An engineering recommendation outlining methods for minimizing risk of ignition from both static and lightning discharge based on current industry standards and practices.
1 LIGHTNING AND STATIC PROTECTION GUIDELINES

by Petro Guardian LLC

This engineering recommendation outlines site protection methods to minimize risk of ignition from both static discharge and lightning strikes based on current industry standards and practices. By applying these guidelines and industry best practices, the likelihood of igniting fire at salt water disposal and oil production facilities due to lightning or static related events will be mitigated but not eliminated.
2 BEST PRACTICES TO PREVENT IGNITIONS FROM LIGHTNING STRIKE AND STATIC DISCHARGE

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# CONTENTS

1 Introduction ............................................. 1
2 Industry Issues ........................................ 2
3 Scope ...................................................... 3
4 Codes and Standards ..................................... 4
5 Safety ...................................................... 5
   5.1 Contractor Responsibility .......................... 5
   5.2 Contractor Work Performance ..................... 5
   5.3 Electrical Safety ..................................... 5
6 Conflicts .................................................. 6
   6.1 General .............................................. 6
   6.2 Application .......................................... 6
   6.3 Contractor Compliance .............................. 6
   6.4 Code Revisions ...................................... 6
   6.5 Deviations ............................................ 6
7 General Work Requirements ......................... 7
   7.1 Work Performance .................................. 7
   7.2 Permits and Inspections ............................ 7
   7.3 System Installation .................................. 7
   7.4 Materials ............................................. 7
8 Grounding Requirements ................................ 9
   8.1 General Grounding Guidelines .................... 9
9 Bonding ..................................................... 14
   9.1 Bonding Requirements .............................. 14
   9.2 Proper Methods ..................................... 14
   9.3 Equipotential Bonding with Utilities ............ 17
   9.4 Equipotential Bonding with Instrumentation ..... 17
10 Lightning Protection .................................... 18
   10.1 Protection Method .................................. 18
   10.2 Air Terminal Type .................................. 19
   10.3 Air Terminal Placement ............................ 19
<table>
<thead>
<tr>
<th>Chapter</th>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>11.1</td>
<td>Key Areas of Static Accumulation</td>
<td>23</td>
</tr>
<tr>
<td></td>
<td>11.2</td>
<td>Fiberglass Tanks and Lined Steel Tanks</td>
<td>23</td>
</tr>
<tr>
<td></td>
<td>11.3</td>
<td>Thief Hatches and Vent Valves</td>
<td>24</td>
</tr>
<tr>
<td></td>
<td>11.4</td>
<td>Truck Load Outs</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>11.5</td>
<td>Methanol Tank Static Protection</td>
<td>26</td>
</tr>
<tr>
<td>12</td>
<td>12.1</td>
<td>Electronics Often Damaged at a Facility</td>
<td>31</td>
</tr>
<tr>
<td></td>
<td>12.2</td>
<td>Common Modes of Lightning Damage to Electronics</td>
<td>32</td>
</tr>
<tr>
<td></td>
<td>12.3</td>
<td>Basic NEC Requirements for Lightning Protection of Electronics</td>
<td>32</td>
</tr>
<tr>
<td></td>
<td>12.4</td>
<td>Recommended Specifications for SPD on Information Technology Systems</td>
<td>33</td>
</tr>
<tr>
<td></td>
<td>12.5</td>
<td>Recommended Specifications for SPD on Power Supply Systems</td>
<td>34</td>
</tr>
<tr>
<td>13</td>
<td></td>
<td>INSPECTION PROGRAM</td>
<td>36</td>
</tr>
<tr>
<td>14</td>
<td>14.1</td>
<td>Appendix 1-A-Typicals</td>
<td>37</td>
</tr>
<tr>
<td></td>
<td>14.2</td>
<td>Appendix 1-B - Referenced Standards</td>
<td>43</td>
</tr>
<tr>
<td>15</td>
<td></td>
<td>2018 Catalog Listed By Category</td>
<td>47</td>
</tr>
</tbody>
</table>
INTRODUCTION

Lightning is an atmospheric discharge of electricity that typically occurs during thunderstorms. A bolt of lightning can travel at a speed of 136,000 miles per hour (220,000 kilometer per hour) and can reach temperatures approaching 54,000 degrees Fahrenheit (°F) [30,000 degrees Celsius (°C)], hot enough to fuse soil or sand into glass.

In some U.S. geographical locations, lightning storms occur as many as 100 times per year. Some of the most powerful and dangerous thunderstorms occur over the United States, particularly over oil fields in the Midwest and the southern states. These storms can also produce large hail and powerful tornados.

A single lightning flash (event) will typically consist of one to twenty or more individual current strikes with the average being between four and seven.

Oil production and disposal sites often report incident of fire due to lightning. On occasion, there are direct strikes and is recommended that such strikes are provided dedicated attachment points with a conductor network that can safely ground the lightning currents. Most of the time, flammable vapors ignite from small sparks caused by nearby lightning events. The process of a lightning event is associated with a rising and falling electromagnetic field. All electrical conductors within this field are stressed, a voltage difference is created from one point to other, thus a flow of current is induced. If metal structures on a production or disposal site are not adequately bonded to each other and adequately grounded, arcing and current flashover occurs across the structures. These events can ignite flammable vapors. Voltage stress on structures can attain high values that can start to generate upward leaders (also known as streamers). Streamer formation is a high energy electrical event and can ignite flammable vapors.

Each year, numerous salt water disposal & oil production tank batteries are damaged or destroyed by lightning. Electrical current produced by a voltage gradient resulting from a lightning flash to a facility can initiate physical damage, fires, equipment damage or injury to personnel. Lightning could ignite flammable gases at a facility. Surface flash-over or arcing of the current between conductive surfaces not in voltage equilibrium can create damage directly by the heat, sparks, and molten metal.

Lightning induces voltage and current surge into power and control cables that can damage electrical, electronic and instrumentation at the facility. Lightning surge voltages and current can reach a facility not only by direct strike, but also indirectly by coupling to utility services and via ground potential rise. Automatic transfer switch, variable frequency drive, UPS, power supply units, PLC control cards and field instrumentation are affected most often.
2 INDUSTRY ISSUES

Explosions and fire that arise due to ignition from lightning and static discharge are detrimental to a production location.

Direct losses because of static and lightning discharge events include:

- Loss of life
- Cleanup costs
- Reconstruction costs
- EPA fines
- Data loss
- Higher insurance costs
- Loss of Product
- Deferred production
- Corporate image

Important elements of the protection system include the consideration of the risk to ignite flammable vapors due to electrostatic discharge from lightning & static related events, and lightning induced high voltage transients into power and control circuits.

This document addresses all aspects of the lightning and static protection system by recommending a combined system for static grounding & lightning protection. All components required for static grounding and bonding are sized to meet the UL96 lightning protection material standard. This minimizes risk of omission, eliminates redundancy and reduces the overall cost of reduction. The lightning protection system proposed minimizes the risk of a direct strike to the structure; ensures that all isolated metal bodies are bonded and grounded using a lightning current rated conductor and all electronics are protected from lightning transients.
This engineering recommendation outlines measures to minimize risk of ignition due to static discharges and lightning strikes. It is based on current industry standards and practices. These recommendations are in no way a 100% guarantee that a production or disposal location will not be subject to a lightning strike or static discharge event. By using this recommendation, the likelihood of fire shall be decreased, but not eliminated.

The recommendations provided in this document shall be applied to all new and existing tank battery installations. All existing batteries that have some form of static and lightning protection systems currently in place will be checked and upgraded to meet the requirements of this document.

This specification shall govern procedures for design, installation and maintenance of lightning and static protection systems for the purposes of:

- Minimizing risk of static discharge within insulated tanks storing volatile fluid where a spark could cause an ignition and result in a fire.
- Minimizing risk of static and lightning discharge at salt water disposal and oil production facilities venting flammable vapors where a spark could cause an ignition and result in a fire.
- Minimizing risk of burning electronics due to lightning transients at salt water disposal and oil production facilities venting flammable vapors where a small fire could ignite a catastrophic fire.

The target audience for this document is: all project engineers, facility engineers, electrical engineers, construction coordinators, field supervisors, technicians, contract engineering firms and contract construction firms.
The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

**API RP74**: Recommended practice for occupational safety for onshore oil and gas production operation.

**API RP 2003**: Protection against ignition arising out of lightning, static and stray current

**NFPA 30**: Flammable and Combustible Liquids Code

**NFPA 780**: Standard for the protection of Lightning Protection Systems

**NFPA 77**: Recommended practices for Static Electricity

**IEEE std, 142**: Powering and grounding of commercial and industrial equipment

**IEEE std 1100**: Recommended Practice for Powering and Grounding Sensitive Electronic Equipment

**IEC 61643-12:2002**: Low-voltage surge protective devices – Part 12: Surge protective devices connected to low voltage power distribution systems – Selection and application principles

**IEC 61643-1 Ed. 1.1 (2002-01)**: Surge protective devices connected to low voltage power

**IEC 62305-1**: Protection against lightning – Part 1: General principles

**IEC 62305-2**: Protection against lightning – Part 2: Risk management

**IEC 62305-3, Protection against lightning – Part 3**: Physical damage to structures and life hazard

**IEC 62305-4**: Protection against lightning – Part 4: Electrical and electronic systems within distribution systems

OSHA- Occupational Safety Health Act
5.1 Contractor Responsibility

The contractor is responsible for maintaining their equipment in safe order, for the development of safe working practices and the sufficient training of their personnel. As a minimum, contractor’s safe working standards shall comply with OSHA CFR 1910.252 and safety practices as required in the Master Service Agreement. In any event, should the inspector inform the contractor of inadequate safety standards, practices, or events on the part of any contractor personnel, such deficiency shall be promptly rectified.

5.2 Contractor Work Performance

It is recommended that installations be designed and installed by qualified, trained, personnel. Training for installers requires a company approved instructor-led course or a private in-house training session. Contractor to perform all work in a safe, workmanlike manner consistent with all industry practices and applicable rules and regulations. In addition, contractor must follow all appropriate documentation and safety procedures including general and site specific.

5.3 Electrical Safety

Electrical work should only be performed on de-energized equipment and wiring unless de-energizing introduces additional or increased hazards or is infeasible due to equipment design or operating limitations.
6.1 General

Where there are conflicts between drawings, data sheets specifications or requisition and the specified code or governmental requirements, such conflicts shall be referred to in writing for resolution.

6.2 Application

If the recommendations for static and lightning protection referenced in the project conflict with this specification, the requirements of this specification shall apply. In all cases, applicable governmental regulations shall be fulfilled.

6.3 Contractor Compliance

The contractor shall comply with changes and/or additions incorporated in the most recent issue or edition of codes, regulations and other references issued up to the time of award of contract.

6.4 Code Revisions

Where there are revisions to codes, regulations or other references listed in the contents of this Specification, the current revisions shall apply to new construction.

6.5 Deviations

Contractor shall obtain the company's written approval for all deviations, exceptions and substitutions to this Specification including those which are permitted subject to the approval of the company.
7 GENERAL WORK REQUIREMENTS

7.1 Work Performance

All work performed by contractor shall be neat, compact and performed by qualified craftsmen with attention to general appearance, accessibility for maintenance and protection of the equipment during installation, construction, transportation and operation.

7.2 Permits and Inspections

The Contractor is responsible for procuring and delivering to the company all permits, and final certificates of inspection and approval required by the governing jurisdictions. No final payment will be issued until delivery of any certificates of inspection and approval is complete.

7.3 System Installation

Contractor shall install, terminate, and test all connections in accordance with the scope of work, specifications and/or drawings. Contractor shall furnish all additional parts and materials as required for a complete and functional installation not listed in company supplied materials.

7.4 Materials

7.4.1 Hazardous Classification

Where applicable, all equipment and fittings shall be rated for the areas indicated on the hazardous area classification drawings.

7.4.2 UL Compliance

All lightning protection wires, connections, and clamps must be UL96 listed products.
7.4.3 Approved Products for Load Outs

All truck loads out wires, connections, and clamps must be approved products.

7.4.4 Static Mitigation

Internal tank static mitigation equipment must be approved prior to installation.
8 GROUNDING REQUIREMENTS

8.1 General Grounding Guidelines

Lightning and static protection systems require an earth electrode (grounding) system to dissipate the electrical energy. The earth electrode systems may consist of single ground electrodes at each down-conductor, multiple ground electrodes, concrete-encased electrodes, ground ring electrodes, radials, plates, or any combination of the above. A low resistance earth ground is preferred.

8.1.1 Grounding Equipment

Ground rods and radials shall be called ground electrodes in this document.

1. Install a minimum 3/4" O.D. x 10' long copper clad steel ground rod unless otherwise stated in design documents. Rods shall be driven to a depth of approximately six inches below grade and covered.

2. The cable to ground rod connections must be made using a UL96 listed clamp. [Appendix 1-A typical 6]

3. All connectors, cable to cable splice and cable to structure clamps will be UL96 listed to handle lightning currents.

4. All connections to ground must be secured in a poly-plastic inspection well. The well lid must be lockable, and the construction material should be able to take 3000lbs of weight. The test
wells shall be min. 10” in diameter and marked for identification of grounding points. In no case shall a ground rod protrude above ground and create a tripping hazard. [Appendix 1-A typical 5]

### 8.1.2 Ground Electrode Placement and Spacing

1. For the lightning protection system on a storage tank battery, ground electrodes shall be driven diametrically opposed and at the farthest extents of the containment. [Appendix 1-A typical 1]

2. Spacing between two earth electrodes cannot exceed 100 feet commonly connected in a lightning protection system. Each lightning protection down conductor must terminate to a ground electrode.

3. Ground rods shall not be spaced closer than twice their driven depth.

4. Where storage tanks are installed inside lined secondary containment barriers, the ground rods shall be installed outside of the containment area. The ground conductor shall be routed over the containment with the acceptable rise to run ration of 1:4. Care should be taken to route the ground cable along other piping or conduit runs to avoid creating a tripping hazard. [Appendix 1-A typical 2a & typical 2b]
5. Where storage tank catwalks cross outside the containment barriers, the ground rods shall be installed outside of the containment area at the foot of the catwalk. The Class 1 aluminum cable must transition to a Class 1 copper cable 24” above ground with a bimetallic splice to avoid galvanic corrosion. [Appendix 1-A typical 4]

6. A UL96 listed Class 1 multi-strand aluminum lightning protection cable shall be extended between the ground rods across the storage tank battery, following a route along the catwalk. This extension will act as a back bone to bond and ground lightning air terminals, isolated vent pipes, thief hatch static protection equipment, in-tank static protection equipment, on tanks instrumentation, vent valves, bull plugs, tank sticks and any other isolated metal structures on top of the tanks. [Appendix 1-A typical 7].
7. Rod to cable connections shall be made using UL 96 rated mechanical connections. All connections are to be completed strictly following the manufacturer's recommendations and inspected prior to burial or project completion.

8. Where grounding conductors are susceptible to physical damage from machinery, vehicles or other objects, they shall be protected by an appropriately sized PVC Schedule 40 conduit. [Appendix 1-A typical 3]

9. A bond shall be made at each isolated pipe rack or cable tray support element.

10. All major equipment (flare stacks, vessels, tanks, exchangers, skids, compressors, generators, low pressure towers, separators, heater-treaters, lamp posts, communication towers, SCADA towers etc.) shall be grounded for lightning and static current with a dedicated ground electrode. If the process area comprises of multiple heater treaters and separators, ground electrodes can be installed at the two ends of the process area, and are bonded to the piping system. In case the process area has extensive automation, use a Class 1 multi-strand lightning protection cable to establish a backbone between the two ground electrodes. Route the backbone along the process piping secured at every 36”. Bond each process skid to the backbone. For every 100ft extension of the backbone, establish additional location for ground electrode. [Appendix 1-A typical 30]

11. For the static mitigation at the truck load out connected to the tank battery, ground electrodes shall be driven next to each load out. Each installed electrode will be secured
within an inspection well. The load-out static protection assembly will be grounded to this point using a #6 green jacked grounding cable. For truck load outs on fiberglass tanks, the ground electrode at the load out will be bonded to the nearest lightning protection ground electrode using a #6 green jacketed grounding cable. This connection is not required for truck load outs for metal tanks.
9.1 Bonding Requirements

Requirements for bonding shall comply with NFPA 77 and NFPA 780. Lightning protection system bonds should be as short and as direct as reasonably achievable. Do not paint or coat LPS bonds and conductors. All conductor must be Class I lightning protection multi-strand aluminum cable.

9.2 Proper Methods

Only mechanical or compression connectors will be used. Use of UL96 listed bonding lugs and pipe clamps is recommended. All isolated metal bodies such as metal fittings, metal piping, metal bull plug on fiberglass tanks, thief hatch on fiberglass tanks, tank stick chassis and vent valves must be bonded to lightning protection system when such isolated bodies are located in the top 50% of the height of the tank. [Appendix 1-A typical 14 & typical 15]
1. Lightning protection conductors shall be fastened to the structure upon which they are placed at intervals not exceeding 3 ft. using UL96 listed fasteners. [Appendix 1-A typical 8, 15]

2. Lightning Protection Conductors shall maintain a horizontal or downward coursing free from “U” or “V” (down and up) pockets.

3. No bend of a conductor shall form an included angle of less than 90 degrees, nor shall it have a radius of bend less than 8 inches. [Appendix 1-A typical 17]

4. Class I lightning conductor shall be routed along non-conductive piping to establish a connection to all air terminals. The air terminal network on the piping must be bonded to the lightning protection system at both ends of the piping. [Appendix 1-A typical 15]

5. A proper bond must be established between the lightning protection conductor and the thief hatch static protection system [Appendix 1-A typical 26]

6. A proper bond must be established between the lightning protection conductor and the intank static protection system. [Appendix 1-A typical 26]

7. A proper bond must be established between the lightning protection conductor and all isolated tank top metal bodies. [Appendix 1-A typical 12]
8. A proper bond must be established between the lightning protection conductor and the vent valve. If the vent valve has a hinged lid, a conductive strap must be used to bond the lid to the flange of the vent valve. [Appendix 1-A typical 11]

9. A proper bond must be established between the lightning protection conductor and the metal bull plug on fiberglass tanks. [Appendix 1-A typical 13]

10. A proper bond must be established between the lightning protection ground and the fiberglass tank load-out static protection system ground.

11. A proper bond must be established between the fiberglass tank C-Veil grounding terminal and fiberglass tank load-out static protection terminal system ground. [Appendix 1-A typical 28a]
9.3 Equipotential Bonding with Utilities

The lightning protection system ground must be bonded to the main electrical service ground at the service entry. This is required to ensure that both the electrical distribution system ground reference and the lightning protection system ground reference exist at the same potential during a lightning event. This is a safety requirement to prevent:

1. electrocution of personnel due to dangerous difference in ground potential
2. igniting fire due to possible flash over resulting from a difference in ground potential
3. to protect electronics from lightning transients resulting from ground potential rise

Grounding systems from separate utilities (Facility electrical, Instrument Ground, Telecommunications, CATV, etc.) shall be bonded together at one and only one point.

9.4 Equipotential Bonding with Instrumentation

Generally, a direct bond cannot be established between the electrical ground and lightning protection ground to isolated control circuit ground. Appropriate surge protection devices are installed on both sides of the instrumentation control cables. These serve as an alternate to bonding to prevent the possible flash over that may damage electronics or ignite fire.
10.1 Protection Method

The lightning protection method being used is as per IEEE std 142 - 3.3.3.3.3 - Charge transfer system. The dissipation array, with its multitude of sharp points, produces a delay in the development of the upward leader. The charged cloud reduces the field potential in the area. Should a lightning strike’s step leader approach, the delay of the upward streamer inhibits contact with the downward leader. Then the downward step leader can attach itself to some other upward streamer that has progressed upward earlier.

1. All air terminals should be connected by horizontal conductors and down conductors to form a two-way path from each air terminal to the grounding electrode system.

2. The possibility of a direct strike to a vent is mitigated by an air terminal of suitable length installed above the venting area.

3. Bend radii for the down conductors should be, if possible, not less than 20 cm (8 in). Sharp bends increase the reactance of the conductor.

4. If the structure has electrically continuous metallic columns, these columns will act as down conductors. The air terminals must be interconnected by conductors to make connection with the columns.

5. The average spacing between down conductors should not exceed 30 m (100 ft).

6. Every down conductor must be connected, at its base, to an earthing or grounding electrode.

7. The ground rod should be placed in undisturbed or firmly packed soil. This electrode can be concrete encased. Ground terminals should contact the earth from the surface downward to avoid flashing at the surface.
10.2 Air Terminal Type

1. In flammable environments, streamer delaying air terminals are to be used. The streamer delay array construction will be of stainless steel material attached to the top of a ½” aluminum air terminal. The charge transfer brushes on the dissipation array will be stainless steel tines facing upwards not more than 4” length. The air terminals should be tested in a recognized high voltage laboratory for emission current and documented delay in breakdown time as compared to a blunt air terminal of same size. [Appendix 1-A typical 18,20]

10.3 Air Terminal Placement

1. The streamer delaying air terminals shall be used and positioned at a spacing no larger than 5m (15ft) as per Level 1 spacing recommended in IEC 62305. Recommended spacing shall be 10 ft not exceeding 15ft. Place air terminals along the outside perimeter of the battery using the outermost piping and/or catwalk handrail(s). [Appendix 1-A typical 20]
2. All tall vertical equipment (vessels, tanks, exchangers, skids, compressors, generators, low pressure towers, separators, heater-treaters, lamp posts, communication towers, etc.) shall be protected with air terminals using the spacing requirements above. [Appendix 1-A typical 24]

a. Large Diameter Closed Roof Tanks: Place air terminals along the perimeter of the storage tank at the recommended spacing. Add a dissipater at the center of the tank. If the distance from the outer perimeter to tank center is more than 15ft, add a center ring of dissipation air terminals with the same spacing.

b. Heater Treater: A single air terminal at top directly is recommended. Keep the air terminal away from the exhaust stack.

c. Vertical Separator: A single air terminal at top directly mounted to the piping is recommended.

d. Vapor Recovery Tower: A single air terminal at top directly mounted to the piping is recommended. Space terminals along the piping if there are multiple VRT.

e. Compressor: Treat the compressor top as a roof and install air terminal at each corner not more than 2ft from the Edges. Maintain the spacing of 10ft not exceeding 15ft.

f. Generator: Treat the generator top as a roof and install air terminal at each corner not more than 2ft from the edges. Maintain the spacing of 10ft not exceeding 15ft.
g. **Lamp Post:** Furnish each lamp post with an air terminal positioned such that it is at least 10” above the lights. If the lamp post is metal, no down conductor is required. For wooden lamp post, connect the air terminal to a down conductor and terminate the conductor to a dedicated ground rod secured within a test well. [Appendix 1-A typical 21]

![Lamp Post Image]

h. **Communication Tower:** Furnish each communication tower with an air terminal positioned such that it is at least 10” above the tower top. If there are any antennas on the top, the air terminal must be installed on an offset and at least 10” higher than the antenna to avoid any interference. Connect the air terminal to a LP down conductor and terminate the conductor to a dedicated ground rod secured within a test well.

i. **SCADA Tower:** Furnish each SCADA tower with a dissipater air terminal positioned such that it is at least 10” above the tower top. If there are any antennas on the top, the air terminal must be installed on an offset and at least 10” higher than the antenna to avoid any interference. Connect the air terminal using the metallic SCADA tower as the lightning conductor to a dedicated ground rod secured within a test well.

3. If the piping is an electrically continuous metal pipe, the air terminals can be installed directly on the piping. If the piping is non-conductive, connect all air terminals using Class 1 lightning conductor. The conductor is to be secured at intervals of no more than 36”.

4. Air terminals must be at least 10” above the structure they are mounted to or protecting. Install 60” offset air terminals on all vent valves. [Appendix 1-A typical 22]
5. Replace existing Wind Sock assembly with a customized windsock with integrated dissipater Assembly. [Appendix 1-A typical 29]
At oil & gas production and SWD sites, fire incidents are reported due to ignition that occurred due to electrostatic discharge. This document provides a set of recommendations to control static electricity accumulation for purposes of preventing fires and explosions. The purpose of this document is to assist the user in identifying the key areas at risk of static generation, accumulation, and discharge; and apply suitable products and practices. As per NFPA 77 – 7.1.2, ignition hazards from static electricity can be controlled by neutralizing the charges, the primary methods of which are grounding isolated conductors and air ionization.

### 11.1 Key Areas of Static Accumulation

1. In the fluid and vapors inside fiberglass and lined steel tanks
2. Across the lid and flange of thief hatches
3. At the enardo valve
4. During fluid exchange at truck load out stations

### 11.2 Fiberglass Tanks and Lined Steel Tanks

The flow of volatile fluids in and out of an insulated tank generates static charge that accumulates on the fluid surface and on the walls of the insulated tank. Inductive neutralizers (per IEEE std. 142 – 3.2.6.4) must be installed within the tank to increase the rate of static relaxation.

The fluids and vapors within the tanks can be highly corrosive. It is recommended that inductive neutralizers selected be made of non-corrosive but conductive materials. The inductive neutralizer must be vertically oriented from top to bottom of the tank with no slack. The neutralizer should be a semi-conductor with little or no capacitance. Conductors such as metal brushes, metal rods, and metal chains have high capacitance, which can result in discharges that ignite flammable vapors and liquids.

The inductive neutralizer shall be attached to the tank through a bolt on the thief hatch. A bonding lug shall be installed above the flange of the thief hatch to bond the thief hatch and static
inductive neutralizer to the facility grounding system. [Appendix 1-A typical 25a & typical 25b and typical 25c]

11.3 Thief Hatches and Vent Valves

The thief hatch lid and flange are connected by a hinged pin that allows the lid to rise and fall back into the seal after it releases excess tank pressure. When the pressure is released, volatile gases may escape into the atmosphere. The sudden separation of two conductive surfaces (lid and the flange) generates a risk of static discharge. With adequate oxygen mixing alongside escaping volatile gases, the static discharge can ignite the gas. Similar ignition risks exist when an operator opens the thief hatch. Many vent valve types also present static discharge risks due to the presence of volatile gasses and a spark gap potential between lid and flange.

1. A stainless steel or aluminum flexible bonding strap is recommended to be installed between the thief hatch lid and flange. A similar flexible bonding strap is recommended for the vent
valve hatch lid and flange. This bond keeps the lid and flange at the same potential even when the two are physically separated. The bonding strap needs to be of adequate width (around 1") and a braided construction is preferred to provide flexibility. [Appendix 1-A typical 27]

2. The bonding strap is attached to a bonding lug on the thief hatch flange. Similarly, a bonding strap is attached to a bonding lug on the vent valve hatch flange. The lug is bonded to the lightning protection grounding system for the facility. [Appendix 1-A typical 16]

11.4 Truck Load Outs

1. Each truck load-out should have a dedicated ground rod installed. The ground rod will be minimum 3/4 x 10’ installed inside an inspection well. The ground rod shall be bonded to the fill pipe using #6 green insulated multi-strand grounding cable. The truck load-out cable shall be connected to the fill pipe clamp. The truck load-out cable assembly will use a large UL96 listed bonding clamp. [Appendix 1-A typical 28a]
2. For load-out stations on fiberglass tanks, the truck load-out ground rod shall be bonded to the tank battery ground rods using #6 green insulated multi-strand grounding cable routed along the fill pipe using the shortest route. If a C-Veil exists, this cable should also be bonded to the C-veil grounding terminals using #6 green insulated multi-strand grounding cable.

3. For load-out stations on steel tanks, no additional bonding is required.

4. All truck grounding points shall be marked with the proper signage to indicate location of bonding point. This is to provide visual indication to the operators to bond truck chassis and to visually verify that the bond is grounded to a ground rod. [Appendix 1-A typical 28b]

5. The truck load-out cable shall be attached to the trucks with the designated grounding equipment provided.

11.5 Methanol Tank Static Protection

11.5.1 Scope

1. This recommended practice applies to the identification, assessment, and control of static electricity for purposes of preventing fires and explosions at methanol storage tanks
11.5.2 Purpose

1. The purpose of this recommended practice is to assist the user in controlling the hazards associated with the generation, accumulation, and discharge of static electricity by providing techniques for controlling the hazards of static electricity for methanol storage tanks.

2. Nothing in this recommended practice is intended to prevent the use of systems, methods, or devices of equivalent or superior quality, strength, fire resistance, effectiveness, durability, and safety over those prescribed by this recommended practice.

11.5.3 Referenced NFPA Publications

1. NFPA 77, Recommended Practice on Static Electricity

11.5.4 Accumulation and Dissipation of Static Charge

1. A static electric charge will accumulate where the rate at which charges separate exceeds the rate at which charges recombine.

2. Separation of electric charge might not in itself be a potential for fire or explosion hazard. There must be a discharge or sudden recombination of the separated charges to pose an ignition hazard. One of the best protections from static electric discharge is a semi conductive path that allows for the controlled recombination of the charges.

3. Dissipation of static electric charges can be affected by grounding isolated conductors and by ionizing the air near insulating materials.

11.5.5 Assessment of Bonding and Grounding

1. Bonding is a process whereby two or more conductive objects are connected by means of a conductor so that they are at the same electrical potential. The objects might or might not be at the same potential as the earth.

2. Grounding is the process of bonding one or more conductive objects to the earth so that they are all at zero (0) electrical potential.

3. In both bonding and grounding, the intent is to eliminate the occurrence of a static discharge.
11.5.6  **Recommended techniques for controlling the hazards of static electricity for methanol storage tanks**

1. The objective of controlling a static electricity hazard is to provide a means whereby charges, separated by whatever cause, can recombine harmlessly before discharges can occur. The primary methods for neutralizing charges are ionization of air and grounding isolated metal structures.

2. **Static Charge Neutralization.**
   a. Air can be made to contain mobile ions that are attracted to surfaces and will eliminate unbalanced static electric charges from those surfaces. It is important to note that these control devices do not prevent the generation of static electric charge. They provide ions of opposite polarity to neutralize the generated static electric charge.
   b. The design of each type of inductive neutralizer consists of sharply pointed elements arranged for placement in the static electric field near and across the charged surfaces. Install a Static Lasso of suitable length connected at the top of the poly tank that hangs vertically to the bottom of the tank.
   c. A charge drawn from ground to the needlelike tips of the Static Lasso® (an inductive neutralizer) produces a concentrated electric field at the tips. When the electrical field is sufficient to produce a localized electrical breakdown of the air (known as corona), it injects ions into the air that are free to move to distant charges of opposite polarity. The flow of ions produced in corona constitutes a neutralizing current over the surface of the fluid where the static charges may have accumulated.
   d. It is critically important that the Static Lasso® (inductive neutralizer) is connected to a secure ground. If the inductive neutralizer is not grounded, sparks can occur.

3. **Bonding and Grounding.**
   a. Bonding is used to minimize the potential difference between conductive objects. Grounding, on the other hand, equalizes the potential difference between the objects and the earth.
   b. Install two sections of 5ft ground rods with a compression coupler to have at-least 8ft of ground rod surface below the grade.
   c. Install a lockable test well over the ground rod to conduct periodic maintenance.
   d. Use a #6 Green PVC jacketed grounding cable to bond the Static Lasso® to the metallic frame of the methanol tank.
e. Use a #6 Green PVC jacketed grounding cable to bond the frame of the methanol tank to the ground rod clamp.

f. To prevent the accumulation of static electricity in conductive equipment, the total resistance of the ground path to earth should be sufficient to dissipate charges that are otherwise likely to be present.

g. Where wire conductors are used, the minimum size of the bonding or grounding wire is dictated by mechanical strength, not by its current-carrying capacity. Stranded or braided wires should be used for bonding wires that will be connected and disconnected.

h. Grounding conductors can be jacketed or bare conductors. Bare conductors can be used because defects are easier to detect while jacketed conductors help identification of the conductor.

i. Permanent bonding or grounding connections can be made by brazing or welding. Temporary connections can be made using bolts, pressure-type ground clamps, or other special clamps.
Lightning discharges will produce electromagnetic pulses that can be coupled onto conductors servicing the structure. The discharges on power utility lines directly induce transients into the power feed. The discharges also lead to a rise in ground potential and are a source for ground transients. These induced transients can be adequate to cause dangerous over-voltages, resulting in fires or damage to critical electrical and electronic hardware. Surge protection devices protect facilities against induced surges on power, communication, data and process control lines.

12.1 Electronics Often Damaged at a Facility

1. Information Technology Systems
   a. PLC control cards
   b. DC power supply units
   c. Pressure Transmitters
2. **Power Supply Systems**
   a. Power Generator ATS
   b. Variable Speed Drives (VFDs)
   c. UPS

### 12.2 Common Modes of Lightning Damage to Electronics

1. Lightning strike to the network of power, phone and communication cable wiring. This network, especially if it is elevated, is an effective collector of the lightning surges. The wiring then conducts the surges directly into the facility, and then to the connected equipment.

2. Lightning travels through the ground (soil), reaching underground cables or pipes. This is another route for lightning to come into a facility. This induces surges in underground cables and into the ground reference for electrical and electronics.

3. Lightning strikes to, or near, the external wiring network common to most outdoor facilities. Light poles, powerlines, flare control panels, drive panels, RTU panels, and security systems can all be struck by lightning, and the lightning surges will then be carried by the wiring, damaging critical circuits and operations.

4. Lightning may strike nearby objects (open field, trees, another facility) that are close to, but not directly connected to the facility. In this situation, the lightning strike radiates a strong electromagnetic field, which can be picked up by wiring (power and instrumentation cables), producing voltages that can damage equipment.

5. Lightning that directly strikes can severely damage a structure without a lightning protection system (LPS) and will generally damage most electronic equipment connected to the facility. The structural damage can normally be prevented by a properly installed LPS, but the LPS alone provides little protection for the electronic equipment.

### 12.3 Basic NEC Requirements for Lightning Protection of Electronics

1. The main facility ground is used as the central ground point to which all lightning currents will be conveyed. Independent, unbonded ground rods are not recommended.

2. The NEC requirements are intended to remove most lightning surge currents from all signal wires entering the facility from utilities. For coaxial cables, only the sheath must be grounded;
for telephone & communication wiring, a special building entrance protector limits the impulse voltage between wires and ground to less than ~1000 V. Sheaths of coaxial cables from antennas must also be bonded to the facility ground.

3. The NEC requirements for connecting all metal piping and large metal parts of the structure to the facility ground serve two purposes: If there is metallic buried piping, bonding it to the facility ground improves the quality of that ground. Also, in the rare event of a direct strike to the piping, or to a metallic part of the structure, the ground bond conducts the lightning current safely into the facility ground. This greatly reduces the voltage differences between the parts of the structure, and therefore decreases possible injury to the residents, and reduces the possibility of a fire at the facility due to surge currents and voltage flash-overs.

4. NEC allows for increased protection in high-lightning areas by the optional installation of the following:
   a. A structural lightning protection system (LPS)
   b. Surge protectors on the AC power wiring
   c. Additional surge protectors on signal wiring
   d. “Supplementary Protection” (also called “Point-of-Use” protection) at the equipment to be protected.

12.4 Recommended Specifications for SPD on Information Technology Systems

1. SPD Class: All SPD devices installed in the control/RTU panel or on the field instrument side have conductors that are exposed to coupling from direct lightning strikes. All these devices are recommended to be Type 1 SPD devices with combined lightning current and surge arrester capability.

2. Operating Voltage & Frequency: Selected device should match the requirements of the operating voltage & frequency of the circuit that it is to protect.

3. Total Rated Lightning Impulse Current: Lightning impulse current internationally is rated as an impulse of 10/350 micro seconds. The recommended withstand capability is 10kA per unit.

4. Rated Lightning Impulse Current per Line: The recommended withstand capability per line is 2.5kA per unit.

5. Total Nominal Surge Current: Surge current is rated as an impulse of 8/20 micro seconds. The recommended withstand capability is 20kA per unit.
6. Nominal Surge Current per Line: The recommended withstand capability is 10kA per line.

7. Voltage protection Level Line: This is the surge voltage that a SPD will allow to pass through. The recommended voltage protection level is operating voltage + 50VDC.

8. Voltage Protection Level Line – PE: The recommended voltage protection level is less than 600VDC.

9. Series Impedance per Line: Surge protection devices are generally installed in series on the control panel side. The series impedance can lead to signal loss. The recommended series impedance is less than 1 ohm. At the field equipment, the SPD devices will be installed in parallel. The series impedance will not be applicable in selection.

10. SPD Monitoring System: The SPD construction should allow possibility to monitor it’s integrity as preventative maintenance.

11. Enclosure Material: For SPD devices installed inside the control panel enclosure, IP20 rated enclosure is adequate. Field installed devices will be rated for IP67 and if required rated for EX environments.

12. Test Standards: UL 497B & IEC 61643-21

13. Approvals: UL, CSA, GOST

12.5 Recommended Specifications for SPD on Power Supply Systems

1. Approvals: ANSI/UL 1449-2006 (a.k.a. UL 1449 3rd Edition) and IEC 61643

2. SPD Class: All service entrance panels are generally all exposed to direct lightning. SPD shall be Type 1 SPD. All branch panels in the field as they are generally all exposed to indirect lightning, SPD shall be Type II for these panels.

3. Nominal Discharge Current Rating: 20 kA per mode for all modes is recommended

4. Max. Surge Current Rating: 200kA rating is recommended

5. Maximum Continuous Operating Voltage (MCOV): It is recommended that the MCOV does not exceed more than 25% of the nominal operating voltage.

6. The SPD shall have Voltage Protection Ratings (VPRs) as follows:

   Voltage protection rating is the part of surge voltage that the SPD allows to pass through. Devices must be tested for impulse current, combination surge wave forms and ring wave
forms. Rating are recommended to be presented in detail for each mode of protection for each surge wave form.

7. Monitoring: LED indicator lights for power and protection status.

8. SPD Design: Modular design is not recommended for service panel protectors. Integrated circuits, permanently-mounted, parallel connected are most recommended.
Implementing a scheduled inspection program will help mitigate tank fires from lightning and static events; however, even the highest quality installations will not be effective over time without a successful inspection program.

It is recommended that protected facilities are inspected every winter (at a minimum) to allow time to make the discovered recommended repairs before the spring storms arrive. Damage to the integrity of the protection system could result from natural causes such as H2S or chloride corrosion, wind storms, hail and more. Man-made damage could result from theft of material, painting, or replacements of parts that may damage or disconnect bonding and grounding components. Inspections should also identify any equipment that has been added to the facility after the original installation which, if left up protected, jeopardizes the entire protection system.

An online custom designed inspection tool is available to record the data during inspection. The software stores the asset information into a digital database. This provides a reference point in time for the facility and photos of repairs to the protection system that are documented in these reports.
14.1 Appendix 1-A-Typical

**Typical 1**
Overhead view of tank battery site

**Typical 2a**
Ration of 4:1 of Class I conductor climbing interior containment wall.

**Typical 2b**
Class I conductor routing on exterior containment wall to ground and test well.

**Typical 3**
Conductor secured by conduit
Best practices to prevent ignitions from lightning and static events

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Typical 10  UL96 listed parallel splice for Class I conductor.

Typical 11  UL96 listed pipe clamp securing metal pipe with Class I conductor on fiberglass tank.

Typical 12  Fiberglass tank top bonding.

Typical 13  Metal bull plug on fiberglass tank bonded with Class I conductor.

Typical 14  UL96 listed adhesive clamp bonded to metal handles atop fiberglass tank.

Typical 15  Fiberglass tank top bonding.
Best practices to prevent ignitions from lightning and static events

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14.2 Appendix 1-B - Referenced Standards

Section 10.0 - Flammable or combustible liquids requirements

- NFPA 30: sec.6.5.4.2 All metallic equipment such as tanks, machinery, and piping where the potential exists for an ignitable mixture to be present shall be bonded and grounded.

Section 10.0 - Grounding requirements

- NFPA 780 sec 4.5.2 Aluminum materials shall not be used within 18 in. (450 mm) of the point where the lightning protection system conductor meets the earth.
- NFPA 780 sec 4.5.2.1 Fittings used for the connection of aluminum down conductors to copper or copper-clad grounding equipment shall be of the bimetallic type.
- NFPA 780 sec.4.13.1.1: Each down conductor shall terminate as a grounding electrode.
- NFPA 780 sec.4.13.2.3.1: The ground rod shall extend vertically not less than 10Ft (3m) into the earth.
- NFPA 780 sec.4.13.2.4: where multiple connected ground rods are used, the separation between any two ground rods shall be at least the sum of their driven depths.
- NFPA 780 sec 4.13.3.3 A test or connection point shall be provided on each concrete-encased electrode to enable periodic maintenance and testing of the ground system.
- NFPA 780 sec.4.13.5.2: Each radial shall be not less than 12Ft in length buried not less than 18” below grade.
- NFPA 77 sec.12.1.4: The tank and all associated equipment, such as piping, pumps, and filters, should be grounded.
- NFPA 77 sec.12.2: Loading of tank vehicles, summary of precautions as per table 12.2

Section 11.0 - Bonding and LP conductors
• NFPA780 sec 4.9.3.2: Permanent exterior metal handrails and ladders that are subject to direct lightning strikes and are electrically continuous shall be permitted to be used as main conductors where the min. thickness is 0.064” (1.63mm).

• NFPA780 sec 4.9.4.1: Conductors shall maintain a horizontal or downward coursing free from “U” or “V” (down and up) pockets.

• NFPA 780 sec 4.9.5: No bend of a conductor shall form an included angle of less than 90 degrees, nor shall it have a radius of bend less than 8 in. (200 mm)

• NFPA 780 sec. 4.10: Conductors shall be fastened to the structure upon which they are placed at intervals not exceeding 3Ft. (0.9m).

• NFPA 780 sec. 4.14.3 Common bonding interconnection shall include all building grounding electrode systems, including lightning protection, electric service, communication, and antenna system grounding electrodes.

Section 12.0 - Lightning Protection

• NFPA780 Table 4.1.1.1.1: Class 1 Air Terminal Solid Aluminum ½” (12mm) min. Class 1 Main conductor Aluminum cross section 98,600 circular mils (50sq.mm) with 14AWG (2sq.mm) size of each strand.

• NFPA780 sec.4.7.2.2: Strike termination devices shall be placed on ridges of pitched roofs and around perimeter of flat or gently sloping roofs at intervals not exceeding 20’ (6m)

• NFPA 780 sec 4.7.11.1 Metal objects having a metal thickness of 3 /16 in. (4.8 mm) or more not located in a zone of protection shall require connection to the lightning protection system in accordance with the following:
  1) The metal object shall be connected to the lightning protection system using a main-size lightning conductor.
  2) The main-size conductor connecting the metal object shall provide two or more paths.
  3) The main-size conductor shall be connected to the metal object with a main-size connector having a surface contact area of not less than 3 in.2 (1940 mm2) or a mini-mum of 1 1/2 in. (38 mm) of contact along the axis of a round surface.
• NFPA780 sec. 4.9: Main conductor shall interconnect all strike termination devices and shall form two or more paths from each strike termination device downwards, horizontally, or rising at no more than one to four (1:4) slope to connections with grounding electrodes.

• NFPA780 sec.4.9.10: At least two down conductors shall be provided on any kind of structure.

• NFPA780 sec. 4.9.10.2: The average distance between all down conductors does not exceed 100Ft.

• NFPA780 sec 4.10: Conductors shall be fastened to the structure upon which they are placed at intervals not exceeding 3Ft.

Section 13.0 - Static Protection

• NFPA77 sec. 8.1.2.3: A charge drawn from the ground to the needlelike tips of an inductive neutralizer produces a concentrated electric field at the tips. This produces a localized electrical breakdown of the air. The flow of ions produced constitutes a neutralizing current.

• NFPA77 sec. 12.1.8.1: Tank gauging rod should be bonded securely and directly downward to the bottom of the tank by a conductive cable or rod to eliminate a spark gap.

• NFPA77 sec. 12.1.11.1: Metal tanks with nonconductive coatings or linings should be treated as nonconductive tanks. The tank should be bonded to the filling system.

• NFPA77 sec. 12.2 Loading of Tank Vehicles: Tanks trucks should be bonded to the fill system, and all bonding and grounding should be in place prior to starting operation.

Section 14.0 - Surge Protection

• NFPA780 sec 4.20.2.1 SPDs shall be installed at all power service entrances.

• NFPA780 sec 4.20.2.2* SPDs shall be installed at entrances of conductive communications systems (including, but not limited to, CATV, alarm, and data) and antenna systems
• NFPA780 sec 4.20.2.3 SPDs shall be installed at all points where an electrical or electronic system conductor leaves a structure to supply another structure if the conductors or cables are run over 100 ft (30 m)

• NFPA780 sec 4.20.2.4* Surge protection shall be permitted for installation at subpanels or branch panels and at the point of utilization (outlet or signal termination; also termed supplementary protection).

• NFPA780 sec 4.20.3.1.2 SPDs at the service entrance shall have a nominal discharge current (In) rating of at least 20 kA 8/20 µs per phase.

• NFPA780 sec 4.20.3.2.2 Signal, data, and communications SPDs shall have a maximum discharge current (Imax) rating of at least 10 kA 8/20 µs when installed at the entrance.

• NFPA780 sec 4.20.5.3 The protection of service entrances shall use Type 1 and for branch panels Type 2 SPDs, in compliance with applicable standards such as ANSI/UL 1449, Standard for Safety for Surge Protective Devices

• NFPA780 sec 4.20.6.4.3 SPDs shall not be grounded through a down conductor of the lightning protection system

• NFPA780 sec 4.20.7.2* SPDs shall be located and installed to minimize lead length. Interconnecting leads shall be routed to avoid sharp bends or kinks.

• NFPA780 sec 4.20.7.4* All SPD components shall be accessible for inspection and maintenance.

• NFPA780 sec 4.20.8* Earth Grounding Electrode. Resistance of the earth electrode system used in the grounding of SPDs shall comply with NFPA 70.
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<td>3/4&quot; x 5' Copper Clad Ground Rod [Use (2) GND 104 with (1) GND 200 ] GND 120</td>
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**Best practices to prevent ignitions from lightning and static events**

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LPA 530 | Bonding Lug with 3" Square of Contact Surface 9/16" Hole Aluminum
---|---
LPA 530A | Bonding Lug with 3" Square of Contact Surface 7/8" Hole Aluminum
LPA 802 | 3 Hole Stamped Adhesive Cable Holder Aluminum
LPA 803 | 1/2" One Hole Cable Strap Aluminum
LPC 401 | Stamped Single Bolt Parallel Cable Splice with 1-1/2" Contact Copper
LPC 4011T | Cast Single Bolt Parallel Splice fits 1-1/2" of Contact Tinned Copper
LPC 411 | Bimetallic Straight Splice
LPC 510T | Hand Rail Clamp 5/8" Beam Thickness Tinned Copper
LPC 512T | Bonding C-Clamp 8" Square of Contact Surface Tinned Copper
LPC 519T | 1" Pipe Clamp U Bolt fits .400" to 1.315" O.D. Tinned Copper
LPC 520T | 1" Pipe Clamp U Bolt fits 3/4" to 1-1/4" O.D. Copper Tinned
LPC 521T | 2" Pipe Clamp U Bolt fits 1.315" to 2.00" O.D. Tinned Copper
LPC 522T | 3" Pipe Clamp U Bolt fits 1.900" to 3" O.D. Tinned Copper
LPC 522TA | 3" Pipe Clamp U Bolt fits 1.900" to 3" O.D. Tinned Copper- No Slots, holes at both ends
LPC 523T | 4" Pipe Clamp U Bolt fits 2.75" to 4.50" O.D. Tinned Copper
LPC 523TA | 4" Pipe Clamp U Bolt fits 2.75" to 4.50" O.D. Tinned Copper- No Slots, holes at both ends
LPC 524T | 6" Pipe Clamp U Bolt fits 4.50" to 6.75" O.D. Tinned Copper
LPC 525T | 8" Pipe Clamp U Bolt fits 6 3/4" to 8" O.D. Tinned Copper
LPC 529T | 10" Pipe Clamp U Bolt fits 8" to 10" O.D. Tinned Copper
LPC 530T | Bonding Lug with 3" Square of Contact Surface 9/16" Hole Tinned Copper
LPC 530TA | Bonding Lug with 3" Square of Contact Surface 7/8" Hole Tinned Copper
LPC 802T | Stamped Adhesive Cable Clip Tinned Copper
LPC 803T | 1/2" One Hole Cable Strap Tinned Copper LPC 901

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<td>LPS 102</td>
<td>Stainless Steel Beam Clamp Base</td>
</tr>
<tr>
<td>LPS 204</td>
<td>Stainless Steel Hose Clamp Fits 2&quot; To 10&quot; Pipe</td>
</tr>
</tbody>
</table>

**STATIC PROTECTION**

* Static Lasso can be custom built for the height of your tank

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SL 12-5</td>
<td>Static Lasso 13'6&quot; overall length with 5 lbs weight</td>
</tr>
<tr>
<td>SLA 12-5</td>
<td>Static Lasso 13'6&quot; overall length with 5 lbs weight</td>
</tr>
<tr>
<td>SLA 16-10</td>
<td>Static Lasso 17'6&quot; overall length with 10 lbs weight- Aluminum hardware</td>
</tr>
<tr>
<td>SL 16-10</td>
<td>Static Lasso 17'6&quot; overall length with 10 lbs weight</td>
</tr>
<tr>
<td>SL 20-0</td>
<td>Static Lasso 20'6&quot; overall length with no weight</td>
</tr>
<tr>
<td>SL 20-5</td>
<td>Static Lasso 21'6&quot; overall length with 5 lbs weight</td>
</tr>
<tr>
<td>SLA 20-10</td>
<td>Static Lasso 21'6&quot; overall length with 10 lbs weight Aluminum</td>
</tr>
<tr>
<td>SL 20-10</td>
<td>Static Lasso 21'6&quot; overall length with 10 lbs weight</td>
</tr>
<tr>
<td>SLA 24-15</td>
<td>Static Lasso 25'6&quot; overall length with 15 lbs weight- Aluminum Hardware</td>
</tr>
<tr>
<td>SL 24-15</td>
<td>Static Lasso 25'6&quot; overall length with 15 lbs weight</td>
</tr>
<tr>
<td>SL 30-15</td>
<td>Static Lasso 31'6&quot; overall length with 15 lbs weight</td>
</tr>
<tr>
<td>SLA 30-20</td>
<td>Static Lasso 31'6&quot; overall length with 20 lbs weight- Aluminum Hardware</td>
</tr>
<tr>
<td>SL 30-20</td>
<td>Static Lasso 31'6&quot; overall length with 20 lbs weight</td>
</tr>
<tr>
<td>LOAD OUT 10</td>
<td>Load Out Cable 10' Length Clamp fits 4&quot; - 4 1/2&quot; OD Pipe</td>
</tr>
<tr>
<td>LOAD OUT 15</td>
<td>Load Out Cable 15' Length Clamp fits 4&quot; - 4 1/2&quot; OD Pipe</td>
</tr>
<tr>
<td>LOAD OUT 20</td>
<td>Load Out Cable 20' Length Clamp fits 4&quot; - 4 1/2&quot; OD Pipe</td>
</tr>
<tr>
<td>LOAD OUT 30</td>
<td>Load Out Cable 30' Length Clamp fits 4&quot; - 4 1/2&quot; OD Pipe</td>
</tr>
<tr>
<td>LO HANGER</td>
<td>Load Out Hanger</td>
</tr>
<tr>
<td>LO SIGN</td>
<td>Aluminum Static Discharge Sign 12&quot; x 12&quot;</td>
</tr>
</tbody>
</table>
### SURGE PROTECTION

#### SINEUP Model

#### MR SERIES

<table>
<thead>
<tr>
<th>Model</th>
<th>Description</th>
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<tbody>
<tr>
<td>MR1403N4160</td>
<td>VRC, 4 MODE, 80 kA PER MODE, 4160 VAC DELTA, NEMA 4X</td>
</tr>
<tr>
<td>MR1403Y4160</td>
<td>VRC, 4 MODE, 80 kA PER MODE, 2400/4160 VAC WYE, NEMA 4X</td>
</tr>
<tr>
<td>FX</td>
<td>Solid Cover NEMA 4X Fusing Module (Outdoor)</td>
</tr>
<tr>
<td>FX1</td>
<td>Clear Cover Fusing Module (Indoor Only)</td>
</tr>
<tr>
<td>FXL</td>
<td>Clear Cover Fusing Module (Indoor Only) with LEDs</td>
</tr>
</tbody>
</table>

#### LR1 SERIES

<table>
<thead>
<tr>
<th>Model</th>
<th>Description</th>
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<tbody>
<tr>
<td>LR1213N4C</td>
<td>VRC, 4 MODES, 50 kA PER MODE, TYPE 1 SPD, 480 VAC DELTA, LED, DRC, UL 1449</td>
</tr>
<tr>
<td>LR1213Y2C</td>
<td>VRC, 4 MODES, 50 kA PER MODE, TYPE 1 SPD, 277/480 VAC WYE 3 PHASE 5 WIRE, LED, DRC, UL 1449</td>
</tr>
<tr>
<td>LR1213Y1C</td>
<td>VRC, 4 MODES, 50 kA PER MODE, TYPE 1 SPD, 120/208 VAC WYE 3 PHASE 5 WIRE, LED, DRC, UL 1449</td>
</tr>
<tr>
<td>LR1211S1C</td>
<td>VRC, 4 MODES, 50 kA PER MODE, TYPE 1 SPD, 120/240 VAC SPLIT PHASE 4 WIRE, LED, DRC, UL 1449</td>
</tr>
</tbody>
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#### LR2 SERIES

<table>
<thead>
<tr>
<th>Model</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>LR2213N4C</td>
<td>FRC, 4 MODES, 50 kA PER MODE, TYPE 2 SPD, 480 VAC DELTA, LED, DRC, UL 1449</td>
</tr>
<tr>
<td>LR2213Y2C</td>
<td>FRC, 4 MODES, 50 kA PER MODE, TYPE 2 SPD, 277/480 VAC WYE 3 PHASE 5 WIRE, LED, DRC, UL 1449</td>
</tr>
<tr>
<td>LR2213Y1C</td>
<td>FRC, 4 MODES, 50 kA PER MODE, TYPE 2 SPD, 120/208 VAC WYE 3 PHASE 5 WIRE, LED, DRC, UL 1449</td>
</tr>
<tr>
<td>LR2211S1C</td>
<td>FRC, 4 MODES, 50 kA PER MODE, TYPE 2 SPD, 120/240 VAC SPLIT PHASE 4 WIRE, LED, DRC, UL 1449</td>
</tr>
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#### TS2 SERIES

<table>
<thead>
<tr>
<th>Model</th>
<th>Description</th>
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<tbody>
<tr>
<td>TS2231P1</td>
<td>FRC, 40 kA PER MODE, 120 VAC 1 PHASE 2W+G, SERIES MOUNT, 30 A, TWO PORT SPD, UL 1449</td>
</tr>
<tr>
<td>TS22324DC</td>
<td>FRC, 4 kA PER MODE, 24 VDC 2W+G, SERIES MOUNT, 30 A, TWO PORT SPD</td>
</tr>
</tbody>
</table>

#### CXS-F1

<table>
<thead>
<tr>
<th>Description</th>
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</tr>
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<tbody>
<tr>
<td>CCTV COAXIAL LINE SPD, F CONNECTOR, 75 OHM, 1 GHz, 20 kA</td>
<td></td>
</tr>
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#### DES-4X

<table>
<thead>
<tr>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>CAT5/CAT6 POE LINE SPD RJ45, NEMA 4X/IP 67 OUTDOOR ENCLOSURE, 10 kA</td>
<td></td>
</tr>
</tbody>
</table>

#### DTS24A2DINS-B

<table>
<thead>
<tr>
<th>Description</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>VRC, 24 VDC 4-20 mA 2W + SHIELD, DIN RAIL TERMINAL STRIP, 10 kA SPD</td>
<td></td>
</tr>
</tbody>
</table>

#### DPS24A3PCR-B

<table>
<thead>
<tr>
<th>Description</th>
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</tr>
</thead>
<tbody>
<tr>
<td>VRC, 24 VDC 4-20 mA 2W + SHIELD, 1/2&quot; STAINLESS STEEL PIPE CONDUIT WITH CAP, 10 kA SPD</td>
<td></td>
</tr>
</tbody>
</table>