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Revision Memo

12/04 General update with notable technical updates to "Equipment Bonding and Grounding" and "Marine Cargo Transfer Equipment" sections. These updates are indicated by an arrow, "↗" on the left-hand side of the page. There have also been numerous changes that are editorial in nature and are not indicated by the arrow.

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1 SCOPE

This practice covers the design of the interface between marine terminals and vessels as it relates to eliminating an electrical ignition source from cargo transfer equipment, and preventing any unnecessary drainage of the marine terminal's cathodic protection system. While this document generally discusses stray and electrostatic currents from a terminal perspective, refer to **EE.111E.96**, Shipboard Safety for Marine Terminal Operators, for similar discussion of shipside concerns such as switch loading precautions and safe sampling/gauging techniques in the presence of static electricity. The electrical zone classification of marine terminals and the design requirements for electrical equipment within these zones are not covered in this Design Practice.

2 REFERENCES

2.1 DESIGN PRACTICE

- DP XXXI-F Cargo Transfer Equipment - Loading Arms
- DP XXXI-G Cargo Transfer Equipment - Dock Hoses
- DP XXXI-H Cargo Transfer Equipment - Offshore Hoses
- DP XXX-I Minimum Safety Requirements for Marine Terminals

2.2 GLOBAL PRACTICES

- GP 3-11-1 Marine Cargo Transfer Hose
- GP 3-11-2 Marine Loading Arms
- GP 4-4-1 Marine Piers and Mooring Facilities
- GP 4-4-2 Marine Shore-Based Gangway
- GP 16-4-1 Grounding and Overvoltage Protection
- GP 19-5-1 Cathodic Protection

2.3 OTHER REFERENCES

1. American Petroleum Institute, Recommended Practice 2003, Protection Against Ignitions Arising Out of Static, Lightning, and Stray Currents, Fourth Edition, Washington, D.C., 1982.
2. Bustin, W. M., Dukek, W. G., *Electrostatic Hazards in the Petroleum Industry*, Letchworth, England, Research Studies Press Ltd., 1983.
3. ICS/OCIMF, *International Safety Guide for Oil Tankers and Terminals* (ISGOTT), Fourth Edition.
4. OCIMF, *Design and Construction Specification for Marine Loading Arms*, Witherby & Co., Ltd., London, England.
5. *Guidelines for Prevention of Electrostatic Ignitions*, ER&E Report No. EE.3M.96.
6. *Guidelines for Insulating Flanges to Prevent Arcing at Marine Terminals*, ER&E Report No. EE.49E.83.
7. *Shipboard Safety for Marine Terminal Operators*, ER&E Report No. EE.111E.96.
8. IEEE 837, *Standard for qualifying Permanent Connections Used in Substation Grounding*
9. ASTM B2, *Standard Specification for Medium-Hard-Drawn Copper Wire*
10. *Recommendation for Cost Effective Maintenance of Marine Loading Arms*, ER&E Report No. EE.3TT.85
11. TMEE 066, Marine Terminal Inspection and Maintenance Guide, EMRE Report No. EE.98E.2000

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3 INTRODUCTION

Any interface between vessel and berth is a potential path across which an electrical current may flow. The risk associated with current flow across this interface is electrical ignition of an atmosphere comprised partly of hydrocarbon vapors due to sparking or arcing.

In particular, static electricity or stray currents can produce incendiary sparks, which may lead to an ignition if a flammable atmosphere is present. In addition, cathodic protection currents passing through the ship-to-shore interface can prematurely reduce the cathodic protection system's effectiveness and lead to unnecessary maintenance costs for the terminal. Due to these circumstances, the design of the ship-to-shore interface must consider electrical isolation to both minimize the risk of electrical ignition and prevent unnecessary drainage of the terminal's cathodic protection system.

4 ELECTRICAL CURRENTS PRESENT AT MARINE FACILITIES

There are two types of electrical current, which may flow between vessel and terminal and present an incendiary spark risk at the ship-to-shore interface. The first is static electricity, which is produced by friction as liquid hydrocarbons flow through conduits at marine terminals. Of particular concern are hydrocarbons called static accumulators, which are unable to naturally dissipate electrostatic charge effectively due to low electrical conductivities. The second type of electrical current is referred to as stray current and is essentially a generalized name given to currents resulting from faulty electrical circuits, cathodic protection systems, and galvanic action.

4.1 ELECTROSTATIC CURRENTS

Static electricity is electricity produced by dissimilar materials through physical contact and separation. Static electricity is generated at marine terminals is from the flow of liquids through conduits such as piping, loading arms, and hoses.

Static electricity generated by flow through pipes and filters is a concern at marine terminals if the cargo transfer system contains ungrounded conductors, or isolated conductors. The electrostatic charge will accumulate on these isolated conductors and may result in arcing/sparking if the accumulated charge becomes high enough and the ungrounded conductor is contacted or nearly contacted by another conductor.

4.2 STRAY CURRENTS

For the purpose of this document, stray currents represent any electrical flow through paths for which the current was not intended. Stray currents may result from faults in electrical circuits, galvanic action, or corrosion of buried metal objects. Although cathodic protection currents are intentional currents, they will be treated under the stray current heading because, similar to stray currents, they could present a risk of current flow across the ship-to-shore interface.

The danger of electrical ignition associated with stray currents is known as arcing. Arcing is the production of an electrical spark due to the abrupt interruption of an electrically continuous flow path. As an electrical path is broken (for instance when a non-insulated loading arm is disconnected from a vessel manifold) the current, regardless of origin, will attempt to flow across the interruption causing a spark.

5 FACILITY DESIGN

The Facility Design Section of this document is divided into two sections, each of which addresses different objectives which can be reached through electrical isolation at the ship-to-shore interface. The first section, Prevention of Electrical Ignitions, discusses the bonding and grounding of marine terminal equipment in general, as well as specific equipment designs which minimize the risks associated with electrical ignitions. The second section, Prevention of Cathodic Protection System Drainage, details means for the terminal to limit additional load on its cathodic protection system while a vessel is moored.

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5.1 PREVENTION OF ELECTRICAL IGNITIONS

Marine terminals located in freshwater as compared to saltwater or brackish water are at lower risk in terms of experiencing stray currents at the ship-to-shore interface because they generally do not employ cathodic protection or experience galvanic action. Freshwater terminals can design for stray current protection by following the procedures discussed below for bonding and grounding terminal piping and equipment. In addition to bonding and grounding, saltwater or brackish terminals should include more effective means of stray current isolation such as the use of an insulating flange or a non-conductive hose length, which are detailed in subsequent sections of this document.

This practice addresses marine terminals in a general manner, making no distinction between freshwater and saltwater terminals in its discussions of ship-to-shore isolation. It is the responsibility of the engineer to assess the risks of stray and electrostatic currents at a particular facility, and to use this document as guidance for terminal design.

5.1.1 Equipment Bonding and Grounding

The terms *bonding* and *grounding* are oftentimes mistakenly used interchangeably. Bonding refers to the practice of providing an electrical connection between two objects in order to prevent a voltage difference from developing between the two. Grounding is the electrical connection of objects to the earth to prevent accumulation of electrostatic charge on the objects. Bonding and grounding together minimize spark production at the marine terminal by providing a continuous electrically conductive path between equipment to allow for stray current flow and electrostatic charge dissipation to the earth.

The information below concerning bonding and grounding is provided to aid in the design of marine terminals with respect to minimizing the risk of electrical ignitions. For further details concerning these procedures refer to **GP 16-4-1, Grounding and Overvoltage Protection**.

- All metal and electrically conductive material should be bonded together to provide a low electrical-resistance continuous path to ground electrostatic and stray currents.
- All bonded equipment should be grounded to earth via grounded electrodes.
 - Berth piling and/or anchorage systems are considered grounded electrodes, provided the system is itself grounded.
 - Pile casings and other large metal objects in intimate contact with the earth are considered grounded electrodes.
 - Buried underground water piping is considered a grounded electrode when it is 10ft (3m) in length. Hydrocarbon, steam, or other process lines shall *not* be used for grounding purposes.
- Man-made grounding electrodes can be made out of driven copper-clad steel rods, with a minimum diameter of 5/8-in. (16 mm) and minimum length of 8-ft (2.5 m). The top of the rod shall be at least 18 in. (450 mm) below grade. If more than one grounding electrode is used in a grounding system, electrode spacing shall be at least 10-ft. (3m) apart.
- Bonding and grounding connections should be permanent in nature by brazing, welding, or with connectors that qualify as permanent grounding connections as per IEEE 837, *Standard for qualifying Permanent Connections Used in Substation Grounding*. On equipment where bonding and grounding connections are above grade and are regularly disconnected for maintenance purposes, connections should be made with bolted or screw type solderless connectors.
- Bonding and grounding conductors shall be bare stranded medium-hard-drawn copper wire as specified in ASTM B2, *Standard Specification for Medium-Hard-Drawn Copper Wire*. Minimum sizes for the conductors are 2 AWG (33.6 mm²) for underground conductors and 6 AWG (13.3 mm²) for aboveground, but may need to be increased in order to meet mechanical strength and thermal stress requirements.
- Bonding and grounding cables should be inspected periodically to assess any deterioration incurred during operations.
- Bonding is not required around flexible metal joints or loading arm swivel joints as they provide adequate conductivity.
- The practice of bonding a vessel to the marine terminal is an attempt to include the vessel in a continuous electrical path to ground, but is not a recommended practice. A vessel is grounded to the earth through contact with water and need not be bonded to terminal equipment. Refer to "Ship/Shore Bonding Wires" of this document for further discussion of this topic.