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MARINE CORPS LOGISTICS BASE
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BO 11140
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BASE ORDER 11140

From: Commanding Officer
To: Distribution List

Subj: INSPECTION AND TESTING OF LIGHTNING PROTECTION AND
GROUNDING SYSTEMS FOR ORDNANCE FACILITIES

Ref: (a) NAVSEA OP-5, Vol. 1 (Series) (NOTAL)
(b) MIL-HDBK 1004/6 (NOTAL)
(c) NFPA-780 (NOTAL)
(d) Earth Ground Megger Instruction Manual (NOTAL)

Encl: (1) Introduction to Lightning Protection Systems
(2) Testing Procedures for Earth Covered Storage
Magazines (24 Month)
(3) Testing Procedures for Magazine Bunker 1651
and Transfer Area
(4) Visual Inspection Procedures (6 Month) and Visual
Inspection Checklist
(5) Drawing with test points and record sheets for
Magazine Bunker 1651 and fence.
(6) Drawing with test points and record sheets for
Transfer Area

1. Purpose. Establish responsibilities, requirements, and test procedures for the inspection, testing, maintenance, and repairs of the lightning protection and grounding systems related to ammunition handling areas aboard MCLB, Albany, GA. This program is established as required by reference (a) and adheres to the guidelines of references (b) through (d). Enclosures (1) through (3) contain the specific procedures and requirements for performing visual inspections and testing of lightning protection and grounding systems.

2. Scope. This instruction provides procedures for visual inspections and electrical testing of all grounding systems to include primary and secondary ground girdles, ordnance grounds,

and structural (lightning protection system) grounding requirements. All visual inspections and electrical testing will be per this instruction and the references.

3. Operational Responsibilities

a. Public Works Branch (PWB) will:

(1) Have overall responsibility for ensuring the lightning protection/grounding systems of all magazine storage areas, handling and loading areas are inspected, maintained, repaired, and tested to ensure they meet the requirements set forth in the references.

(2) Manage the lightning protection and grounding system program.

b. Electrical Trades Unit of PWB will:

(1) Set up and maintain a grounding system test plan for the visual and electrical testing of primary and secondary ground system components. The test plan for magazines, storage, and handling areas shall identify the ground system test locations along with a listing of items to be tested and type of test to be conducted.

(2) Perform electrical tests on all primary lightning protection systems and secondary grounding systems, including ordnance ground, static ground, structural ground, metal masses, gates, etc., as required. Clearly mark the test reference point (TRP), and static ground when required by the references. Electrical testing of systems is required every 24 months. Lightning protection and grounding systems (new construction) require testing on a monthly basis for the first 12 months.

(3) Visually inspect all primary lightning protection and grounding systems (ordnance ground, structural ground, metal masses, fences and gates) as required. Spot-check electrical equipment and installation when performing visual inspections. Provide personnel required to perform visual inspections and electrical testing of lightning protection and ground systems with a grounding system inspection report and test point location for each facility. The inspection plan must identify all inspection points and shall be signed by the individual performing the inspection. Repair immediately minor

discrepancies found during inspections. Major discrepancies shall be reported to PWB and a request made for corrective action. Record all discrepancies and/or corrective actions on report. Visual inspections are required every six months.

(4) Train all personnel required to perform visual inspection and electrical testing of lightning protection and ground systems. Assign only certified personnel to perform tests and inspections. Train members of the command required to augment the visual inspection team.

(5) Update written test procedures established in this instruction as per changes in requirements, or major changes in systems. Record and review all test data and maintain for six inspection cycles. Analyze all test data for trend development and to determine that all referenced specifications are met. Schedule any necessary corrective action to correct discrepancies found during inspections or reported from the Explosive Safety Officer (ESO).

(6) Document all test results on the grounding system test plan using enclosures (4) through (6) and forward one copy to MCLB's ESO.

c. Public Works Engineering Department will:

(1) Ensure that drawings for all new explosive buildings, magazines, new additions, and replacement of equipment includes all necessary bonding, grounding, and lightning protection requirements per the references.

(2) Assist other organizations with technical advice.

(3) Provide scale drawings of each facility in the lightning protection and grounding system test program as required.

(4) Contact PWB inspector and ESO to review plans prior to installation of or major changes to lightning protection or grounding systems.

d. The Resident Officer In Charge of Construction will:

(1) Monitor contract work closely to make sure that grounding systems are not painted over, dismantled, or damaged by contractors.

(2) Ensure that when new metal doors, doorframes, metallic masses (400 square inches or larger), gutters, downspouts, etc., are replaced, the contractor will install or replace grounding systems and test as per requirements.

(3) Contact PWB inspector and ESO to review plans prior to installation of or major changes to lightning protection or grounding systems.

(4) Ensure new facilities have proper grounding systems and are tested as per the references, and notify PWB to place facilities on grounding test schedule.

(5) Ensure no excavation work is performed in the vicinity of ordnance facilities (buildings/magazines) before identifying the location of the primary and secondary girdles.

e. Explosive Safety Officer will:

(1) Review drawings for all new explosive buildings, magazines, new additions, and replacement of equipment to ensure they include all necessary bonding, grounding, and lightning protection requirements per the references.

(2) Perform inspections and surveys of all bonding, grounding, and lightning protection systems installed in explosive operating buildings, storage areas, magazines, and workplaces during scheduled and unscheduled inspections.

(3) Report to PWB any lightning protection or grounding deficiencies, testing, or additional system installation or repair requirements.

(4) Review and oversee the activities lightning protection and grounding system program.

f. Base Property Control Officer will:

(1) Ensure that all explosive operating facilities, storage facilities, and handling pads with lightning, electrical, and electrostatic grounding systems are made available to maintenance personnel for inspection, maintenance repairs, and testing.

BO 11140

(2) Ensure that personnel assisting PWB with visual inspections of lightning protection and grounding systems are trained by PWB. This training will be documented.

(3) Report to PWB any lightning protection or grounding deficiencies, testing, or additional system installation or repair requirements.



JOHN P LOPEZ

DISTRIBUTION: A

Introduction to Lightning Protection Systems

1. The lightning protection system consists of a primary lightning grounding system and a secondary ground girdle. The primary grounding system is equipped with lightning mast and down conductor. These masts are linked together with underground wire cable. The secondary ground girdle is a continuous wire girdle 3 feet from the building then buried 3 feet in the earth; these two wire girdles are separately installed around the structure. These wire girdles are connected in not less than two places in order to maintain the same potential to each other, and they are tested to 25 ohms or less to earth. The girdles serve as grounding for the structure and grounding for the lightning protection systems. They are tested by using the 3 point fall of potential method, using the test reference point (TRP) as primary ground test point. A calibrated digital megger shall be used to make this test.

2. The secondary ground girdle serves as an earth ground for the building and all other grounds used in the structure. Bonds to the secondary ground girdle shall be less than 1 ohms resistance. All the buildings' structural steel and all the metallic objects within the primary girdle which exceed 400 square inches, both inside and outside, are connected to the ground girdle and shall be at the same potential as the lightning protection system. This prevents side flash and static build-up in and around the facility being protected. Figure 5-4 of NAVSEA OP-5, Volume 1, gives an overview of a typical ordnance handling building and depicts the fact that all grounds are bonded together at the lowest point to the secondary ground girdle.

3. Keeping these design facts in mind, this base order has been developed to assist in the testing of the systems on above ground ammunition storage buildings, earth covered magazines, ready service lockers, handling buildings and pads, and visual inspection procedures. The results of the 24-month lightning/grounding test must be recorded and maintained for a minimum of 5 years. The visual inspection shall follow the check sheet and be performed every 6 months. Trained personnel familiar with the systems will always accomplish the lightning protection/grounding system testing.

BO 11140

WARNING

DISCONNECT ALL ORDNANCE FROM
STATIC AND ORDNANCE GROUNDS DURING TEST

WARNING

ALL INSTRUCTIONS FOR USE OF COMMUNICATION EQUIPMENT
IN ORDNANCE AREAS
SHALL BE STRICTLY ADHERED TO AT ALL TIMES

ENCLOSURE (1)

**Testing Procedures for Earth Covered Storage Magazines
(24 Month)**

1. GENERAL. The concrete construction of an earth-covered magazine is reinforced with steel bars. Some earth-covered magazines have steel casings inside. These reinforcement bars or casings are connected to or are considered the primary lightning protection and grounding system. This forms an umbrella of protection (FARADAY CAGE) for the ordnance stored inside the structure. This system is tested to 25 ohms or less to a TRP (earth ground).

2. TESTING. Test as follows:

STEP 1 - Ensure that the James G. Bittle earth tester (megger) or equivalent tester is calibrated and that all of its equipment and cables are present. Follow floor diagram of all the test points to be tested.

NOTE:

A RECORD SHEET TO RECORD READINGS AND FLOOR/AREA DIAGRAM IS PROVIDED WITH THIS SOP IN ENCLOSURE (5).

STEP 2 - Locate the ground girdle (if applicable) for the structure. According to design, it is 3 feet from the structure and buried 3 feet in the ground (located in test well or under white PVC cap by bulkhead wall).

NOTE:

USUALLY, IF THERE IS A GROUND GIRDLE CABLE IT WILL EXTEND OUT OF THE GROUND CLOSE TO THE HEADWALL AND CONTINUE INTO THE STRUCTURE. SOMETIMES THE GROUND CABLE WILL EXTEND OUT OF THE FLOOR INSIDE THE BUILDING.

STEP 3 - Clean a connection point on the ground girdle, wire, cable, rod or some point on structural steel. This is where the earth tester will be connected for the earth test (25 ohms or less is required). This cleaned area is called your test reference point (TRP). Continuity readings will be taken from this point after the earth ground test. Disconnect all cables from ground rod (when used).

STEP 4 - Test the ground girdle, record the reading and date on the six cycle record sheet provided, and reconnect all cables. Secure the earth tester in its case.

STEP 5 - Zero a digital resistance tester if the leads have been changed. Test continuity from the TRP to all metallic objects of or around the structure, including doors, conduit, structural overhangs over doors, metal ventilators, security grates under the ventilator inside, etc. Connections to the ground girdle shall be 1 ohm or less. Record the continuity readings on the test record sheet.

STEP 6 - Check inside the earth covered magazine for a ground system. Test to 1 ohm or less continuity to the ground girdle. Record readings on the sheet.

STEP 7 - The lightning mast shall not be closer than 6 feet to the structure and no further away than 25 feet. EXAMPLE: Mast 40 feet high 20 feet and from the structure is 1/2 the height of the mast. EXAMPLE: Mast 60 feet high 25 feet from the structure, wood mast shall be capped at the top and have two down conductors. The mast shall be high enough to protect the structure from a lightning strike.

STEP 8 - Inspect to ensure that the ventilator and security grate is NOT bonded from the ventilator down to a ground inside the magazine. It shall be bonded from the top and outside to the ground girdle.

3. SUMMARY

a. Ensure that all readings are recorded on the test record sheet. Check with previous readings for any variations. This will let you know if there are any possible system integrity problems.

b. File the test record sheet for use during the next 24-month test, this record can be used for six 24 month tests. Report discrepancies of test to the PWB and ESO for corrective action.

Testing Procedures for Ordnance Handling Buildings and Transfer Areas

1. General. Operating buildings/transfer areas grounding system are typically comprised of a primary lightning protection system and a secondary ground girdle. These buildings/transfer areas typically have ordnance grounds installed inside, which is an isolated grounding system design for assembly/disassembly of ordnance.

2. Testing. Test as follows:

STEP 1 - Ensure that the James G. Bittle earth tester (megger) or equivalent tester is calibrated and that all of its equipment is present. Follow floor plan grounding diagram for all points to be tested.

NOTE:

A RECORD SHEET TO RECORD READINGS AND AREA DIAGRAM IS PROVIDED WITH THIS SOP IN ENCLOSURE (6).

STEP 2 - Locate the wire that bonds the lightning masts together around the building/transfer area to be tested (primary girdle). The test reference point (TRP) connection is located in the test well or next to mast.

STEP 3 - Clean a connection point on the wire cable or grounding rod. This is where the earth tester will be connected for the earth test, 25 ohms or less is required. This cleaned area on the wire cable (or rod) is your TRP. Continuity readings will be taken from this point (after the earth ground test). Disconnect all cables from rod.

STEP 4 - Test the primary system. Also test any ordnance grounding system, as both have the same result requirements (25 ohms or less). Record the test readings and date on the test record sheets provided. Reconnect all cables. Secure the earth tester in its case.

STEP 5 - Using a zeroed digital resistance meter with long leads, check for continuity from the TRP to the first lightning mast, from the second mast to the third and so on. A high reading will indicate a break in the wire cable you are reading

back through the system. No reading will indicate there is more than one break in the cable linking the mast together.

STEP 6 - If the continuity readings from mast to mast are good (less than 1 ohm), record and go to the next step. If breaks were detected, disconnect the wire cable from the mast and run a new cable continuously from mast to mast. Turn in a discrepancy report and corrective actions.

STEP 7 - The lightning mast shall not be closer than 6 feet to the structure and no further away than 25 feet. EXAMPLE: Mast 40 feet high 20 feet and from the structure is 1/2 the height of the mast. EXAMPLE: Mast 60 feet high 25 feet from the structure, wood mast shall be capped at the top and have two down conductors. The mast shall be high enough to protect the structure from a lightning strike.

STEP 8 - Inspect all metallic objects passing through the zone of lightning protection to the building/ transfer area being protected. These objects are usually steam pipes, railroad tracks, etc. These objects shall be bonded prior to entering the lightning protection zone. Bond them to the primary lightning protection girdle, and make these areas a test point.

NOTE:

ELECTRICAL TRANSMISSION LINES AND COMMUNICATIONS LINES SHALL BE BURIED FOR THE LAST 50 FEET PRIOR TO ENTERING THE STRUCTURE.

STEP 9 - You have completed the test and inspection on the primary lightning protection system. Verify there is continuity from lightning mast to lightning mast and back to your test reference point. All metallic objects (400 square inches or more) within or passing through the zone of protection must be connected to the primary lightning protection system. Record all readings as required on the test record sheet.

STEP 10 - Locate the ground girdle. According to design, it is 3 feet from the structure and buried 3 feet in the ground.

NOTE:

MOST OF THE TIME THE GROUND GIRDLE CABLE CAN BE LOCATED BY SEEING A CABLE RUNNING OUT OF THE GROUND CLOSE TO THE FOOTER AND THEN RUNNING TO STRUCTURAL STEEL. THE GROUND CABLE MAY BE LOCATED ON THE FLOOR INSIDE THE BUILDING.

STEP 11 - Identify all of the cables around the structure. Then run a continuity check from these cables to the primary lightning protection TRP (1 ohm or less is required). Label these cables as; ground girdle, power ground, static, or ordnance grounds, as required. If no reading can be established, the secondary and primary girdle is not connected together. Check for grandfather clauses (for older systems). Notify base ESO and PWB. Make repairs or turn in a request for corrective action, as required.

STEP 12 - Zero the digital resistance tester if the leads have been changed. Test continuity from the ground girdle to all metallic objects within the primary grid (i.e., anything inside or outside the structure 400 square inches or more), including windows, doors, conduit, structural overhangs, ladders, etc. Connection shall be 1 ohm or less. Record the readings on the six cycle test record sheet.

3. SUMMARY

a. Ensure that all readings are recorded on the six cycle test record sheet. Check with previous readings for any variations. This will let you know if there is any possible system integrity problem.

b. File the test record sheet for use during the next 24-month test, this record can be used for six 24 month tests. Report discrepancies of test to the ESO and PWB for corrective action.

NOTE:

ALL METALLIC OBJECTS (400 square inches or more) WITHIN THE PRIMARY GIRDLE OF AN ORDNANCE OPERATING BUILDING SHALL BE AT THE SAME POTENTIAL AS THE LIGHTNING PROTECTION SYSTEM.

BO 11140

NOTE:

GROUNDS ARE CONNECTED TO THE LOWEST POINT NEAR THE GROUND
GIRDLE. HIGHER CONNECTIONS ARE CONSIDERED TO BE CONNECTED TO
THE DOWN TRAP OF THE SYSTEM.

ENCLOSURE (3)

**Visual Inspection Procedures
(6 Month)**

1. GENERAL. The visual inspection shall be conducted every 6 months. The following procedures will be followed.

2. INSPECTION.

STEP 1 - Ensure that any large metal objects within the primary grid, or inside of the lightning masts, are connected to the primary ground girdle or bonded to structural steel.

STEP 2 - Inspect cables connected to lightning masts to ensure that they are in good condition and are at least AWG #1/0 or larger, made of bare copper wire, are attached to the mast, have no sharp bends in wire, and have no more than 1/3 of the strands are broken. Repair, replace, or install new cables as needed.

STEP 3 - On lightning-protected buildings, inspect to see that there are no trees in the protected area.

STEP 4 - Randomly inspect all grounding systems connections to see that they are secure and free from paint, corrosion, or foreign materials that may impair ground system efficiency. Make repairs as necessary. Inspect both inside and outside of building.

STEP 5 - Check to see that all metal masses (400 square inches or larger) are connected to the secondary ground girdle. Examples of masses are metal siding doors, shutters, and trusses. Repair or add bonding as needed.

STEP 6 - Check ordnance ground buses, static ground buses, and instrumentation ground buses for clear identification of each, and make sure connections are secure (via pull test) and connection points are free from paint, corrosion, or foreign material that may impair the efficiency of the system. Repair if needed.

STEP 7 - Check to see that all utilities coming into the buildings are buried the last 50 feet.

STEP 8 - Check to ensure all 120 volt single phase receptacles installed outdoors or in wet locations are ground fault circuit interrupters. Repair if needed.

STEP 9 - Ensure all metallic conductors, including intrusion detection lines, water, electrical, steam, air conditioning lines, etc., are run underground the last 50 feet to the building.

STEP 10 - Ensure fences are bonded to lightning protection system if they come within 50 feet or as determined by NFPA PA-78. Ensure all fences are grounded within (or every) 50 feet if high tension lines cross fencing are directly overhead or run parallel to fences. Ensure that fences are grounded at places where personnel may routinely touch the fence and areas where structure and materials are located within 6 feet of the fence.

STEP 11 - Review previous test records to ensure fences are bonded from gate post to gate post, gate post to gate, and gate post to secondary ground girdle, if within zone of protection. If outside zone of protection, ensure ground rods are driven on each side of gatepost in place of connecting to secondary girdle.

3. SUMMARY. File these records for use during the next 6-month inspection. Report discrepancies of test to the ESO and PWB for corrective action.

**VISUAL INSPECTION CHECKLIST FOR EXPLOSIVE
STORAGE MAGAZINE/TRANSFER AREA
DATA SHEET**

DATE _____

INSPECTED BY _____

	YES/NO/NA	COMMENTS
1. <u>FENCES</u>		
a. Bond across gates	_____	_____
b. Gates grounded.	_____	_____
2. <u>DOORS/VENTILATORS/AIR TERMINALS</u>		
a. Metal doors and frames bonded to grounding system.	_____	_____
b. Roof ventilator security grate intact and bonded.	_____	_____
c. Roof ventilator covers, if metal, bonded to grounding system.	_____	_____
d. Door/wall ventilator screens intact and grounded.	_____	_____
e. All air terminals bonded and tight.	_____	_____
3. <u>GROUNDING</u>		
a. All munitions grounded, if applicable.	_____	_____
b. Grounding straps/connectors in good condition and properly attached.	_____	_____
c. Grounding straps electrically tested within last 12 months.	_____	_____
d. Grounding points marked to prevent misidentification.	_____	_____
4. <u>BONDING STRAPS</u>		
a. Connections are clean and free of paint.	_____	_____

BO 11140

b. Connections are tight.

c. Do bonding straps need replaced?

RECORD SHEET FOR AMMO BUNKER 1651
3-POINT FALL-OF-POTENTIAL (25 OHMS MAXIMUM)

<u>Test Reference Point</u>	<u>Resistance (ohms)</u>
T-1	_____

Bonding Measurements (1 ohm maximum)

<u>Point to Point Test</u>	<u>Resistance (ohm)</u>
T-1 to T-2	_____
T-1 to T-6	_____
T-6 to T-3	_____
T-6 to T-4	_____
T-6 to T-5	_____
T-6 to T-7	_____
T-6 to T-8	_____
T-6 to T-9	_____
T-6 to T-10	_____
T-6 to T-11	_____
T-6 to T-12	_____
T-6 to T-13	_____
T-6 to T-14	_____
T-6 to T-15	_____
T-6 to T-16	_____
T-6 to T-17	_____

Date _____

Tester Used _____ Serial Number _____

Calibration Date _____

Tested by _____

ENCLOSURE (5)

ENCLOSURE (5)