

**MICHIGAN DEPARTMENT OF TRANSPORTATION
BUREAU OF AERONAUTICS - STANDARD SPECIFICATION
L-109
Installation of Airport Transformer Vault and Vault Equipment**

DESCRIPTION

1.1 This item shall consist of an airport transformer vault or a prefabricated metal housing constructed and installed in accordance with this specification at the location and in accordance with the design and dimensions shown in the plans. This work shall also include the installation of conduits in floor and foundation, painting and lighting of the vault or metal housing, and the furnishing of all incidentals necessary to produce a completed unit. Included as a separate part under this item or as a separate item where an existing vault is to be utilized shall be the furnishing of all vault equipment, wiring, electrical buses, cable, conduit, potheads, and grounding systems. This work shall also include the painting of equipment and conduit; the marking and labeling of equipment and the labeling or tagging of wires; the testing of the installation; and the furnishing of all incidentals necessary to place it in operating condition as a completed unit to the satisfaction of the engineer.

EQUIPMENT AND MATERIALS

2.1 General.

(a) Airport lighting equipment and materials covered by FAA specifications shall have the prior approval of the Federal Aviation Administration, Airports Service, Washington, D.C. 20591, and shall be listed in the most recent Advisory Circular 150/5345-1, Approved Airport Lighting Equipment.

(b) All other equipment and materials covered by other referenced specifications shall be subject to acceptance through manufacturer's certification of compliance with the applicable specification

when requested by the engineer.

VAULT AND PREFABRICATED METAL HOUSING

2.2 Concrete. The concrete for the vault shall be proportioned, placed, and cured in accordance with Item P-610, Structural Portland Cement Concrete, using 3/4 inch maximum size coarse aggregate.

2.3 Reinforcing Steel. Reinforcing steel bars shall be intermediate or structural grade deformed-type bars and shall meet the requirements of AASHO M 31.

2.4 Brick. Brick shall conform to ASTM C-62, Grade SW.

2.5 Asbestos Cement Duct. Asbestos cement duct and fittings shall be in accordance with Fed. Spec. W-C-571.

2.6 Fiber Conduit. Fiber conduit and fittings shall be in accordance with Fed. Spec. W-C-581.

2.7 Rigid Steel Conduit. Rigid steel conduit and fittings shall be in accordance with Fed. Spec. WW-C-581.

2.8 Lighting. Vault or metal-housing light fixtures shall be of a vapor-proof type.

2.9 Outlets. Convenience outlets shall be heavy-duty duplex units designed for industrial service.

2.10 Switches. Vault or metal-housing light switches shall be single-pole switches.

2.11 Floor Drains. The floor drains shall be similar to type Z-798-A (or equal), as manufactured by the Z. A. Zurn Manufacturing Company.

2.12 Paint.

(a) Red lead priming paint for ungalvanized metal surfaces and the mixing thereof shall conform to the 97% grade in Fed. Spec. TT-R-191. The red lead shall be furnished in paste form and delivered to the job in the original unbroken packages bearing the maker's name and brand. The raw linseed oil, turpentine, and drier shall be in accordance with the Federal specifications listed below:

Raw Linseed Oil	TT-L-215
Turpentine	TT-T-801
Drier; Paint, Liquid, Type I	TT-D-651

(b) White paint for body and finish coats on metal and wood surfaces shall be ready-mixed paint conforming to Fed. Spec. TT-P-102.

(c) Priming paint for wood surfaces shall be mixed on the job by thinning the above specified white paint by adding 1/2 pint of raw linseed oil to each gallon.

(d) Paint for the floor, ceiling, and inside walls shall be in accordance with Fed. Spec. TT-E-487. Walls and ceiling shall be light gray and the floor shall be medium gray.

(e) The roof coating shall be hot asphalt material in accordance with Fed. Spec. SS-R-451.

2.13 High-Voltage Bus. High-voltage bus shall be standard weight 3/8 inch IPS copper tubing or it may be insulated copper cable of the size and voltage rating specified.

2.14 Bus Connectors. Connectors shall be similar to Burndy Type NT (or equal) for copper tubing. Connectors for insulated bus cable shall be of the proper size and type for the service intended.

2.15 Bus Supports. Bus supports shall be similar to Westinghouse No. 527892 (or equal), insulated for 7,500 volts, single clamp type for 2-bolt flat mounting.

2.16 Ground Bus. Ground bus shall be 1/8 inch X 3/4 inch copper bus bar.

2.17 Square Duct. Duct shall be square similar to that manufactured by the Square D Company (or equal), or the Trumbull Electric Manufacturing Company (or equal). The entire front of the duct on each section shall consist of hinged or removable cover for ready access to the interior. The cross section of the duct shall be not be less than 4 by 4 inches except where otherwise shown in the plans.

2.18 Ground Rods. Ground rods shall be copper or copper-clad of the length and diameter specified in the plans.

2.19 Potheads. Potheads shall be similar to G&W Type N, Shape C (or equal), unless otherwise specified. Potheads shall be furnished with plain insulator bushings and conduit couplings. Potheads shall have a rating not less than the circuit voltage.

2.20 Prefabricated Metal Housing. The prefabricated metal housing shall be in accordance with Advisory Circular 150/5340-9.

2.21 FAA-Approved Equipment. Certain items of airport lighting equipment installed in vaults are covered by individual FAA equipment specifications. The specifications are listed below:

AC 150/5345-3	Specification for L-821 Airport Lighting Panel for Remote Control of Airport Lighting	AC 150/5345-21	Specification for L-813 Static Indoor Type Constant Current Regulator Assembly; 4 KW and 7.5 KW; for Remote Operation of Taxiway Lights
AC 150/5345-5	Specification for L-847 Circuit Selector Switch, 5000 Volt, 20 Ampere	AC 150/5345-35	Specification for L-816 Circuit Selector Cabinet Assembly for 600 Volt Series Circuits
AC 150/5345-7	Specification for L-824 Underground Electrical Cables for Airport Lighting Circuits		
AC 150/5345-10	Specification for L-828 Constant Current Regulator With Stepless Brightness Control		
AC 150/5345-11	Specification for L-812 Static Indoor Type Constant Current Regulator Assembly; 4 KW and 7.5 KW; with Brightness Control for Remote Operation		
AC 150/5345-13	Specification for L-841 Auxiliary Relay Cabinet Assembly for Pilot Control of Airport Lighting Circuits		
AC 150/5345-18	Specification for L-811 Static Indoor Type Constant Current Regulator Assembly, 4 KW; with Brightness Control and Runway Selection for Direct Operation		

2.22 Other Electrical Equipment. Constant-current regulators, distribution transformers, oil switches, cutouts, relays, terminal blocks, transfer relays, circuit breakers, and all other regularly used commercial items of electrical equipment not covered by FAA equipment specifications shall conform to the applicable rulings and standards of the Institute of Electrical and Electronic Engineers or the National Electrical Manufacturers Association. When specified, test reports from a testing laboratory indicating that the equipment meets the specifications shall be supplied. In all cases, equipment shall be new and a first-grade product. This equipment shall be supplied in the quantities required for the specific project and shall incorporate the electrical and mechanical characteristics specified in the proposal and plans.

2.23 Wire. Wire in conduit rated up to 5,000 volts shall conform to Advisory Circular 150/5345-7, Specification for L-824 Underground Electrical Cables for Airport Lighting Circuits, for rubber insulated neoprene-covered wire, or Fed. Spec. J-C-30, Type RHW, for rubber insulated fibrous-covered wire. For ratings up to 600 volts, thermoplastic wire conforming to Fed. Spec. J-C-30, Types TW, THW, and THWN, shall be used. The wires shall be of the type, size, number of conductors, and voltage shown in the plans or in the proposal.

(a) Control Circuits. Wire shall be

not less than No. 12 AWG and shall be insulated for 600 volts. If telephone control cable is specified, No. 19 AWG telephone cable conforming to the United States Department of Agriculture, Rural Electrification Administration (REA) Bulletin 345-14 shall be used.

(b) Power Circuits.

1. 600 volts maximum-Wire shall be No. 6 AWG or larger and insulated for at least 600 volts.
2. 3,000 volts maximum-Wire shall be No. 6 AWG or larger and insulated for at least 3,000 volts.
3. Over 3,000 volts-Wire shall be No. 6 AWG or larger and insulated for at least the circuit voltage.

CONSTRUCTION METHODS

3.1 General. The contractor shall construct the transformer vault or prefabricated metal housing at the location indicated in the plans. Vault construction shall be reinforced concrete, concrete masonry, or brick wall as specified. The metal housing shall be prefabricated equipment enclosure to be supplied in the size specified. The mounting pad or floor details, installation methods, and equipment placement are shown in the plans.

The contractor shall clear, grade, and seed the area around the vault or metal housing for a minimum distance of 10 feet on all sides. The slope shall be not less than ½ inch per foot away from the vault or metal housing in all directions.

3.2 Foundation and Walls.

(a) Reinforced concrete construction. The contractor shall construct the foundation and walls in accordance with the details shown in the plans. Unless otherwise specified, internal ties shall be of the

mechanical type so that when the forms are removed the ends of the ties shall be at least 1 inch beneath the concrete surface; the holes shall be plugged and finished to prevent discoloration. Reinforcing steel shall be placed, as shown in the drawings, and secured in position to prevent displacement during the concrete placement.

The external surfaces of the concrete shall be thoroughly worked during the placing operation to force all coarse aggregate from the surface. Thoroughly work the mortar against the forms to produce a smooth finish free from air pockets and honeycomb.

The surface film of all pointed surfaces shall be removed before setting occurs. As soon as the pointing has set sufficiently, the entire surface inside and outside of the vault shall be thoroughly wet with water and rubbed with a No. 16 carborundum stone, or equal quality abrasive, bringing the surface to a paste. All form marks and projections shall be removed. The surface produced shall be smooth and dense without pits or irregularities. The materials which have been ground into a paste during the rubbing process shall be spread or brushed uniformly over the entire surface (except the interior surfaces that are to be painted shall have all paste removed by washing before painting) and permitted to reset. Final exterior finish shall be obtained by rubbing with No. 30 carborundum stone, or an equal quality abrasive. The surface shall be rubbed until the entire surface is smooth and uniform in color.

(b) Brick and concrete construction.

When this type of construction is specified, the foundation shall be concrete conforming to the details shown in the plans. The outer edge of the foundation at the floor level shall be beveled 1-1/2 inches at 45°. Brick walls shall be 8 inches thick, laid in running bond with every sixth course a header course. Brick shall be laid in cement mortar (1 part masonry cement and 3 parts sand) with full mortar bed and shovelled joints. All joints shall be completely filled with mortar, and facing brick shall be back-parged

with mortar as work progresses. All joints shall be 3/8 inch thick, exterior joints tooled concave, and interior joints struck flush. Both interior and exterior brick surfaces shall be cleaned and nail holes, cracks, and other defects filled with mortar. When specified, a nonfading mineral pigment mortar coloring shall be added to the mortar. Steel reinforcing bars, 3/8 inch in diameter and 12 inches long, shall be set vertically in the center of the brick wall on not more than 2 foot centers to project 2½ inches into the concrete roof slab. Lintels for supporting the brickwork over doors, windows, and louvers shall consist of two 4- X 3- X 3/8-inch steel angles. Lintels shall be painted with one coat of red lead before installation, and all exposed parts shall be painted similar to doors and window sash after installation.

Window sills may be concrete poured in place or precast concrete as indicated in the plans. All exposed surfaces shall have a rubbed finish as specified under reinforced concrete construction. After completion, all interior and exterior faces of walls shall be scrubbed with a solution of muriatic acid and water in the proportions of not less than 1 part acid to 10 parts of water. All traces of efflorescence, loose mortar, and mortar stain shall be removed, and the walls washed down with clear water.

(c) Concrete masonry construction.

When this type of construction is specified, the foundation shall be concrete conforming to the details shown in the plans. The concrete masonry units shall be standard sizes and shapes and shall conform to ASTM C-90 and shall include the closures, jambs, and other shapes required by the construction as shown in the plans. Standard construction practice shall be followed for this type of work including mortar, joints, reinforcing steel for extensions into roof slab, etc. Plaster for interior walls, if specified, shall be portland cement plaster.

3.3 Roof. The roof shall be reinforced concrete as shown in the plans. Reinforcing steel shall be placed as shown in the drawing

and secured in position to prevent displacement during the pouring of the concrete. The concrete shall be poured monolithically and shall be free of honeycombs and voids. The surface shall have a steel-trowled finish and shall be sloped as shown in the drawing. The underside of the roof slab shall be finished in the same manner as specified for walls.

One brush or mop coat of hot asphalt roof coating shall be applied to the top surface of the roof slab. The asphalt material shall be heated to within the range specified by the manufacturer and immediately applied to the roof. The finished coat shall be continuous over the roof surface and free from holidays and blisters. Smears and dribbles of asphalt on the roof edges and building walls shall be removed.

3.4 Floor. The floor shall be reinforced concrete as shown in the drawings. When present, all sod, roots, refuse, and other perishable material shall be removed from the area under the floor to a depth of 8 inches, unless a greater depth is specified in the invitation for bids. This area shall be backfilled with materials consisting of sand, cinders, gravel, or stone. Fill shall be placed in layers not to exceed 4 inches and shall be thoroughly compacted by tamping or rolling. A layer of building paper shall be placed over the fill prior to placing concrete. The floor surfaces shall have a steel-trowled finish. The floor shall be level unless a drain is specified, in which case the floor shall be pitched 1/4-inch per foot downward toward the drain. A 1/4- inch asphalt felt expansion joint shall be placed between floor and foundation walls. The floor shall be poured monolithically and shall be free of honeycombs and voids.

3.5 Floor Drain. If shown in the plans, a floor drain and dry well shall be installed in the center of the floor of the equipment room. The dry well shall be excavated 4 X 4 feet square and to a depth of 4 feet below the finished floor elevation and shall be backfilled to the elevation of the underside of the floor with gravel-which shall all pass a 2-inch mesh sieve and shall all be

retained on a 1/4-inch mesh sieve. The gravel backfill shall be placed in 6-inch maximum layers, and the entire surface of each layer shall be tamped either with a mechanical tamper or with a hand tamper weighing not less than 25 pounds and having a face area of not more than 36 square inches nor less than 16 square inches. The drain inlet shall be set flush in the concrete floor. The drain shall have a clear opening of not less than 8 inches in diameter.

3.6 Conduits in Floor and Foundation.

Conduits shall be installed in the floor and through the foundation walls in accordance with the details shown in the plans. All underground conduit shall be painted with a bituminous compound. Conduit shall be installed with a coupling or metal conduit adapter flush with the top of the floor. All incoming conduit shall be closed with a pipe plug to prevent the entrance of foreign material during construction. Space conduit entrances shall be left closed.

3.7 Doors. Doors shall be metal-clad fireproof Class A doors conforming to requirements of the National Electric Code and local electrical codes.

3.8 Painting. The floor, ceiling, and inside walls of concrete construction shall first be given a hardening treatment, after which the contractor shall apply two coats of paint as specified below, except that interior face brick walls need not be painted. The hardening treatment shall consist of applying two coats of either a commercial floor hardener or a solution made by dissolving 2 pounds of magnesium fluosilicate or zinc sulphate crystals in 1 gallon of water. Each coat shall be allowed to dry at least 48 hours before the next application. After the second treating coat has dried, the surfaces shall be brushed clean of all crystals and thoroughly washed with clear water. Paint for walls and ceiling shall be a light gray color approved by the engineer. The floor paint shall be a medium gray color approved by the engineer. Before painting, the surfaces shall be dry and clean. The first coat shall be thinned by

adding 2/3-quart of spar varnish and 1/3-quart of turpentine to each gallon of paint. The second coat shall be applied without thinning. All doors, lintels, and windows shall be cleaned to remove any rust or foreign material and shall be given one body and one finish coat of white paint. Bare metal surfaces shall be given a prime coat of red lead prior to the body and finish coats.

3.9 Lights and Switches. The contractor shall furnish and install a minimum of two duplex convenience outlets in the vault room. Where a control room is specified, at least two duplex outlets shall be installed.

INSTALLATION OF EQUIPMENT IN VAULT OR PREFABRICATED METAL HOUSING

3.10 General. The contractor shall furnish, install, and connect all equipment, equipment accessories, conduit, cables, wires, buses, grounds, and support necessary to insure a complete and operable electrical distribution center for the airport lighting system as specified herein and shown in the plans. When specified, an emergency power supply and transfer switch shall be provided and installed.

The equipment installation and mounting shall comply with the requirements of the National Electrical Code and local code agency having jurisdiction.

3.11 Power Supply Equipment.

Transformers, regulators, booster transformers, and other power supply equipment items shall be furnished and installed at the location shown in the plans or as directed by the engineer. The power supply equipment shall be set on steel "H" sections, "I" beams, channels, or concrete blocks to provide a minimum space of 1½ inches between the equipment and the floor. The equipment shall be placed so as not to obstruct the oil-sampling plugs of the oil-filled units; and nameplates shall, so far as possible, not be obscured.

If specified in the plans and specifications, equipment for an alternate power source or an emergency power generator shall be furnished and installed. The alternate power supply installation shall include all equipment, accessories, an automatic changeover switch, and all necessary wiring and connections. The emergency power generator set shall be the size and type specified.

3.12 Switchgear and Panels. Oil switches, fused cutouts, relays, transfer switches, panels, panel boards, and other similar items shall be furnished and installed at the location shown in the plans or as directed by the engineer. Wall or ceiling-mounted items shall be attached to the wall or ceiling with galvanized bolts of not less than 3/8-inch diameter engaging metal expansion shields or anchors in masonry or concrete vaults.

3.13 Duct and Conduit. The contractor shall furnish and install square-type exposed metallic ducts with hinged covers for the control circuits in the vault. These shall be mounted along the walls behind all floor-mounted equipment and immediately below all wall-mounted equipment. The hinged covers shall be placed to open from the front side with the hinges at the front bottom.

Wall brackets for square ducts shall be installed at all joints 2 feet or more apart with intermediate brackets as specified. Conduit shall be used between square ducts and equipment or between different items of equipment when the equipment is designed for conduit connection. When the equipment is not designed for conduit connection, conductors shall enter the square-type control duct through insulating bushings in the duct or on the conduit risers.

3.14 Cable Entrance and High-Voltage Bus System. Incoming underground cable from field circuits and supply circuits will be installed outside the walls of the transformer vault as a separate item under Item L-108. The contractor

installing the vault equipment shall bring the cables from the trench or duct through the entrance conduits into the vault and make the necessary electrical connections. For the incoming and outgoing high-voltage load circuits, the contractor shall furnish and install rigid metallic conduit risers, surmounted by potheads, from floor level to the level as shown in the plans.

The incoming high-voltage power supply service to the vault shall enter below the floor of the vault and shall rise from the floor level in a rigid metallic conduit riser, surmounted by a pothead, as described above. Using insulated high-voltage cable, the incoming power service shall be connected from the pothead to the oil-fused cutouts or to the specified disconnecting switch or equipment. From the oil-fused cutouts or disconnecting device, the insulated service conductors shall be connected to the overhead voltage bus system of the vault. The high-voltage bus system shall utilize the materials specified and shall be mounted and installed in accordance with the requirements of the National Electrical Code or the local code agency having jurisdiction.

3.15 Wiring and Connections. The contractor shall make all necessary electrical connections in the vault in accordance with the wiring diagrams furnished and as directed by the engineer. In wiring to the terminal blocks, the contractor shall leave sufficient extra length on each control lead to make future changes in connections at the terminal block. This shall be accomplished by running each control lead the longest way around the box to the proper terminal. Leads shall be neatly laced in place.

3.16 Marking and Labeling. All equipment, control wires, terminal blocks, etc., shall be tagged, marked, or labeled as specified below:

(a) **Wire identification.** The contractor shall furnish and install self-sticking wire labels or identifying tags on all control wires at the point where they connect to control

equipment or to the terminal blocks. Wire labels, if used, shall be of the self-sticking preprinted type and of the manufacturer's recommended size for the wire involved. Identification markings designated in the plans shall be followed. Tags, if used, shall be of fiber not less than 3/4-inch in diameter and not less than 1/32-inch thick. Identification markings designated in the plans shall be stamped on tags by means of small tools dies. Each tag shall be securely tied to the proper wire by a nonmetallic cord.

(b) Labels. The contractor shall stencil identifying labels on the cases of regulators, breakers, and distribution and control relay cases with white oil paint as designated by the engineer. The letters and numerals shall be not less than 1 inch in height and shall be of proportionate width. The contractor shall also mark the correct circuit designations in accordance with the wiring diagram on the terminal marking strips which are a part of each terminal block.

METHOD OF MEASUREMENT

4.1 The quantity of vaults to be paid for under this item shall consist of the number of vaults constructed in place and accepted as a complete unit.

4.2 The quantity of prefabricated metal housings to be paid for under this item shall consist of the number of housings constructed in place and accepted as a complete unit.

4.3 The quantity of vault or prefabricated metal housing equipment to be paid for under this item shall consist of all equipment installed, connected, and accepted as a complete unit ready for operation.

BASIS OF PAYMENT

5.1 Payment will be made at the contract unit price for each completed and accepted vault or prefabricated metal housing equipment

installation. This price shall be full compensation for furnishing all materials and for all preparation, assembly, and installation of these materials, and for all labor, equipment, tools, and incidentals necessary to complete the item.

The first three digits of any item for work included under this specification shall be 109, i.e. 109XXXX.

Payment will be made under:

- Item L-109-5.1 Construction of Airport Transformer Vault in Place-per unit.
- Item L-109-5.1 Installation of Airport Transformer Vault Equipment in Place-per unit.
- Item L-109-5.1 Construction of Prefabricated Metal Housing and Foundation in Place-per unit.
- Item L-109-5.1 Installation of Prefabricated Metal Housing Equipment in Place-per unit.

FEDERAL SPECIFICATIONS REFERENCED IN ITEM L-109

<u>Number</u>	<u>Title</u>
J-C-30	Cable and Wire, Electrical (Power, Fixed Installation)
W-C-581	Conduit and Fittings; Nonmetallic, Rigid, (Bituminized Homogeneous Fiber).
SS-R-451	Roof-Coating; Asphalt, Brushing-Consistency
TT-D-651	Drier, Paint, Liquid

ASTM C-62 Specification for Building
Brick (Solid Masonry Units
Made from Clay or Shale)

**RURAL ELECTRIFICATION
ADMINISTRATION BULLETIN
REFERENCED IN ITEM L-109**

<u>Number</u>	<u>Title</u>
REA Bulletin 345-14	REA Specification for Fully Color-Coded, Polyethylene-Insulated, Double Polyethylene- Jacketed Telephone Cables for Direct Burial

**MICHIGAN DEPARTMENT OF TRANSPORTATION
BUREAU OF AERONAUTICS - STANDARD SPECIFICATION
Installation of Airport Transformer Vault and Vault Equipment
Standard Supplemental Specification No. L-109**

This supplemental specification augments and amends the specification of like number published in Federal Aviation Administration Advisory Circular 150/5370-1A, Standard Specifications for Construction of Airports, published May, 1968, and such subsequent changes as may be published to date.

Additional information pertinent to this specification may be shown on the plan sheets.

SPECIFICATION ITEM NO. L-109, AIRPORT TRANSFORMER VAULT AND VAULT EQUIPMENT, is amended as follows:

CONSTRUCTION METHODS

Installation of Equipment in Vault or Prefabricated Metal Housing

109-3.16 Marking and Labeling. ADD the following:

(c) Cards. Where equipment is furnished with cardholders, the contractor shall furnish cards, if necessary, and shall print or type the correct circuit designations on the cards. Each card shall be protected with a transparent plastic cover furnished, if necessary, by the contractor.

(d) Wiring Diagram. The contractor shall install a wiring diagram furnished by the engineer showing final connections and identification markings. The diagram shall be installed on a wall of the vault room under glass in a 1½ inch wide by ¾ inch thick wood frame. The diagram shall be mounted where directed by the engineer.

(e) Signs. The contractor shall furnish and install a sign on the outside face of the vault fireproof door, at approximately 5 feet above the floor level. The sign shall be enameled metal containing words "DANGER" and "HIGH VOLTAGE" on it (red-on-white, or white-on-red) in letters at least 2 inches high.

109-3.17 Grounding. ADD this new section:

The contractor shall furnish and install a permanent and effective grounding system in the vault for all transformer and switch cases, panelboard and relay cabinets, outlet boxes, pull boxes, conduit, etc., and for all neutral conductors. At least 2 ground rods shall be furnished and installed outside the building by the contractor and the vault grounding system shall be electrically connected to the ground rods.

(a) Grounding Conductors. The ground bus inside the vault shall be mounted ¼ inch out from the wall and 6 inches above the floor. Connections to the ground bus bar from equipment and to ground rods or plates shall be No. 6 bare copper wire or larger. Grounding conductors shall be attached to neutral circuits, equipment cases, conduits, cabinets, relay boxes and to ground rods or plates by means of suitable lugs, pressure connectors, or clamps. Connections which depend upon solder shall not be used.

(b) Rods. Ground rods installed outside the vault shall be spaced at least 6 feet apart and at least 3 feet from the vault foundation. The rods shall be driven into the ground so that the top is at least 6 inches below grade.

(c) Plates. Where rock conditions prevent the driving of ground rods, as specified above, grounding plates may be used if authorized by the engineer. A minimum of 3 plates spaced at least 6 feet apart and at least 3 feet from the vault foundation shall be used for each separate ground. Each plate shall be of copper not less than 18 inches square and not less than 0.06 inch thick. Plates shall be embedded in an area of permanent moisture, unless otherwise specified. The plates shall be set in a horizontal plane, as deep as possible in rock fissures or depressions to obtain the best available ground. There shall be a minimum of 3 inches of earth under the plate, and a minimum of 1 foot of earth backfilled above the plate with the backfill approximately flush with the surrounding surface.

(d) Resistance. The resistance to ground of any part of the grounding system shall not exceed 10 ohms.

109-3.18 Testing. ADD this new section:

The entire vault equipment installation shall be tested in operation as a completed unit prior to acceptance. Tests shall include resistance, voltage, and current readings, as required by the engineer. Testing equipment shall be furnished by the contractor. Tests shall be conducted as directed by the engineer and shall be to his satisfaction. The contractor shall be responsible for all equipment and materials furnished, and any equipment or materials found to be defective or damaged shall be replaced by the contractor at his own expense.