masts, permanent metal parts of structures, and overhead ground wires installed in catenary lightning protection systems.

Integral Air Terminal System. An integral LPS is one that has the strike termination device mounted on the structure to be protected.

Mast System. A mast system consists of one or more poles with a strike termination device connected to an earth electrode system by down conductors.

Subject Matter Expert (SME). The person with the knowledge and ability to guide Laboratory and DOE personnel in the area of lightning protection as delegated by the LANL Fire Marshal.

Surge. A transient wave of current, potential, or power in an electric circuit. Surges do not include longer duration temporary over-voltages (TOV) consisting of an increase in the power frequency voltage for several cycles.

Surge Arrester. A protective device for limiting surge voltage by discharging or bypassing surge currents. It also prevents continued flow of follow current while remaining capable of repeating these functions. Surge arresters are installed on electrical service entrances, antenna cables, telephone service entrance, and other wire service entrance (fire alarm and security).

Transfer Impedance. A transmittance expressed as a ratio of the electric field on the interior of a shielded enclosure divided by the current density on the exterior of the shield.

4.0 RESPONSIBILITIES

4.1 MSS-Division Leader

Receives and approves or rejects, in conjunction with the AHJ, requests for variances from this criterion. Maintains the record of decision for all variance requests.

4.2 MSS- Maintenance Programs (MP)

Responsible for administrative content and for monitoring applicability and implementation status of this Criterion. MSS-MP will assist organizations that are not applying or meeting the implementation expectations contained herein or will elevate their concerns to the appropriate level of LANL management.

Basis: P950, Conduct of Maintenance. MSS-MP should provide technical Assistance to support implementation of this Criterion.

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4.3 Facility Operations Director (FOD)

Responsible for implementation of this O&M Criterion for identified systems/ equipment within their facility boundaries.

4.4 Operations Manager (OM)

Responsible to the FOD for implementing operation portions of this Criterion and for coordinating transfer of systems/ equipment to the Maintenance Manager for maintenance activities. The OM with concurrence of the FOD will prioritize implementation within budget allocations.

4.5 Maintenance Manager (MM)

Responsible to the FOD and the MSS-Division Leader for implementing the maintenance portions of this Criterion and for coordinating the transfer of systems/ equipment to the Operations Manager at the conclusion of maintenance activities. The MM with concurrence of the FOD will prioritize implementation within budget allocations.

4.6 Authority Having Jurisdiction (AHJ)

The AHJ(LANL Fire Marshal) is responsible for providing a decision on specific technical questions regarding the systems or equipment relevant to this criterion.

5.0 PRECAUTIONS AND LIMITATIONS

5.1 Precautions

This section is not intended to identify all applicable precautions necessary for implementation of this Criterion. A compilation of all applicable precautions shall be contained in the implementing procedure(s) or work control authorization documents. The following precautions are intended only to assist the author of a procedure or work control document in the identification of hazards/ precautions that may not be immediately obvious.

5.1.1 Follow the safety precautions listed in NFPA 780, Annex M, when inspecting, testing, or maintaining lightning protection systems.

5.1.2 For all work performed on an elevated surface provide for fall protection as outlined in P 101-20 Fall Protection Program.

5.1.3 Aerial lifts or similar devices shall conform to 29CFR 1910.67.

5.2 Limitations

The intent of this Criterion is to identify the minimum requirements and recommendations for SSC operation and maintenance across the Laboratory. Each user is responsible for the identification and implementation of additional facility specific requirements and recommendations based on their authorization basis and unique equipment and conditions, (e.g., equipment history, manufacturer warranties, operating environment, vendor O&M requirements and guidance, etc.).

Nuclear facilities and moderate to high hazard non-nuclear facilities will typically have additional facility-specific requirements beyond those presented in this Criterion. Nuclear facilities shall implement the requirements of DOE Order 431.1 as the minimum programmatic requirements for a maintenance program. Additional requirements and recommendations for SSC operation and maintenance may be necessary to fully comply with the current DOE Order or the Code of Federal Regulations (CFR) identified above.

This Criterion does not specify inspection test and maintenance requirements for lightning detection and notification systems used a substitute for Inoperable or Impaired lightning protection systems. Refer to DOE M 440.1-1A. For requirements for lightning detection notification systems.

6.0 REQUIREMENTS

Minimum requirements that Criterion users should follow are specified in this section. Requested variances to these requirements should be prepared and submitted to MSS-MP in accordance with P 950, Conduct of Maintenance, for review and approval. The Criterion users are responsible for analysis of operational performance and SSC replacement or

refurbishment based on this section. Laws, codes, contractual requirements, engineering judgment, safety matters, and operations and maintenance experience drive the requirements contained in this section.

6.1 Operations Requirements

An LPS inspection shall be performed when

- Any alterations or repairs are made to a protected structure. Record modifications to lightning protection systems in the record drawings and other pertinent documents.
- Any known lightning discharge to the system.
- There are visible indications on the structure that an act of nature such as a storm, flood, tornado, earthquake, etc., or other act could have affected the integrity of the LPS.

Basis: DOE M 440.1-1A, Chapter X, Section 3.2.2. NFPA 780, D-1.1.1.

6.2 Maintenance Requirements

6.2.1 Personnel Qualifications - Lightning Protection System Inspector

Personnel responsible for maintenance, inspection and testing of lightning protection systems for explosive facilities must be knowledgeable of and properly trained in the fundamentals described in NFPA 780 and DOE M 440.1-1A (Explosives Safety Manual)

Basis: DOE M 440.1-1A, Chapter X, Section 3, Inspection and Testing of Lightning Protection System

Note: LPS inspectors and installer qualification may be demonstrated by certification by the Lightning Protection Institute (LPI), Underwriters Laboratory (UL), or by documented evaluation by the LPS SME and AHJ.

6.2.2 Lightning Protection System Inspections Tests and Maintenance (ITM)

6.2.2.1 Conventional Facilities (structures not subjected to DOE M440.1-1A

None

6.2.2.2 Structures with Catenary, Integral, or Mast Lightning Protection Systems

6.2.2.2.1 Visual Inspection

Elements of the lightning protection system shall be visually inspected as specified in DOE M 440.1-1A. The visual inspection of lightning protection systems shall be conducted at least annually. Any evidence of corrosion, broken wires or connections, or any other problem that would negate the system's usefulness will be noted and repaired.

Visual inspections are made to ascertain the following:

- The system is in good repair.
- There are no loose connections that might result in high resistance joints.
- No part of the system has been weakened by corrosion or vibration.
- All down conductors and ground terminals are intact.
- All conductors and system components are fastened securely to their mounting surfaces and are protected against accidental mechanical displacement as required.
- There have not been additions or alterations to the protected structure that would require additional protection.
- There has been no visual indication of damage to surge suppression (overvoltage) devices.
- The system complies in all respects with the current edition of this standard.

A visual inspection shall be performed of applicable surge suppression devices and other LPS components after all lightning flash events where there are visible indications on the structure of a lightning strike and any time there is modification, maintenance or repair to the structure, or penetration that could affect the SSD or LPS component.

6.2.2.2.2 Testing

- Resistance-to-earth testing of the earth electrode ground system shall be conducted at least every 47 months to afford testing during all seasons. It shall also be tested any time major modifications, maintenance, or repair to the structure, or LPS components require the bond or connection to be broken.

  Note: Refer to NFPA 780 Annex E for more on resistance-to-earth testing.

- Electrical resistance measurements of visible external bonds shall be taken at least every 47 months to afford testing during all seasons. Visible internal bonds shall be tested at least every five years. Such measurements are also required when there are visible indications on the structure that an act of nature such as an earthquake, tornado, flood, etc., or other act could have affected the integrity of the bonds; and any time modification, maintenance, or repair to the structure, penetration or LPS components require the bond or connection to be broken.

  Basis: DOE M 440.1-1A, Chapter X, Paragraph 3.2.1

6.2.2.2.3 Acceptable Electrical Test Measurements

Required earth electrode ground resistance-to-earth readings shall be 25 ohms or less. Corrective action shall be initiated when the threshold resistance (25 ohms) is exceeded unless it is not feasible to meet the threshold resistance criterion. In that case, Facility Management is authorized to establish alternative resistance standards up to a limit of 200 ohms without waiver or exemption. However, before taking this

option, reasonable means to improve the grounding system must be considered. Alternative standards must include determination of a baseline system resistance and a testing methodology with criteria to determine system serviceability. Testing shall be conducted only with instruments designed specifically for resistance-to-earth testing.

The resistance of required bonds shall not exceed 1 ohm. Larger readings require tightening or re-securing the bonds.

6.2.2.3 Structures with Faraday Cage or Faraday-Like Shield Lightning Protection System

6.2.2.3.1 Visual Inspection

Visual inspections are made to ascertain the following:

- Bonds and surge suppressors shall be visually inspected every two years to validate the installation and serviceability.

A visual inspection shall be performed of applicable surge suppression devices and other LPS components after all lightning flash events where there are visible indications on the structure of a lightning strike and any time there is modification, maintenance, or repair to the structure, or penetration that could affect the SSD or LPS component.

6.2.2.3.2 Testing

- Electrical resistance measurements of visible bonds shall be taken, as a minimum, once every five years. Such measurements are also required when there are visible indications on the structure that a act of nature such as an earthquake, tornado, flood, etc., or other act could have affected the integrity of the bonds; and any time modification, maintenance, or repair of the structure, penetration or LPS components require the bond or connection to be broken. Transfer impedance measurements shall be taken every fifteen years. Such measurements are also required when there are visible indications on the structure that an act of nature such as an earthquake, tornado, flood, etc., or other act could affect the integrity of the internal structure bonds; and any time there is major modification, maintenance or repair to the structure.

Basis: DOE M 440.1-1A, Chapter X, paragraph 3.2.2

6.2.2.3.3 Acceptable Electrical Test Measurements

The bond resistance should be less than 1.00 ohm. Although a resistance of 1.00 ohm or lower is preferred, a 1.5 ohm resistance is acceptable where necessary for joining of existing structural elements by rebar bonding. Larger readings require tightening or re-securing the bonds.

6.2.3 Inspection and Testing Results

Inspection guides or forms should be prepared and made available to the authority responsible for conducting inspections of lightning protection systems. These guides should contain sufficient information to guide the inspector through the inspection process so that he or she may document all areas of importance relating to the methods of installation, the type and condition of system components, test methods, and the proper recording of the test data obtained.

6.2.3.1 Records and Test Data

The inspector or inspection authority should compile and maintain records pertaining to the following:

6.2.3.2 Conventional Facilities (When Inspected)

- General condition of air terminals, conductors, and other components
- General condition of corrosion-protection measures
- Security of attachment of conductors and components
- Resistance measurements of various parts of the ground terminal system
- Any variations from the requirements contained in this standard
- A diagram of the structure or room showing all points requiring measurements or visual inspection and location of surge suppressors.

6.2.4 Explosive Facilities

6.2.4.1 Structures with Catenary, Integral, or Mast NFPA 780 Lightning Protection Systems

Required earth electrode ground resistance-to-earth readings shall be 25 ohms or less. Corrective action shall be initiated when the threshold resistance (25 ohms.) is exceeded unless it is not feasible to meet the threshold resistance criterion. In that case, Facility Management is authorized to establish alternative resistance standards up to a limit of 200 ohms without waiver or exemption. However, before taking this option reasonable means to improve the grounding system must be considered. Alternative standards must include determination of a baseline system resistance and a testing methodology with criteria to determine system serviceability. Testing shall be conducted only with instruments designed specifically for resistance-to-earth testing.

The resistance of required bonds shall not exceed 1 ohm. Larger readings require tightening or re-securing the bonds.

6.2.4.2 Structures with Faraday Cage/Faraday-like Shield Lightning Protection System

The bond resistance should be less than 1.00 ohm. Although resistance of 1.00-ohm or lower is preferred, a 1.5-ohm resistance is acceptable where necessary for joining of

existing structural elements by rebar bonding. Larger readings require tightening or re-securing the bonds.

6.2.5 LPS State of Readiness Determination

Lightning Protection System (LPS) state of readiness is based on the condition of the system's installation and materials compared to requirements in system design documents and the code of record.

6.2.5.1 *The LPS State of Readiness determination is determined in accordance with P 315 Conduct of Operations Manual. The LPS system inspection report's deficiencies shall be entered into the Fire Protection System Impairment database in accordance with Criterion 733:* Fire Protection System Impairment Control Program. *(Ref.10.11)*

Note: An impairment would reflect a LPS that had deficiencies that are not expected to render the system ineffective. Examples include:

- Detached fasteners that do not cause the conductors to sag or otherwise come into contact with building component that are conducting (other than parts of the LPS itself),
- A loose connection, provided that a second path to ground exists (except connection to an air terminal),
- A single air terminal deficient in a line of three.

7.0 RECOMMENDED AND GOOD PRACTICES

The information provided in this section is recommended based on acceptable industry practices, and should be implemented by each user based on his/ her unique application and operating history of the subject systems/ equipment.

Appendix A to this document contains recommended lightning protection system inspection and testing schedules.

Appendix B to this document contains recommended lightning protection system maintenance items to be addressed.

7.1 Operations Recommendations

There are no operational recommendations for this Criterion.

7.2 Maintenance Recommendations (All Facilities)

7.2.1 Visual inspection

7.2.1.1 It is recommended that lightning protection systems be visually inspected at least annually. In some areas where severe climatic changes occur, it might be advisable to visually inspect systems semiannually or following extreme changes in ambient temperatures. Complete, in-depth inspections of all systems should be completed every 3 to 5 years. It is recommended that critical systems be inspected every 1 to 3 years, depending on occupancy or the environment where the protected structure is located.

7.2.2 Testing

7.2.2.1 In most geographical areas, and especially in areas that experience extreme seasonal changes in temperature and rainfall, it is advisable to stagger inspections so that earth resistance measurements, for example, are made in the hot, dry months as well as the cool, wet months. Such staggering of inspections and testing is important in assessing the effectiveness of the lightning protection system during the various seasons throughout the year.

Basis: NFPA 780, B-1.5.

7.2.3 Design and Configuration Documentation

Maintain up-to-date drawings of the LPS. Maintain copies of design calculations.

Basis: NFPA 780, B-1.5.

7.2.4 Maintenance and Testing Logs

Record routine inspections and tests using logs for each lightning protection system.

Basis: NFPA 780, B-1.5.

7.2.5 Maintenance and Testing Procedures

Prepare specific maintenance and testing procedures and other work-related documents (e.g., lightning protection system drawings) for each maintenance category. Use inspection and test procedures to provide appropriate work directions and to ensure that maintenance is done safely, efficiently, and according to this maintenance document. LPI documents may be used as a guide.

Basis: NFPA 780, B-1.5.

8.0 GUIDANCE

8.1 Operations Guidance

There is no operational guidance for this Criterion.

8.2 Maintenance Guidance

Appendix B of NFPA 780 provides the following guidance for inspecting and maintaining lightning protection systems:

8.2.1 Inspection of Lightning Protection Systems

8.2.2 Frequency of Inspections

It is understood that all new lightning protection systems must be inspected following completion of their installation. However, it is also very important to make periodic inspections of existing systems. The interval between inspections should be determined by such factors as the following:

- Classification of structure or area protected
- Level of protection afforded by the system
- Immediate environment (corrosive atmospheres)
- Type of surface to which the lightning protection components are attached
- Trouble reports or complaints

8.2.3 It is recommended that lightning protection systems be visually inspected at least annually**.** In some areas where severe climatic changes occur, it may be advisable to visually inspect systems semiannually or following extreme changes in ambient temperatures. Complete, in-depth inspections of all systems should be completed every three to five years. It is recommended that critical systems be inspected every one to three years depending on occupancy or the environment where the protected structure is located.

8.2.4 In most geographical areas, and especially in areas that experience extreme seasonal changes in temperature and rainfall, it is advisable to stagger inspections so that earth resistance measurements, for example, are made in the hot, dry months as well as the cool, wet months. Such staggering of inspections and testing is important in assessing the effectiveness of the lightning protection system during the various seasons throughout the year.

8.3 Maintenance of Lightning Protection Systems

8.3.1 General

Maintenance of a lightning protection system is extremely important even though the lightning-protection design engineer has taken special precautions to provide corrosion protection, and has sized the components according to their particular exposure to lightning damage. Many system components tend to lose their effectiveness over the years because of corrosion factors, weather-related damage, and stroke damage. The physical as well as the electrical characteristics of the lightning protection system must be maintained in order to maintain compliance with design requirements.

9.0 REQUIRED DOCUMENTATION

Maintenance history shall be maintained to include, as a minimum, the parameters listed in the Table 9-1 below:

Table 9-1 Documentation Parameters

MAINTENANCE HISTORY DOCUMENTATION PARAMETERS				
PARAMETER	ML 1	ML 2	ML 3	ML 4
Maintenance Activities				
Repair / Installation	X	X	X	X
PM Activities	X	X	X	X
Inspection Records				
Inspection Date	X	X	X	X
SSC Condition	X	X	X	X
General conditions of air terminals, conductors and other components	X	X	X	X
General conditions of corrosion-protection measures	X	X	X	X
Security of attachments of conductors and components	X	X	X	X
Resistance measurements of various parts of the ground terminal system	X	X	X	X
Any variations from the requirements contained in NFPA 780 or LANL Criterion 507	X	X	X	X
Condition of surge arresters	X	X	X	X
Electrical Test Records				
Electrical continuity of concealed components	X	X	X	X
Resistance between strategic points of the system	X	X	X	X
Ground resistance of ground terminals	X	X	X	X
Transfer Impedance Measurements for Faraday Cages	X	X	X	X

Basis: Documentation of the parameters listed in Table 9-1 above satisfies the requirements of P950, Conduct of Maintenance, Criteria 2, which states; "Maintenance activities, equipment problems, and inspection and test results are documented". For ML definitions, see P950, Conduct of Maintenance

10.0 REFERENCES

The following references, and associated revisions, were used in the development of this document.

10.1 P 315, Conduct of Operations Manual

10.2 P 950, Conduct of Maintenance

10.3 DOE Order 433.1, Maintenance Management Program for DOE Nuclear Facilities

10.4 DOE O 430.1B, Real Property Asset Management

10.5 DOE M 440.1-1, Explosives Safety Manual

10.6 LANL ID No.00-033, LANL-LAAO/ CPAP-00-01-LP-01, DOE/ AL Annual ES&H Review

10.7 NFPA 780, Lightning Protection Code

10.8 O&M Criterion 733: Fire Protection System Impairment Control Program.

11.0 APPENDICES

Appendix A: Lightning Protection System Maintenance Schedule

Appendix B: Lightning Protection System Recommended Maintenance Items

APPENDIX A
LIGHTING PROTECTION SYSTEM MAINTENANCE SCHEDULE

Parameter	Facilities used for storage, processing, and handling of explosive materials.	Non-Explosive Structures
REF.	DOE M-440.1-1	NFPA 780 B-1.1.2
Visual Inspections	Should be conducted every seven months and shall be conducted at least annually	Recommended at least every three years
Electrical Testing (earth resistance)	Should be conducted every 14 months and shall be conducted at least every 47 months.	Complete in-depth inspections of all systems should be completed every three. It is recommended that critical systems be inspected every one to three years.

APPENDIX B

LIGHTING PROTECTION SYSTEM RECOMMENDED MAINTENANCE ITEMS

ITEM No.	ACTIVITY
1	Inspect air terminals.
2	Inspect bonds to metal bodies.
3	Inspect tee-splicers and other connectors.
4	Inspect through roof connectors.
5	Inspect cable holders.
6	Inspect down conductors and grounds.
7	Check for additions or alterations to structure.
8	Measure ground terminal resistance.
9	Test continuity of concealed parts.
10	Measure system resistance
11	Inspect surge arresters.