

# **Recommended Practice for Design, Installation, and Maintenance of Electrical Systems for Fixed and Floating Offshore Petroleum Facilities for Unclassified and Class I, Zone 0, Zone 1, and Zone 2 Locations**

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# Design, Installation, and Maintenance of Electrical Systems for Fixed and Floating Offshore Petroleum Facilities for Unclassified and Class I, Zone 0, Zone 1, and Zone 2 Locations

## 1 General

### 1.1 Scope

**1.1.1** This document recommends minimum requirements and guidelines for the design, installation, and maintenance of electrical systems on fixed and floating petroleum facilities located offshore. For facilities classified as Division 1 or Division 2, reference API 14F. These facilities include drilling, producing and pipeline transportation facilities associated with oil and gas exploration and production. This recommended practice (RP) is not applicable to Mobile Offshore Drilling Units (MODUs) without production facilities. This document is intended to bring together in one place a brief description of basic desirable electrical practices for offshore electrical systems. The recommended practices contained herein recognize that special electrical considerations exist for offshore petroleum facilities. These include:

- a) inherent electrical shock possibility presented by the marine environment and steel decks;
- b) space limitations that require that equipment be installed in or near hazardous (classified) locations;
- c) corrosive marine environment;
- d) motion and buoyancy concerns associated with floating facilities.

**1.1.2** This RP applies to both permanent and temporary electrical installations. The guidelines presented herein should provide a high level of electrical safety when used in conjunction with well-defined area classifications. This RP emphasizes safe practices for hazardous (classified) locations on offshore petroleum facilities but does not include guidelines for classification of areas; for guidance on the classification of areas refer to API 505.

**1.1.3** Advantages of area classification using zones are as follows.

**1.1.3.1** Often, particularly for new installations and for installations that are subject to upgrade or revision, it is advantageous to classify locations as “Zones” in accordance with Article 505 of the *NEC* versus “Divisions” as per Article 500. These advantages may include reduced initial capital expenditures, enhanced safety, or facilities that are more easily and more economically maintained.

**1.1.3.2** In the Zone classification system, locations classified as Division 1 in the Division classification system can now be classified and further divided into Zone 0 and Zone 1 locations. Electrical equipment suitable for Zone 1 locations is not required to be suitable for locations where flammable gases and vapors may be present continuously or for long periods of time, i.e. Zone 0 locations. Thus, the protection techniques for equipment to be installed in Zone 1 locations can be less demanding than the protection techniques for equipment to be installed in Division 1 locations. This may result in more cost effective installations or equipment that is more easily maintained.

**1.1.3.3** Due to the application of increased safety (protection Type “e”) equipment, fewer field-installed sealing fittings are required for Zone 1 and Zone 2 equipment than for Division 1 and Division 2 equipment. Fewer field-installed sealing fittings reduce the chance for installation errors, enhancing safety. Much of the equipment approved for Zone 1 and Zone 2 uses plastics (versus metals), reducing corrosion, which can result in reducing maintenance costs and enhancing safety. Also, since the most hazardous locations (Zone 0 locations) are identified, such locations can be avoided for the installation of most electrical equipment. This also can enhance safety.

## 1.2 Applicability of *National Electrical Code*

**1.2.1** Electrical systems for offshore petroleum facilities shall be designed and installed in accordance with the *National Electrical Code*, 2011 edition, except where specific departures are noted.

## 2 Normative References

### 2.1 General

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.

### 2.2 Industry Codes, Guides, and Standards

Various organizations have developed numerous codes, guides and standards that have substantial acceptance by industry and governmental bodies. Codes, guides, and standards useful in the design and installation of electrical systems are listed below as references only. These are not considered to be a part of this RP except for those specific sections of documents referenced elsewhere in this RP.

API Recommended Practice 2L, *Planning, Designing, and Constructing Heliports for Fixed Offshore Platforms*

API Recommended Practice 11S3, *Recommended Practice for Electrical Submersible Pump Applications*

API Recommended Practice 14C, *Analysis, Design, Installation and Testing of Basic Surface Safety Systems on Offshore Production Platforms*

API Recommended Practice 14F, *Design, Installation, and Maintenance of Electrical Systems for Fixed and Floating Offshore Petroleum Facilities for Unclassified and Class I, Division 1 and Division 2 Locations*

API Recommended Practice 14G, *Fire Prevention and Control on Open Type Offshore Production Platforms*

API Recommended Practice 14J, *Design and Hazards Analysis for Offshore Production Facilities*

API Recommended Practice 55, *Conducting Oil and Gas Producing and Gas Processing Plant Operations Involving Hydrogen Sulfide*

API Recommended Practice 75, *Development of a Safety and Environmental Management Program for Outer Continental Shelf Operations and Facilities*

API Recommended Practice 500, *Classification of Locations for Electrical Installations at Petroleum Facilities Classified as Class I, Division 1 and Division 2*

API Recommended Practice 505, *Classification of Locations for Electrical Installations at Petroleum Facilities Classified as Class I, Zone 0, Zone 1, and Zone 2*

API Recommended Practice 540, *Electrical Installations in Petroleum Processing Plants*

API Specification 17E, *Specifications for Subsea Umbilicals*

API Standard 541, *Form-wound Squirrel-Cage Induction Motors, 500 HP and Larger*

API Standard 546, *Brushless Synchronous Machines, 500 kVA and Larger*

API Standard 547, *General Purpose Form-Wound Squirrel Cage Induction Motors—250 HP and Larger*

API Recommended Practice 2003, *Protection Against Ignitions Arising Out of Static, Lightning, and Stray Currents*

API Publication 2216, *Ignition Risk of Hydrocarbon Vapors by Hot Surfaces in the Open Air*

API Publication 2218, *Fireproofing Practices in Petroleum and Petrochemical Processing Plants*

ANSI C37.06 <sup>1</sup>, *American National Standard Guide for High-Voltage Circuit Breakers Rated on Symmetrical Current Basis Designated “Definite Purpose for Fast Transient Recovery Voltage Rise Times”*

ANSI C37.12, *For AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis—Specification Guide*

ANSI C37.20.1, *Standard for Metal-Enclosed Low-Voltage Power Circuit Breaker Switchgear*

ANSI C37.20.2, *Standard for Metal-Clad and Station-Type Cubicle Switchgear*

ANSI C57.12.70, *Terminal Markings and Connections for Distribution and Power Transformers*

ANSI C84.1, *Voltage Ratings for Electric Power Systems and Equipment (60 Hz)*

ANSI Y32.9, *Graphic Symbols for Electrical Wiring and Layout Diagrams used in Architecture and Building Construction*

ASME A17.1 <sup>2</sup>, *Safety Code for Elevators and Escalators*

ASME A17.1A Addenda to ANSI/ASME A17.1, *Safety Code for Elevators and Escalators*

ASME A17.5, *Elevator and Escalator Electrical Equipment*

ASTM B117 <sup>3</sup>, *Standard Practice for Operating Salt Spray (Fog) Apparatus*

ASTM D178, *Standard Specification for Rubber Insulating Matting*

ASTM D4066, *Standard Specification for Nylon Injection and Extrusion Materials (PA)*

ASTM E119, *Standard Test Methods for Fire Tests of Building Construction and Materials*

ASTM SI10-2002, *Standard for Use of the International System of Units (SI): The Modern Metric System*

CSA C22.1 <sup>4</sup>, *Canadian Electrical Code, Part I*

CSA C22.2 No. 30, *explosionproof Enclosures for Use in No. 30 Class I, Hazardous Locations*

CSA C22.2 No. 157, *Intrinsically Safe and Nonincendive Equipment for Use in Hazardous Locations*

CSA C22.2 No. 245, *Marine Shipboard Cable*

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<sup>1</sup> American National Standards Institute, 25 West 43<sup>rd</sup> Street, 4<sup>th</sup> floor, New York, New York 10036, [www.ansi.org](http://www.ansi.org).

<sup>2</sup> American Society of Mechanical Engineers, 3 Park Avenue, New York, New York 10016, [www.asme.org](http://www.asme.org).

<sup>3</sup> American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, Pennsylvania 19428-2959, [www.astm.org](http://www.astm.org).

<sup>4</sup> Canadian Standards Association, 5060 Spectrum Way, Suite 100, Mississauga, Ontario, L4W 5N6, Canada, [www.csa.ca](http://www.csa.ca).

CSA Plus 2203, *Hazardous Locations—Guide for the Design, Testing, Construction, and Installation of Equipment in Explosive Atmospheres*

FF-844 <sup>5</sup>, *Foundation Fieldbus Specification H1 Cable Test Specification September 27, 2007*

FM 3600 <sup>6</sup>, *Electrical Equipment for Use in Hazardous (Classified) Locations, General Requirements*

FM 3610, *Intrinsically Safe Apparatus and Associated Apparatus for Use in Class I, II and III, Division 1, Hazardous (Classified) Locations*

FM 3611, *Nonincendive Electrical Equipment for Use of Class I, Division 2, Class II, Division 2, and Class III, Divisions 1 and 2, Hazardous (Classified) Locations*

FM 3615, *explosionproof Electrical Equipment General Requirements*

FM 3620, See NFPA No. 496

FM 3810, *Electrical Equipment for Measurement, Control, and Laboratory Use*

IADC IADC-DCCS-1-91 <sup>7</sup>, *Guidelines for Industrial System DC Cable for Mobile Offshore Drilling Units*

ICEA P-32-382 <sup>8</sup>, *Short Circuit Characteristics of Insulated Cables*

ICEA P-45-482, *Short Circuit Characteristics of Metallic Shields and Sheaths of Insulated Cable*

IEC 60050-426 <sup>9</sup>, *International Electrotechnical Vocabulary (IEV)—Chapter 426—Electrical Apparatus for Explosive Atmospheres*, 2008

IEC 62271-100, *Switchgear and Controlgear – Part 100: Alternating Current Circuit Breakers*, 2008

IEC 68-2-52, *Basic Environmental Testing Procedures, Part 2: Tests Test KB: Salt Mist, Cyclic (Sodium Chloride Solution)*, 1996

IEC 61158-2, *Industrial communication networks – Fieldbus Specifications – Part 2*, 2007

IEC 62271-200, *A.C. Metal-Enclosed Switchgear and Controlgear for Rated Voltages Above 1 kV and Up to and Including 52 kV*, 2011

IEC 60331, Part 11 and Part 21, *Tests for electric cables under fire conditions-circuit integrity*, 2009 and 1999

IEC 60363, *Short-Circuit Current Evaluation with Special Regard to Rated Short-Circuit Capacity of Circuit Breakers in Installations in Ships*, 1972

IEC 60529, *Degrees of Protection Provided by Enclosures (IP Code)*, 2001

IEC 60533, *Electromagnetic Compatibility of Electrical and Electronic Installations in Ships*, 1999

IEC 60947-2, *Low-Voltage Switchgear and Controlgear, Part 2: Circuit Breakers*, 2009

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<sup>5</sup> Fieldbus Foundation, 9005 Mountain Ridge Drive, Bowie Bldg - Suite 200, Austin, TX 78759-5316, [www.fieldbus.org](http://www.fieldbus.org).

<sup>6</sup> Factory Mutual Research Corporation, 1151 Boston-Providence Turnpike, Norwood, Massachusetts 02062, [www.fmgglobal.com](http://www.fmgglobal.com).

<sup>7</sup> International Association of Drilling Contractors, P.O. Box 4287, Houston, Texas 77210, [www.iadc.org](http://www.iadc.org).

<sup>8</sup> Insulated Cable Engineers Association, P.O. Box P, South Yarmouth, Massachusetts 02664, [www.icea.net](http://www.icea.net).

<sup>9</sup> International Electrotechnical Commission, 3 rue de Varembé, P.O. Box 131, CH-1211, Geneva 20, Switzerland, [www.iec.ch](http://www.iec.ch).

IEEE C37.04 INT 1<sup>10</sup>, *Rating Structure for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis*, 2010

IEEE Standard C37.010, *Application Guide for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis*, 2005

IEEE Standard C37.13, *Standard for Low-Voltage AC Power Circuit Breakers Used in Enclosures*, 2008

IEEE Standard C37.14, *Standard for Low-Voltage DC Power Circuit Breakers Used in Enclosures*, 2002

IEEE Standard C37.27, *Application Guide for Low-Voltage AC Power Circuit Breakers Applied with Separately Mounted Current-Limiting Fuses*, 2008

IEEE Standard C37.102, *Guide for AC Generator Protection*, 2006

IEEE Standard 45, *Recommended Practice for Electrical Installations on Shipboard*, 2002

IEEE Standard 100, *The Authoritative Dictionary of IEEE Standard Terms, Seventh Edition*, 2000

IEEE Standard 141, *Electric Power Distribution for Industrial Plants, Red Book*, 1993

IEEE Standard 142, *Grounding of Industrial and Commercial Power Systems, Green Book*, 2007

IEEE Standard 242, *Protection and Coordination of Industrial and Commercial Power Systems, Buff Book*, 2001

IEEE Standard 303, *Auxiliary Devices for Rotating Electrical Machines in Class I, Division 2 and Zone 2 Locations*, 2004

IEEE Standard 315, *Graphic Symbols for Electrical and Electronics Diagrams*, 1993

IEEE 446, *Emergency and Standby Power Systems for Industrial and Commercial Applications*, 2000

IEEE Standard 450, *Maintenance, Testing, and Replacement of Vented Lead-Acid Storage Batteries for Stationary Applications*, 2002

IEEE Standard 484, *Installation Design and Installation of Vented Lead-Acid Storage Batteries for Stationary Applications*, 2008

IEEE Standard 485, *Sizing Lead-Acid Storage Batteries for Stationary Applications*, 1997

IEEE Standard 515, *Testing, Design, Installation, and Maintenance of Electrical Resistance Heat Tracing for Industrial Applications*, 2011

IEEE Standard 835, *Standard Power Cable Ampacity Tables*, 2006

IEEE Standard 841, *Standard for the Petroleum and Chemical Industry—Severe Duty Totally Enclosed Fan-Cooled (TEFC) Squirrel-Cage Induction Motors-Up to and Including 500 hp*, 2009

IEEE Recommended Practice 1100, *Recommended Practice for Powering and Grounding Electronic Equipment, Emerald Book*, 2005

IEEE 1120, *Guide for the Planning, Design, Installation, and Repair of Submarine Power Cable Systems*

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<sup>10</sup> Institute of Electrical and Electronics Engineers, 445 Hoes Lane, Piscataway, New Jersey 08854, [www.ieee.org](http://www.ieee.org).

IEEE Standard 1202, *Standard for Flame Propagation Testing of Wire and Cable*, 2006

IEEE Standard 1242, *Guide for Specifying and Selecting Power, Control and Special Purpose Cable for Petroleum and Chemical Plants*, 2005

IEEE Standard 1566, *Standard for Performance of Adjustable Speed AC Drives Rated 375 kW and Larger*, 2005

IEEE Recommended Practice 1580, *Recommended Practice for Marine Cable for Use on Shipboard and Fixed or Floating Marine Platforms*, 2010

IES RP-1<sup>11</sup>, *American National Standard Practice for Office Lighting*, 2004

IES RP-7, *American National Standard Practices for Industrial Lighting*, 2001

IES, *Lighting Handbook*

IMCA-AODC 035<sup>12</sup>, *Code of Practice for Safe use of Electricity Underwater*

IMO<sup>13</sup>, *International Convention for the Safety of Life at Sea, SOLAS 1974*, as amended

IP 15<sup>14</sup>, *Model Code of Safe Practice in the Petroleum Industry, Part 15: Area Classification Code for Petroleum Installations*

ISA-5.1<sup>15</sup>, *Instrumentation Symbols and Identification*, 2009

ISA-51.1, *Process Instrumentation Technology*, 1979 (R1993)

ISA-92.00.01, *Performance Requirements for Toxic Gas-Detection Instruments*, 2010

ISA-RP92.0.02, Part II, *Installation, Operation, and Maintenance of Toxic Gas-Detection Instruments: Hydrogen Sulfide*, 1998

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ISA-TR12.13.03, *Guide for Combustible Gas Detection as a Method of Protection*, 2009

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ANSI/ISA-12.27.01, *Requirements for Process Sealing Between Electrical Systems and Flammable or Combustible Process Fluids*, 2011

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<sup>11</sup> Illuminating Engineering Society, 120 Wall Street 17th Floor, New York, New York 10005-40001, [www.iesna.org](http://www.iesna.org).

<sup>12</sup> International Marine Contractors Association, 52 Grosvenor Gardens, London, SW1W 0AU, United Kingdom, [www.imca-int.com](http://www.imca-int.com)

<sup>13</sup> International Maritime Organization, 4 Albert Embankment, London, England, SE17BP, United Kingdom, [www.imo.org](http://www.imo.org).

<sup>14</sup> Institute of Petroleum, 61 New Cavendish Street, London W1M8AR, United Kingdom, [www.energyinst.org.uk](http://www.energyinst.org.uk).

<sup>15</sup> The Instrumentation, Systems, and Automation Society, 67 Alexander Drive, P.O. Box 12277, Research Triangle Park, North Carolina 27709, [www.isa.org](http://www.isa.org).

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ANSI/ISA-12.10.05, (IEC 61241-10 Mod) *Electrical Apparatus for Use in Zone 20, Zone 21 and Zone 22 Hazardous (Classified) Locations—Classification of Zone 20, Zone 21 and Zone 22 Hazardous (Classified) Locations*, 2004

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ANSI/ISA-RP12.13.02, (IEC 61779-6 Mod), *Recommended Practice for the Installation, Operation, and Maintenance of Combustible Gas Detection Instruments*, 2003

ANSI/ISA-60079-1, *Explosive Atmospheres – Part 1: Equipment Protection by Flameproof Enclosures “d”*, 2009

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ANSI/ISA-60079-6 (12.26.01), *Explosive Atmospheres – Part 6: Equipment Protection by Oil Immersion “o”*, 2009

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ANSI/ISA-60079-11 (12.02.01), *Electrical Apparatus for Use in Class I, Zone 0, 1, and 2 Hazardous (Classified) Locations—Intrinsic Safety “i”*, 2011

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ANSI/ISA-RP12.06.01, *Recommended Practice for Wiring Methods for Hazardous (Classified) Locations Instrumentation Part 1: Intrinsic Safety*, 2003

ISA-RP12.12.03, *Recommended Practice for Portable Electronic Products Suitable for Use in Class I and II, Division 2, Class I Zone 2 and Class III, Division 1 and 2 Hazardous (Classified) Locations*, 2011

ANSI/ISA-TR12.21.01, *Use of Fiber Optic Systems in Class I Hazardous (Classified) Locations*, 2004

ANSI/ISA-TR12.24.01 (IEC 60079-10 Mod), *Recommended Practice for Classification of Locations for Electrical Installations Classified as Class I, Zone 0, Zone 1, or Zone 2*, 1998

ANSI/ISA-12.27.01, *Requirements for Process Sealing Between Electrical Systems and Potentially Flammable or Combustible Process Fluids*, 2003

ANSI/ISA-TR12.06.01, *Electrical Equipment in a Class I, Division 2/Zone 2 Hazardous Locations*, 1999

NACE SP0176 <sup>16</sup>, *Corrosion Control of Steel, Fixed Offshore Platforms Associated with Petroleum Production*, 2007

NEMA 250 <sup>17</sup>, *Enclosures for Electrical Equipment (1,000 Volts Maximum)*

NEMA FG 1, *Fiberglass Cable Tray Systems*

<sup>16</sup> NACE International (formerly the National Association of Corrosion Engineers), 1440 South Creek Drive, Houston, Texas 77218-8340, [www.nace.org](http://www.nace.org).

<sup>17</sup> National Electrical Manufacturers Association, 1300 North 17<sup>th</sup> Street, Suite 1752, Rosslyn, Virginia 22209, [www.nema.org](http://www.nema.org).

NEMA MG 1, *Motors and Generators*

NEMA MG 2, *Safety Standard for Construction and Guide for Selection, Installation, and Use of Electric Motors and Generators*

NEMA MG 10, *Energy Management Guide for Selection and Use of Fixed-Frequency Medium AC Squirrel-Cage Polyphase Induction Motors*

NEMA ICS 1, *Standards for Industrial Control and Systems General Requirements*

NEMA ICS 2.1, *Seismic Testing of Motor Control Centers*

NEMA 2.3, *Instructions for the Handling, Installation, Operation, and Maintenance of Motor Control Centers*

NEMA 2.4, *NEMA and IEC Devices for Motor Service—A Guide for Understanding the Differences*

NEMA ICS 6, *Industrial Controls and Systems Enclosures*

NEMA VE 1, *Metal Cable Tray Systems*

NEMA VE 2-2006, *Cable Tray Installation Guidelines*

NEMA WC 70, *Power Cables rated 200 Volts or Less for the Distribution of Electrical Energy*

NEMA WC 71, *Standard for Non-Shielded Cables Rated 2001-5000 Volts for Use in the Distribution of Electric Energy* (Supersedes WC 3, WC 5, WC 7, & WC 8)

NEMA WC 74, *5 – 46 KV Shielded Power Cables for Use in the Distribution of Electric Energy* (Supersedes WC 3, WC 5, WC 7, & WC 8)

NFPA 30<sup>18</sup>, *Flammable and Combustible Liquids Code*

NFPA 20, *Standard for the Installation of Stationary Pumps for Fire Protection*

NFPA 37, *Standard for the Installation and Use of Stationary Combustion Engines and Turbines*

NFPA 54, *National Fuel Gas Code*

NFPA 69, *Explosion Prevention Systems*

NFPA 70, *National Electrical Code*

NFPA 70B, *Recommended Practice for Electrical Equipment Maintenance*

NFPA 70E, *Standard for Electrical Safety in the Workplace*

NFPA 77, *Recommended Practice on Static Electricity*

NFPA 90A, *Standard for the Installation of Air Conditioning and Ventilating Systems*

NFPA 91, *Standard for Exhaust Systems for Air Conveying of Vapors, Gases, Mists, and Non-particulate Solids*

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<sup>18</sup> National Fire Protection Association, 1 Batterymarch Park, Quincy, Massachusetts 02169-7471, [www.nfpa.org](http://www.nfpa.org).



NFPA 99, *Standard for Health Care Facilities*

NFPA 101, *Life Safety Code*

NFPA HAZ01, *Fire Protection Guide to Hazardous Materials (Replaces NFPA 325)*

NFPA 496, *Standard for Purged and Pressurized Enclosures for Electrical Equipment in Hazardous (Classified) Locations*

NFPA 497, *Recommended Practice for the Classification of Flammable Liquids, Gases, or Vapors and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas*

NFPA 780, *Standard for the Installation of Lightning Protection Systems*

NFPA, *Electrical Installations in Hazardous Locations*

UL 13 <sup>19</sup>, *Power Limited Circuit Cables*

UL 44, *Thermoset-Insulated Wire and Cable*

UL 50, *Enclosures for Electrical Equipment*

UL 62, *Flexible Cords*

UL 83, *Thermoplastic-Insulated Wires and Cables*

UL 347, *High Voltage Industrial Control Equipment*

UL 489, *Molded Case Circuit Breakers, Molded Case Switches, and Circuit Breaker Enclosures*

UL 508, *Industrial Control Equipment*

UL 514A, *Metallic Outlet Boxes*

UL 514B, *Conduit, Tubing, and Cable Fittings*

UL 514C, *Nonmetallic Outlet Boxes, Flush-Device Boxes, and Covers*

UL 515, *Electrical Resistance Heat Tracing for Commercial and Industrial Applications*

UL 583, *Electric-Battery-Powered Industrial Trucks*

UL 595, *Marine-Type Electric Lighting Fixtures*

UL 674 *Safety Standard for Electric Motors and Generators for Use in Division 1 Hazardous (Classified) Locations, Class I, Groups C and D*

UL 698, *Safety Standard for Electric Industrial Control Equipment for Use in Hazardous (Classified) Locations, Class I, Groups A, B, C, and D, and Class II, Groups E, F, and G*

UL 698A, *Industrial Control Panels Relating to Hazardous (Classified) Locations*

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<sup>19</sup> Underwriters Laboratories, 333 Pfingsten Road, Northbrook, Illinois 60062, [www.ul.com](http://www.ul.com).

UL 781, *Portable Electric Lighting Units for Use in Hazardous (Classified) Locations*

UL 783, *Electrical Flashlights and Lanterns for Use in Hazardous (Classified) Locations, Class I, Groups C and D*

UL 823, *Electric Heaters for Use in Hazardous (Classified) Locations*

UL 844, *Electric Lighting Fixtures for Use in Hazardous (Classified) Locations*

UL 845, *Motor Control Centers*

UL 877, *Circuit Breakers and Circuit-Breaker Enclosures for Use in Hazardous (Classified) Locations*

UL 891, *Safety—Dead Front Switchboards*

UL 894, *Switches For Use in Hazardous (Classified) Locations*

UL 913, *Intrinsically Safe Apparatus and Associated Apparatus for Use in Class I, II, and III Division 1 Hazardous (Classified) Locations*

UL 1002, *Electrically Operated Valves for Use in Hazardous (Classified) Locations*

UL 1008, *Transfer Switch Equipment*

UL 1010, *Receptacle-Plug Combinations for Use in Hazardous (Classified) Locations*

UL 1042, *Electric Baseboard Heating Equipment*

UL 1072, *Medium-Voltage Power Cables*

UL 1096, *Electric Central Air Heating Equipment*

UL 1104, *Marine Navigation Lights*

UL 1203, *Explosionproof and Dust-Ignition-Proof Electrical Equipment for Use in Hazardous (Classified) Locations*

UL 1277, *Power and Control Tray Cable with Optional Optical-Fiber Members*

UL 1309, *Marine Shipboard Cable*

UL 1558, *Switchgear Assemblies, Metal Enclosed Low Voltage Power Circuit Breaker Type*

UL 1569, *Metal-Clad Cables*

UL 1570, *Fluorescent Lighting Fixtures*

UL 1571, *Incandescent Lighting Fixtures*

UL 1572, *High Intensity Discharge Lighting Fixtures*

UL 1574, *Track Lighting Systems*

UL 1581, *Reference Standard for Electrical Wires, Cables, and Flexible Cords*

UL 1604, *Electrical Equipment for Use in Hazardous Locations, Class I and II, Division 2, and Class III, Divisions 1 and 2 Hazardous (Classified) Locations*

UL 1709, *Rapid Rise Fire Tests of Protection Materials for Structural Steel*

UL 1836, *Outline for Electric Motors and Generators for Use in Class I, Division 2 and Class II, Division 2 Hazardous (Classified) Locations*

UL 2196, *Tests for Fire Resistive Cables*

UL 2225, *Metal-Clad Cables and Cable-Sealing Fittings for Use in Hazardous (Classified) Locations*

UL 2250, *Instrumentation Tray Cable*

UL 60947-1, *Low Voltage Switchgear and Controlgear—Part 1 General Rules*

UL 60947-4-1, *Low Voltage Switchgear and Controlgear—Part 4-1 Contactors and Motor Starters*

## 2.3 Government Codes, Rules, and Regulations

Federal regulatory agencies have established certain requirements for the design, installation, and operation of facilities on offshore production platforms. These requirements may influence the design, installation, and operation of the electrical systems. In addition to federal regulations, certain state, municipal, and local regulations may be applicable. The following documents may pertain to offshore oil and gas producing operations and should be used when applicable.

## 2.4 Code of Federal Regulations (CFR)

DOI/Bureau of Mines Bulletin 627 <sup>20</sup>, *Flammability Characteristics of Combustible Gases and Vapors*

NOTE No longer available from Bureau of Mines, but published in ANSI/ISA-TR12.13.01.

DOI/BSEE 30 CFR Part 250 <sup>21</sup>, *Oil and Gas and Sulphur Operation in the Outer Continental Shelf*

DOL/OSHA 29 CFR Part 1910 <sup>22</sup>, *Subpart H. Process Safety Management of Highly Hazardous Chemicals*

DOL/OSHA 29 CFR Part 1910, *Subpart S. Electrical (Occupational Safety and Health Administration)*

DOL/OSHA 29 CFR Part 1926, *Subpart K. Electrical Construction (Occupational Safety and Health Administration)*

DOT 49 CFR Parts 190, 191, 192, 193, and 195 <sup>23</sup>, *Pipeline Safety Regulations*

DOT/FAA <sup>24</sup>, *Heliport Design (Advisory Circular 150/5390-2A)*

<sup>20</sup> U.S. Department of the Interior, Bureau of Mines. The *Code of Federal Regulations* is available from the U.S. Government Printing Office, Washington, D.C. 20402.

<sup>21</sup> U.S. Department of the Interior, Bureau of Safety and Environmental Enforcement. The *Code of Federal Regulations* is available from the U.S. Government Printing Office, Washington, D.C. 20402.

<sup>22</sup> Occupational Safety and Health Administration. U.S. Department of Labor, The *Code of Federal Regulations* is available from the U.S. Government Printing Office, Washington, D.C. 20402.

<sup>23</sup> U.S. Department of Transportation. The *Code of Federal Regulations* is available from the U.S. Government of Printing Office, Washington, D.C. 20402.

<sup>24</sup> U.S. Department of Transportation, Federal Aviation Administration. The *Code of Federal Regulations* is available from the U.S. Government Printing Office, Washington, D.C. 20402.

DOT/FAA, *Obstruction Marking and Lighting* (Advisory Circular 70/7460-1F)

DHS/USCG 33 CFR Parts 140 – 147 <sup>25</sup>, *Subchapter N. Outer Continental Shelf Activities*

DHS/USCG 33 CFR Part 67, *Subchapter C. Aids to Navigation*

DHS/USCG 46 CFR Part 58, *Subchapter F, Main and Auxiliary Machinery and Related Systems*

DHS/USCG 46 CFR Parts 107 – 109, *Shipping Subchapter I-A. Mobile Offshore Drilling Units*

DHS/USCG 46 CFR Parts 110 – 113, *Shipping Subchapter J. Electrical Engineering*

LADOTD/HSAC <sup>26</sup>, *Offshore Heliport Design Guide*, APT No. 5100-R223

## 2.5 Classification Society Rules and Regulations

Classification societies have also established certain requirements for the design and installation of facilities on offshore production platforms. In addition to statutory requirements, these requirements may also influence the design and installation of the electrical systems. The following documents pertain to offshore oil and gas producing operations and may be applicable:

ABS <sup>27</sup>, *Rules for Building and Classing Steel Vessels*

ABS, *Rules for Building and Classing Mobile Offshore Drilling Units*

DNV <sup>28</sup>, *Rules for Classification of Mobile Offshore Units*

DNV, *Rules for Classification of Fixed Offshore Installations*

LR <sup>29</sup>, *Rules and Regulations for the Classification of Mobile Offshore Units*

LR, *Rules and Regulations for the Classification of Floating Offshore Installations at a Fixed Location*

LR, *Rules and Regulations for the Classification of Fixed Offshore Installations*

## 3 Acronyms, Terms, and Definitions

### 3.1 Acronyms

For the purposes of this document, the following acronyms apply.

ABS	American Bureau of Shipping
AFCI	arc-fault circuit interrupter
AHJ	authority having jurisdiction
ANSI	American National Standards Institute

<sup>25</sup> U.S. Department of Homeland Security, United States Coast Guard,. The *Code of Federal Regulations* is available from the U.S. Government Printing Office, Washington, D.C. 20402.

<sup>26</sup> Louisiana Department of Transportation and Development, Helicopter Safety Advisory Committee.

<sup>27</sup> American Bureau of Shipping, 16855 Northchase Drive, Houston, Texas 77060, [www.eagle.org](http://www.eagle.org).

<sup>28</sup> Det Norske Veritas, Veritasveien 1, 1322, Hovik, Oslo, Norway, [www.dnv.com](http://www.dnv.com).

<sup>29</sup> Lloyd's Registrar, 71 Fenchurch Street, London EC3M4BS, United Kingdom, [www.lr.org](http://www.lr.org).

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API	American Petroleum Institute
ASD	adjustable speed drive
ASHRAE	American Society of Heating, Refrigerating, and Air Conditioning Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
AWG	american wire gauge
BSSE	Bureau of Safety and Environmental Enforcement of the U.S. Department of the Interior
CSA	Canadian Standards Association
EP	explosionproof
EPR	ethylene propylene rubber
FA	forced air
FP	flameproof
FM	factory mutual research corporation
FPS	floating production system
FPSO	floating production storage offloading
FPU	floating production unit
GFCI	ground fault circuit interrupter
HMWPE	high molecular weight polyethylene
HP	horsepower
Hz	hertz (cycles per second)
IADC	International Association of Drilling Contractors
IEC	International Electrotechnical Commission
IECEX	The IECEX System (see 3.2.60)
IEEE	Institute of Electrical and Electronics Engineers
IES	Illuminating Engineering Society of North America
IEV	International Electrotechnical Vocabulary
IMCA	International Marine Contractors Association
IMMS	Integrated Marine Monitoring System
IMO	International Maritime Organization
ISA	The International Society for Measurement and Control (formerly Instrument Society of America)
kVA	kilovolt-ampere
kW	kilowatt
LEL	lower explosive limit (LFL preferred)
LFL	lower flammable limit
MODU	mobile offshore drilling unit
MMS	Minerals Management Service, U.S. Department of the Interior (superceded by BSEE)
NACE	National Association of Corrosion Engineers
NEC	National Electrical Code

NEMA	National Electrical Manufacturers Association
NFPA	National Fire Protection Association
NRTL	Nationally Recognized Testing Laboratory
OA	open air
PA	public address
PE	polyethylene
PVC	polyvinyl chloride
SALM	single anchor leg mooring (buoy)
TEFC	totally enclosed fan cooled
TLP	tension leg platform
TENV	totally enclosed non-ventilated
UL	Underwriters Laboratories Inc.
USCG	United States Coast Guard
XLPE	crosslinked polyethylene

## 3.2 Definitions, Abbreviated

For the purposes of this document, the following definitions apply.

### 3.2.1

#### **accessible (as applied to equipment)**

Admitting close approach: not guarded by locked doors, elevation, or other effective means. (See **accessible, readily**.)

### 3.2.2

#### **accessible, readily**

Capable of being reached quickly for operation, renewal, or inspections, without requiring those to whom ready access is requisite to climb over or remove obstacles or to resort to portable ladders, etc. [See **accessible (as applied to equipment)**.]

### 3.2.3

#### **accessible (as applied to wiring methods)**

Capable of being removed or exposed without damaging the building structure or finish, or not permanently closed in by the structure or finish of the building.

### 3.2.4

#### **adjustable speed drive**

##### **ASD**

A device that is used to control the speed of an AC motor by varying the frequency of the voltage supplied to it. These are also known as variable frequency drives, adjustable frequency drives and other, similar, names.

### 3.2.5

#### **AEx**

Required marking prefix for electrical apparatus to be installed in hazardous (classified) locations meeting one or more types of protection in accordance with harmonized American National (ANSI) Standards as defined in Article 505 of the *NEC*.

### **3.2.6**

#### **aluminum, copper-free (or low copper content)**

Aluminum alloys containing 0.4 % or less copper.

### **3.2.7**

#### **apparatus, intrinsically safe**

Apparatus in which all the circuits are intrinsically safe.

### **3.2.8**

#### **approved**

Acceptable to the authority having jurisdiction. [Electrical devices that are listed or approved by a NRTL (e.g. UL, FM or CSA) normally are acceptable].

NOTE The means for identifying listed equipment may vary for each organization concerned with product evaluation, some of which do not recognize equipment as listed unless it is also labeled. The authority having jurisdiction should utilize the system employed by the listing organization to identify a listed product.

### **3.2.9**

#### **area, enclosed (room, building, or space)**

A three-dimensional space enclosed by more than two-thirds of the possible projected plane surface area and of sufficient size to allow personnel entry. For a typical building, this would require that more than two-thirds of the walls, ceiling, and/or floor be present (see API 505).

### **3.2.10**

#### **area, safe**

See location, nonhazardous (unclassified).

### **3.2.11**

#### **arc-fault circuit interrupter**

##### **AFCI**

A device intended to provide protection from the effects of arc faults by recognizing characteristics unique to arcing and by functioning to de-energize the circuit when an arc fault is detected.

### **3.2.12**

#### **associated apparatus**

Apparatus used in intrinsically safe systems in which the circuits are not necessarily intrinsically safe themselves but affect the energy in the intrinsically safe circuits and are relied on to maintain intrinsic safety, see *NEC* Articles 504.4 and 505.8 for additional details.

### **3.2.13**

#### **atmosphere, explosive**

A mixture with air, under atmospheric conditions, of flammable substances in the form of gas, vapor, mist, or dust in which, after ignition, combustion spreads throughout the unconsumed mixture.

### **3.2.14**

#### **bus, cable**

An approved assembly of insulated conductors with fittings and conductor terminations in a totally enclosed protective metal housing, see *NEC* Article 370.

### **3.2.15**

#### **busway**

A grounded metal enclosure containing bare or insulated conductors that usually are copper or aluminum bars, rods or tubes, see *NEC* Article 368.

**3.2.16****cable, circuit integrity**

Cable that is used for critical circuits to ensure survivability for continued circuit operation for a specified time under fire conditions. See 6.7.8 for recommended applications and cable selection.

**3.2.17****cable, impervious sheathed**

Cable constructed with an impervious metallic or nonmetallic overall covering that prevents the entrance of gases, moisture or vapors into the insulated conductor or cable.

**3.2.18****cable, ITC**

Type ITC instrumentation tray cable is a factory assembly of two or more 300V insulated copper conductors, Nos. 22 through 12 AWG, with or without grounding conductor(s), and enclosed in a nonmetallic sheath with or without an armor as defined by *NEC* Article 727.

**3.2.19****cable, ITC-ER**

Type ITC instrumentation tray cable is a factory assembly of two or more 300V insulated copper conductors, Nos. 22 through 12 AWG, with or without grounding conductor(s), and enclosed in a nonmetallic sheath with or without an armor as defined by *NEC* Article 727. This cable is suitable for exposed runs (ER) between cable tray and utilization equipment where the cables are supported and secured.

**3.2.20****cable, ITC-HL**

Type ITC instrumentation tray cable is a factory assembly of two or more 300V insulated copper conductors, Nos. 22 through 12 AWG, with or without grounding conductor(s), and enclosed in a nonmetallic sheath with or without an armor as defined by *NEC* Article 727. This cable is suitable for use in Class I Zones 1 and 2. Reference *NEC* Article 505 for installation details.

**3.2.21****cable, jacketed**

Cable with a nonmetallic protective covering.

**3.2.22****cable, marine**

Same as cable, marine shipboard.

**3.2.23****cable, marine shipboard**

Impervious sheathed armored or non-armored cable constructed in accordance with UL 1309/CSA C22.2 No. 245, or IEEE-1580, except that an overall impervious sheath is required over the armored construction, and listed as "Shipboard Cable, Marine" by a Nationally Recognized Testing Laboratory (NRTL).

**3.2.24****cable, MC**

Metal-clad cable as defined by *NEC* Article 330.

**3.2.25****cable, MC-HL**

Metal-clad cable for hazardous locations as defined in UL 2225.



### **3.2.26**

#### **cable, MI**

Mineral-insulated metal-sheathed cable as defined by *NEC* Article 332.

### **3.2.27**

#### **cable, MV**

Medium voltage single or multiphase solid dielectric insulated conductor or cable rated 2001 Volts or higher as defined by *NEC* Article 328.

### **3.2.28**

#### **cable, PLTC**

Type PLTC nonmetallic-sheathed, power-limited tray cable. Suitable for cable trays and consisting of a factory assembly of two or more insulated copper (solid or stranded) conductors suitable for 300 Volts, Nos. 22 through 12 AWG, under a nonmetallic jacket. The cable is resistant to the spread of fire, and the outer jacket is sunlight- and moisture-resistant as defined by *NEC* Article 725.

### **3.2.29**

#### **cable, PLTC-ER**

Type PLTC nonmetallic-sheathed, power-limited tray cable. Suitable for cable trays and consisting of a factory assembly of two or more insulated copper (solid or stranded) conductors suitable for 300 Volts, Nos. 22 through 12 AWG, under a nonmetallic jacket. The cable is resistant to the spread of fire, and the outer jacket is sunlight- and moisture-resistant as defined by *NEC* Article 725. This cable is suitable for exposed runs (ER) between cable tray and utilization equipment where the cables are supported and secured. Reference *NEC* Article 725 for installation details.

### **3.2.30**

#### **cable, TC**

Power and control tray cable as defined by *NEC* Article 336.

### **3.2.31**

#### **cable, TC-ER**

Power and control tray cable as defined by *NEC* Article 336. This cable is suitable for exposed runs (ER) between cable tray and utilization equipment where the cables are supported and secured. Reference *NEC* Article 336 for installation details.

### **3.2.32**

#### **circuit, intrinsically safe**

A circuit in which any spark or thermal effect is incapable of causing ignition of a mixture of flammable or combustible material in air under test conditions prescribed by ANSI/UL 913 and ANSI/ISA-60079-11.

### **3.2.33**

#### **classified locations**

A hazardous (classified) location is a location classified as Division 1 or Division 2, or Zone 0, Zone 1, or Zone 2.

### **3.2.34**

#### **Class I location**

A Class I location is one in which flammable gases or vapors are or may be present in the air in quantities sufficient to produce explosive or ignitable mixtures. (See *NEC* Article 500 and *NEC* Article 505 and API 500 and API 505.)

### **3.2.35**

#### **Class I, Division 1 location**

A Class I, Division 1 location is a location: 1) in which ignitable concentrations of flammable gases or vapors exist continuously, intermittently, or periodically under normal operating conditions; or 2) in which ignitable concentration of such gases or vapors may exist frequently because of repair or maintenance operations or because of leakage; or 3) in which breakdown or faulty operation of equipment or processes might release ignitable concentrations of

flammable gases or vapors, and might also cause simultaneous failure of electrical equipment (see *NEC* Article 500 and API 500).

### **3.2.36**

#### **Class I, Division 2 location**

A Class I, Division 2 location is a location: 1) in which volatile flammable liquids or flammable gases are handled, processed, or used, but in which the hazardous liquids, vapors, or gases will normally be confined within closed containers or closed systems from which they can escape only if accidental rupture or breakdown of such containers or systems or abnormal operation of equipment occurs; or 2) in which hazardous concentrations of gases or vapors are normally prevented by positive mechanical ventilation but that might become hazardous through failure or abnormal operation of the ventilating equipment; or 3) that is adjacent to a Class I, Division 1 location, and to which hazardous concentration of gases or vapors might occasionally be communicated unless such communication is prevented by adequate positive-pressure ventilation from a source of clean air, and effective safeguards against ventilation failure are provided. (See *NEC* Article 500 and API 500.)

### **3.2.37**

#### **code of practice**

A term referring to a document that describes basic safety features and methods of protection and recommends, e.g. the selection, installation, inspection, and maintenance procedures that should be followed to ensure the safe use of electrical apparatus.

### **3.2.38**

#### **component, make/break**

Components having contacts that can interrupt a circuit (even if the interruption is transient in nature). Examples of make/break components are relays, circuit breakers, servo potentiometers, adjustable resistors, switches, connectors, and motor brushes.

### **3.2.39**

#### **component, protective (as applied to intrinsic safety)**

A component that is so unlikely to become defective in a manner that will lower the intrinsic safety of the circuit that it may be considered not subject to fault when analyses or tests for intrinsic safety are made.

### **3.2.40**

#### **conditions, normal**

Equipment is generally considered to be under normal conditions when it conforms electrically and mechanically with its design specifications and is used within the limits specified by the manufacturer.

### **3.2.41**

#### **control drawing**

A drawing or other document provided by the manufacturer of intrinsically safe or associated apparatus that details the allowed interconnections between the intrinsically safe and associated apparatus.

### **3.2.42**

#### **device, arcing**

A device that, during its normal operation, produces an arc with sufficient energy to cause ignition of an ignitable mixture.

### **3.2.43**

#### **device, hermetically sealed**

Equipment sealed against the entrance of an external atmosphere where the seal is made by fusion, for example, soldering, brazing, welding, or the fusion of glass to metal.

### **3.2.44**

#### **device, high-temperature**

A device whose maximum operating temperature exceeds 80 % of the autoignition temperature in degrees Celsius (°C) of all the gas or vapor involved see 4.2.

### **3.2.45**

#### **device, sealed**

A device so constructed that it cannot be opened during normal operational conditions or operational maintenance and is sealed to restrict entry of an external atmosphere. Such devices may be incorporated into equipment having the type of protection referred to as "nC."

### **3.2.46**

#### **dilution, continuous**

The technique of supplying a protective gas flow continuously to an enclosure containing an internal potential source of flammable gas or vapor for the purpose of diluting any flammable gas or vapor that could be present to a level below its LFL/LEL.

### **3.2.47**

#### **EEx**

Designation of explosion-protected electrical apparatus complying with harmonized CENELEC Standards.

### **3.2.48**

#### **Encapsulation**

A type of protection in which the parts that could ignite an explosive atmosphere by either sparking or heating are enclosed in an encapsulant in such a way that this explosive atmosphere cannot be ignited. This type of protection is referred to as "m."

### **3.2.49**

#### **enclosure, electrical**

The case or housing of electrical apparatus provided to prevent personnel from accidentally contacting energized parts, and/or to protect the equipment from physical damage and the environment. Also, certain enclosures serve to prevent electrical equipment from being a source of ignition of flammable mixtures outside the enclosure.

### **3.2.50**

#### **enclosure, explosionproof**

An enclosure that is capable of withstanding an explosion of a gas or vapor within it and of preventing the ignition of an explosive gas or vapor that may surround it, and that operates at such an external temperature that a surrounding explosive gas or vapor will not be ignited thereby.

### **3.2.51**

#### **enclosure, NEMA type**

A United States (NEMA) system of rating standard levels of protection provided to electrical apparatus by enclosures for 1) the protection of persons against contact with live or moving parts inside the enclosure, 2) the protection provided by the enclosure against ingress of solids and/or liquids, 3) the protection provided by the enclosure against the deleterious effects of corrosion, and 4) the protection provided by the enclosure against damage to the formation of external ice. This enclosure type is in addition to (and not an alternative to) the types of protection necessary to ensure protection against ignition in hazardous (classified) locations, see Table 10.

### **3.2.52**

#### **enclosure, purged and pressurized**

An enclosure supplied with clean air or an inert gas at sufficient flow and positive pressure to reduce to an acceptably safe level any flammable gas or vapor concentration initially present, and to maintain this safe level by positive pressure with or without continuous flow, see 4.3.5.

**3.2.53****entity concept**

A concept that allows interconnection of intrinsically safe apparatus to associated apparatus not specifically examined in such a combination. The criteria for interconnection is that the voltage ( $V_{\max}$ ) and current ( $I_{\max}$ ) which intrinsically safe apparatus can receive and remain intrinsically safe, considering faults, should be equal to or greater than the voltage ( $V_{oc}$  or  $V_t$ ) and current ( $I_{sc}$  or  $I_t$ ) levels which can be delivered by the associated apparatus, considering faults and applicable factors. In addition, the maximum unprotected capacitance ( $C_i$ ) and inductance ( $L_i$ ) of the intrinsically safe apparatus, including interconnecting wiring, should be equal to or less than the capacitance ( $C_a$ ) and inductance ( $L_a$ ) that can safely be connected to the associated apparatus. If these criteria are met, then the combination may be connected without compromising intrinsic safety. For additional information refer to ANSI/ISA-RP12.06.01.

**3.2.54****entry, cable (cable gland)**

A device permitting the introduction of an electric cable into an electrical apparatus.

**3.2.55****entry, direct**

A method of connection of an electrical apparatus to the external circuits by means of the connecting facilities inside the main enclosure or in a terminal compartment having a free opening to the main enclosure see IEC 60050, IEV 426-04-07.

**3.2.56****entry, indirect**

A method of connection of an electrical apparatus to the electrical circuits by means of a terminal box or a plug and socket connection which is external to the main enclosure, see IEC 60050, IEV 426-04-08.

**3.2.57****equipment, oil-immersed**

Equipment immersed in electrical insulating oil for the purpose of preventing an ignitable or corrosive gas or vapor from coming in physical contact with the equipment or for the purpose of reducing arcing of circuit breaking devices.

**3.2.58****Ex**

Designation of explosion-protected electrical apparatus complying with IEC standards.

**3.2.59****Ex component**

Part of electrical apparatus for explosive atmospheres which is not to be used alone in such atmospheres and which requires additional evaluation of any electrical apparatus with which it is used.

**3.2.60****Ex scheme**

An international system of certification for explosion-protected electrical apparatus administered by the IEC and known as the *IEC System for Certification to Standards Relating to Equipment for use in Explosive Atmospheres* (IECEx System) as described by IECEx-01. The eventual goal of this scheme is that a manufacturer of hazardous location electrical apparatus would be able to obtain a single 'Ex' Certificate of Conformity from one Certification Laboratory and provide that product in any participating country without legal or technical obstacle and without the need to get it recertified locally.

### **3.2.61**

#### **explosive limits**

The explosive limits of a gas or vapor are the lower and upper percentages by volume of concentration of gas in a gas-air mixture that will form an ignitable mixture, see Appendix to ANSI/ISA-RP12.13.02 for U.S. Bureau of Mines Bulletin 627, *Flammability Characteristics of Combustible Gases and Vapors*.

### **3.2.62**

#### **exposed (as applied to live parts)**

Capable of being inadvertently touched or approached nearer than a safe distance by a person. It is applied to all parts that are not suitably guarded, isolated, or insulated; see accessible and concealed (*NEC*).

### **3.2.63**

#### **exposed (as applied to wiring methods)**

On or attached to the surface or behind panels designed to allow access; see accessible: as applied to wiring methods (*NEC*).

### **3.2.64**

#### **facility, manned**

A facility on which people are routinely accommodated for more than 12 hours per day.

### **3.2.65**

#### **Flameproof**

A type of protection of electrical apparatus in which an enclosure will withstand an internal explosion of a flammable mixture which has penetrated into the interior, without suffering damage and without causing ignition, through any joints or structural openings in the enclosure, of an external explosive atmosphere consisting of one or more of the gases or vapors for which it is designed. This type of protection is referred to as “d.”

NOTE See also enclosure, explosionproof.

### **3.2.66**

#### **Flammable**

Capable of igniting easily, burning intensely or having a rapid rate of flame spread.

### **3.2.67**

#### **gas, protective**

The gas used for pressurization or for the dilution of flammable gases to a level well below their lower explosive limit, usually below 25 % LFL/LEL. The protective gas may be air, nitrogen, other nonflammable gas, or a mixture of such gases.

### **3.2.68**

#### **gas groups (division classification method)**

For purposes of testing, approval, and area classification, various air mixtures (not oxygen enriched) are grouped as shown below.

### **3.2.69**

#### **Group A**

Atmospheres that do or may contain acetylene.

### **3.2.70**

#### **Group B**

Atmospheres that do or may contain hydrogen, or other substances specified by NFPA 497.

### **3.2.71**

#### **Group C**

Atmospheres that do or may contain hydrogen sulfide (H<sub>2</sub>S), or other substances specified by NFPA 497.

**3.2.72****Group D**

Atmospheres that do or may contain natural gas, hydrocarbons or other substances specified by NFPA 497.

**3.2.73****gas, Group I**

A term used by ANSI/ISA-TR-12.24.01 (IEC 60079-10 MOD) to describe atmospheres containing firedamp (a mixture of gases, composed mostly of methane, found underground, usually in mines). Since this RP does not apply to installations underground in mines, this term is not used further.

**3.2.74****gas, Group II**

The group used to describe gases found aboveground and subdivided into IIC, IIB, and IIA, as noted below, according to the nature of the gas or vapor, for protection techniques “d,” “ia,” and “ib” and, where applicable, “n” and “o.”

**3.2.75****gas, Group IIA**

Atmospheres containing acetone, ammonia, ethyl alcohol, gasoline, methane, propane, or flammable gas, flammable liquid produced vapor, or combustible liquid produced vapor mixed with air that may burn or explode having either a maximum experimental safe gap (MESG) value greater than 0.90 mm or a minimum igniting current ratio (MIC ratio) greater than 0.80, see NFPA 497.

**3.2.76****gas, Group IIB**

Atmospheres containing acetaldehyde, ethylene, or flammable gas, flammable liquid produced vapor, or combustible liquid produced vapor mixed with air that may burn or explode having either a MESG value greater than 0.50 mm and less than or equal to 0.90 mm or a MIC ratio greater than 0.45 and less than or equal to 0.80, see NFPA 497.

**3.2.77****gas, Group IIC**

Atmospheres containing acetylene, hydrogen, or flammable gas, flammable liquid produced vapor, or combustible liquid produced vapor mixed with air that may burn or explode, having either a MESG value less than or equal to 0.50 mm or a MIC ratio less than or equal to 0.45, see NFPA 497.

**3.2.78****grounded (earthed)**

Connected to earth or to some conducting body that serves in place of earth.

**3.2.79****ignition capable**

Apparatus or wiring that under normal conditions, or under specified abnormal conditions, can release sufficient electrical or thermal energy to cause ignition of a specific explosive atmosphere.

**3.2.80****increased safety**

A type of protection applied to electrical apparatus that does not produce arcs or sparks in normal service and under specified abnormal conditions, in which additional measures are applied so as to give increased security against the possibility of excessive temperatures and of the occurrence of arcs and sparks. This type of protection is referred to as “e.”

**3.2.81****ingress protection (IP), degree of**

A system of rating standard levels of protection provided by apparatus for the protection of persons against contact with live or moving parts inside the apparatus, as well as the protection provided by apparatus against ingress of

solids and/or liquids. This type of protection classification is in addition to (and not an alternative to) the types of protection necessary to ensure protection against ignition in hazardous (classified) locations. Definitions are found in IEC 60529, also see **enclosure type**.

### **3.2.82**

#### **intrinsic safety**

A type of protection in which a portion of the electrical system contains only intrinsically safe apparatus, circuits, and wiring that is incapable of causing ignition in the surrounding atmosphere. No single device or wiring is intrinsically safe by itself (except for battery-operated, self-contained apparatus such as portable pagers, transceivers, gas detectors, etc., which are specifically designed as intrinsically safe self-contained devices) but is intrinsically safe only when employed in a properly designed intrinsically safe system. This type of protection is referred to as “i.”

NOTE See also associated apparatus.

### **3.2.83**

#### **intrinsic safety barrier**

A component containing a network designed to limit the energy (voltage and current) available to the protected circuit in the hazardous (classified) location under specified fault conditions.

### **3.2.84**

#### **intrinsic safety ground bus**

A grounding system that has a dedicated conductor separate from the power system so that ground currents will not normally flow and that is reliably connected to a grounding electrode. (For further information, refer to Article 504 of NEC and ANSI/ISA-RP12.06.01.)

### **3.2.85**

#### **intrinsically safe circuit**

A circuit in which any spark or thermal effect, produced either normally or in specified fault conditions, is incapable, in the specified test conditions, of causing ignition of a given explosive atmosphere.

### **3.2.86**

#### **intrinsically safe electrical apparatus**

Electrical apparatus in which all the circuits are intrinsically safe circuits.

### **3.2.87**

#### **intrinsically safe system**

An assembly of interconnected intrinsically safe apparatus, associated apparatus, other apparatus, and interconnecting cables in which those parts of the system that may be used in hazardous (classified) locations are intrinsically safe circuits.

### **3.2.88**

#### **Labeled**

Equipment or materials with a label, symbol, or other identifying mark of an organization that is acceptable to the authority having jurisdiction and concerned with product evaluation that maintains periodic inspection of production of labeled equipment or materials and by whose labeling the manufacturer indicates compliance with appropriate standards or performance in a specified manner.

NOTE Some testing agencies use the term approved, listed, or certified to indicate compliance with the applicable standard.

### **3.2.89**

#### **lighting fixtures, enclosed and gasketed**

Lighting fixtures (formerly referred to as “vapor-tight”) designed to prevent the entrance of gas and vapors. Such enclosures will not absolutely prevent the entrance of gases and vapors, as such tend to “breathe” as they are heated and cooled.

**3.2.90****listed**

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

**NOTE** The means for identifying listed equipment may vary for each organization concerned with product evaluation, some of which do not recognize equipment as listed unless it is also labeled. The authority having jurisdiction should utilize the system employed by the listing organization to identify a listed product.

**3.2.91****maintenance, corrective**

Any maintenance activity that is not normal in the operation of equipment and requires access to the equipment's interior. Such activities are expected to be performed by a qualified person. Such activities typically include locating causes of faulty performance, replacement of defective components, adjustment of internal controls, and the like.

**3.2.92****maintenance, operational**

Any maintenance activity, excluding corrective maintenance, intended to be performed by the operator and required in order for the equipment to serve its intended purpose. Such activities typically include the correcting of zero on a panel instrument, changing charts, record keeping, adding ink, and the like.

**3.2.93****minimum ignition energy****MIE**

The smallest amount of energy that can ignite the most easily ignitable mixture of a specific gas or vapor-in-air mixture or dust-in-air mixture.

**3.2.94****maximum experimental safe gap****MESG**

The maximum clearance between two parallel metal surfaces that has been found, under specified test conditions, to prevent an explosion in a test chamber from being propagated to a secondary chamber containing the same gas or vapor at the same concentration.

**3.2.95****minimum igniting current ratio****MIC ratio**

The ratio derived by dividing the minimum current required from an inductive spark discharge to ignite the most easily ignitable mixture of a gas or vapor by the minimum current required from an inductive spark discharge to ignite methane under the same test conditions.

**3.2.96****mixture, ignitable (flammable)**

A gas-air mixture that is capable of being ignited by an open flame, electric arc or spark or high temperature. See **explosive limits**.

**3.2.97****nonincendive circuit**

A circuit, other than field wiring, in which any arc or thermal effect produced, under intended operating conditions of the equipment, is not capable, under specified test conditions, of igniting the flammable gas-, vapor-, or dust-air mixture. See also **nonincendive field wiring**.



### 3.2.98

#### **nonincendive component**

A component having contacts for making or breaking an incendive circuit, and the contacting mechanism is constructed so that the component is incapable of igniting the specified flammable gas or vapor-air mixture. The housing of a nonincendive component is not intended to exclude the flammable atmosphere or contain an explosion. Such devices may be incorporated into equipment having the type of protection referred to as "nC."

### 3.2.99

#### **nonincendive equipment**

Equipment having electrical/electronic circuitry and components that are incapable, under normal conditions, of causing ignition of the flammable gas-, vapor-, or dust-air mixture due to arcing or thermal effect. Such devices may be incorporated into equipment having the types of protection referred to as "nA," "nC," or "nR."

### 3.2.100

#### **nonincendive field wiring**

Wiring that enters or leaves an equipment enclosure and, under normal operating conditions of the equipment, is not capable, due to arcing or thermal effects, of igniting the flammable gas-, vapor-, or dust-air mixture. Normal operation includes opening, shorting, or grounding the field wiring. See also **nonincendive circuit**.

### 3.2.101

#### **number, temperature identification (T Code/Temperature Class)**

A system of classification by which one of 14 temperature classes (for zones, six temperature classes) is allocated to apparatus. The temperature class represents the maximum surface temperature of any part of the apparatus that may come in contact with the flammable gas or vapor mixture.

### 3.2.102

#### **oil-resistant**

Ability to withstand exposure to oil as defined by ANSI C-33.80, see UL Std 83.

### 3.2.103

#### **oil sealed**

See **equipment, oil immersed**.

### 3.2.104

#### **oil-immersion**

Type of protection in which the electrical apparatus or parts of the electrical apparatus are immersed in a protective liquid in such a way that an explosive atmosphere which may be above the liquid or outside the enclosure cannot be ignited. This type of protection is referred to as "o."

### 3.2.105

#### **panelboard**

A single panel or group of panel units designed for assembly in the form of a single panel; including buses, automatic overcurrent devices, and equipped with or without switches for the control of light, heat, or power circuits; designed to be placed in a cabinet or cutout box placed in or against a wall or partition and accessible only from the front.

### 3.2.106

#### **potting**

The encapsulation of electrical components with epoxy, elastomeric, silicone or asphaltic or similar compounds for the purpose of excluding moisture or vapors. Potted components are not necessarily hermetically sealed.

**3.2.107****powder filling**

A type of protection in which the parts capable of igniting an explosive atmosphere are fixed in position and completely surrounded by filling material to prevent the ignition of an external explosive atmosphere. This type of protection is referred to as “q.”

**NOTE** This type of protection may not prevent the surrounding explosive atmosphere from penetrating into the apparatus and Ex components and being ignited by the circuits. However, due to the small free volumes in the filling material and due to the quenching of a flame which may propagate through the paths in the filling material, an external explosion is prevented.

**3.2.108****pressurization**

The technique of guarding against the ingress of the external atmosphere into an enclosure by maintaining a protective gas therein at a pressure above that of the external atmosphere. This type of protection is referred to as “p.”

**3.2.109****pressurization, Type X**

A method of reducing the classification within an enclosure from Division 1/Zone 1 to nonhazardous (unclassified).

**3.2.110****pressurization, Type Y**

A method of reducing the classification within an enclosure from Division 1/Zone 1 to Division 2/Zone 2.

**3.2.111****pressurization, Type Z**

A method of reducing the classification within an enclosure from Division 2/Zone 2 to nonhazardous (unclassified).

**3.2.112****protection, special**

An IEC protection technique other than those that have been standardized. This type of protection is referred to by IEC 60079-0 as “s.”

**3.2.113****protection, type of**

The specific measures applied to electrical apparatus to avoid ignition of a surrounding explosive atmosphere. Examples are “e” and “n.”

**3.2.114****purging**

In a pressurized enclosure, the operation of passing a quantity of protective gas through the enclosure and ducts, so that the concentration of the explosive gas atmosphere is brought to a safe level.

**3.2.115****restricted breathing**

A protection technique in which the gas- or vapor- tight integrity of an enclosure is assured so that short-term presence of a flammable gas or vapor cloud around the enclosure will not cause the concentration inside the enclosure to reach the LFL/LEL because of breathing or diffusion. This type of protection is referred to as “nR.”

**3.2.116****seal, environmental**

A seal that uses O-rings, epoxy, molded elastomer, silicone compound, or potting compound to prevent corrosion due to moisture or vapors.

### **3.2.117**

#### **seal, explosionproof cable**

A cable termination fitting filled with compound and designed to contain an explosion in the enclosure to which it is attached or to minimize passage of flammable gases or vapors from one location to another. An explosionproof conduit seal may also be used in combination with a cable termination fitting as an explosionproof cable seal.

### **3.2.118**

#### **seal, explosionproof conduit**

A sealing fitting, filled with a poured potting compound, designed to contain an explosion in the enclosure to which it is attached and to minimize passage of flammable gases or vapors from one location to another.

### **3.2.119**

#### **seal, factory**

A construction where components capable of initiating an internal explosion due to arcing, sparking, or thermal effects under normal conditions are isolated from the wiring system by means of factory installed flame-proof seal or joint for the purpose of eliminating the need for an external, field-installed conduit seal and, in some cases, a field-installed cable seal.

### **3.2.120**

#### **seal, hermetic**

See device, **hermetically sealed**.

### **3.2.121**

#### **simple apparatus (as applied to intrinsic safety)**

A device that will not generate or store more than 1.2 V, 0.1 A, 25 mW, or 20  $\mu$ J. Examples are switches, thermocouples, light-emitting diodes, connectors, and resistance temperature detectors (RTDs). Apparatus reliant on voltage or current limiting or suppression devices for remaining within the limits given in the definition, and sensors (e.g. certain gas detector sensors) that utilize catalytic reaction or other electrochemical mechanisms are excluded by IEC 60079-11 from the category of "simple apparatus". Temperature limitations as described in 4.2 are applicable to simple apparatus.

### **3.2.122**

#### **source of release**

A point from which flammable gases or vapors, flammable liquid, combustible dusts, or ignitable fibers or flyings may be released into the atmosphere.

### **3.2.123**

#### **sunlight-resistant**

Ability to withstand exposure to direct sunlight as defined by UL Std 1581.

### **3.2.124**

#### **system, intrinsically safe**

An assembly of interconnected intrinsically safe apparatus, associated apparatus, and interconnecting cables in which those parts of the system that may be used in hazardous (classified) locations are intrinsically safe circuits. An intrinsically safe system may include more than one intrinsically safe circuit.

### **3.2.125**

#### **temperature, autoignition (AIT)**

The minimum temperature required to initiate or cause self-sustained combustion of a solid, liquid, or gas independently of the heating or heated element.

**3.2.126****ventilation, adequate**

Ventilation (natural or artificial) that is sufficient to prevent the accumulation of significant quantities of vapor-air mixtures in concentrations above 25 % of their lower flammable (explosive) limit, LFL (LEL). See 6.3.2 of API 500 or 6.6.2 of API 505, as applicable.

**3.2.127****ventilation, inadequate**

Ventilation that is less than adequate. See 6.3.3 of API 500 or 6.6.3 of API 505, as applicable.

**3.2.128****type of protection**

See **protection, type of**.

**3.2.129****unclassified location**

An unclassified location is a location not classified as Division 1 or Division 2, or Zone 0, Zone 1, or Zone 2.

NOTE Within this document, the term unclassified location is used synonymously with the term nonclassified location.

**3.2.130****zone**

A method of specifying the probability that a location is made hazardous by the presence, or potential presence, of flammable concentrations of gases and vapors, or combustible mixtures of dusts.

**3.2.131****Zone 0 (IEC)**

An area in which an explosive gas atmosphere is present continuously or for long periods. (See IEC 60050, IEC 426-03-03.)

**3.2.132****Zone 0, Class I (NEC)**

A Class I, Zone 0 location is a location 1) in which ignitable concentrations of flammable gases or vapors are present continuously; or 2) in which ignitable concentrations of flammable gases or vapors are present for long periods of time, see *NEC* Section 505.5(B)(1)

**3.2.133****Zone 1 (IEC)**

An area in which an explosive gas atmosphere is likely to occur in normal operation, see IEC 60050, IEC 426-03-04.

**3.2.134****Zone 1, Class I (NEC)**

A Class I, Zone 1 location is a location 1) in which ignitable concentrations of flammable gases or vapors are likely to exist under normal operating conditions; or 2) in which ignitable concentrations of flammable gases or vapors may exist frequently because of repair or maintenance operations or because of leakage; or 3) in which equipment is operated or processes are carried on, of such a nature that equipment breakdown or faulty operations could result in the release of ignitable concentrations of flammable gases or vapors and also cause simultaneous failure of electrical equipment in a mode to cause the electrical equipment to become a source of ignition; or 4) that is adjacent to a Class I, Zone 0 location from which ignitable concentrations of vapors could be communicated, unless communication is prevented by adequate positive-pressure ventilation from a source of clean air and effective safeguards against ventilation failure are provided, see *NEC* Article 505.5(B)(2).

### **3.2.135**

#### **Zone 2 (IEC)**

An area in which an explosive gas atmosphere is not likely to occur in normal operation and, if it does occur, is likely to do so only infrequently and will exist for a short period only, see IEC 60050, IEC 426-03-05.

### **3.2.136**

#### **Zone 2, Class I (NEC)**

A Class I, Zone 2 location is a location 1) in which ignitable concentrations of flammable gases or vapors are not likely to occur in normal operation, and if they do occur, will exist only for a short period; or 2) in which volatile flammable liquids, flammable gases, or flammable vapors are handled, processed, or used, but in which the liquids, gases, or vapors normally are confined within closed containers or closed systems from which they can escape only as a result of accidental rupture or breakdown of the containers or system, or as the result of the abnormal operation of the equipment with which the liquids or gases are handled, processed, or used; or 3) in which ignitable concentrations of flammable gases or vapors normally are prevented by positive mechanical ventilation, but which may become hazardous as the result of failure or abnormal operation of the ventilation equipment; or 4) that is adjacent to a Class I, Zone 1 location, from which ignitable concentrations of flammable gases or vapors could be communicated, unless such communication is prevented by adequate positive-pressure ventilation from a source of clean air, and effective safeguards against ventilation failure are provided, see *NEC* Section 505.5(B)(3).

## **3.3 Definitions Specific to Floating Facilities**

### **3.3.1**

#### **Cargo**

A flammable gas or vapor or combustible liquid, flammable liquid, or liquefied flammable gas with a (closed cup) flash point below 60 °C (140 ° F).

### **3.3.2**

#### **cargo handling room**

Any enclosed space where cargo is pumped, compressed, or processed. Examples of cargo handling rooms are cargo pump rooms, cargo compressor rooms, and cargo valve rooms.

### **3.3.3**

#### **cargo tank**

Any tank or vessel, located in the below deck area, designed to contain cargo.

### **3.3.4**

#### **corrosion-resistant material or finish**

A term used to describe any material or finish that meets the testing requirements of ASTM B117 or Test Kb in IEC 68-2-52 for 200 hours and does not show pitting, cracking, or other deterioration more severe than that resulting from a similar test on passivated AISC Type 304 stainless steel.

### **3.3.5**

#### **corrosive location**

A location exposed to the weather, salt water, or other corrosive substances such as drilling fluids.

### **3.3.6**

#### **drip-proof**

Equipment enclosed so that it meets at least a NEMA 250 Type 1 with a drip shield, NEMA 250 Type 2, or IEC IP 32 rating.

**3.3.7****embarkation station**

A location from which persons embark into survival craft or are assembled prior to embarking into survival craft.

**3.3.8****space, machinery**

An enclosed area that contains rotating equipment or internal combustion machinery with a total aggregate power is at least 500 brake horsepower or a place containing internal combustion machinery, thermal fluid heaters, or fired boilers that use fuel gas or a liquid fuel that has a flash point of less than 43.3 °C (110 °F).

**3.3.9****location not requiring an exceptional degree of protection**

A location that is not exposed to the environmental conditions outlined in the definition of 3.3.9. These locations include: a) accommodation spaces such as quarters buildings, b) dry store rooms, and c) other locations with similar environmental conditions.

**3.3.10****location requiring an exceptional degree of protection**

A location exposed to weather, seas, splashing, pressure-directed liquids, or similar moisture conditions. These locations include a) on-deck areas; b) machinery spaces; c) cargo spaces; d) locations within a galley or pantry area, laundry, or water closet that contains a shower or bath; and e) other spaces with similar environmental conditions.

**3.3.11****water-tight**

Equipment so enclosed that it meets at least a NEMA 250 Type 4 or 4X or an IEC IP 55 or 56 rating.

## **4 Electrical Equipment for Hazardous (Classified) Locations**

### **4.1 General**

**4.1.1** The selection of proper electrical equipment for offshore petroleum facilities depends directly on whether a particular area is classified or not, and whether a classified area is Class I, Zone 0, Zone 1, or Zone 2. Because the safety of an installation is highly sensitive to equipment selection, it is very important to have a clear understanding of the reasons behind the classification of areas and of the different methods employed by electrical equipment manufacturers to make their equipment suitable for the different hazardous (classified) locations.

**4.1.2** Through design engineering judgment in planning electrical installations for offshore petroleum facilities, most equipment may be placed in lower classified or unclassified locations to reduce the amount of special equipment required. The degree of classification may be reduced or eliminated by purging, as described in 4.3.5, or with the use of gas detection as allowed in API 505, section 6.8. The use of a gas detection system as a method of protection shall be designed, installed and maintained in accordance with ISA-TR 12.13.03. For electrical equipment installed in buildings in unclassified locations, see 12.6.

**4.1.3** *Use of Division rated equipment in Zone classified locations.* Equipment listed and marked in accordance with 4.6 for Class I, Division 1 hazardous (classified) locations may be used in Class I, Zone 1 or 2 locations for the same gas and with a suitable temperature rating. Equipment listed and marked in accordance with 4.6 for Class I, Division 2 hazardous (classified) locations may be used in Class I, Zone 2 locations for the same gas and with a suitable temperature rating.

**4.1.4** The "Definitions" section of this RP includes brief definitions of hazardous (classified) locations and various types of equipment used in hazardous (classified) locations. This section expands upon certain of these definitions and provides guidance to proper application of electrical equipment. For specific guidance on classification of petroleum facilities, refer to API 505.

**4.1.5 Dual classification.** In instances of areas within the same facility classified separately, Class I, Zone 2 locations may abut but shall not overlap, Class I, Division 2 locations. Class I, Zone 0 or 1 locations shall not abut Class I, Division 1 or 2 locations.

**4.1.6 Reclassification.** Class I, Division 1 or 2 locations may be reclassified as Class I, Zone 0, 1, or 2 locations provided that all of the space classified due to a single flammable source is reclassified.

## **4.2 High-temperature Devices**

**4.2.1** High-temperature devices are defined as those devices whose maximum operating temperature exceed 80 % of the autoignition temperature in degrees Celsius (°C) of the gas or vapor involved. The maximum operating temperature refers to the skin temperature of components in the interior of enclosures and to the surface temperature of lamps inside lighting fixtures. For offshore applications, the most commonly encountered explosive gas is natural gas, composed primarily of methane. The autoignition temperature of natural gas is usually considered to be 900 °F (482 °C) and any device whose operating temperature exceeds 726 °F (386 °C) in natural gas environments should be considered a high-temperature device. The autoignition temperature of hydrogen sulfide is usually considered to be 500 °F (260 °C) and any device whose operating temperature exceeds 406 °F (208 °C) in H<sub>2</sub>S environments should be considered a high-temperature device. A review of production installations should be made to determine the presence of other gases with lower autoignition temperatures.

**4.2.2** High temperature devices shall be installed in flameproof, explosionproof, or purged and pressurized enclosures unless they have been determined to be suitable for the location by a nationally recognized testing laboratory.

**4.2.3** Certain equipment (Zone-rated equipment) is tested by nationally recognized testing laboratories and given one of 6 temperature classification numbers ("T" ratings). This equipment may exceed the temperature determined by the "80 % rule," but the "T" rating shall be below the autoignition temperature of the specific gas or vapor involved. As an example, equipment rated T1 has been verified not to exceed 450 °C (842 °F), and therefore is suitable for most natural gas applications. Reference *NEC* Table 505.9(D)(1).

**4.2.4** Certain other equipment (Division-rated equipment) is given one of 14 Temperature classes (also known as "T" ratings). Reference *NEC* Table 500.8(C). The remarks made under 4.2.3, apply also to this equipment.

## **4.3 Protection Techniques Related To Equipment Suitable for use in Locations Classified as Division 1 or Division 2**

**NOTE** This section is included in Recommended Practice 14FZ because equipment approved for Division-classified locations may, in certain cases, be installed in Zone-classified locations (see 6.4.1.5).

### **4.3.1 Explosionproof Equipment**

**4.3.1.1** An explosionproof assembly is electrical equipment packaged in an enclosure that is capable of withstanding an internal explosion and preventing its propagation to the external atmosphere. Such explosionproof equipment is suitable for use in both Division 1 and Division 2 locations.

**4.3.1.2** Explosionproof enclosures breathe when the ambient temperature changes and, therefore, may accumulate flammable gases within. If an explosion occurs within, the enclosure should withstand a very rapid buildup of pressure. The gases escaping will relieve the pressure buildup. These gases should be cooled sufficiently before they reach the surrounding atmosphere to prevent ignition if the surrounding atmosphere is flammable. Three methods are widely used to achieve this cooling:

- a) precision ground flanges or joints machined to specific widths and narrow tolerances;
- b) threaded joints; and

c) precision serrated joints.

**4.3.1.3** In addition, the surface temperature of the enclosure shall not be higher than 80 % of the autoignition temperature in °C of the gas or vapor involved or the assembly should be determined to be suitable for the specific area by a recognized testing laboratory ("T-rated"). See 4.2.3.

**4.3.1.4** It is important that explosionproof enclosures be installed and maintained in accordance with the manufacturer's instructions. If covers are not installed with the number and specified types of bolts, properly torqued, or other specified securing devices, internal explosions can discharge insufficiently cooled gasses that are capable of igniting external flammable atmospheres. Additionally, external flammable atmospheres can be ignited if precision ground flanges or joints are damaged by mechanical means or corrosion or if all entries are not provided with approved entry methods or specified stopping plugs. See 12.1.1.

### **4.3.2 Hermetically Sealed Devices**

Hermetically sealed devices are designed to prevent hazardous gases from coming in contact with sources of ignition such as arcing contacts. These devices are suitable for use in Division 2 and unclassified locations. The materials employed to accomplish the hermetic sealing should be resistant to mechanical abuse and durable enough to withstand normal aging, exposure to hydrocarbons and any other chemicals and the effects of severe weather. The bond between the different materials employed should be permanent, mechanically strong, and capable of withstanding the surrounding environment.

**NOTE** Hermetically sealed enclosures are sealed through glass-to-metal or metal-to-metal fusion at all joints and terminals. Enclosures whose seals are accomplished by O-rings, epoxy, molded elastomer, potting or silicone compounds are not to be considered hermetically sealed unless such equipment has been determined to be suitable for the specific Division 2 location by a NRTL.

### **4.3.3 Intrinsically Safe Systems**

**4.3.3.1** Intrinsically safe circuits are incapable of releasing sufficient electrical or thermal energy under prescribed test conditions (as specified by ANSI/UL 913) to cause ignition of a specific hazardous atmospheric mixture in its most easily ignitable concentration. Test conditions include both normal and abnormal operating conditions. Abnormal equipment conditions include accidental damage to or failure of the equipment, wiring, insulation, or other components and exposure to overvoltage. Normal conditions include periods of adjustment and maintenance. The most common applications are found in the fields of instrumentation and communications.

**4.3.3.2** Intrinsically safe apparatus is apparatus in which all the circuits are intrinsically safe. Associated apparatus are apparatus in which the circuits are not necessarily intrinsically safe themselves, but are apparatus that affect the energy in the intrinsically safe circuits and are relied upon to maintain intrinsic safety. Typically, associated apparatus are shunt diode safety barriers (frequently referred to as intrinsically safe barriers) that limit the transfer of energy to a level that cannot ignite flammable atmospheres. The devices are connected in series with signal conductors to transducers and other devices in process plants. Associated apparatus shall be installed in an unclassified location or provided an alternate type protection (e.g. an explosionproof enclosure) suitable for the area in which it is installed.

**4.3.3.3** An intrinsically safe system is an assembly of interconnected intrinsically safe apparatus, associated apparatus, and interconnecting cables in which those parts of the system that may be used in hazardous (classified) locations are intrinsically safe circuits. Intrinsically safe systems are suitable for use in unclassified, Division 1 or Division 2 locations. However, such systems may require that specific equipment items, such as controllers or panel instruments, be located in an unclassified location. Where a nationally recognized testing laboratory has rated such equipment (apparatus) intrinsically safe, it may be employed with various end devices to form an intrinsically safe system. No end device is intrinsically safe by itself, but is intrinsically safe only when employed in a properly designed intrinsically safe system. Proper design of an intrinsically safe system requires adherence to strict rules, detailed mathematical analysis, and, in most cases, laboratory testing. UL 913, ANSI/ISA-60079-11, and NEC Article 504 should be followed closely when designing and installing an intrinsically safe system. Also, control drawings should



be followed closely. Control drawings are drawings or other documentation provided by the manufacturer of the intrinsically safe or associated apparatus that detail the allowed interconnection between the intrinsically safe and associated apparatus.

**4.3.3.4** The two most important advantages of intrinsically safe equipment are as follows.

**4.3.3.4.1 Safety**

Intrinsically safe apparatus does not require explosionproof enclosures. Thus, missing bolts and covers, open enclosures during maintenance and testing operations, corroded conduit systems, etc., do not impair the safety of the systems from the standpoint of igniting gas or vapors. The low voltages and currents involved may reduce the hazard of electrical shock.

**4.3.3.4.2 Convenience**

Wiring for intrinsically safe systems needs only to meet the requirements of *NEC* Article 504, eliminating the requirement for bulky, explosionproof enclosures. Intrinsically safe apparatus and wiring may be installed using any of the wiring methods suitable for unclassified locations. Maintenance and calibration operations can be performed in hazardous (classified) locations without de-energizing the equipment or shutting down process equipment.

**4.3.4 Nonincendive Equipment**

**4.3.4.1** Nonincendive equipment shall not be capable of igniting a hazardous mixture under normal circumstances, but ignition is not necessarily prevented under abnormal circumstances. Such equipment is suitable for use only in Division 2 and unclassified locations. Nonincendive equipment is similar in design to other equipment suitable for Division 2 locations; however, in nonincendive equipment, sliding or make-and-break contacts need not be explosionproof, oil-immersed, or hermetically sealed, as such contacts are incapable of releasing sufficient energy to cause ignition under normal operating conditions.

**4.3.4.2** Because portions of the system may operate at energy levels potentially capable of causing ignition, wiring methods used shall conform to area classification requirements. Nonincendive equipment is normally limited to instrumentation and communications systems. When employing nonincendive systems, extreme care should be exercised.

**4.3.5 Purged Enclosures**

**4.3.5.1** Purging (also referred to as pressurizing) is a method of installing electrical equipment in a hazardous (classified) location without using explosionproof enclosures. NFPA 496 provides information for the design of purged enclosures and purging methods to reduce the classification of the area within an enclosure:

- a) from Division 1 to unclassified (Type X purging);
- b) from Division 1 to Division 2 (Type Y purging);
- c) from Division 2 to unclassified (Type Z purging).

**4.3.5.2** NFPA 496 discusses the different requirements for purging of small enclosures, power equipment enclosures, and large volume enclosures such as control rooms. On an offshore platform, the use of humid salt air for purging may cause corrosion damage to equipment; thus, use of inert gas or dehydrated clean air should be considered where practicable. The source of clean air should be from an unclassified location.

## 4.4 Protection Techniques Related to Equipment Approved for Zone 0, Zone 1, or Zone 2 Locations

### 4.4.1 General

Acceptance of Protection Techniques related to equipment approved for zones may vary between AHJs. Specific requirements may have to be addressed for AHJ approvals.

### 4.4.2 Flameproof “d”

Flameproof is a type of protection of electrical equipment in which the enclosure will withstand an internal explosion of a flammable mixture that has penetrated into the interior, without suffering damage and without causing ignition, through any joints or structural openings in the enclosure, of an external explosive atmosphere consisting of one or more of the gases or vapors for which it is designed. This protection technique is permitted for equipment in Class I, Zone 1 locations for which it is approved. For further information, see ANSI/ISA-60079-1 2009, *Explosive Atmospheres—Part 1: Equipment Protection by Flameproof Enclosures “d”*.

### 4.4.3 Pressurization “p”

**4.4.3.1** In some cases, hazards may be reduced or hazardous (classified) locations limited or eliminated by adequate positive-pressure ventilation from a source of clean air in conjunction with effective safeguards against ventilation failure. Pressurization “p” is a type of protection of electrical equipment that uses the technique of guarding against the ingress of the external atmosphere that may be explosive, into an enclosure by maintaining a protective gas therein at a pressure above that of the external atmosphere. This protection technique is permitted for equipment in those Class I, Zone 1 or Zone 2 locations for which it is approved. For further information, see *Standard for Purged and Pressurized Enclosures for Electrical Equipment*, ANSI/NFPA 496. For further information, see *Electrical Apparatus for Explosive Gas Atmospheres—Part 2: Electrical Apparatus, Type of Protection “p”*, IEC 60079-2; and *Electrical Apparatus for Explosive Gas Atmospheres—Part 13: Construction and Use of Rooms or Buildings Protected by Pressurization*, IEC 60079-13.

**4.4.3.2** From Zone 1 to unclassified (Type px pressurization).

**4.4.3.3** From Zone 1 to Zone 2 (Type py pressurization).

**4.4.3.4** From Zone 2 to unclassified (Type pz pressurization).

### 4.4.4 Intrinsic Safety “ia”, “ib”, and “ic”

**4.4.4.1** Intrinsically safe circuits are incapable of releasing sufficient electrical or thermal energy under prescribed test conditions to cause ignition of a specific hazardous atmospheric mixture in its most easily ignitable concentration. Test conditions include both normal and abnormal operating conditions. Abnormal equipment conditions include accidental damage to or failure of the equipment, wiring, insulation, or other components and exposure to overvoltage. Normal conditions include periods of adjustment and maintenance. The most common applications are found in the fields of instrumentation and communications. Intrinsic safety is designated as Type “i” protection. Type “i” protection is subdivided into categories “ia”, “ib”, and “ic.”

**4.4.4.1.1** “Intrinsic Safety” suitable for use in Zones 0, 1, and 2 locations is designated category “ia” by ANSI/ISA-60079-11 (12.02.02)-2002.

**4.4.4.1.2** “Intrinsic Safety” suitable for use in Zones 1 and 2 locations is designated category “ib” by ANSI/ISA-60079-11 (12.02.02)-2002.

**4.4.4.1.3** “Intrinsic Safety” suitable for use in Zone 2 locations is designated category “ic” by ANSI/ISA-60079-11 (12.02.02)-2002.

NOTE For further information, see *Intrinsically Safe Apparatus and Associated Apparatus for Use in Class I, II, and III, Hazardous Locations*, ANSI/UL 913; and *Electrical Apparatus for Explosive Gas Atmospheres—Part 11: Intrinsic Safety “i.”*

**4.4.4.2** Simple apparatus incorporated in intrinsically safe circuits is permitted in Class I, Zone 0 or Zone 1 locations, according to the category of the associated apparatus. Such apparatus need not be listed, certified, or approved, provided that the associated apparatus is suitably listed, certified, or approved and provided that neither the capacitance nor the inductance of the simple apparatus, considered together with the electrical parameters of the field cabling, exceeds the relevant limits given in the documentation or marking of the associated apparatus.

**4.4.4.3** Intrinsically safe associated apparatus, designated by [ia], [ib], or [ic], is connected to intrinsically safe equipment (“a”, “ib”, or “ic,” respectively), but is located outside the hazardous (classified) location unless also protected by another type of protection (such as flameproof).

#### **4.4.5 Type of Protection “n”**

Type “n” protection is a type of protection applied to electrical equipment such that, in normal operation, the electrical equipment is not capable of igniting a surrounding explosive gas atmosphere and a fault capable of causing ignition is not likely to occur. This protection technique is permitted for equipment in Class I, Zone 2 locations for which it is approved. Type of protection “n” is further subdivided into nA, nC, nL, and nR. See Table 1 for the descriptions of subdivisions for type of protection “n.” For further information, see ANSI/ISA-60079-15 (12.12.02)-2009, *Electrical Apparatus for Use In Class I, Zone 2 Hazardous (Classified) Locations Type of Protection —“n”*, ISA-S12.12.01.

NOTE The use of nL protection technique is a departure from the *NEC* as the type of protection nL is not listed in the 2011 edition of the *NEC*.

#### **4.4.6 Oil Immersion “o”**

Oil Immersion is a type of protection in which the electrical equipment or parts of the electrical equipment are immersed in a protective liquid in such a way that an explosive atmosphere that may be above the liquid or outside the enclosure cannot be ignited. This protection technique is permitted for equipment in Class I, Zone 1 locations for which it is approved. For further information, see ANSI/ISA-60079-6, *Explosive Atmospheres—Part 6: Equipment Protection by Oil Immersion “o”*.

#### **4.4.7 Increased Safety “e”**

Increased Safety is a type of protection applied to electrical equipment that does not produce arcs or sparks in normal service and under specified abnormal conditions, in which additional measures are applied so as to give increased security against the possibility of excessive temperatures and of the occurrence of arcs and sparks. This protection technique is permitted for equipment in Class I, Zone 1 locations for which it is approved. For further information, see ANSI/ISA-60079-7 (12.16.01) 2008, *Explosive Atmospheres—Part 7: Equipment protection by increased safety “e”*.

#### **4.4.8 Encapsulation “ma” and “mb”**

Encapsulation is a type of protection in which the parts that could ignite an explosive atmosphere by either sparking or heating are enclosed in a compound in such a way that this explosive atmosphere cannot be ignited. This protection technique is permitted for equipment in Class I, Zone 1 locations for which it is approved. For further information, see ANSI/ISA-60079-18, *Electrical Apparatus for Use In Class I, Zone 1 Hazardous (Classified) Locations Type of Protection—Encapsulation “m”*. Encapsulation suitable for use in Zone’s 0, 1 and 2 locations is designated category “ma”. Encapsulation suitable for use in Zones 1 and 2 locations is designated category “mb”.

#### **4.4.9 Powder Filling “q”**

Powder Filling is a type of protection in which the parts capable of igniting an explosive atmosphere are fixed in position and completely surrounded by filling material (glass or quartz powder) to prevent the ignition of an external

**Table 1—Types of Protection Designation**

Designation	Technique	Zone <sup>a</sup>
d	Flameproof enclosure	1,2
e	Increased safety	1,2
ia	Intrinsic safety	0,1,2
ib	intrinsic safety	1,2
ic	Intrinsic safety	2
[ia] <sup>b</sup>	Intrinsically safe associated apparatus	Non-hazardous
[ib] <sup>b</sup>	Intrinsically safe associated apparatus	Non-hazardous
[ic] <sup>b</sup>	Intrinsically safe associated apparatus	Non-hazardous
ma	Encapsulation	0,1,2
mb	Encapsulation	1,2
nA	Non-sparking equipment	2
nC	Sparking equipment in which the contacts are suitably protected other than by restricted breathing enclosure.	2
nL	Energy Limited – Limit the energy of sparks and surface temperatures	2
nR	Restricted breathing enclosure	2
o	Oil immersion	1,2
px	Pressurization	1
py	Pressurization	1
pz	Pressurization	2 <sup>c</sup>
q	Powder-filled	1,2
<sup>a</sup> Does not address use where a combination of techniques is used. <sup>b</sup> See 4.4.4.2. <sup>c</sup> Dependent upon factors such as the provision of automatic shutdown or alarm only on loss of pressurization, the arrangement for the exhaust of the protective gas, the inclusion of sparking/arcing or high temperature devices within the enclosure, etc.		

explosive atmosphere. This protection technique is permitted for equipment in Class I, Zone 1 locations for which it is approved. For further information, see ANSI/ISA-60079-5, *Explosive Atmospheres—Part 5: Equipment Protection by Powder Filling “q”*.

## 4.5 General Purpose Equipment

General purpose equipment or equipment in general purpose enclosures is permitted in Zone 2 locations if the equipment does not constitute a source of ignition (arcing, sparking, or high-temperature devices) under normal operating conditions.

## 4.6 Listing, Marking and Documentation

### 4.6.1 Listing

Equipment that is listed for a Zone 0 location is permitted in a Zone 0, Zone 1, or Zone 2 location of the same gas or vapor. Equipment that is listed for a Zone 1 location is permitted in a Zone 1 or Zone 2 location of the same gas or vapor.

### 4.6.2 Marking

**4.6.2.1** Equipment for use in locations classified by the Zone classification system shall be marked in accordance with (a) or (b) below:

a) **Division Equipment.** Equipment approved for Class I, Division 1 or Class I, Division 2 locations shall be marked to show the class, group and operating temperature or temperature range (see “temperature identification number”) referenced to a 40 °C (104 °F) ambient as follows:

- 1) Class I, Division 1 or Class I, Division 2, as applicable.
- 2) Applicable gas classification group(s).
- 3) Temperature classification.

NOTE 1 The “Class I, Division 1” marking is allowed in Class I, Zone 1 or Class I, Zone 2 locations. Such equipment may also be marked as Class I, Zone 1.

NOTE 2 The “Class I, Division 2” marking is allowed in Class I, Zone 2 locations. Such equipment may also be marked as Class I, Zone 2.

NOTE 3 Equipment suitable for ambient temperatures between –20 °C to +40 °C shall require no ambient temperature marking. Equipment suitable for ambient temperatures other than –20 °C to +40 °C shall additionally be marked with the maximum and minimum ambient temperature in degrees Celsius. The marking shall include either the symbol “Ta” or “Tamb”.

NOTE 4 It is recommended that the end user specify that the marking on dual-marked equipment used in Class I, Zone 1 or Class I, Zone 2 classified locations contain the information required by 4.6.2.1(b).

b) **Zone Equipment.** Equipment approved for Class I, Zone 0, Zone 1, or Zone 2 locations shall be marked as follows:

- (i) Class
- (ii) Zone
- (iii) Symbol “AEx”
- (iv) Protection technique(s)
- (v) Applicable gas classification group(s)
- (vi) Temperature classification

An example of such a required marking is “Class I, Zone 0 AEx ia IIC T6.”

Electrical equipment of types of protection e, m, p, or q (including ma, mb, px, py, or pz) shall be marked Group II. Electrical equipment of types of protection d, ia, ib, [ia], or [ib] (including ic or [ic]) shall be marked Group IIA, or IIB, or IIC, or for a specific gas or vapor. Electrical equipment of types of protection n shall be marked Group II unless it contains enclosed-break devices, nonincendive components, or energy-limited equipment or circuits, in which case it shall be marked Group IIA, IIB, or IIC, or a specific gas or vapor. Electrical equipment of other types of protection shall be marked Group II unless the type of protection utilized by the equipment requires that it shall be marked Group IIA, IIB, or IIC, or a specific gas or vapor. An explanation of marking required is shown below.

## 4.7 Gas Group

**4.7.1** Zone equipment of certain types is allocated to one of three Groups (IIA, IIB, or IIC). Equipment of any of these groups is suitable for use in natural gas environments.

**NOTE** Group IIC equipment, and equipment marked Group II, without suffix letter, is suitable where gases or vapors of any Group can be present. Group IIB equipment is suitable where gases or vapors of Group IIB or IIA (but not IIC) can be present. Group IIA equipment is suitable only where no flammable gas or vapor other than of Group IIA can be present.

**4.7.2** Division equipment of certain types is marked to show one or several of four Gas Groups (A–D). Equipment marked for Group D is suitable for use in natural gas environments.

## 5 Electric Power Generating Stations

### 5.1 General

**5.1.1** Electric power generating stations discussed in this section consist of one or more generator sets that may be either portable or permanent by design. These recommendations include both sound engineering practices and special considerations for safe and reliable operation on offshore petroleum facilities.

**5.1.2** Natural gas fueled prime movers are most practical for the majority of applications, but diesel engines are usually utilized where natural gas is not available or for standby or portable units. Gasoline engines normally are unacceptable.

**5.1.3** The location and installation of generating sets should allow access for inspection, maintenance, and repair. There should be sufficient space between the generator set and surrounding objects to provide accessibility. It is recommended that sufficient room and lifting capability be provided to facilitate service and removal of the generator rotor or its armature.

**5.1.4** The generator and its driving unit should be mounted on a common rigid sub-base or other means engineered to ensure proper alignment. For reciprocating engine driven generators, it is recommended that any local instrument and electrical control panels be isolated to prevent damage from vibration.

### 5.2 Prime Movers

#### 5.2.1 Sizing

It is recommended that prime movers for generator applications have a minimum continuous shaft horsepower (HP) output according to Equation (1):

$$HP_{MIN} = \frac{Design\ kw\ Load}{0.746 \times Generator\ Efficiency} \quad (1)$$

The efficiency of 25 kW and larger generators typically ranges from 0.88 to 0.94. Allowing 1.5 HP per kW output yields a conservative prime mover power requirement. All prime mover ratings should be adjusted for the highest

expected ambient temperatures offshore and derated for total system inlet and exhaust pressure losses and end of life degradation. Generally, gas turbines are much more sensitive to these conditions. Special consideration should be made when sizing prime movers for service where large motors will be started across the line. See 5.3.2.1 for further information.

### **5.2.2 Air Intakes**

It is recommended that engine combustion air intakes be located in unclassified locations to minimize the risk of ingestion of flammable mixtures. All diesel-fueled prime movers shall be equipped with an air-intake shutoff valve or other suitable device that operates on an overspeed condition that requires shutdown of the prime mover.

### **5.2.3 Exhausts**

It is recommended that engine exhausts be located in unclassified locations, whenever possible, to minimize the risk of ignition of flammable mixtures.

### **5.2.4 Speed**

Reciprocating engines normally are coupled directly to generators and operate at either 720 rpm, 900 rpm, 1200 rpm or 1800 rpm for 60 Hz generators. For reduced maintenance and increased life, it is recommended that reciprocating-type engines for prime (continuous) power installations be operated at 1200 rpm or less. Reciprocating-type engines for standby (non-continuous) applications often are operated at speeds up to 1800 rpm. Gas turbines normally operate at higher speeds and drive generators through gearbox assemblies.

### **5.2.5 Reciprocating Engine Controls**

**5.2.5.1** Automatic controls shall be provided to shut down all reciprocating engines that are driving generators and open generator breaker when any of the following occur:

- a) low lube oil pressure;
- b) high jacket water temperature;
- c) overspeed shutdowns should operate independently of governor controllers and should be set at no more than 115 % of rated speed;
- d) overvoltage, and for generators 500 kW and larger, it is recommended that overvoltage shutdown controls be provided and that generator circuit breakers be tripped and voltage regulators are de-energized;
- e) over crank/fail to start;
- f) high exhaust temperature when applicable, such as turbocharged units.

**5.2.5.2** Optional shutdown controls include:

- a) low lube oil level;
- b) low jacket water level;
- c) underspeed, it is recommended to open generator circuit only and leave engine running to facilitate system recovery;
- d) vibration, for generators 250 kW and larger;

- e) high lube oil temperature;
- f) undervoltage, for generators 500 kW and larger, it is recommended to open generator circuit only and leave engine running to facilitate system recovery;
- g) underfrequency, for generators 500 kW and larger, it is recommended to open generator circuit only and leave engine running to facilitate system recovery;
- h) loss of excitation, for generators 950 kW or larger or units that are to be paralleled;
- i) generator differential, for generators 950 kW or larger;
- j) overfrequency, for generators 500 kW or larger.

### **5.2.6 Gas Turbine Controls**

**5.2.6.1** Automatic controls shall be provided to shut down gas turbines that are driving generators and open the generator circuit breakers when any of the following conditions occur:

- a) fail to crank, fail-to-start, fail to ignite;
- b) high running exhaust temperature;
- c) high lube oil temperature;
- d) low lube oil pressure;
- e) underspeed;
- f) overspeed, shutdowns should operate independently of governor controllers and should not be set more than 115 % of rated speed;
- g) vibration;
- h) Overvoltage, and for generators 500 kW and larger, it is recommended that overvoltage shutdown controls be provided and that generator circuit breakers be tripped and voltage regulators be de-energized;
- i) high bearing temperature;
- j) high Inlet air filter differential pressure.

**5.2.6.2** Optional shut-down controls include:

- a) overfrequency, for generators 500 kW and larger;
- b) loss of excitation, for generators 950 kW and larger or units that are to be paralleled;
- c) generator differential for generators 950 kW and larger;
- d) undervoltage, and for generators 500 kW and larger, it is recommended to open generator circuit only and leave engine running to facilitate system recovery;



e) underfrequency, and for generators 500 kW and larger, it is recommended to open generator circuit only and leave engine running to facilitate system recovery.

## **5.2.7 Governors**

The prime-mover governor performance is critical to satisfactory electric power generation in terms of constant frequency, response to load changes, and the ability to operate in parallel with other generators. Three basic types of governors are discussed below.

### **5.2.7.1 Mechanical Governors**

The mechanical-type governor has the slowest response to load changes and provides the least accuracy in speed control, and, therefore, should be considered only for small generator units where close frequency control is not required. It is not suitable for continuous parallel operation.

### **5.2.7.2 Hydraulic-mechanical Governors**

The hydraulic-mechanical governor provides fast response to load changes and close speed control. This governor can be equipped with an electric motor to allow for remote speed control. The governor is adjustable to operate in either isochronous (constant speed) or droop (speed decreases with load) mode, thus allowing its use for continuous parallel generator operation.

### **5.2.7.3 Electronic Governors**

**5.2.7.3.1** The electronic analog or digital governor system provides the highest accuracy and fastest response. It senses engine speed from either the frequency of the generated voltage or a magnetic pickup installed on the engine.

**5.2.7.3.2** Automatic load sharing control and automatic synchronization can be incorporated with this type governor and is desirable for multi-unit continuous parallel operation. Generally, load sharing controls for paralleled units ensure that each online generator delivers its proportionate share of total load. Proportionate share is determined according to the nameplate ratings of each online generator.

### **5.2.7.4 Governor—General Requirements**

**5.2.7.4.1** The steady state speed variation should not exceed 0.5 % (e.g. 0.3 Hz for a 60 Hz machine) of rated speed at any load condition.

**5.2.7.4.2** Each prime mover should be under control of a governor capable of limiting the speed, when full load is suddenly removed, to a maximum of 110 % of the rated speed.

**5.2.7.4.3** For emergency generators, the prime mover and regulating governor shall be capable of assuming the sum total of all emergency loads upon closure to the emergency bus. The response time and speed deviation shall be within 5 seconds and 10 % respectively for 50 % load steps.

## **5.2.8 Starting Systems**

Electric motor, compressed air and natural gas pneumatic motor, and hydraulic motor starters are available for both reciprocating engines and small-to-medium-sized gas turbines. All three types of starters may be safely used in hazardous (classified) locations, provided that electric starter systems are approved for the area. It is recommended that engine-starting batteries not be used for control system power because of a potentially significant voltage drop during and immediately following cranking.

## **5.2.9 Fuel Systems**

A fail-closed fuel shut-down valve should be provided on natural gas-fueled prime movers. An air intake shut-off valve should be installed on diesel-fueled prime movers. These valves would be operated under emergency conditions that require prime mover/generator shutdown as identified by a SAFE Chart analysis performed in accordance with API 14C.

## **5.2.10 Ignition Systems**

For prime movers installed in hazardous (classified) locations, ignition systems should be designed and installed to minimize the possibility of the systems being a source of ignition to surrounding flammable gases. All engines with electrical ignition systems should be equipped with a system designed to minimize the potential for the release of sufficient electrical energy to cause ignition of an external, ignitable mixture. Systems verified by a Nationally Recognized Testing Laboratory (NRTL) as suitable for hazardous (classified) locations are recommended. Reference ANSI/ISA- 12.20.01 *General Requirements for Electrical Ignition Systems for Internal Combustion Engines in Class I, Division 2 or Zone 2, Hazardous (Classified) Locations*. Breaker point distributor-type ignition systems should not be used in areas classified as Class I, Zones 0, 1, or 2, by API 505. All wiring should be minimized in length; kept in good condition, clean, clear of hot or rubbing objects; suitable for the voltage; and suitable for the ambient temperature. Supplemental mechanical protection of the wiring (metallic or nonmetallic) is not required.

## **5.3 Generators**

### **5.3.1 General**

Electric generators should be designed to perform in accordance with NEMA Standards Publication MG1. Generators used offshore normally are three-phase, except for small systems that serve only single-phase loads. It is recommended that API/ANSI 546 be considered for the design and testing of medium voltage generators: For testing of synchronous generators, IEEE Std 115 may also be referenced.

### **5.3.2 Selection and Sizing**

#### **5.3.2.1 Sizing**

Generators are designed to carry full nameplate rating in kilowatts (kW) provided the nameplate kilovolt ampere (kVA) rating is not exceeded. Generators normally are rated for 0.8 power factor (power factor = kW/kVA) at sea level. Air-cooled units are designed to operate in 40 °C (104 °F) ambient conditions. Generators operated in ambient temperatures in excess of 40 °C (104 °F), such as in unit enclosures, should be properly derated. Where generators are totally enclosed and water cooled (TEWAC), the generator should be designed to operate at the maximum site cooling water temperature. The generator station rating should be at least equal to the highest expected system operating load. It is recommended that each generator should be at least equal to the driver output. A generator operated in excess of its continuous rating will experience a significant reduction in life. If the system load has a large motor or a group of motors starting simultaneously, an analysis of the voltage dip during starting should be performed. It is recommended that this analysis be performed when the total horsepower of the motors being started simultaneously exceeds 20 % of the generator nameplate kVA rating. The generator prime mover rating may also need to be increased to be able to accelerate motor(s) to rated speed. Techniques such as soft starting (e.g. reduced voltage autotransformer starters, electronic soft starters, and adjustable speed drives) may be utilized to reduce the required capacity of generators when motor starting is of concern.

#### **5.3.2.2 Load Analysis**

It is recommended that a load analysis be performed to determine the aggregate power requirements of all the electric power consuming devices under the various operating conditions of the facility. Operating load factors should be determined for each individual item of equipment and for conditions of operation. The minimum power requirement is of special importance when diesel-engine prime movers are used to avoid excessive maintenance due to the

operation of engines at light loads for long time periods. It is recommended that the load analysis be documented and retained for later review (e.g. by the AHJ or engineering).

### **5.3.2.3 Frequency**

Generators used offshore in North America are normally 60-Hertz design. Outside this region, generators may be 60 or 50 Hertz design depending on the location.

### **5.3.2.4 Voltage**

Generator design voltage normally matches the majority of the load requirements or is selected for a higher voltage when standard ampacity or short circuit ratings of switchgear at the load voltage are exceeded. The following are recommended system design voltages for 60 Hertz systems: 120/240 Volt single-phase, and 208Y/120, 480, 480Y/277, 600, 2400, 4160, 6900, and 13,800 Volt three-phase. When using a 50 Hertz system, care should be taken to maintain the V/Hz ratio of the original equipment design.

### **5.3.2.5 Generator Design**

**5.3.2.5.1** Revolving field, brushless-type generators are recommended to eliminate all arcing contacts and to reduce maintenance requirements. The use of permanent magnet exciters should be considered. If a residual magnetism-type exciter is used, it should have capability of voltage buildup after 2 months without operation. It is recommended that generators have a design temperature rise of 80 °C (176 °F), by resistance, (NEMA Class B), but be constructed with a minimum of NEMA Class F insulation to provide optimum balance between initial cost and long-life operations. Generators normally are designed for 40 °C (104 °F) ambient temperatures, and thus should be derated in accordance with manufacturer's recommendations if operated in higher ambient temperatures. Insulation of generator windings with quality insulation materials that are designed to be resistant to the salt laden moist atmosphere at offshore locations is recommended. Open, drip-proof generators normally are acceptable, particularly if the generators are installed in buildings or other enclosures that prevent direct exposure to outdoor conditions. Totally enclosed generators will provide optimum protection of windings in outdoor installations. Space heaters should be considered to help keep windings dry when machines are not operating. It is extremely important for reliable operation that space heaters be adequately sized. If a generating station is to be totally shut down for extended periods of time, it is good practice to provide some means of drying the stator windings prior to restarting to avoid generator damage.

**5.3.2.5.2** Special evaluation of winding geometry should be considered if dissimilar machines are to be paralleled. Equipment manufacturers should be consulted for equipment compatibility.

**5.3.2.5.3** Design temperature ratings for generators are based on the maximum insulation system temperature at the hottest spot as follows:

- a) Class B (130 °C, 266 °F);
- b) Class F (155 °C, 311 °F);
- c) Class H (180 °C, 356 °F).

This is referred to as the total temperature rating and consists of the ambient temperature plus a temperature rise plus hot spot allowance.

**5.3.2.5.4** Generators should be designed and specified on total temperature rating, including ambient temperature, temperature rise, and any hot spot allowance. The user should provide the necessary information to the manufacturer so the generator can be properly designed. In some cases, a generator based on the industry standard 40 °C (104 °F) ambient temperature may be used or specified. In these cases, the machine should be derated in accordance with manufacturer's recommendations for operating at higher ambient temperatures.

**5.3.2.5.5** The rotor insulation shall have Class F (155 °C, 311 °F) total temperature rating and operate at a Class B temperature rise over a 40 °C (104 °F) ambient temperature. For longer rotor life, a Class H (180 °C, 356 °F) insulation system operated at a Class B rise could be considered.

**5.3.2.5.6** It is recommended that all form-wound coils for ac generators utilize vacuum-pressure impregnated solvent-less epoxy insulation systems. It is recommended that after final cure, the windings shall be given an anti-fungal treatment. Vacuum-pressure impregnated solvent-less polyester insulation systems is acceptable for generator rewind and repair applications.

**5.3.2.5.7** Generators exposed to weather should be totally enclosed with either air to air cooled (TEAAC), totally enclosed air to water (TEWAC), or provided with an IP 56 enclosure. Where TEWAC enclosures are used on generators, they shall be of double tube construction and be equipped with leak detection.

**5.3.2.5.8** The generator winding shall be capable of withstanding, without mechanical damage, for 30 seconds, a bolted three-phase and phase-to-ground short-circuit at its terminals when operating at the highest capability kVA, rated power factor, and at 5 % overvoltage.

**5.3.2.5.9** The windings shall also be capable of withstanding, without damage, any other short-circuit at its terminals of 30 seconds duration or less, provided the machine phase currents under fault conditions are such that the negative sequence current ( $I_2$ ) expressed in terms of per unit stator current at highest capability kVA, and the duration of the fault in seconds ( $t$ ) are limited to values, which given by the integrated product of  $(I_2)^2 t$  (negative phase sequence current squared times time), is equal to or less than 40.

**5.3.2.5.10** The generator shall be capable of withstanding for 10 seconds, without damage, an excitation level in the field winding corresponding to a fault current of 300 % of design full load current in addition to associated short-circuit heating and forces in the armature winding.

### **5.3.3 Voltage Regulators**

**5.3.3.1** Solid state voltage regulators are recommended for high reliability, long life, fast response and stable regulation.

**5.3.3.2** At least one voltage regulator shall be provided for each generator. Voltage regulation should be automatic and should function under steady state load conditions between 0 % and 100 % load at all power factors that can occur in normal use. Voltage regulators should be capable of maintaining the voltage within the range of 97.5 % to 102.5 % of the rated voltage at steady state. A means of adjustment should be provided for the voltage regulator circuit.

**5.3.3.3** Under motor starting or short-circuit conditions, the generator and voltage regulator together with the prime mover and excitation system should be capable of maintaining short-circuit current of such magnitude and duration as required to properly actuate the associated electrical protective devices. This shall be achieved with a value of not less than 300 % of generator full-load current for a duration of 2 seconds, or of such additional magnitude and duration as required to properly actuate the associated protective devices.

**5.3.3.4** For single-generator operation (no reactive droop compensation), the steady state voltage for any increasing or decreasing load between zero and full load at rated power factor under steady state operation should not vary at any point more than  $\pm 2.5$  % of rated generator voltage. For multiple units in parallel, a means should be provided to automatically and proportionately divide the reactive power between the units in operation.

**5.3.3.5** Under transient conditions, when the generator is driven at rated speed at its rated voltage, and is subjected to a sudden change of symmetrical load within the limits of specified current and power factor, the voltage should not fall below 80 % nor exceed 120 % of the rated voltage. However, it is recommended to limit the motor starting voltage drop to 15 %. The voltage should then be restored to within  $\pm 2.5$  % of the rated voltage in not more than 2.0 seconds.

**5.3.3.6** For two or more generators with reactive droop compensation, the reactive droop compensation should be adjusted for a voltage droop of no more than 4 % of rated voltage for a generator.

**5.3.3.7** Where two or more generators are arranged to operate in parallel, it is recommended that isochronous kilowatt load sharing governors or controllers and voltage regulators with reactive differential compensation capabilities or cross current compensation be provided. Care should be taken if operating machines in parallel to ensure that the system minimum load does not decrease and cause a reverse power condition.

**5.3.3.8** Where power electronic devices (such as adjustable speed drives, soft starters, and switching power supplies) create measurable waveform distortions (harmonics), means should be taken to avoid malfunction of the voltage regulator, e.g. by conditioning of measurement inputs by means of effective passive filters.

**5.3.3.9** Power supplies and voltage sensing leads for voltage regulators should be taken from the generator side of the generator circuit breaker. Short-circuit protection should be set at no less than 500 % of the transformer rating or interconnecting wiring ampacity, whichever is less. It is recommended that a means be provided to disconnect the voltage regulator from its source of power.

#### **5.3.4 Protective Devices**

##### **5.3.4.1 General**

Unless specifically noted for the generator protection, all protection functions may be included in one multi-function relay or several single function relays or any combination of multi-function and single function relays as deemed appropriate for the application. Generator decrement should be considered when determining the overcurrent settings. For additional information on generator protection and grounding schemes, refer to IEEE Std C37.102-2006, *Guide for AC Generator Protection*, and IEEE Std 242-2001, *Recommended Practices for the Protection and Coordination of Industrial and Commercial Power Systems*.

##### **5.3.4.2 Overload and Short Circuit**

**5.3.4.2.1** It is recommended that generators be protected with molded case or power circuit breakers. If a power circuit breaker is used, the use of short time and long time breaker trips is recommended to permit better coordination with other breakers or fuses in the distribution system. The overcurrent trip setting should not exceed 115 % of the generator full load current. To reduce the probability of damage to unprotected cabling, the cable length between the generator and power circuit breakers with integral current transformers should be minimized and the cable routing should be designed to reduce the possibility of mechanical damage. Current transformers, if provided, for the power circuit breaker should be on the neutral side of the generator to detect faults inside the machine especially where differential relaying is not used.

**5.3.4.2.2** If a molded case circuit breaker is used, a circuit breaker rated for continuous operation at 100 % of its trip rating (i.e. a 100 % rated breaker as opposed to a standard (80 % rated) molded case breaker) will allow full utilization of the generator nameplate capacity.

**5.3.4.2.3** The use of series boost equipment or a permanent magnet generator (PMG) should be considered to provide adequate short circuit current for proper operation of the breaker during fault conditions.

**5.3.4.2.4** In generating stations with two or more units not intended to be operated in parallel, generator circuit breakers should be electrically or mechanically interlocked to prevent accidental out-of-phase paralleling. Molded case circuit breakers may be used for single or parallel operation; however, for larger sized units that will be paralleled, power circuit breakers are recommended because of their faster operating speed and greater flexibility.

**5.3.4.2.5** It is recommended that circuit breakers equipped with instantaneous trip devices or instantaneous elements on overcurrent relays not be used on single generators or two generators operated in parallel or generators that have differential protection. When differential protection is not provided, it is recommended that instantaneous breaker trips be used on generators that normally operate in parallel with three or more other generators. To ensure proper coordination the instantaneous trip setting should be above, but as close as practicable to, the maximum asymmetrical short circuit current available from any one generator.

**5.3.4.2.6** Interrupting capacity of circuit breakers should be adequate to interrupt available fault current, considering short circuit current magnitude and power factor (reference ANSI C37.06, IEEE C37.13, and UL 489). The available fault current should be re-evaluated when additional generating capacity is added to an existing system.

#### **5.3.4.3 Reverse Power**

When two or more generators are to operate continuously in parallel, each unit should be provided with a reverse power relay to trip the generator breakers in the event of reverse power flow. The prime mover may be left running to facilitate a quick restoration of electrical power.

#### **5.3.4.4 Undervoltage and Overvoltage Sensing Devices**

Undervoltage and overvoltage sensing devices with time delay trips should be considered for protection of the electrical system. The prime mover control system or an undervoltage trip device should open the generator main circuit breaker when the prime mover is shut down.

#### **5.3.4.5 Underfrequency and Overfrequency Sensing Devices**

Underfrequency and overfrequency sensing devices with time delay trips should be considered for protection of electrical systems.

#### **5.3.4.6 Synchronizing Controls**

It is recommended that the controls of generators intended to be paralleled be equipped with:

- a) Synchroscopes or synchronizing lights, or both, to show when generators are in phase. A synchroscope provides more accurate indication of phase relationship and should be considered in most applications for smoother switching operations. The synchronizing indicators should be visible from the speed and voltage setting controls.
- b) A synchronizing check relay in the breaker closing circuit of electrically operated circuit breakers to prevent out-of-phase paralleling. Consideration should be given to the installation of automatic synchronizing controls on units greater than 250 kW. Consideration should be given to connecting the synch check relay to one phase and the automatic synchronizer to another phase. This helps to ensure proper phase rotation.
- c) Interlocking controls to assure that all other generator circuit breakers for non-operating generators and incoming feeders are open when an oncoming generator breaker is closed on a dead bus. Dead bus schemes should include both bus voltage sensing and breaker position sensing to provide a redundant interlock.
- d) Synchronizing Controls shall include voltage comparison on units greater than 250kW.

#### **5.3.4.7 Ground-fault Detection**

**5.3.4.7.1** When the electrical system is ungrounded, a ground-fault indication system is recommended.

**5.3.4.7.2** When the electrical system is high resistance grounded, a ground-fault alarm is required. For systems up to and including 4160 Volts, automatic tripping devices are not required if the system insulation (e.g. cable, motors, transformers, etc.) is rated for the increased voltage during ground fault conditions (i.e. 173 % rated). For high resistance grounded systems greater than 4160 Volts, ground fault protective devices should be provided to open the generator circuit breaker if coordinated downstream devices do not clear the fault.

**5.3.4.7.3** When the electrical system is low resistance grounded, ground fault protective devices should be provided to open the generator circuit breaker if coordinated downstream devices do not clear the fault.

**5.3.4.7.4** When the electrical system is solidly grounded and the main generator protective device is rated 1000 amperes or greater, ground fault protective devices should be provided to open the generator breaker if coordinated downstream devices do not clear the fault. Consideration should be given to providing ground fault protection for generators with protective devices rated less than 1000 amperes.

NOTE For additional information on generator protection and grounding schemes, refer to IEEE Std 141, 142 and 242.

#### **5.3.4.8 Control Voltage**

For personnel safety, it is recommended that control voltage for generator instrumentation be nominal 120 Volts AC or less. The use of a dedicated battery for DC control voltage or capacitors for AC trip units is recommended for the circuit breaker trip coils on power breakers to ensure trip voltage availability.

#### **5.3.4.9 Special Considerations**

**5.3.4.9.1** For generators 1000 kVA and larger or with voltage ratings greater than 600 Volts, the following protective relaying should be considered in addition to (or in lieu of) the minimum relaying listed above.

**5.3.4.9.2** Induction disc, static or microprocessor type protective relays with self diagnostics are recommended to operate generator circuit breakers. Microprocessor type relays provide greater flexibility in setting and are easily tested.

**5.3.4.9.3** Voltage restraint or voltage control overcurrent relays (function 51V).

**5.3.4.9.4** Instantaneous current differential relays to detect internal generator faults (function 87).

**5.3.4.9.5** Reverse VARs or loss of excitation (loss of field) relays on paralleled units (function 40).

**5.3.4.9.6** Ground-fault time-overcurrent relay (function 51G or 51N).

**5.3.4.9.7** Negative phase sequence overcurrent relay for protection against unbalanced current (function 46).

**5.3.4.9.8** Stator winding temperature relay (function 49).

**5.3.4.9.9** Voltage balance relay on machines greater than 3000 kW, where a separately derived power source is feeding the voltage regulator. This relay may be used to block the misoperation of protective functions (e.g. 32, 40, and 51V) and protect the system from generator voltage regulator runaway (function 60).

**5.3.4.9.10** Inadvertent or accidental energizing protection may be included to protect the machine from accidental energization when the generator is off-line (function 27/50).

**5.3.4.9.11** For large or critical generation application, also consider the following protection: overexcitation (function 24, V/Hz), breaker failure (function 62BF or 50BF), rotating field ground fault (function 64F), stator ground fault differential (function 87N).

**5.3.4.9.12** Where applicable, consider trip coil supervision.

#### **5.3.4.10 Multiple Unit Stations**

When a shutdown is initiated, it is recommended that in multiple unit stations, the generator main circuit breaker or contactor be opened by either the prime mover shutdown system or the generator control panel.

#### **5.3.5 Metering**

##### **5.3.5.1 Nonparallel Operation**

Minimum metering should include an ammeter (with a selector switch to meter all phases), a voltmeter, and a frequency meter. A voltmeter selector switch (to provide metering of all phases), a running time meter, a power factor meter, and a wattmeter are optional.

##### **5.3.5.2 Parallel Operation**

In addition to the minimum metering described in 5.3.5.1, a wattmeter is necessary for continuous parallel operation. A VAR-meter and a power factor meter are optional.

### **5.4 Generator Station Packaging Considerations**

**5.4.1** A generator station may consist of one or more generating units. The following factors should be considered in designing electrical generating units or stations.

- a) Electrical equipment in generating stations shall be suitable for the area classification.
- b) For continuous power applications, a standby generator is desirable to facilitate maintenance and repair.
- c) Portable generating units for temporary service or standby units that are used only upon prime power failure usually are self-contained, skid-mounted units. Lifting frames and weather protecting enclosures are desirable.
- d) Vibration problems usually can be reduced by mounting electrical controls and metering separately from the generating unit's skid.
- e) In larger stations, it normally is desirable to locate all electrical switchgear in a separate unclassified room. Environmental control of such rooms improves reliability of the electrical switchgear equipment.
- f) The noise level of turbine driven units can be reduced by providing an enclosure for each unit or by locating units in separate rooms.
- g) Adequate space should be provided for maintenance and repair.
- h) The installation of fire and gas detection systems should be considered for enclosed generator units.

### **5.5 Switchboards**

#### **5.5.1 Scope**

The scope of this section includes: switchboards, metal-enclosed switchgear, metal enclosed low voltage power circuit breaker switchgear, and metal-clad switchgear.



## 5.5.2 Definitions

### 5.5.2.1

#### **switchboard**

A metal-enclosed panel or assembly of panels that may contain molded case, insulated case or power circuit breakers, bolted pressure contact or fusible switches, protective devices, and instruments. These devices may be mounted on the face or the back of the assembly. Switchboards are generally accessible from the rear as well as from the front; however, they can be front accessible only.

### 5.5.2.2

#### **metal-enclosed switchgear**

A switchgear assembly completely enclosed on all sides and the top with metal (except for ventilating openings and inspection widows) containing primary power circuit switching or interrupting devices, or both, with buses and connections. The assembly may include control and auxiliary devices. Access to the interior of the enclosure is provided by doors, removable covers, or both.

### 5.5.2.3

#### **metal-enclosed low voltage power circuit breaker switchgear**

A switchgear assembly that contains either stationary or withdrawable low voltage power circuit breakers for use on low voltage systems with a maximum rating of 635 VAC or 3200 VDC.

### 5.5.2.4

#### **metal-clad switchgear**

A switchgear assembly that contains medium voltage, withdrawable electrically operated power circuit breakers. Barriers and shutters are required when the circuit breakers are withdrawn. Insulated bus is required throughout. The maximum voltage rating is 38 kV.

## 5.5.3 General

**5.5.3.1** Switchgear and switchboards should be arranged to provide convenient and safe access to qualified personnel to operate and perform maintenance on all electrical apparatus and equipment. Switchgear and switchboards should be provided with working space in accordance with this RP. Switchboards operating at a root-mean-square (RMS) voltage less than 1000 Volts should meet the requirements of UL Std 891 for dead-front switchboards or ANSI C37.20.1 or UL 1558 for low voltage metal enclosed power circuit breaker switchgear. Switchgear operating at 1000 Volts or more should comply with ANSI C37.20.2. for metal-clad switchgear.

**5.5.3.2** The sides, rear, and front of switchgear and switchboards should be suitably guarded and metal enclosed. Switchgear and switchboards shall be dead-front type construction.

**5.5.3.3** Electric grade non-conducting deck coverings meeting ASTM D178 (e.g. non-conducting mats) or non-conducting gratings should be provided in each working area in front of and behind switchboards.

**5.5.3.4** Consideration should be given to mitigation of electrical arc flash. This can include arc resistant switchgear, arc detection/suppression, or physical isolation of switchgear with remote operation and monitoring. See 6.11.2 for additional information for arc flash considerations.

**5.5.3.5** Switchgear and Switchboards shall have a warning label indicating potential electric arc flash hazard. Consider labeling the equipment with the potential amount of incident energy and/or the level of arc flash PPE required. Refer to NFPA 70E for calculation methods and typical examples. Refer to 6.11.2 for further information.

## 5.5.4 Bus Bars

**5.5.4.1** Generator switchgear and switchboard bus bars should be designed on a basis of maximum generator rating. Each bus and each bus connection should be rated for the maximum current to which it can be subjected.

**5.5.4.2** Bus bars should be sized for a maximum temperature rise of 65 °C (149 °F) over a 40 °C (104 °F) ambient.

**5.5.4.3** Copper bar is recommended for all bus. Consideration should be given to provide an insulated covering over busbars to minimize corrosion and arc flash.

**5.5.4.4** All generator and feeder circuits supplied by the switchgear and switchboard should have overcurrent protection. Bus and wiring connections should be accessible and it is recommended that locking devices be utilized on bus connections to prevent loosening due to vibration.

**5.5.4.5** It is recommended that instrument and control wiring be Type TBS, or SIS stranded copper, Class C or better, minimum wire size No. 14 AWG. All wiring should meet the flame-retardant requirements of UL 83 or UL 44 and, if used on a hinged panel, should be extra flexible.

**5.5.4.6** Each device should have a nameplate showing the device's function. Each interrupting device including power circuit breakers should have a nameplate showing the electrical load served and the continuous rating of the interrupting device.

**5.5.4.7** The secondary winding of each instrument transformer, both potential and current types, should be grounded. All doors and hinged panels on which electrical devices are mounted should be grounded with a ground wire of minimum size No. 14 AWG. The metal cases of all instruments, relays, meters, and instrument transformers should be grounded.

**5.5.4.8** Terminals for systems of different voltage should be separate from each other and the applicable voltages should be clearly marked.

## **5.5.5 Arrangement of Equipment**

**5.5.5.1** Low voltage (600 Volt and less) air power circuit breakers should meet ANSI C37.13. Low voltage power circuit breakers with proper insulation barriers may be installed in switchboards per UL-891 or in low voltage switchgear per ANSI C37.20.1. Low voltage molded case circuit breakers should meet the requirements of UL 489 and installed in suitable metal enclosed structures meeting the requirements of UL 891.

**5.5.5.2** Medium voltage (601 Volts to 34.5kV) power circuit breakers should be vacuum or SF6 and be rated in accordance with ANSI C37.04. Metal-clad switchgear including medium voltage power circuit breakers should comply with the requirements found in ANSI C37.20.2.

**5.5.5.3** All voltage regulator elements should be provided with enclosing cases to protect them from damage. All fuses, except those protecting instrument and control circuits, should be mounted on or be accessible from the front of the switchboard. It is recommended that components and fuses in circuits operating at voltages greater than 220 VAC be installed in a dead front manner to minimize the likelihood of accidental electric shock. Consideration should be given to using fuses, terminals and other electrical devices over 50 Volts that provide finger safe protection from voltage exposure either by guard or design. This includes such devices as pull out fuse blocks, tilt out fuses and draw out components.

**5.5.5.4** Two or more potential transformers should be provided to supply 120V 3Ø for generator metering. Voltage Transformers (VTs, also known as PTs) should be metering class (ANSI C57.13 Group1) and sized to operate within the rated accuracy limits. PTs should be provided with time delay primary and secondary fuses. Systems with two PT's should be connected in an open delta corner grounded configuration.

**5.5.5.5** Three Current Transformers (CTs) should be provided to supply 5A 3Ø for generator metering. CTs should be metering class (ANSI C57.13 Group1) and sized to operate within the rated accuracy limits. CTs should be wired with #12 AWG minimum wire using ring tongue terminals. CT circuits should be wired through shorting type terminal blocks.

## 5.6 Special Requirements for Floating Facilities

### 5.6.1 Prime Movers

Prime movers should meet 46 *CFR* Subpart 58.10. Additionally, turbines should meet applicable ABS *Steel Vessel Rules*, Part 4, Chapter 2, Section 3 (reproduced as Annex B for the convenience of the reader) or to the requirements of other classification societies (e.g. Lloyd's Register and Det Norske Veritas) acceptable to the AHJ.

### 5.6.2 Generators

Generators should meet the construction and test requirements of ABS *Steel Vessel Rules*, Part 4, Chapter 8, Section 3 (reproduced as Annex B for the convenience of the reader) or the requirements of other classification societies (e.g. Lloyd's Register and Det Norske Veritas) acceptable to the AHJ.

### 5.6.3 Emergency Power Systems

**5.6.3.1** Floating facilities shall be furnished with an emergency power system designed for a minimum of 18 hours of continuous operation.

**5.6.3.2** An emergency switchboard, powered from the emergency power source, should be provided. The emergency switchboard should be located in a space separate and remote from the main switchboard. The emergency switchboard should be located in the same space as the emergency power source, in an adjacent space, or as close as practical. Unless an independent source of battery power is provided, the following loads should be arranged so that they can be energized from the emergency power source.

- a) Navigation lights, if operated from AC voltage.
- b) An adequate number of lighting fixtures in machinery spaces (rooms) to allow essential operations and observations under emergency conditions and to allow restoration of service.
- c) Emergency and exit lighting fixtures.
- d) An adequate number of lighting fixtures to allow safe operation of power-operated water-tight doors.
- e) An adequate number of lighting fixtures to allow the safe launching of survival craft—including muster stations, embarkation stations, survival craft, launching appliances for launching craft, and the area of the water where the crafts are to be launched.
- f) All electrical communication systems that are necessary under emergency conditions and that do not have an independent battery source of power.
- g) All power operated water-tight door systems.
- h) All fire and smoke detection, suppression and extinguishing systems.
- i) All combustible and toxic gas detection systems.
- j) All lighting relative to helicopter operations and landing.
- k) The general alarm system.
- l) All machinery, controls, and alarms for passenger elevators.

- m) All permanently installed battery chargers servicing equipment that is required to be powered from the emergency source.
- n) A sufficient number of bilge pumps to maintain safe operations during emergency conditions.
- o) A sufficient number of fire pumps to maintain adequate fire fighting water pressure. Fire pump requirements can be satisfied by other means, such as engine-driven pumps.
- p) Electric blow-out-preventer controls.
- q) Ballast control systems as necessary to maintain safe operation during emergency conditions.
- r) Permanently installed diving equipment that is dependent on the facility for its source of power.
- s) Emergency generator starting compressors, lube oil pumps, lube oil heaters, jacket water heaters and space heaters.
- t) Control systems for all equipment that is required for emergency operations.

#### **5.6.4 Emergency Power Distribution System**

**5.6.4.1** The emergency switchboard should be supplied during normal operation from the main switchboard by an interconnecting feeder. This interconnecting feeder should be protected against short circuit and overload at the main switchboard and, where arranged for feedback, short circuit at the emergency switchboard. The interconnecting feeder should be disconnected automatically at the emergency switchboard upon failure of the main source of electrical power.

**5.6.4.2** The power from the facility generating plant for the emergency loads should be supplied to the emergency loads by an automatic transfer device or system located remotely from the main switchboard.

**5.6.4.3** Upon interruption of normal power or if there is a voltage drop (excluding power system transients or normal motor starting activity) of the normal source (device setting allowed between 15 % to 40 %), the prime mover driving the emergency power source should start automatically. When the voltage of the emergency source reaches 85 % to 95 % of nominal value, the emergency loads should transfer automatically to the emergency power source. The transfer to emergency power should be accomplished within 45 seconds after failure of the normal power source.

**5.6.4.4** All non-emergency loads (and the interconnection feeder when the system is arranged for feedback operation) should be automatically disconnected at the emergency switchboard upon detection of 95 % of full load current of the emergency generator to prevent an overload condition.

**5.6.4.5** For ready availability of the emergency source of electrical power to emergency loads, arrangements should be made where necessary to disconnect automatically nonemergency loads from the emergency switchboard upon loss of facility normal power.

#### **5.6.5 Emergency Generators**

**5.6.5.1** Emergency generator should be sized to supply 100 % of connected loads that are essential for safety in an emergency condition. Where redundant equipment is installed so that not all loads operate simultaneously, these redundant loads need not be considered in the calculation.

**5.6.5.2** The prime movers of generators should be provided with all accessories necessary for operation and protection of the prime mover, including a self-contained cooling system that ensures continuous operation in an ambient temperature of at least 45 °C (113 °F).

**5.6.5.3** Any liquid fuels used should have a (closed cup) flash point of 43 °C (110 °F) minimum.

**5.6.5.4** Emergency generators should be capable of carrying full rated load within 45 seconds after loss of the normal power source with the intake air, room ambient temperature, and starting equipment at a minimum of 0 °C (32 °F). Except for a thermostatically controlled electric water-jacket heater connected to the emergency bus, generator prime movers should not require a starting aid to meet this requirement.

**5.6.5.5** Generators should start by hydraulic, compressed air, or electrical means.

**5.6.5.6** Generators should maintain proper lubrication and not spill oil when inclined 30 degrees to either side of the vertical.

**5.6.5.7** Generator sets should shut down automatically upon loss of lubricating oil pressure, overspeed, or operation of a fixed fire extinguishing system in the emergency generator room.

**5.6.5.8** Diesel fueled engines should be provided with an audible alarm that sounds on low oil pressure and high cooling water temperature.

**5.6.5.9** Gas turbines should meet the shutdown and alarm requirements in 5.2.6.

**5.6.5.10** An independent fuel supply should be provided for prime movers. For liquid fueled prime movers, a fuel tank sized for 18 hours of full load operation will satisfy this recommendation.

**5.6.5.11** Each emergency generator should be equipped with a dedicated starting device with an energy-storage capability of at least six consecutive starts, three automatic and three manual. A second, separate source of starting energy may provide three of the required six starts. Except for the starting air compressor, the starting, charging, and energy storing devices should be in the emergency generator room.

**5.6.5.12** Hydraulic starting systems should be provided with a means for manual recharge. A hand-powered pump will satisfy this recommendation.

**5.6.5.13** The starting air receiver for compressed air starting systems should be supplied from one of the following sources of air:

**5.6.5.13.1** The main or auxiliary compressed air receivers with a check valve in the emergency generator room to prevent back flow of compressed air to the ship service system, and there should be a hand-cranked, diesel-powered air compressor for recharging the air receiver.

**5.6.5.13.2** If an electrically driven air compressor is automatically operated, is powered from the emergency power source, and supplies other auxiliaries, there should be a check valve at the inlet of the starting air receiver to prevent back flow of compressed air to the other auxiliaries. There should be a hand-cranked, diesel-powered air compressor for recharging the air receiver.

**NOTE** If acceptable to the AHJ, an alternative battery starting system may be provided for the diesel-powered air compressor for recharging the air receiver. The battery starting system shall be designed with an energy-storage capability of at least six consecutive starts.

**5.6.5.14** It is recommended that all emergency generators utilize permanent magnet exciters. If a residual magnetism-type exciter is used, it should have capability of voltage buildup after 2 months without operation. Automatic field flashing type exciter systems should not be used.

### 5.6.6 Switchboards

**5.6.6.1** Switchgear and switchboards subject to dripping liquids from above should have a drip shield. Optionally NEMA 12 construction may be considered. It is recommended that switchgear and switchboards on floating facilities be provided a door at each entrance to a working space and front non-conducting handrails (and rear non-conducting guardrails if the switchgear and switchboard has a rear working space). It is recommended that no piping be installed above switchboards, but, if piping is necessary, only welded or brazed joints should be used.

**5.6.6.2** Molded-case type circuit breakers installed in generator or distribution switchboards should be mounted or arranged such that the circuit breakers can be removed from the front without first unbolting bus or cable connections or de-energizing the supply.

**5.6.6.3** The switchgear and switchboards, and the associated bus bars, circuit breakers, and enclosed equipment, shall be designed for temperature extremes and conditions expected. The following temperature rise and ambient temperature values should be used:

- a) 65 °C (149 °F) rise, 40 °C (104 °F) ambient in accommodation areas, and similar spaces;
- b) 65 °C (149 °F) rise, 45 °C (113 °F) ambient in main and auxiliary machinery spaces;
- c) 50 °C (122 °F) rise, 50 °C (122 °F) ambient for rotating machinery and propulsion equipment in main and auxiliary machinery spaces containing significant heat sources such as reciprocating or turbine engines.

## 6 Electrical Distribution Systems

### 6.1 Scope

**6.1.1** This section describes basic electrical distribution systems as applied to offshore petroleum facilities (excluding submarine cables and cathodic protection systems). Guidelines are presented for selecting conductor sizes, insulation and protective jackets for conductors, circuit protection, and wiring methods for both hazardous (classified) and unclassified locations. Recommendations are presented for circuit protection, grounding, enclosure selection and working clearances; additional requirements for floating facilities are included. Special emphasis is placed on proper conduit and cable sealing. While this section relies primarily on provisions of the *NEC*, recognition is given to proven practices in the marine and the offshore oil and gas industries.

**6.1.2** The *NEC* has evolved through careful development over a long period of time, during which time utility power systems, utility communication systems, railroad activities, mining activities and marine activities were excluded from its scope. For this reason, literal application of the *NEC* provisions to the power systems, communications, transportation and subsurface activities of the offshore drilling and producing industry may not always be practicable. Although departing from the *NEC*, this recommended practice provides a sound technical basis for the design and installation of safe and efficient electrical systems for offshore petroleum facilities.

### 6.2 Voltage Level Selection

**6.2.1** The selection of voltage level is a significant factor in the design of any power distribution system. Factors affecting voltage level selection include the following:

- a) voltage ratings of equipment to be served;
- b) distance that power is to be distributed;
- c) allowable voltage drops;

- d) magnitudes and densities of present and future loads;
- e) available voltages from other sources (such as shore power or other existing facilities).

**6.2.2** A typical offshore electrical system will consist of one or both of the voltage ranges described below:

#### **6.2.2.1 600 Volts or Less**

This voltage range is commonly used to directly supply utilization equipment, such as motors and lighting. Typical voltages utilized are 600 Volt, three-phase; 480 Volt, three-phase; 208Y/120 Volt, three-phase; and 120/240 Volt, single-phase.

#### **6.2.2.2 Greater Than 600 Volts**

This voltage range is commonly used for distribution purposes and as the utilization voltage for large motors. Common uses of this range offshore include distributing power to platforms via submarine cables and supplying large motors (typically above 200 HP). Typical voltages utilized are 2400; 4160; 6900; 13800; and 34500 volts. Some submersible pump installations require special voltages in this range.

### **6.3 Conductor Selection**

#### **6.3.1 General**

Conductor sizing in power and lighting circuits is determined by the allowable ampacity of the conductor, the wiring method, raceway selection, ambient temperatures, allowable voltage drops in the circuits, and the temperature limitations of devices to which the conductors are attached.

#### **6.3.2 Ampacity**

**6.3.2.1** The allowable ampacity is based on the maximum allowable conductor temperature which, in turn, is controlled by the temperature rating of the insulation.

**6.3.2.2** The allowable ampacities for low voltage copper conductors shall be determined by one of the following methods:

- a) Ampacities as given in *NEC* Article 310.15(B). The tables in *NEC* Article 310 as well as the accompanying notes and correction factors should be used.
- b) Under engineering supervision, conductor ampacities may be calculated in accordance with *NEC* Article 310.15(C).
- c) For NRTL-listed marine shipboard cables, ampacities for low voltage cables shown in Table 2 and Table 3 should be used.
- d) For critical circuit cables (see 6.7.8) using 27 % nickel coated copper conductors, ampacities for low voltage applications are given in Table 2A. Alternate conductor compositions with similar performance may be used with the manufacturer's ampacity limits. For critical circuit cables (see 6.7.8) using copper or tinned copper conductors, ampacities should be determined using the tables in *NEC* Article 310 or Table 2 and Table 3 as appropriate.

**6.3.2.3** For medium voltage cables, ampacities at various conductor temperatures are given in Table 4, Table 5, and Table 6.

**6.3.2.4** Termination considerations are also a limiting factor in the ampacity selection of conductors (see 6.3.5).

### Capacity Based on 45 °C (113 °F) Ambient

[illegible]



**Table 2A—Allowable Ampacities of Insulated Nickel Coated Copper Conductors (27 % Nickel) Rated 0 Through 2000 Volts, 75 °C (140 °F), Not More Than Three Current-Carrying Conductors in Raceway, Cable Maximum Current-carrying Capacity Based on 45 °C (113 °F) Ambient**

AWG	mm <sup>2</sup>	Circular Mils	Nickel Coated Copper conductor (27 % Nickel) Ampacity
			75°C
18	0.82	1620	7
16	1.31	2580	8
14	2.08	4110	15
12	3.31	6530	18
10	5.26	10,380	25
8	8.37	16,510	32
6	13.3	26,240	41
4	21.15	41,740	53
2	33.62	66,360	73
1/0	53.5	105,600	98
2/0	67.44	133,100	110
4/0	107.2	211,600	147
250	126.7	250,000	168
350	177.3	350,000	205
500	253.3	500,000	254
750	380	750,000	315
1000	507	1,000,000	364
1250	633.3	1,250,000	397
1500	760	1,500,000	426
2000	1013.3	2,000,000	459

**Table 3—Ampacities for Marine Shipboard Single-conductor Distribution Cables, 2000 Volts or Less DC Only, Copper Conductors, Single-banked (Single-layered), Maximum Current-carrying Capacity Based on 45 °C (113 °F) Ambient**

Table		Single-conductor Cable			
kcmil	mm <sup>2</sup>	75 °C	90 °C	100 °C	110 °C
750	380.0	617	738	802	841
1000	506.7	747	896	964	1021
1250	633.3	865	1038	1126	1183
1500	760.0	980	1177	1276	1342
2000	1013.0	1195	1435	1557	1636

**Notes to Table 2 and Table 3—Ampacity Adjustment Factors for More Than Three Conductors  
in a Cable with No Load Diversity**

Number of Conductors				Percent of Values in Table 1 for Three-conductor Cable as Adjusted for Ambient Temperature, if Necessary		
4 through 6				80		
7 through 9				70		
10 through 20				50		
21 through 30				45		
31 through 40				40		
41 through 60				35		
1) The allowable ampacities in the tables are based on the conductor temperature rise in a given ambient. When selecting conductor sizes and insulation ratings, consideration shall be given to the following.  a) The actual conductor operating temperature shall be compatible with the connected equipment, especially at the connection points, see 6.3.5.  b) Conductor selection should be coordinated with circuit and system overcurrent and short circuit protection to avoid cable damage during through-fault conditions. Refer to ICEA P32-382 for short circuit withstand capabilities of conductors and to ICEA P45-482 for short circuit withstand capabilities of metallic shields and sheaths.						
2) Current-carrying capacity of four-conductor cables where one conductor is not a current-carrying phase conductor (e.g. neutral or grounding conductor) is the same as three-conductor cables.						
3) If ambient temperatures differ from 45 °C (113 °F), cable ampacities should be multiplied by the following factors:						
Ambient Temperature	30 °C	40 °C	50 °C	55 °C	60 °C	70 °C
75 °C rated cables	1.13	1.08	0.91	0.81	0.71	
90 °C rated cables	1.10	1.05	0.94	0.88	0.82	0.67
100 °C rated cables	1.09	1.04	0.95	0.90	0.85	0.74
110 °C rated cables	1.08	1.04	0.96	0.92	0.88	0.78
4) The current-carrying capacities are for cable installations with cables arranged in a single bank per hanger and are 85 % of the calculated free air values. For those instances where cables are double banked, the current-carrying capacities shall be decreased by multiplying the value shown by 0.8.						
5) For cables with maintained spacing of at least 1 cable diameter apart, the ampacities may be increased by dividing the values shown by 0.85.						
6) Single conductor cables sizes 1/0 and larger may be installed in a single bank triangular configuration, consisting of phases A, B, and C, and the ampacity is given in Table 2. If more than one circuit, or parallel runs of the same circuit are installed, there should be a maintained minimum spacing of 2.15 times one conductor diameter between each triangular configuration group.						

**6.3.2.5** See ICEA P32-382 to determine conductor short circuit withstand currents.

### **6.3.3 Cable Shielding Considerations for Medium Voltage Power Cables**

#### **6.3.3.1 General**

NEC 310.10(E) requires shielding on insulated conductors operated above 2000 Volts. However, non-shielded, ozone-resistant insulated conductors with a maximum phase-phase voltage of 5000 volts in type MC cable can be used.

#### **6.3.3.2 Construction**

Shielding of an electric power cable is the practice of confining the electric field of the cable to the insulation surrounding the conductor. This is accomplished by the use of a non-magnetic conductor over a semiconducting layer applied over the insulation. The metallic components of the shield are designed to carry cable-charging current.

**Table 4—Ampacities for Three-conductor Medium Voltage Power Cable, 2001 Volts to 35 kV, Copper Conductor Single-banked (Single-layered), Maximum Current-carrying Capacity Based on 45 °C (113 °F) Ambient**

AWG or kcmil	mm <sup>2</sup>	Circular Mills	Three-conductor Cable					
			Up to 8 kV Shielded		8,001 V to 15,000 V Shielded		15,001 V to 35,000 V Shielded	
			90 °C	105 °C	90 °C	105 °C	90 °C	105 °C
8	8.37	16,510						
6	13.30	26,240	75	85				
4	21.15	41,740	99	112				
2	33.62	66,360	129	146	133	150		
1	42.40	83,690	149	168	151	170	149	172
1/0	53.50	105,600	171	193	174	196	174	196
2/0	67.44	133,100	197	222	199	225	198	225
3/0	85.02	167,800	226	255	229	259	230	257
4/0	107.20	211,600	260	294	263	297	262	294
250	126.70	250,000	287	324	291	329	291	327
263	133.10	262,600	296	334	299	338	299	336
313	158.60	313,100	328	370	331	374	329	373
350	177.30	350,000	352	397	355	401	351	400
373	189.30	373,700	365	412	367	414	363	414
444	225.20	444,400	387	437	388	438	402	470
500	253.30	500,000	434	490	434	490	432	490
535	271.20	535,300	449	507	449	507	447	507
646	327.50	646,400	496	560	497	561	496	559
750	380.00	750,000	541	611	542	612	541	609
777	394.00	777,700	550	621	550	621	550	619
1,000	506.70	1,000,000	622	702	623	703	622	703

Shields can be designed to carry ground-fault current. The user should consider the ground fault current and the length of time the shield should carry this current. The conductivity of the shield is determined by the cross-sectional area and resistivity of the metal tape, braids, or wires employed in conjunction with the semiconducting layers.

### 6.3.3.3 Grounding

The shields of power cables should be solidly grounded at a minimum of one point for safety and reliable operation. If shields are not properly grounded, the voltage in the shield can elevate to near conductor potential, creating hazards to personnel as well as potential degradation of the jacket or covering.

#### 6.3.3.3.1 Single Point Grounding

Grounding at only one end will result in a voltage buildup on the shield. The magnitude of the voltage is a function of the geometry of the shielded cable installation, the phase current, and the distance from the point of grounding. Care should be taken to limit this voltage to safe levels of 25 Volts or less.

**Table 5—Ampacities for Medium Voltage Power Cable, 2001 Volts to 35 kV, Copper Conductor, Single-conductor in Triplexed or Triangular Configuration, Maximum Current-carrying Capacity Based on 45 °C (113 °F) Ambient**

AWG or kcmil	mm <sup>2</sup>	Circular Mils	Single-conductor Cable (in Triplexed or Triangular Configuration)					
			Up to 8 kV Shielded		8,001 V to 15,000 V Shielded		15,001 V to 35,000 V Shielded	
			90 °C	105 °C	90 °C	105 °C	90 °C	105 °C
6	13.30	26,240	92	106				
4	21.15	41,740	121	135				
2	33.62	66,360	159	187	164	187		
1	42.40	83,690	184	216	189	216	192	216
1/0	53.50	105,600	212	245	217	242	220	245
2/0	67.44	133,100	244	284	250	284	250	284
3/0	85.02	167,800	281	327	288	327	288	327
4/0	107.20	211,600	325	375	332	375	332	375
250	126.70	250,000	360	413	366	413	366	413
263	133.10	262,600	371	425	377	425	376	425
313	158.60	313,100	413	473	418	471	416	471
350	177.30	350,000	444	508	448	505	446	505
373	189.30	373,700	460	526	464	523	462	523
444	225.20	444,400	510	581	514	580	512	580
500	253.30	500,000	549	625	554	625	551	625
535	271.20	535,300	570	648	574	648	570	648
646	327.50	646,400	635	720	638	720	632	720
750	380.00	750,000	697	788	697	788	689	788
777	394.00	777,700	709	802	709	802	701	802
1,000	506.70	1,000,000	805	913	808	913	798	913

### 6.3.3.3.2 Multipoint Grounding

If the shield is grounded at both ends, circulating currents can exist, which can act as a heat source affecting the insulation and reducing the effective current carrying capability of the cable. This becomes significant when the shield losses exceed 5 % of the conductor losses. Grounding the shield at both ends also protects the cable shielding against induced electrical interference transients resulting from lightning, faults, and switching surges. An additional benefit derived from multipoint grounding is the division of cable ground fault current in the shield in the event of a cable or splice failure. This division of current reduces potential cable shield damage and increases the opportunity for local repairs. In the event of the loss of integrity of a ground connection, multipoint grounding affords an additional safety factor.

### 6.3.4 Voltage Drop

**6.3.4.1** Voltage drop should be considered in all cases when selecting conductor sizes, although it normally will not be the controlling factor. Conductors in branch or feeder circuits sized to prevent voltage drops exceeding 3 % will provide reasonable efficiency of operations, provided that the total voltage drop to the farthest load does not exceed 5 %. Individual motor feeders may have greater voltage drops, provided that the operating voltage is within the tolerance defined in 7.2.3. Higher voltage drops may limit the available fault currents to protective devices resulting in a circuit breaker or protective device that may not operate within the expected clearing time.

**Table 6—Ampacities for Single-conductor Medium Voltage Power Cable, 2001 Volts to 35 kV, Copper Conductor Single-banked (Single-layered), Maximum Current-carrying Capacity Based on 45 °C (113 °F) Ambient, Shields Grounded on One End (Open-circuited Shields)**

AWG or kcmil	mm <sup>2</sup>	Circular Mils	Single-conductor Cable (in Triplexed or Triangular Configuration)					
			Up to 8 kV Shielded		8,001 V to 15,000 V Shielded		15,001 V to 35,000 V Shielded	
			90 °C	105 °C	90 °C	105 °C	90 °C	105 °C
6	13.30	26,240	91	103				
4	21.15	41,740	12	135				
2	33.62	66,360	158	178	158	178		
1	42.40	83,690	182	205	182	205	178	204
1/0	53.50	105,600	210	237	210	237	205	237
2/0	67.44	133,100	242	273	241	272	236	270
3/0	85.02	167,800	279	315	278	314	271	311
4/0	107.20	211,600	324	366	321	362	315	364
250	126.70	250,000	359	405	356	402	348	400
263	133.10	262,600	370	418	366	413	358	412
313	158.60	313,100	413	466	409	462	397	459
350	177.30	350,000	444	501	440	497	425	494
373	189.30	373,700	462	522	456	515	442	513
444	225.20	444,400	515	581	508	573	495	540
500	253.30	500,000	557	629	549	620	537	617
535	271.20	535,300	580	655	571	645	557	642
646	327.50	646,400	652	736	641	724	619	720
750	380.00	750,000	720	813	706	797	678	793
777	394.00	777,700	735	830	721	814	692	810
1,000	506.70	1,000,000	859	970	842	951	806	948

### 6.3.5 Terminations

Conductors should be sized to limit conductor operating temperatures to those designated for the termination devices involved. For low voltage NRTL-listed devices, unless marked with higher temperature limits, the terminals of devices rated 100A or less typically are limited to operating temperatures of 60 °C (140 °F), and devices rated in excess of 100A typically are limited to 75 °C (167 °F). In selecting circuit conductors, the designer should assure that the actual conductor temperature does not exceed the temperature rating of the terminal device. The derating required for motor circuits and continuous loads on devices such as circuit breakers, that limits the actual current allowed in circuit wiring, can be considered when determining conductor operating temperature. Other factors such as ambient temperature within enclosures and the single conductor configuration of most terminations also can be taken into account when determining the actual conductor temperatures attainable.

### 6.3.6 DC Motor Power Conductors

For guidance in sizing cables for DC motors in drilling applications, use the following criteria, primarily extracted from the IADC *Interim Guidelines for Industrial System DC Cable for Mobile Offshore Drilling Units* (IADC-DCCS-1). This is a departure from the NEC.

**Notes to Table 4, Table 5, and Table 6**

- 1) The allowable ampacities are based on the conductor temperature rise in a given ambient. When selecting conductor sizes and insulation ratings, consideration shall be given to the following:
  - a) The actual conductor operating temperature shall be compatible with the connected equipment, especially at the connection points, see 6.3.5.
  - b) Conductor selection should be coordinated with circuit and system overcurrent and short circuit protection to avoid cable damage during through-fault conditions. See ICEA P32-382 to determine conductor short circuit withstand current.
- 2) Current-carrying capacity of four-conductor cables where one conductor is not a current-carrying phase conductor (e.g. neutral or grounding conductor) is the same as three-conductor cables.
- 3) If ambient temperatures differ from 45 °C (113 °F), cable ampacities should be multiplied by the following factors:

Ambient Temperature				
Conductor Temperature	40 °C	45 °C	50 °C	55 °C
90 °C	1.05	1.00	0.94	0.90
105 °C	1.04	1.00	0.96	0.92

- 4) Double banking of medium voltage cables is not recommended.
- 5) The current-carrying capacities are for cable installations with cables arranged unspaced in a single bank per hanger and are 85 % of the calculated free air values.
- 6) For cables with maintained spacing of at least 1 cable diameter apart, the ampacities may be increased by dividing the values shown by 0.85.
- 7) Minimum conductor size for 35 kV cable is 1/0.
- 8) Specific notes for Table 5:
  - a) Each triplexed or triangular configuration of single-conductor cable shall consist of phases A, B, and C.
  - b) If more than one circuit, or parallel runs of the same circuit, are installed, there should be a maintained spacing of 2.15 times one single-conductor cable diameter between each triplexed or triangular configuration group.
- 9) Specific notes for Table 6:
  - a) Ampacities given are based on operation with open circuited shields.
  - b) Cable lengths should be limited to maintain a shield voltage below 25 Volts. See 6.3.3.3.1
  - c) More than three conductors without maintained spacing require additional derating. For four to six conductors multiply the value in the table by 0.8. For seven to nine conductors multiply the value in the table by 0.7. Ten or more conductors require special calculation for derating.
  - d) It is recommended that single conductors be installed in a triplexed or triangular configuration, each consisting of phases A, B, and C, to reduce electrical losses and to allow for grounding of the shield on both ends without significant cable derating due to circulating current in the shield.

**6.3.6.1 Single Conductor Cable Selection**

**6.3.6.1.1** These guidelines apply to DC motors nominally rated 750 Volts DC armature voltage.

**6.3.6.1.2** The cable size shall have a current carrying capacity determined by multiplying the duty factor times the lesser of one of the following:

- a) the continuous current rating of the motor;
- b) the continuous current limit setting of the power supply.

**6.3.6.1.3** The duty factors to be used are as follows:

- a) mud pumps, cement pumps—0.80;
- b) drawworks, rotary tables—0.65;
- c) top drives, power swivels—0.8.

**6.3.6.1.4** The cables need only be sized for a maximum ambient temperature of 45 °C (113 °F).

**6.3.6.1.5** The voltage rating of the cables shall be 1000 volts minimum.

## 6.4 Wiring Methods for Hazardous (classified) Locations

### 6.4.1 General

**6.4.1.1** The purpose of this section is to provide practical guidance to the unique conditions encountered in wiring offshore petroleum facilities. Wiring methods for areas classified by API 505 and associated departures from the *NEC* are summarized in Table 7 for electrical systems typically installed on offshore facilities. This section should be used in conjunction with API 505 that provides guidance for classification of areas. In addition, the following special conditions should be considered when selecting wiring methods for Zone 1 locations.

**6.4.1.2** Most Zone 1 designated areas on offshore facilities are areas that actually do not have ignitable concentrations of gases or vapors present for any appreciable length of time. Thus, a simultaneous electrical fault and release of hazardous gases or vapors in these areas is highly unlikely.

**6.4.1.3** Except for specific applications allowed elsewhere in this document, locations that are continuously exposed to a hazardous concentration of gases or vapors (such as the vapor space within tanks and vessels containing hydrocarbons that are vented to the atmosphere) are classified as Zone 0 and shall not contain electrical equipment or wiring of any kind unless the system is specifically approved as intrinsically safe (protection technique “ia”).

**Table 7—Wiring Methods for Hazardous (classified) Locations**  
(See 6.4, 6.6, 6.7, and 6.8 for Explanations and Qualifications)

Power and Lighting Systems	Zone 1	Zone 2
Threaded, rigid metal conduit	X	X
MI cable	X	X
MC-HL cable	X	X
MC cable with a gas/vapor-tight continuous corrugated aluminum sheath with an overall PVC (or other suitable polymeric material) jacket and grounding conductors		X
MV cable		X
Marine shipboard cable		
Armored and sheathed	X <sup>a,b</sup>	X <sup>a,b</sup>
Nonarmored		X <sup>a,b</sup>
ITC-HL cable NRTL-listed for Class I, Zone 1 locations with a gas/vapor-tight continuous corrugated aluminum sheath and an overall PVC (or other suitable polymeric material) jacket	X	X
ITC, ITC-ER		X
TC, TC-ER or PLTC, PLTC-ER cable		X
Enclosed and gasketed busway, enclosed gasketed wireways, cable bus		X
Application-specific cables that satisfy mechanical sheath requirements and flame propagation requirements of IEEE 1202		X <sup>a</sup>
<sup>a</sup> Departure from the <i>National Electrical Code (NEC)</i> .		
<sup>b</sup> Marine Shipboard Cable for offshore petroleum facilities should be designed and installed in accordance with IEEE Std 45, <i>Electrical Installations on Shipboard</i> , except where specific departures are noted.		

**6.4.1.4** Oil treaters with electric grids, electric motor-driven skim pile or oil sump submersible pumps protected per NEC 501.125 (A)(4) as allowed in Zone classified locations reference 6.4.1.4., and electric motor-driven down-hole submersible pumps in wells are not subject to the requirements of 6.4.1.2. In the case of oil treaters, such vessels should be equipped with a device (such as a float switch) to de-energize and ground the grid before the liquid level falls below the electrical equipment. In the case of electric motor-driven submersible pumps, the design of the submersible drive motors and the associated downhole pump cable shall ensure that the pump cable is vented in accordance with the manufacturer's recommendations for proper venting of flammable gases or liquids that may be transmitted through the core of the cable. For electric downhole submersible pumps, see API 11S3.

**6.4.1.5** Use of Division rated equipment in Zone classified locations is allowed as follows:

- a) Equipment listed and marked for Class I, Division 1 classified locations (reference API 14 F) may be used in Class I, Zone 1 or Zone 2 locations for the same gas and with a suitable temperature rating.
- b) Equipment listed and marked for Class I, Division 2 classified locations (reference API 14 F) may be used in Class I, Zone 2 locations for the same gas and with a suitable temperature rating.

## **6.4.2 Power and Lighting Systems**

**6.4.2.1** The energy levels contained in traditional power and lighting circuits exceed what is allowed to be used in a Zone 0 location. For special applications refer to 6.4.7.

**6.4.2.2** The wiring methods recommended for Zone 1 locations are:

- a) type MC-HL cable;
- b) threaded rigid copper-free aluminum conduit;
- c) threaded rigid steel, hot dipped galvanized conduit, coated with polyvinyl chloride (PVC), (or other suitable material) and with the interior protected by additional means over the hot dipped galvanized coating;
- d) armored marine shipboard cable, with an overall impervious sheath over the armor;
- e) type ITC-HL cable that is NRTL-listed for use in Class I, Zone 1 locations, with a gas/vaportight continuous corrugated aluminum sheath and with an overall PVC (or other suitable polymeric material) jacket.

**6.4.2.3** Additional wiring methods acceptable for Zone 1 are listed below.

**6.4.2.3.1** *MI (mineral-insulated, metal-sheathed) cable.* MI cable is a factory assembled cable consisting of solid copper or nickel-clad copper conductors insulated with a highly compressed refractory mineral insulation (normally magnesium oxide) and clad with an overall copper or alloy steel sheath. It is impervious to fire at temperatures below the melting temperature of its conductors or sheath. However, type MI cable insulation is hygroscopic and particular care should be taken to protect the ends against moisture absorption during shipment, storage, and termination. Because no sealing fittings are required where MI cables enter flameproof or explosionproof enclosures (if approved flameproof or explosionproof terminations are utilized), MI cables can be used to advantage where crowded conditions make installations difficult. It is recommended that MI cable with copper sheath be jacketed with a flame retardant, sunlight- and oil-resistant material. When the sheath is made of alloy steel, one of the conductors shall be used as an equipment-grounding conductor in accordance with *NEC* Article 250.

**6.4.2.3.2** *Rigid Metal Conduit.* Threaded rigid steel, hot dipped galvanized conduit without an additional external or internal protective coating. Threaded rigid steel conduit not complying with 6.4.2.2 c) is not recommended for outdoor use offshore due to the highly corrosive atmosphere. It is acceptable for indoor use in locations where the ambient heat of equipment minimizes condensation (e.g. a compressor building) or where humidity control is provided.



**6.4.2.3.3 Intermediate Metal Conduit.** IMC is not recommended for outdoor use offshore in a Zone 1 area because its thinner wall thickness (compared to rigid metal conduit) may not provide suitable corrosion allowance. Also, intermediate metal conduit, because of its manufacturing process, is available with only the exterior hot dipped galvanized.

**6.4.2.4** Wiring methods recommended for Zone 2 locations are:

- a) the wiring methods recommended for use in Zone 1 locations as listed in 6.4.2.2;
- b) type MC or MC-HL cable with a gas/vaportight continuous corrugated aluminum sheath, an overall PVC (or other suitable polymeric material) jacket, and grounding conductors in accordance with *NEC* 250-122;
- c) nonarmored marine shipboard cable, with an overall impervious sheath.

**6.4.2.5** Additional wiring methods acceptable for Zone 2 locations are:

- a) the wiring methods acceptable for use in Zone 1 locations as listed in 6.4.2.3;
- b) type MC cable;
- c) type TC cable or Type TC-ER cable;
- d) type MV cable;
- e) enclosed and gasketed busways and busducts if designed and installed in accordance with 6.7.3;
- f) enclosed and gasketed wireways;
- g) Type ITC or ITC-ER Cable;
- h) Type PLTC cable or PLTC-ER.

**NOTE 1** It is recommended that an overall PVC (or other suitable polymeric material) jacket be included for Type MC, and MV cables. Cables without the overall jacket are acceptable for indoor use in locations where the ambient heat of the equipment minimizes condensation or where humidity control is provided. A continuous corrugated aluminum armor or sheath is recommended over an interlocked armor or sheath.

**NOTE 2** Good engineering judgment should be used in applications utilizing cables listed in 6.4.2.4. For example, it may be necessary to provide additional mechanical protection for certain cables.

### **6.4.3 Instrumentation, Control, and Communication Systems Wiring**

**6.4.3.1** Wiring methods as described in 6.4.2 for power and lighting circuits are recommended for remote-control, signaling, and communications circuits for both Zone 1 and Zone 2 locations.

**6.4.3.2** In Zone 2 locations, ITC, ITC-ER and PLTC, PLTC-ER cables can be used. In addition, application-specific cables that satisfy the mechanical sheath requirements for type MC or TC cables and meet the flame propagation requirements of IEEE 1202 may be used.

**6.4.3.3** Intrinsically safe system wiring in Zone 0, Zone 1, or Zone 2 locations (see 4.3.3) may utilize any method acceptable for wiring in unclassified locations provided that the wiring method is suitable for the environment; meets the requirements of the IEEE Std 1202 flammability test, CSA FT-4 flammability test, or the Cable Tray Flame Test described in UL 1581; and is installed in accordance with *NEC* Article 504. The IEEE Std 1202 or CSA FT-4 test is preferred. In addition, some installation situations may require sealing (gas blocking type seal) of cable and cable cores at area classification boundaries to minimize the passage of gases or process fluids from one area to another, or to a non-hazardous area.

**6.4.3.4** Communication cables used in FieldBus applications should meet the requirements of FF-844 or IEC 61158-2 in addition to the requirements for use in hazardous (classified) locations in 6.4.3.2 and 6.4.3.3. For information on Foundation FieldBus applications, refer to AG-140 and AG-163.

#### **6.4.4 Sheath Grounding**

**6.4.4.1** All armor or other metal coverings of cable shall be electrically continuous throughout their entire length and shall be effectively grounded. All cable terminations shall use NRTL-listed grounding type terminators.

**6.4.4.2** When utilizing TC or shipboard cables, which do not inherently provide a grounding means, the equipment grounding path should be carefully considered. The armor of shipboard cable shall be grounded, but cannot be used as the grounding conductor. Thus, an appropriately sized grounding conductor should be included within each cable, or other adequate grounding means provided to comply with *NEC* Article 250. In unclassified and Zone 2 locations, when the metallic sheath is approved as a grounding conductor, the continuous corrugated metallic sheath of type MC cable or the combined metallic sheath and grounding conductors may be used as the grounding conductor when used with termination fittings that are NRTL-listed to meet UL 514B.

#### **6.4.5 Flexible Cords**

Flexible cords designated for extra-hard usage by *NEC* Table 400.4 may be used in Zone 1 or Zone 2 locations in accordance with *NEC* Article 505.15, but are recommended only for temporary service in Zone 1 locations.

#### **6.4.6 Heat Trace Cables**

For Heat Trace Systems, refer to 11.6.

#### **6.4.7 Special Considerations for Cables and Equipment in Hazardous (classified) Locations**

**6.4.7.1** Careful consideration should always be given to the routing of cable trays and cables to avoid mechanical damage. TC, non-armored PLTC, ITC, MV, shipboard cables, and other similar non-armored cables are not as mechanically rugged as armored cables. These non-armored cables should be installed within a continuous cable support system or cable tray to provide protection against mechanical damage. Whenever the cables leave the support system or cable tray, they should be mechanically protected by installing them in conduit, angles, channels or raceways or by other suitable means. TC-ER, PLTC-ER, ITC-ER cables require protection from mechanical damage and are more rugged than standard TC, PLTC, or ITC but are not as rugged as armored cables. Refer to *NEC* 336.10 (7) for -ER additional information.

**6.4.7.2** All cables, except flexible cords, not installed in a metal raceway such as rigid or flexible metal conduit shall meet the requirements of the IEEE Std 1202 flammability test, CSA FT-4 flammability test, or the Cable Tray Flame Test described in UL 1581. The IEEE Std 1202 or CSA FT-4 test is preferred. Listed Marine Shipboard Cables, Type MC-HL cables, and cables suitable for use in cable trays in accordance with the *NEC* (e.g. TC, ITC or PLTC) meet at least one of the above requirements. Other cables, except flexible cords, should have the designation "Cable Tray Use" or "CT Use" marked on or in the cable. Flexible cords shall meet the requirements of UL 1581 VW-1 or CSA FT-1 as a minimum.

**6.4.7.3** Where flexibility is required, the following systems are recommended:

**6.4.7.3.1** In Zone 1 locations, flameproof or explosionproof, flexible metal conduit, or armored and sheathed marine shipboard cable with flexible stranded conductors. For portable equipment, a flexible cord designated for extra-hard usage by *NEC* Table 400-4 and containing an equipment grounding conductor; reference *NEC* 505.17.2.

**6.4.7.3.2** For fixed equipment in Zone 2 locations, liquid-tight flexible metallic conduit (6 ft maximum) with an external or internal bonding jumper; or, flexible cord approved for extra-hard usage and containing an equipment grounding conductor or methods for Zone 1 in 6.4.7.3.1. Where practical, the length of flexible connections should not

exceed 3 ft. (1 m). For portable equipment, flexible cord approved for extra-hard usage and containing an equipment grounding conductor; reference *NEC 505.17.2*.

**6.4.7.4** In Zone 1 locations, all electrical equipment (except intrinsically safe equipment and equipment inside purged enclosures in accordance with 4.3.5) including fittings, junction boxes, pull boxes, unions, enclosures and flexible conduit shall be flameproof (Type d), explosionproof, increased safety (Type e), encapsulated (Type m), oil immersed (Type o), or powder-filled (Type q). Flameproof or explosionproof conduit or cable seals, as appropriate, shall be installed on all cable terminations at direct entry flameproof or explosionproof enclosures.

**6.4.7.5** In Zone 2 locations, conduit fittings, unions, non-arcing devices and junction boxes (with or without splices or terminations) need not be flameproof or explosionproof, except when necessary to maintain the integrity of a flameproof or explosionproof enclosure as described in 6.8. Equipment containing high temperature devices shall be flameproof or explosionproof or otherwise approved for the area. Arcing devices such as switches, circuit breakers, fuses, receptacles, relays, timers, slip rings, commutators, and other devices that produce an arc during normal operation need not be flameproof or explosionproof if one of the following conditions is satisfied;

**6.4.7.5.1** The contacts of instrumentation and control devices are immersed in oil (Type o);

**6.4.7.5.2** The contacts for power devices (such as circuit breakers and motor starters) are immersed in oil and specifically approved for the purpose (Type o);

**6.4.7.5.3** The contacts are hermetically sealed;

**6.4.7.5.4** The contacts are in a restricted breathing enclosure (Type nR);

**6.4.7.5.5** The contacts are in a powder-filled enclosure (Type q);

**6.4.7.5.6** The devices are in nonincendive circuits;

**6.4.7.5.7** The devices are part of an intrinsically safe system (Type ia, ib or ic);

**6.4.7.5.8** The devices are contained within a purged and pressurized enclosure utilizing Type X or Type Z purging in accordance with NFPA 496;

**6.4.7.5.9** Fuses are of the nonindicating, filled, current limiting type and used for the protection of motors, appliances and lamps;

**6.4.7.5.10** Fuses are of the nonindicating, filled, current limiting type and used in instrumentation and control circuits not subject to overloading under normal operating conditions.

## **6.5 Wiring Methods for Unclassified Locations**

**6.5.1** It is recommended that, in general, the wiring methods and electrical equipment employed for unclassified outdoor locations be similar to those recommended for Zone 2 locations. Experience has shown this to be effective for reasons of corrosion resistance, minimized parts inventory, and system flexibility to accommodate changes in the location of process equipment.

**6.5.2** It is recommended that wiring methods for unclassified indoor areas such as quarters buildings and offices follow commercial and industrial wiring practices suitable for the environment.

**6.5.3** Marine shipboard cable for offshore petroleum facilities should be designed in accordance with IEEE RP 1580 and installed in accordance with IEEE Std. 45, except where specific departures are noted.

## **6.6 Wiring Methods for Drilling and Workover Rigs**

**6.6.1** It is recognized that the use of drilling and workover rigs simultaneously with production operations frequently occurs on offshore platforms. To provide the flexibility required by drilling rigs and in recognition of the temporary nature of the installation, the following exception to the above wiring methods is allowed:

**6.6.1.1** The use of nonarmored cable (e.g. flexible stranded marine shipboard cable, etc.) is acceptable in Zone 1 locations on drilling and workover rigs for the interconnection of movable modules and movable equipment, provided that it meets the design and installation criteria of 6.4.7.1, 6.4.7.2, and 6.7.1. Fixed wiring, including that on movable and portable modules, should meet applicable portions of this RP.

**6.6.2** For guidance in sizing cables for DC motor applications in drilling rig service, see 6.3.6.

**6.6.3** On drilling and workover rigs where the drill floor module is skidded from well to well on a fixed deck, special wiring considerations are required for cable connections between the fixed deck and drill floor module.

**6.6.3.1** Cables from the fixed deck to the moveable structure should be provided with mechanical protection as follows:

- a) installed and routed to avoid excessive mechanical stress on individual cables or their terminations;
- b) installed so that the minimum bend radius of the cables employed will not be exceeded.

**6.6.3.2** Care should be taken when choosing cable types since repeated flexing can damage the armor or conductors on certain types of cables.

**6.6.3.3** Adequately sized grounding conductors should be installed to maintain equipment ground continuity. Bonding an electrical device to the welded structure of a moveable module is not necessarily an adequate grounding means since a moveable module is not welded or otherwise effectively bonded to the fixed structure.

**6.6.3.4** Moveable modules should be adequately bonded to the fixed structure to minimize arcing from modules to fixed structures and electrical shock hazards if ground faults should occur in electrical equipment on the module.

## **6.7 General Wiring Considerations**

### **6.7.1 Cable Systems**

**6.7.1.1** Cable systems employing impervious jackets, by inherent design, do not tend to breathe and accumulate moisture. Jacketed cables are therefore often used for many offshore platform wiring systems. Cables, including portable cords and armored shipboard cable, should be provided with a flame retardant, sunlight- and oil-resistant outer jacket that provides superior resistance to the environment present in offshore petroleum facilities. All cables (except MI cables) should have stranded conductors in preference to solid conductors to provide superior flexibility and resistance to fatigue. Care should be exercised to assure the proper selection and installation of termination fittings to provide positive armor/metallic sheath grounding, watertight sealing and mechanical anchoring.

**6.7.1.2** Special attention should be devoted to applications involving festooning or where exposed to high vibration, repeated flexing, excessive movement, or twisting. Cables that utilize flexible or extra flexible conductor stranding, braided armors, or braided shields should be considered for such applications.

**6.7.1.3** When cable systems are subject to vibration or other unwanted movement (including differential movement between modules, transportation accelerations, seismic movement, etc.), the cables shall be appropriately restrained to prevent chafing and fatigue.

**6.7.1.4** When three-phase single-conductor or direct current single conductor cable systems are employed, they are to be securely bound in circuit groups to prevent excessive movement due to fault-current magnetic forces. The fixing means shall be suitable for the cable size and available fault current. The mechanical forces between conductors during a short-circuit is a function of the peak short-circuit current, and the center-to-center spacing between the conductors and may be estimated by the formula below:

$$F_t = \frac{(0.17 \times i_p^2)}{S} \quad (2)$$

where

$F_t$  is maximum force on conductor in Newtons/meter;

$i_p$  is peak short circuit current in kilo-Amperes;

$S$  is center to center spacing between conductors in meters.

One technique to prevent excessive movement of cable systems is to employ fault-rated cable cleats.

**6.7.1.5** Cables utilizing low smoke, halogen-free materials should be considered in living quarters where such cables are installed utilizing open wiring methods. The low smoke and toxic emission properties of these cables allow for safe egress of personnel during a fire condition.

**6.7.1.6** Where a cable can be immersed in liquid or exposed to vapor continuously or for lengthy periods, the cable shall be of a type suitable for such conditions, or shall be appropriately protected. Either the insulation or conductors shall be of a type approved for such conditions, or the insulation shall be protected by a sheath of a type approved for such conditions, or the cables shall be enclosed in a casing (such as a metallic pipe) capable of withstanding the liquid or vapor.

## **6.7.2 Conduit Systems**

Conduit systems are not airtight and thus breathe and accumulate moisture in the offshore environment; this moisture may lead to internal corrosion. Consideration should be given to the use of either copper-free aluminum conduit or PVC-coated (or other suitable coating material) hot-dipped galvanized conduit with additional interior protection over the hot-dipped galvanized coating to provide long-lasting environmental protection. It is recommended for power and lighting circuits that single conductor wire installed in conduit be stranded copper wire suitable for wet locations, and meet the following minimum criteria: 75 °C (167 °F) and 600 Volt.

## **6.7.3 Busways**

It is recommended that the outdoor use of busways be avoided wherever possible. If design conditions are such that other methods are not feasible, it is recommended that busway installations meet all of the following conditions.

- a) Busway should be nonventilated, totally enclosed, and gasketed outdoor construction, including the splice locations, and should be constructed of suitable corrosion resistant material.
- b) The busway design should incorporate large air spaces between phases and ground, including the splice locations. Sandwich-type duct designs that utilize only mechanical insulation systems between live parts and ground are not recommended. Experience has shown that surface tracking may occur due to the moist salt-laden environment, particularly at splice locations.
- c) All bus bars within busways should be insulated, in addition to the insulator support system.

- d) The busway design should allow the splice points or plates to be insulated to at least the same insulation value as the insulation system on the bus bars.
- e) Electrical space heaters should be installed at close intervals within the busway system to prevent internal condensation and moisture buildup.

NOTE Electrical space heaters and thermostats installed in hazardous (classified) locations shall be suitable for the location.

- f) Wherever possible, the interior of the busway enclosure should be maintained under positive pressure, utilizing pressurizing air that is clean and obtained from an unclassified location. The use of dehumidified air is recommended.

#### **6.7.4 Bend Radius**

The bend radius of a cable should not be less than the minimum as defined by the *NEC* (for *NEC* wiring methods) or IEEE 45 (for marine shipboard cable), as applicable.

#### **6.7.5 Lighting Fixtures**

Some hazardous location fixtures require that integral lighting fixture wiring be high-temperature type SF-2, 200 °C (392 °F), or other suitable high-temperature wiring.

#### **6.7.6 DC Conductor Insulation**

Conductors used for DC service above approximately 40 VDC in wet locations should have a thermosetting insulation material such as EPR, XLPE, XLPO or other insulation suitable for the application. In wet locations, thermoplastic insulation such as PVC may be adversely affected by DC voltages. This deleterious effect is caused by a phenomenon known as electro-osmosis or electrical endosmosis.

#### **6.7.7 Cables Over 2000 Volts**

It is recommended that installations over 2000 Volts AC utilize any of the following:

- a) type MC cable with continuous corrugated aluminum sheath with Type MV insulated conductors;
- b) armored marine shipboard cable with suitably insulated conductors;
- c) rigid metal conduit with Type MV insulated conductors or Type MV cable.

#### **6.7.8 Circuit Integrity Cable**

**6.7.8.1** Cable for use in critical circuits (otherwise referred to as critical circuit cable, fire rated cable, or fire rated circuit integrity cable) should be selected based the type of potential fire exposure and fire endurance (heat flux).

**6.7.8.2** Some applications that should be considered for the use of circuit integrity cable include critical communication, fire alarms or detection, non-fail safe critical devices, electric motor operated shutdown valves, or electric fire pumps. Cables that are required to operate under fire conditions and are subject to potential fire exposure and serve critical applications determined by the operator should be tested by a third party to the required test conditions as shown below.

**6.7.8.2.1** Cables designated as circuit integrity cable, in addition to meeting the flame test of IEEE Std 1202, should also meet the minimum circuit integrity flame test for 90 minutes at 1000 °C (1832 °F) with the equipment of IEC 60331-11 and the procedures of IEC 60331-21 for cables rated to and including 1000 V; IEC 60331-23 for electric

data cable; or IEC 60331-25 for optical fiber cable. Cables that pass the UL 2196 per ASTM E119 test for two hours may also be identified as circuit integrity cable.

**6.7.8.2.2** For the specific applications that involve circuit integrity cables to be installed in an area that may be subject to a hydrocarbon pool fire, the cable should be qualified to withstand a hydrocarbon pool fire per the requirements of API 2218.

### **6.7.9 Motor Lead Cables for Adjustable Speed Drives (ASD) Applications**

Refer to 11.8.6 for special considerations.

### **6.7.10 Splices**

**6.7.10.1** Inline splices in electrical cables that are not in junction boxes should be minimized to maintain circuit reliability; however, any such splices should maintain the electrical and mechanical integrity of the unspliced cable. When it is necessary to splice conductors, the conductors should be spliced (joined) with either suitable splicing devices or by brazing, welding, or soldering with fusible metal or alloy. Soldered splices should first be mechanically secured. All spliced conductors should either be covered with an insulation equivalent to that of the conductors or should be made with a suitable insulating device. Ground paths and mechanical protection should be restored to their equivalent original integrity.

**6.7.10.2** Because of different characteristics of copper and aluminum, splicing and terminating connectors and soldering lugs should be suitable for the material of the conductor. Conductors of dissimilar metals (such as copper and aluminum) should not be intermixed in a splicing connector or terminal where physical contact occurs between the conductors unless the connector or terminal is suitable for the purpose. When materials such as solder, fluxes, inhibitors, and compounds are used in making splices, they should be of a type that will not adversely affect the conductors, installation, or equipment.

**6.7.10.3** Performance tests for continuity, shorts, and conductor-to-conductor and conductor-to-ground insulation resistance should be run on all 480 Volt and above, inline, spliced cable conductors not in junction boxes. One method to verify splice conductivity is through the use of current injecting low impedance testers.

**6.7.10.4** For additional information concerning splicing, refer to *NEC* Articles 110.14 and 400.9.

### **6.7.11 Recommended Numbers of Conductors, Pairs, and Triads**

The number of conductors, pairs and triads will vary with application. Common cable uses on floating and fixed facilities are shown in Table 8 and Table 9. Cables containing other pair and triad configurations are allowed but may not be readily available, which may result in increased difficulty when performing maintenance cable replacement.

### **6.7.12 Ambient Temperature Considerations**

Unless demonstrated otherwise by engineering calculation or empirical data, an ambient temperature of 40 °C (104 °F) should be utilized unless otherwise stated below:

- a) a 45 °C (113 °F) ambient temperature in boiler rooms, engine rooms and machinery spaces;
- b) a 30 °C (86 °F) ambient temperature in air conditioned spaces.

### **6.7.13 Mixing of Metric and NPT Threads**

The mixing of metric and NPT threads for straight and tapered threads on the same equipment should be avoided. The correct type of threads shall be specified and installed or listed or labeled thread adapters suitable for the location shall be used.

**Table 8—Common Power and Control Cables Sizes and Configurations**

Size	600 V Marine Shipboard	600 V Type TC, TC-ER, MC, MC-HL	2.4 kV Non-shielded Type MV, MC, MC-HL	5-35 kV Shielded Type MV, MC, MC-HL
Number of Conductors				
16	3, 4, 7, 10, 24, 37, 60			
14, 12	3, 4, 5, 10, 20, 37	3, 3+G, 4, 4+G, 5, 7, 9, 12, 19, 37		
10	3, 4	3, 3+G, 4, 4+G, 7		
8, 6, 4	3	3+G, 4+G		
2	3	3+G, 4+G	3+G	3+G (15 kV)
1/0	3	3+G		3+G (35 kV)
2/0	3	3+G, 4+G	3+G	
4/0	1, 3	3+G, 4+G	3+G	3+G
250	1	3+G		
313	3			
350, 500		3+G, 4+G	3+G	3+G
535	3			
750		3+G		3+G
Legend:				
G grounding conductor(s)				

**Table 9—Common Instrumentation Cable Sizes and Configurations**

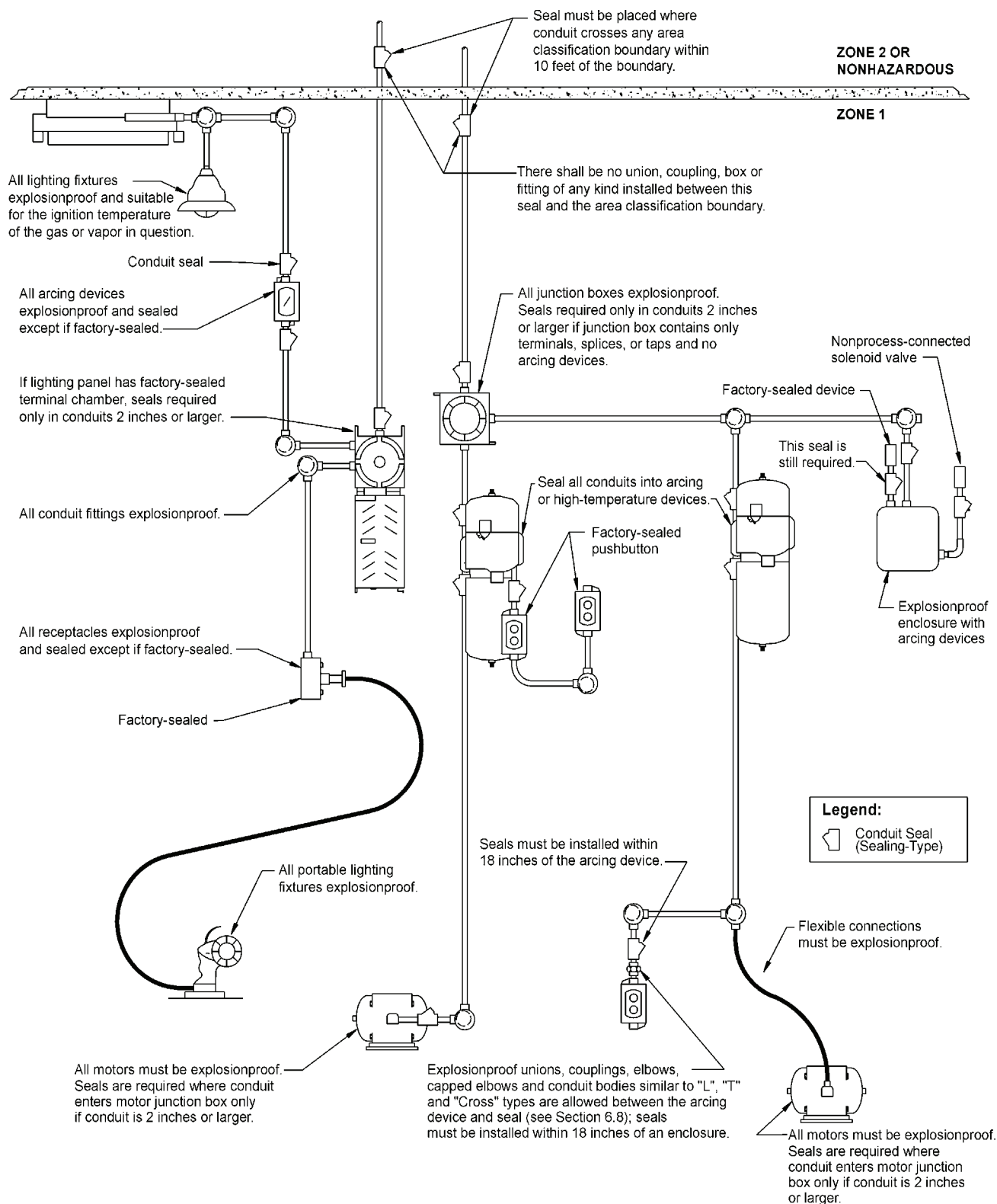
Size	600 V Marine Shipboard		300 V/600 V Types PLTC, ITC, TC, MC	
	No. Pairs	No. Triads	No. Pairs	No. Triads
18	1, 2, 3, 4, 5, 8, 12, 18, 24	1, 4, 8, 12	1, 2, 4, 8, 12, 24	1, 4, 8, 12
16	1, 2, 3, 4, 8, 10, 12, 24	1, 4, 8, 12	1, 2, 4, 8, 12, 24	1, 4, 8, 12
14	1, 2			

## 6.8 Conduit and Cable Seals and Sealing Methods

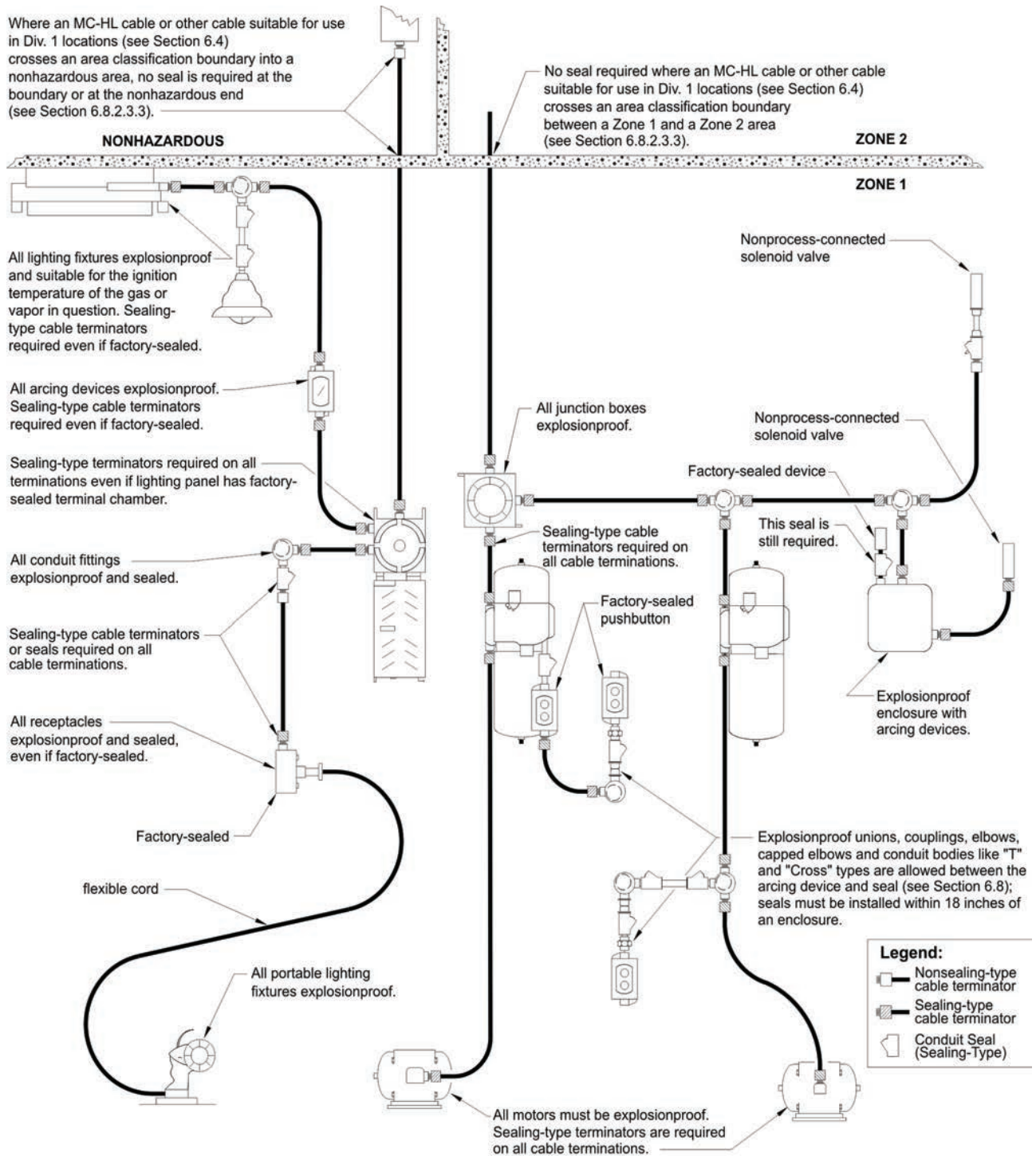
### 6.8.1 General

In this section, all references to seal(s) and sealing, except for seals required for process-connections in 6.8.2.2, refer to an approved conduit or cable seal designed to contain an explosion in the enclosure to which it is attached, and is approved for use in Class I, Division 1 or Zone 1 locations. A sealing-type cable terminator that is NRTL-approved to comply with UL 2225 meets these criteria. A sealing-type fitting that is NRTL-approved to comply with UL 886 meets these criteria. Seals should be installed in accordance with *NEC* requirements. (See *NEC* Article 505.16.) Refer to Figure 1, Figure 2, Figure 3, Figure 4, Figure 5, Figure 6, Figure 7, Figure 8, Figure 9, and Figure 10 for typical installations.



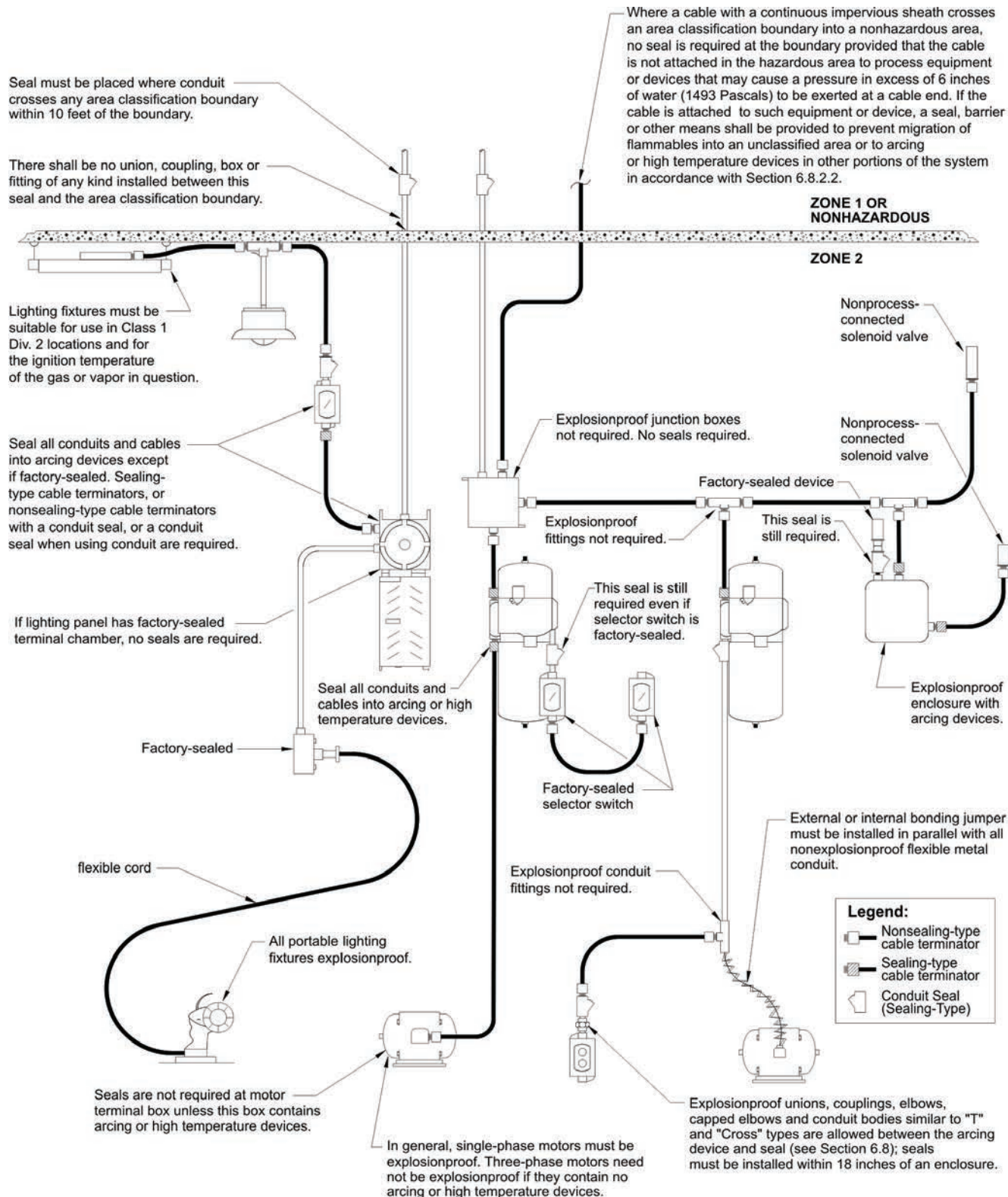


**Figure 1—Typical Class I, Zone 1 Electrical Installation Conduit System Utilizing Class I, Division I Equipment and Wiring Methods**



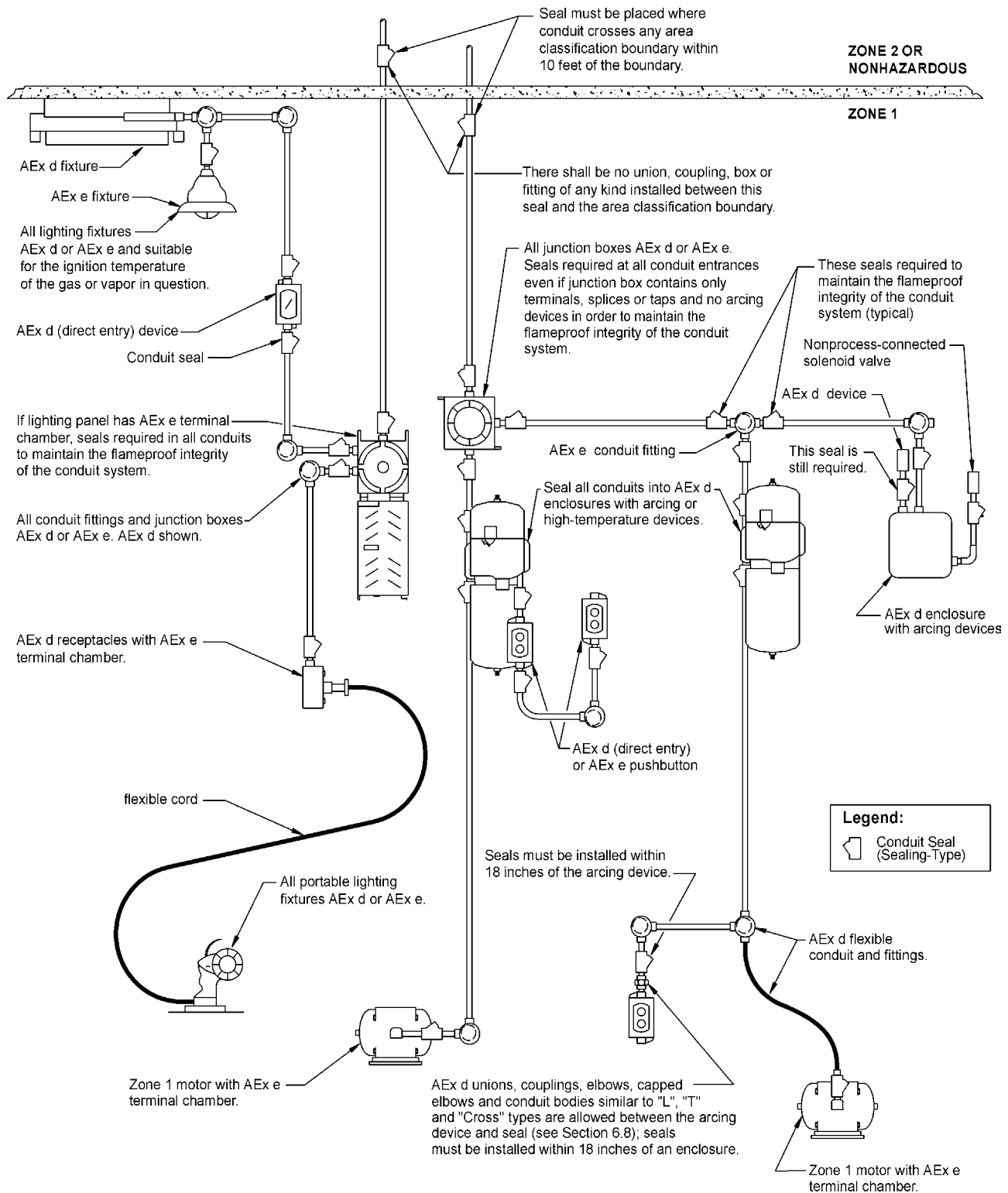
Note: See Section 6 for cables approved for use in Zone 1 locations.

**Figure 2—Typical Class I, Zone 1 Electrical Installation Cable System Utilizing Class I, Division 1 Equipment and Wiring Methods**



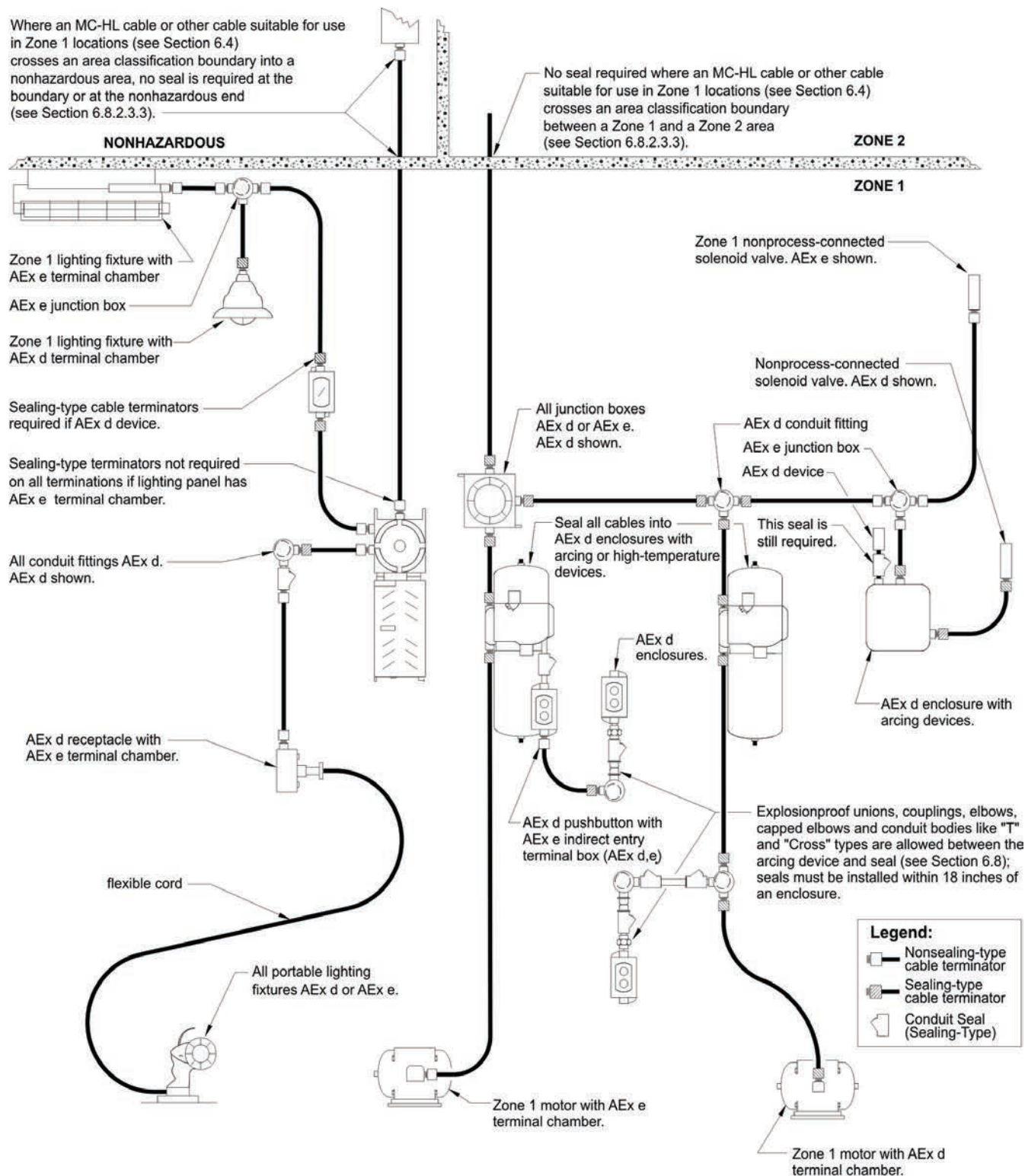
Note: See Section 6 for cables approved for use in Zone 2 locations.

**Figure 3—Typical Class I, Division Zone 2 Electrical Installation Conduit or Cable System Utilizing Class I, Division 2 Equipment and Wiring Methods**

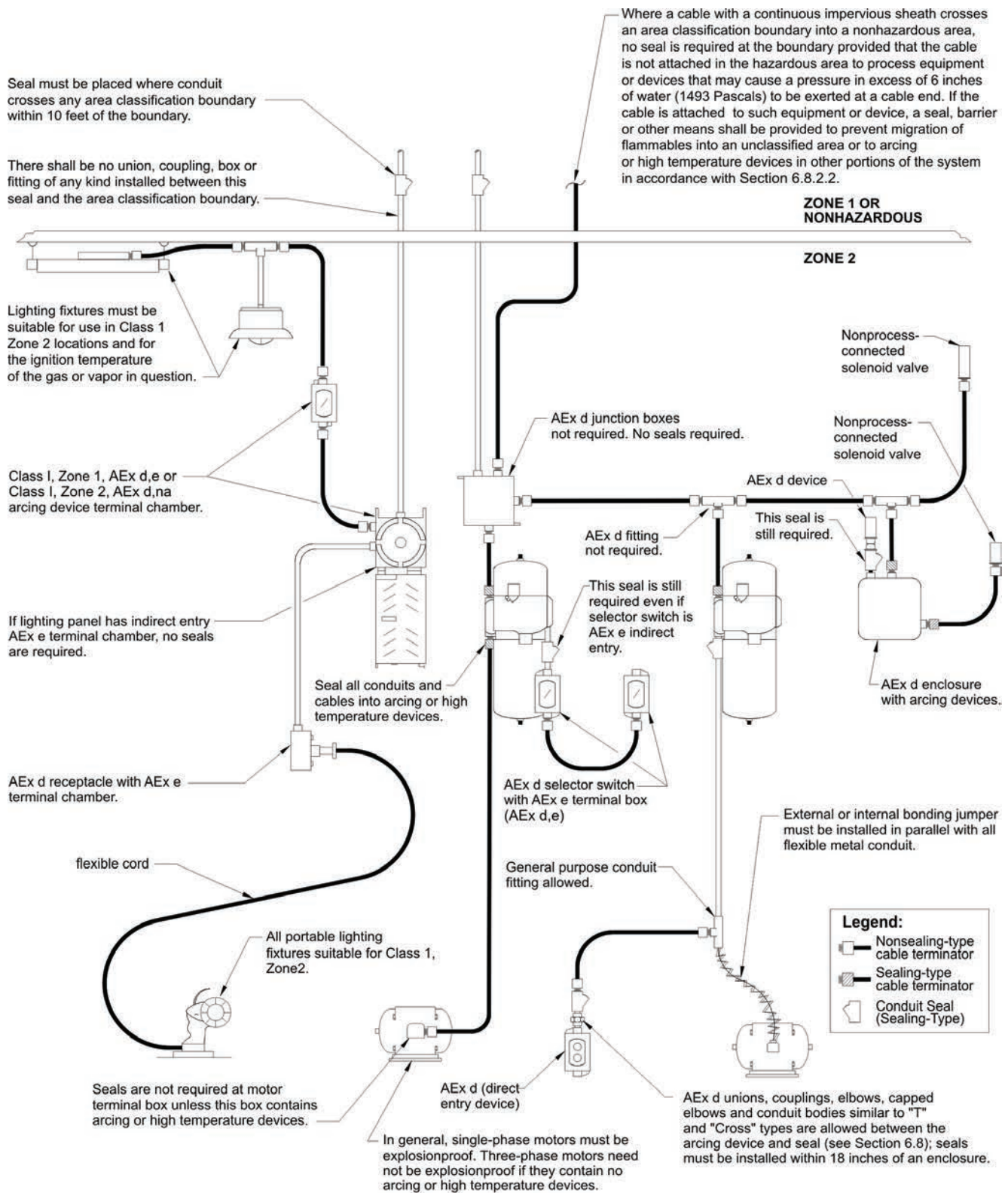


**Figure 4—Typical Class I, Zone 1 or Zone 2 Electrical Installation Conduit System Utilizing Class I, Zone 1 Equipment and Wiring Methods**



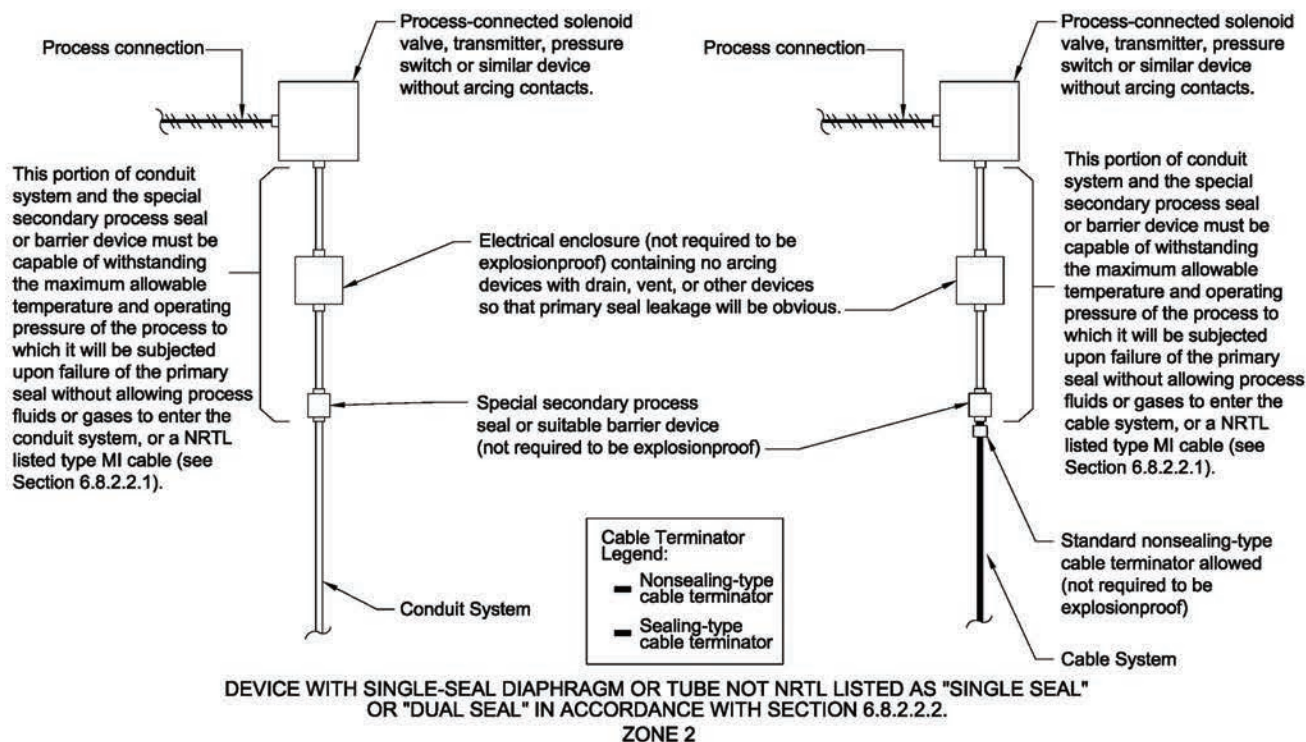
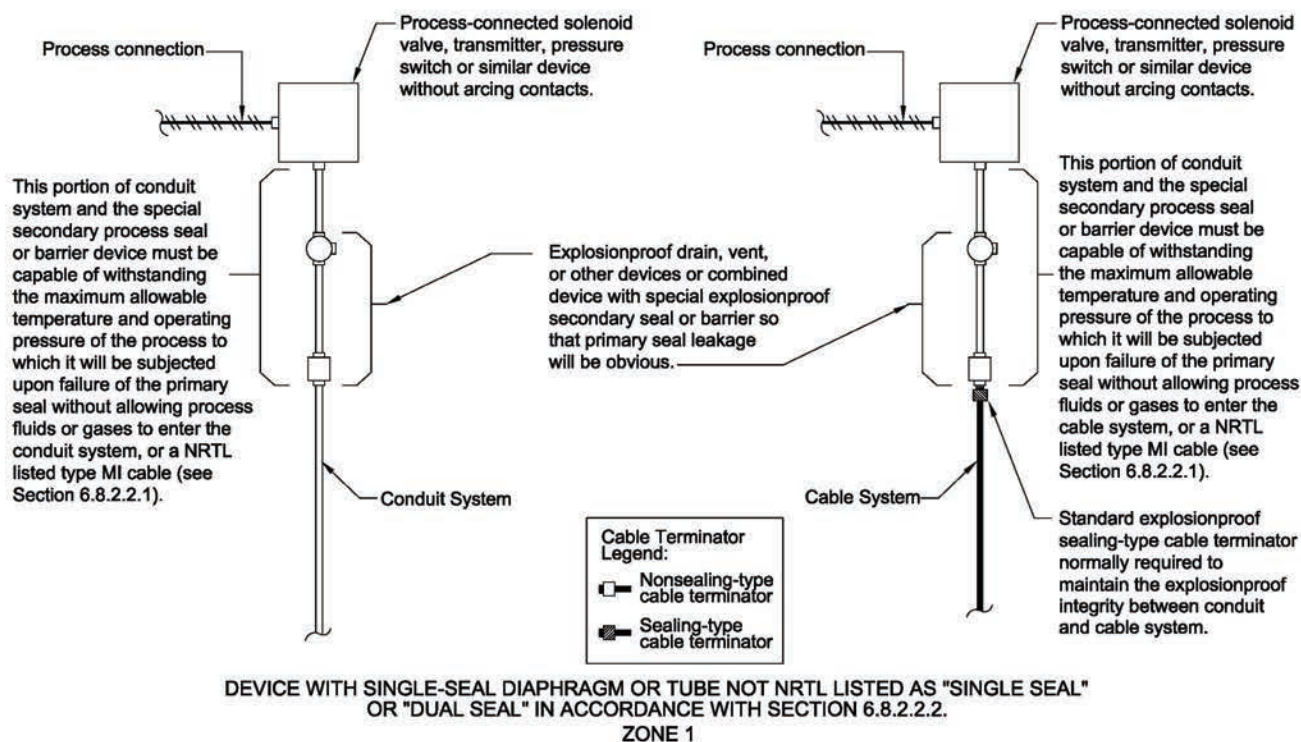


**Figure 5—Typical Class I, Zone 1 or Zone 2 Electrical Installation Cable System Utilizing Class I, Zone 1 Equipment and Wiring Methods**

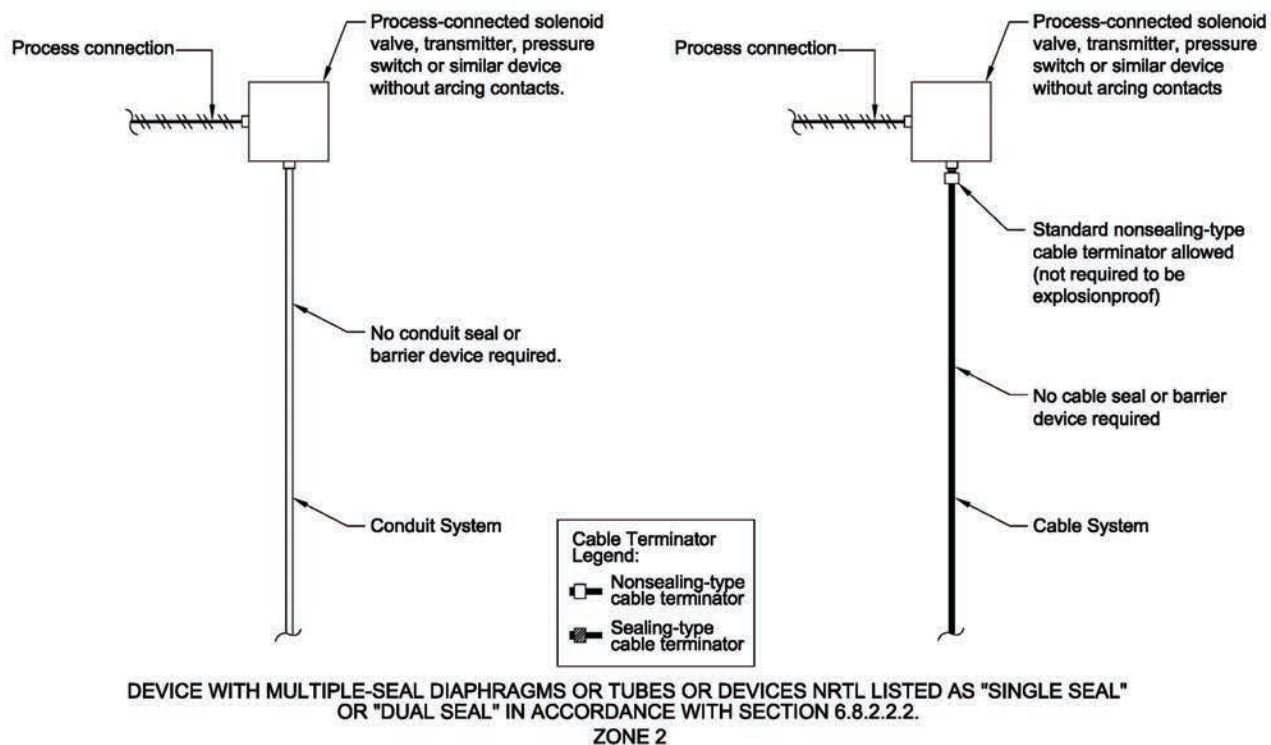
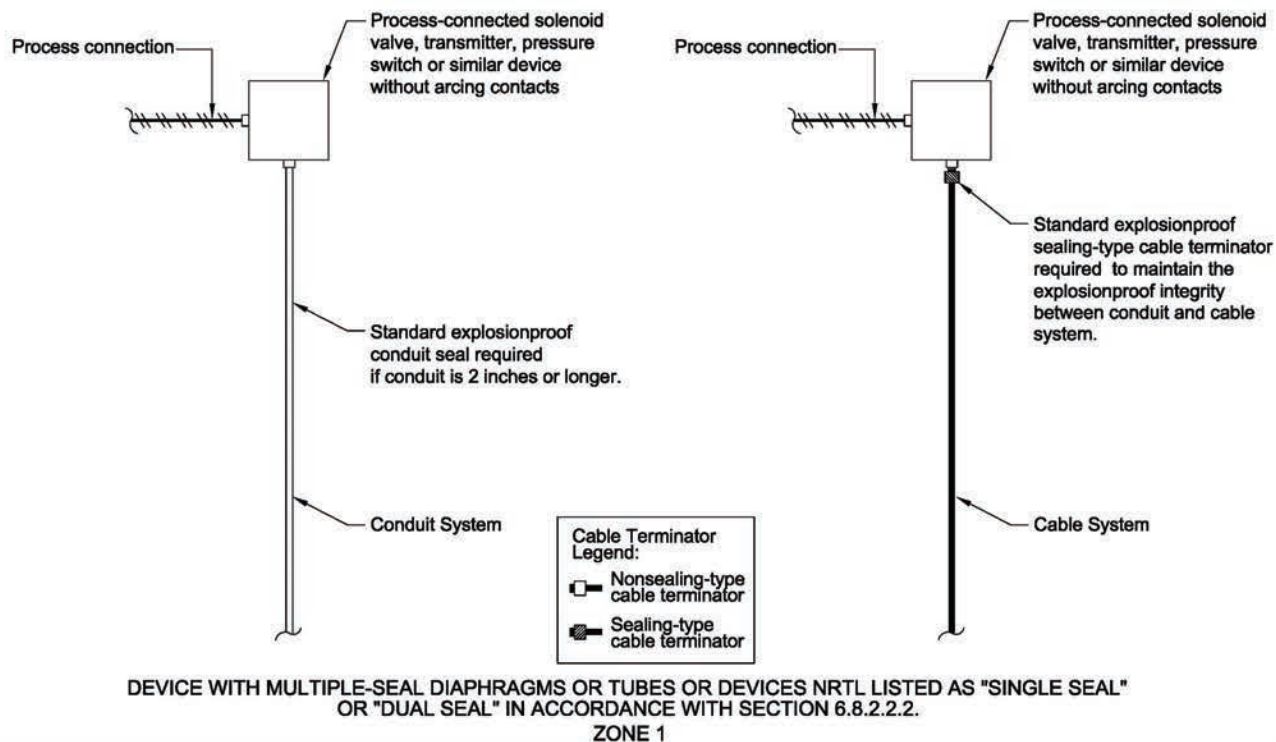


**Figure 6—Typical Class I, Zone 2 Electrical Conduit or Cable Installation Utilizing Class I, Zone 2 Equipment and Wiring Methods**





**Figure 7—Typical Class I, Zone 1 or Zone 2 Electrical Installation Conduit or Cable Connections to Flammable Fluid Process-Connected Nonarcing Devices with Single-Seal Diaphragms or Tubes**

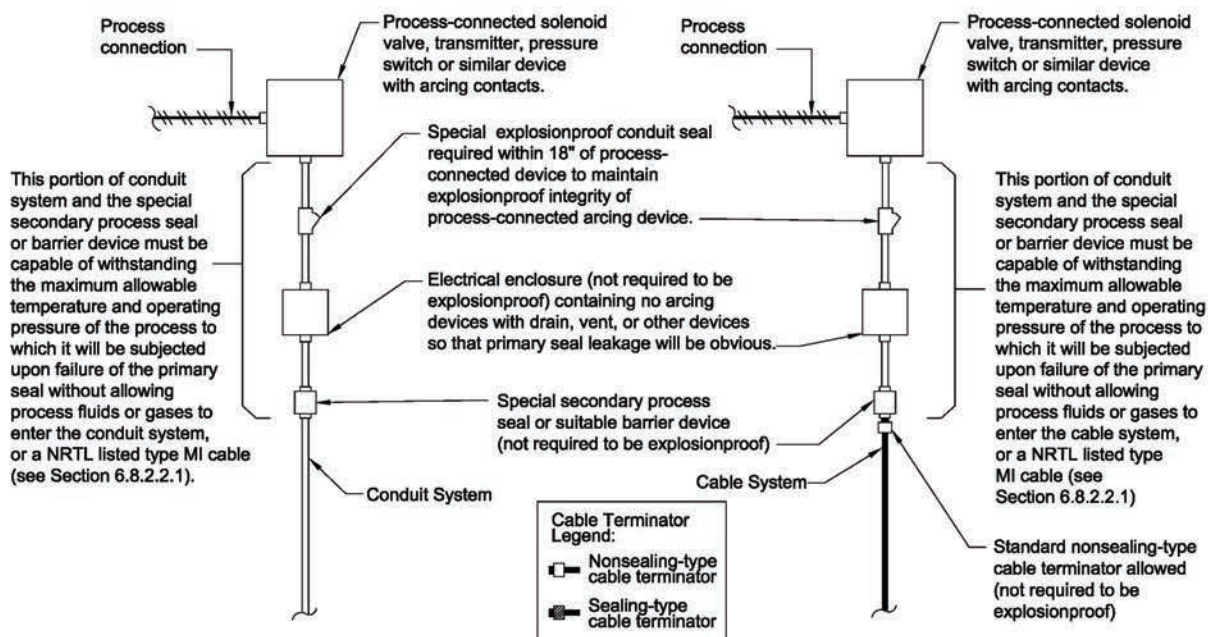


**Figure 8—Typical Class I, Zone 1 or Zone 2 Electrical Installation Conduit and Cable Connections to Flammable Fluid Process-Connected Nonarcing Devices with Multiple-Seal Diaphragms or Tubes**

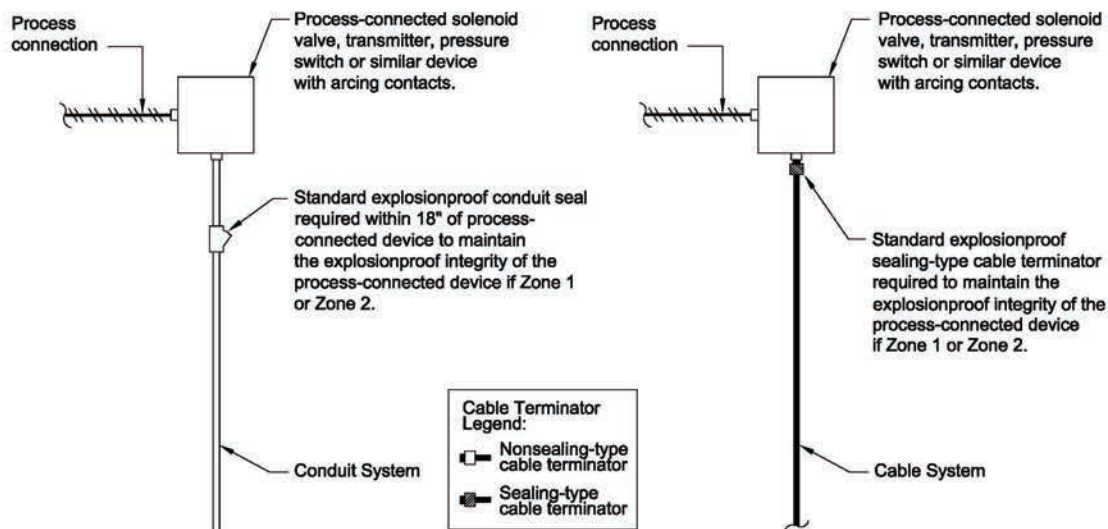


Same as Figure 7 "Device with Single-Seal Diaphragm or Tube - Zone 1" example except that an additional special explosionproof conduit seal is required within 18" of the process-connected arcing device to maintain the explosionproof integrity of the process-connected arcing device or a NRTL listed type MI cable as used (see Section 6.8.2.2.1).

DEVICE WITH SINGLE-SEAL DIAPHRAGM OR TUBE NOT NRTL LISTED AS "SINGLE SEAL" OR "DUAL SEAL" IN ACCORDANCE WITH SECTION 6.8.2.2.1.  
ZONE 1

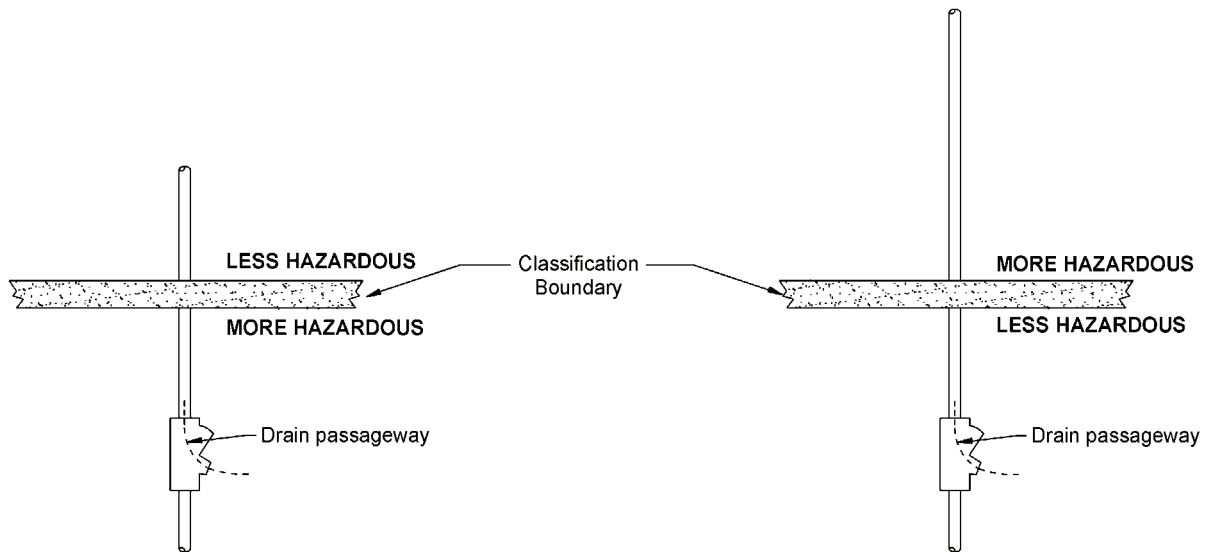


DEVICE WITH SINGLE-SEAL DIAPHRAGM OR TUBE NOT NRTL LISTED AS "SINGLE SEAL" OR "DUAL SEAL" IN ACCORDANCE WITH SECTION 6.8.2.2.2.  
ZONE 2

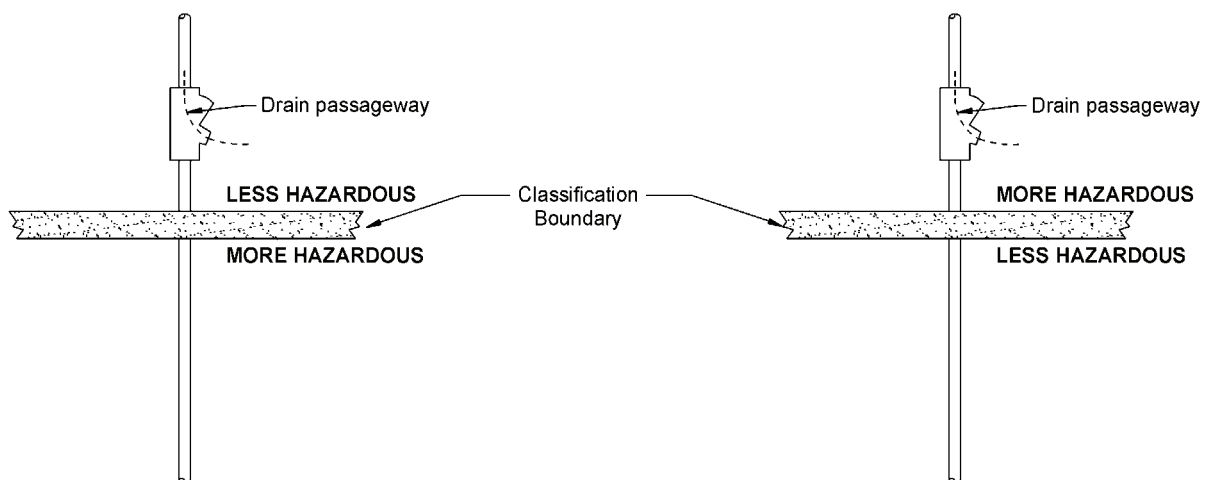


DEVICE WITH MULTIPLE-SEAL DIAPHRAGMS OR TUBES NOT NRTL LISTED AS "SINGLE SEAL" OR "DUAL SEAL" IN ACCORDANCE WITH SECTION 6.8.2.2.2.  
ZONE 1 OR ZONE 2

Figure 9—Typical Class I, Zone 1 or Zone 2 Electrical Installation Conduit or Cable Connections to Flammable Fluid Process-Connected Nonarcing Devices with Multiple-Seal Diaphragms or Tubes



**WRONG**



**RIGHT**

**Figure 10—Typical Class I, Zone 1 or Zone 2 Electrical Installation Placement of Drain Seals**

## **6.8.2 Seal Requirements**

### **6.8.2.1 Enclosure Entries**

**6.8.2.1.1** In Zone 1 and Zone 2 locations, a seal shall be installed in every conduit or cable entering an enclosure containing an arcing or high-temperature device where the enclosure is required to be flameproof or explosionproof.

**6.8.2.1.2** Cables installed in Zone 1 locations require a seal at all terminations required to be direct entry flameproof or explosionproof.

**6.8.2.1.3** Multiconductor Type MC cables shall be sealed with an approved fitting after removal of the overall jacket and any other covering so the sealing compound will surround each individual insulated conductor in such a manner as to minimize the passage of gases and vapors. An exception to this requirement is that cables containing shielded cables and twisted pair cables do not require the removal of the shielding material or separation of the twisted pairs provided the termination is made with an NRTL-approved means to minimize the entrance of gases and vapors and to prevent propagation of flame into the cable core. The conventional sealing-type cable terminator NRTL-approved to comply with UL 2225 does not inherently meet the criteria for this exception.

**6.8.2.1.4** Where cables with a gas/vaportight continuous sheath capable of transmitting gases or vapors through the cable core are installed within conduit, the annulus space between the conduit and the cable(s) shall be sealed with sealing compound, and the cable core shall be sealed after removing the jacket and any other coverings so that the sealing compound will surround each individual conductor and the outer jacket. An exception for multiconductor cables, shielded cables, and twisted pair cables with a gas/vaportight continuous sheath capable of transmitting gases or vapors through the cable core, is that such cables are permitted to be considered as a single conductor by sealing the cable in the conduit within 18 in. (457 mm) of the enclosure, but it is also necessary to seal the cable end within the enclosure by an approved means to minimize the entrance of gases or vapors and to prevent the propagation of flame into the cable core.

**6.8.2.1.5** The conduit system between an enclosure and a required seal shall be flameproof or explosionproof, even in Zone 2 locations, as the conduit system should be able to withstand the same internal explosive pressure as the enclosure to which it is attached. In Zone 1 and Zone 2 locations, approved flameproof or explosionproof unions, reducers, couplings, elbows, capped elbows, and conduit bodies similar to L, T, or Cross types are the only enclosures or fittings allowed between the sealing fitting and the enclosure. The conduit bodies cannot be larger than the largest trade size of the interconnecting conduit/nipples. Exceptions to this requirement for type "d" and "e" enclosures are provided in *NEC* 505.16(B)(1). In Zone 1 locations when using explosionproof equipment, seals shall be installed in each 2 in. size or larger conduit run entering an enclosure that contains splices, taps, or terminals. All seals should be installed as close as practicable, but in no case more than 18 in. (457 mm) from the enclosures to which they are attached.

### **6.8.2.2 Process Sealing Requirements**

**6.8.2.2.1** This section applies to devices installed on process lines or process vessels containing flammable fluids that includes, but is not limited to, canned pumps, submersible pumps, flow, pressure, temperature, or analysis measurement instruments. A process seal is a device to prevent flammable process fluids from entering conduit or cable systems and being transmitted to unclassified locations or to electrical arcing or high-temperature devices in other portions of the system if the primary seal fails. One of the following means shall be provided to prevent process fluids from entering the electrical raceway or cable system.

**6.8.2.2.2** Process connected electrical equipment that incorporates a single process seal, such as single compression seal, diaphragm, or tube (such as a Bourdon tube or a thermowell) to isolate flammable or combustible

fluids from entering a conduit or cable system capable of transmitting fluids, shall be provided with an additional means to mitigate a single process seal failure. The additional means may include, but is not limited to the following:

- a) suitable barrier meeting the process temperature and pressure conditions that the barrier will be subjected to upon failure of the single process seal. There shall be a vent or drain between the single process seal and the suitable barrier. Indication of the single process seal failure shall be provided by visible leakage, an audible whistle, or other means of monitoring.
- b) NRTL listed Type MI cable assembly, rated at not less than 125 % of the process pressure and not less than 125 % of the maximum process temperature (in degrees Celsius), installed between the cable or conduit and the single process seal.
- c) drain or vent located between the single process seal and a conduit or cable seal. The drain or vent shall be sufficiently sized to prevent over-pressuring the conduit or cable seal above 6 in. water column (1493 Pa). Indication of the single process seal failure shall be provided by visible leakage, an audible whistle, or other means of monitoring.

**6.8.2.2.3** Process-connected electrical equipment that does not rely on a single process seal or is NRTL listed and marked "single seal" or "dual seal" in accordance with ANSI/ISA-12.27.01 does not require an additional means of sealing as required above.

### **6.8.2.3 Hazardous (Classified) Area Boundaries**

**6.8.2.3.1** Wherever a conduit run passes from a Zone 0 location to a Zone 1 location, from a Zone 1 location to a Zone 2 location, from a Zone 2 location to an unclassified location, or any combination thereof, a seal shall be placed in the conduit run at the boundary, on either side. Except for approved flameproof or explosionproof reducers at the conduit seal, the conduit system shall not contain any union, coupling, box, or other fitting between the sealing fitting and the point at which the conduit leaves the Zone 1 or Zone 2 location. An exception to the above is that unbroken rigid metal conduit that passes completely through a Zone 1 or a Zone 2 location is not required to be sealed at the classification boundary if the termination points of the unbroken conduit are in unclassified locations and the conduit has no fitting less than 12 in. (305 mm) beyond each boundary.

**6.8.2.3.2** If drain seals are utilized at an area classification boundary, care should be exercised in the placement of such seals to ensure that gases or vapors cannot be communicated across the boundary through the conduit system by way of the seal's drain passage. Figure 10 illustrates proper and improper placement of drain seals at classification boundaries.

**6.8.2.3.3** Cables with a gas/vaportight continuous sheath do not have to follow the same sealing requirements as conduit systems when crossing area classification boundaries. Such cables are not required to be sealed unless the cable is attached to process equipment or devices that may cause a pressure in excess of 6 in. of water (1493 Pa) to be exerted at a cable end, in which case a seal, barrier or other means shall be provided to prevent migration of flammable fluids into an unclassified location or to arcing or high-temperature devices in other portions of the system (in accordance with *NEC* Article 505). No seal is then required at the boundary location. Cables with a gas/vaportight impervious continuous sheath are permitted to pass through an area classification boundary without seals. Cables that do not have a gas/vaportight continuous sheath shall be sealed at the boundary of the Zone 1, Zone 2 and unclassified locations.

**6.8.2.3.4** For additional information on seals for hazardous (classified) area boundaries, refer to *NEC* 505.16.

### 6.8.3 Installation

In addition to being placed in proper locations, all of the following practices should be observed when installing sealing fittings.

- a) Sealing fittings should be accessible.
- b) Sealing fittings should be mounted only in the position(s) for which they were designed. Some seals are designed only to be installed vertically; some can be installed either vertically or horizontally; a third type can be installed in any position.
- c) Pouring hubs should be properly oriented. The hub through which the sealing compound is to be poured shall be installed above the sealing cavity to properly pour the seal.
- d) Only sealing compound and fiber approved for a particular sealing fitting should be used, and the manufacturer's instructions should be followed for the preparation of dams (if applicable) and the preparation and installation of the sealing compound.
- e) No splices or taps are allowed in seals. Sealing compounds are not insulating materials and may absorb moisture, causing grounding of the circuit conductors.
- f) Seals with drain provisions should be installed to allow drainage of conduits where water or other liquids may accumulate in the conduit system. See Figure 10 for the proper placement of drain seals.
- g) Factory-sealed devices, such as toggle switches, push buttons, lighting panels, and lighting fixtures, eliminate the need for externally sealing those particular devices, except for cables in Zone 1 locations. However, a factory seal for one device cannot be used in place of a seal for another device unless specifically approved for that purpose. Most factory-sealed devices and enclosures have been designed and tested to withstand an explosive pressure from within their own enclosures only, and not from an explosive pressure from the opposite direction.

## 6.9 Circuit Protection

### 6.9.1 General

**6.9.1.1** The purpose of a circuit protection device is to open a circuit before a conductor (or its insulation or shield) is damaged by an overcurrent or through fault condition. These devices also protect system components such as bus structures, motor starters, transformers, and lighting panels, which have limited current-carrying and short-circuit ratings and which will be damaged if these ratings are exceeded. To accomplish these objectives, circuit-protection devices shall meet all of the following:

- a) the device shall be sized to automatically interrupt the flow of abnormal currents without damage to conductors or equipment;
- b) the device shall be rated to continuously carry design load currents at design voltage;
- c) the interrupting capacity of the device shall equal or exceed available short circuit currents.

**6.9.1.2** Two devices used for circuit protection are fuses and circuit breakers. Some advantages and disadvantages to be considered when selecting circuit protective devices are listed in Table 10.

**6.9.1.3** With few exceptions that are defined in *NEC Article 240, Overcurrent Protection*, the *NEC* requires that all conductors be protected by means of a fuse or circuit breaker of a rating not greater than the conductor's current carrying capacity. For example, a single conductor No. 12 AWG 75 °C (167 °F) copper wire should be protected with no larger than a 20-ampere fuse or breaker. This rule prohibits (with specific exceptions discussed in *NEC Article 240*)

**Table 10—Circuit Protection Devices—Advantages and Disadvantages**

<b>Circuit Breakers</b>
<p>Advantages</p> <ol style="list-style-type: none"> <li>1. Prevent single phasing.</li> <li>2. More suitable for remote operation.</li> <li>3. Resettable operation without replacement.</li> <li>4. Discourage improper replacement.</li> <li>5. More suitable for EP enclosures.</li> <li>6. More suitable for GFCI and AFCI installations.</li> <li>7. Available with shunt trip or low voltage release options.</li> </ol> <p>Disadvantages</p> <ol style="list-style-type: none"> <li>1. Moderate operating speed.</li> <li>2. Limited interrupting capacities for larger frame sizes.</li> <li>3. Mechanically complex and not necessarily fail-safe.</li> </ol>
<b>Fuses</b>
<p>Advantages</p> <ol style="list-style-type: none"> <li>1. Mechanically simple and fail-safe.</li> <li>2. Fast operating speed.</li> <li>3. High interrupting capacities.</li> <li>4. More easily coordinated.</li> <li>5. Greater size selection available.</li> <li>6. Current-limiting fuses may be beneficial for reducing arc-flash hazards.</li> </ol> <p>Disadvantages:</p> <ol style="list-style-type: none"> <li>1. Nonrepetitive operations.</li> <li>2. Require proper procedures for safe replacement.</li> <li>3. Spare inventory required.</li> <li>4. Possible single phasing.</li> <li>5. Subject to replacement with an improperly rated fuse.</li> </ol>

the practice of tapping a conductor with a small conductor without providing proper overcurrent protection for the smaller conductor at the point of the tap.

**6.9.1.4** Circuit-protection devices should be coordinated with upstream and downstream circuit-protection devices to provide selectivity such that only the circuit-protective device immediately upstream of the overload or short circuit condition will open.

## **6.9.2 Circuit Breaker Selection**

**6.9.2.1** Molded-case circuit breakers normally used on low voltage power distribution systems are widely used in hazardous (classified) locations due to their availability in approved flameproof or explosionproof enclosures. Molded-

case-type circuit breakers should meet the requirements of UL 489. Thermal magnetic breakers should be used for all circuit-breaker applications, except as an integral part of combination motor starters where magnetic only breakers are recommended. Thermal magnetic circuit breakers are sized by both frame size and trip rating. Each frame size is available with several trip ratings. The magnetic (instantaneous) setting is usually nonadjustable for smaller-sized thermal magnetic breakers. This magnetic trip, where adjustable, should be set at the lowest value that will not trip under maximum inrush conditions. Thermal magnetic breakers should be loaded only to 80 % of their trip rating unless rated for 100 % continuous load.

**6.9.2.2** Power circuit breaker usage normally is limited to generator breaker or large-sized feeder breaker applications. Power circuit breakers should meet the requirements of ANSI C37.04. Some of the significant features of power circuit breakers are as follows:

- a) remote operation capability;
- b) spring-operated (stored energy) closing and opening;
- c) fixed mount (available in low voltage only) or drawout type;
- d) availability of one of the following trip curve arrangements:
  - 1) "instantaneous" and "long time";
  - 2) "short time" and "long time";
  - 3) "instantaneous", "short time" and "long time" trip units.
- e) Availability of multiple auxiliary contacts;
- f) Adaptability to protective relaying.

## **6.10 Grounding**

### **6.10.1 General**

There are two types of grounding, described below. System grounding primarily is concerned with the protection of electrical equipment by stabilizing voltages with respect to ground. Equipment grounding primarily is concerned with the protection of personnel from electric shock by maintaining the potential of noncurrent-carrying equipment at or near ground potential. In hazardous (classified) locations, proper grounding minimizes ignition-capable sparking resulting from inadvertent contact between electrical equipment and any other grounded object.

### **6.10.2 System Grounding**

**6.10.2.1** All generators and other separately derived systems directly feeding single-phase loads that utilize a neutral shall have their neutrals solidly grounded. This would apply normally to 120/240 Volt single-phase and 208Y/120 or 480Y/277 Volt three-phase systems. Three-phase systems feeding only three-phase loads or single-phase loads not using a neutral may be operated solidly grounded, or, if the line-to-neutral voltage is greater than 150 Volts, ungrounded, high impedance grounded or low impedance grounded. The choice of system ground will vary with the specific application and system design. For additional discussion on grounding, refer to IEEE Std 142.

**6.10.2.2** For sizing system grounding electrode conductors, refer to *NEC* Table 250.66.

**6.10.2.3** Any grounded, separately derived system should be connected to ground at only one point. If systems are operating in parallel, these systems may be individually grounded, or grouped for grounding, at a common point. At all

other points any grounded neutral conductor (including the neutral in lighting panels, bus boxes, power supplies, and electronic equipment) shall be insulated from ground.

**6.10.2.4** Each individual neutral conductor should have white or natural gray insulation or be identified with a white marking or other equally effective means at each termination and accessible box opening throughout the system. Green insulated conductors shall not be re-identified (re-marked) as neutral conductors or phase conductors.

**6.10.2.5** The facility structure or hull of a floating facility shall not serve as a current-carrying conductor except for the following systems:

- a) cathodic protection systems;
- b) limited and locally grounded systems, such as battery systems for engine starting and control that have a one-wire system and have the ground lead connected to the engine;
- c) insulation level monitoring devices with circulating currents not exceeding 30 mA;
- d) welding systems with a structure or hull return;

NOTE When welding on facilities with the welding machine located on an adjacent vessel or barge, the facilities should be effectively bonded to the vessel or barge to avoid galvanic corrosion of the facility or the vessel.

- e) ground-fault detection systems.

### **6.10.3 Equipment Grounding**

**6.10.3.1** Grounding of electrical equipment on fixed and floating offshore petroleum facilities in a positive manner is of particular importance because personnel standing on steel decks or in contact with steel framing present a low impedance path to ground, effectively grounded. In addition, the dampness and salt spray contribute to the breakdown of insulation and to the possibility of leakage on the surface of insulators and similar devices. On platforms with wooden or concrete decks, equipment-grounding conductors should be installed between electrical equipment and a grounding network. It is recommended that all metal equipment, such as buildings, skids, and vessels be grounded to the steel structure or grounding network. Exposed, noncurrent-carrying metal parts of fixed equipment that may become energized because of any condition shall be grounded. Equipment that is welded to the structure or deck is considered to be adequately grounded. The physical contact obtained when equipment is bolted to a steel structure is not necessarily an adequate effective ground because of paint and possible corrosion. Exposed, noncurrent-carrying metal parts of portable electrical equipment shall be grounded through a conductor in the supply cable to the grounding pole in the receptacle.

NOTE 1 When the external equipment grounding conductor connection is complete the connection and terminal components should be treated with special compounds to protect connections against corrosion.

NOTE 2 Clips and clamps (e.g. alligator clips, beam clamps, and spring-loaded clamps) are not to be employed as a temporary or permanent external equipment grounding conductor

NOTE 3 The mating surface for the grounding connection should be clean of all nonconductive materials (e.g. grease, oil, and paint).

**6.10.3.2** For sizing equipment grounding conductors, refer to *NEC* Table 250.122.

**6.10.3.3** Each individual grounding conductor should be bare, or, if insulated, have a continuous outer finish that is either green or green with one or more yellow stripes. Alternatively, the grounding conductor can be identified with a green marking or other equally effective means at each termination and accessible box opening throughout the system. Conductors with green insulation or markings should not be used for any purpose other than grounding.



**6.10.3.4** To provide the desired safety, equipment grounding should satisfy all of the following.

- a) Grounding shall limit the voltage (normally to 42 V maximum) that may be present between the equipment in question and any other grounded object with which personnel may be in contact at the same time.
- b) For solidly grounded systems, grounding should present a low impedance path for short circuit current to return to the source of power, thus opening a fuse or tripping a circuit breaker. This requires that the equipment ground be bonded to the system ground.
- c) Visible supplemental grounding should be considered for electrical utilization equipment fed from a high resistance grounded electrical distribution system.

#### **6.10.4 Ground Fault Indication**

**6.10.4.1** A ground fault indication system should be installed on each separately-derived AC electrical power distribution system (e.g. generators and transformers) that is not solidly or low impedance grounded. This system shall be designed to provide an indication of a ground fault condition, with the ground fault indicators provided at a location(s) that is commonly accessed by operating personnel. Separate, ground fault indication systems are not required when ground fault protection systems are provided.

### **6.11 Electrical Enclosures**

#### **6.11.1 General**

Electrical conductors, buses, terminals, or components that present a shock hazard are not permitted to be uninsulated if exposed.

**6.11.1.1** Electrical equipment enclosures are provided for both personnel and equipment protection. For offshore use, it is recommended that enclosures be constructed of corrosion-resistant materials, such as copper-free aluminum, stainless steel (Type 316 usually preferred because Type 303 and 304 are more subject to pitting-type corrosion), suitable plastic, fiberglass, or hot-dipped galvanized steel. Enclosure hardware constructed of Type 316 stainless steel is recommended.

**6.11.1.2** Refer to Table 11 for a listing and description of various NEMA enclosures available. For additional information, see NEMA ICS6 and NEMA 250. Refer to Table 12 for a listing and description of various IEC enclosures available. For additional information, see IEC 60529 for IP ratings. Refer to NEMA MG 1 for additional information concerning enclosures for rotating apparatus.

**6.11.1.3** Space heaters, breathers, or drains, or a combination of such, should be considered for all enclosures as a means of preventing internal moisture buildup and consequent, equipment-corrosion damage.

**6.11.1.4** Interior electrical equipment exposed to dripping liquids or falling solid particles should be manufactured to at least NEMA Type 2 or IP 32 degree of protection, as appropriate for the service intended.

**6.11.1.5** Electrical equipment in locations exposed to splashing, pressure-directed liquids or similar moisture conditions should be manufactured to meet at least a NEMA type 4 or 4X or IP 55 or 56 rating, as appropriate for service intended.

**6.11.1.6** It is recommended that electrical equipment in locations exposed to weather, but not exposed to the conditions defined in 6.11.1.5, be manufactured to meet NEMA 4, 4X or 7, or IP 55 or 56. Explosionproof or flame-proof enclosures may not provide protection against the ingress of water; breathers and drains may be required to prevent the accumulation of moisture.

**Table 11—NEMA Enclosures**

<b>NEMA Type No.</b>	<b>Type of Enclosure</b>	<b>Characteristics</b>	<b>Intended Use</b>	<b>Typical Offshore Applications</b>
1	General Purpose, Surface Mounting	A general-purpose (NEMA Type 1) enclosure is designed to meet the latest general specifications for enclosures of Underwriters' Laboratories. This enclosure is intended primarily to prevent accidental contact with enclosed electrical apparatus. A NEMA Type 1 enclosure is suitable for general-purpose application indoors where atmospheric conditions are normal. It is not dust-tight or water-tight.	To prevent accidental contact with live parts, indoors, where normal atmospheric conditions prevail.	Lighting panels, motor control centers, disconnect switches, etc., in unclassified locations inside buildings.
1-A	Semi Dust-tight	A semi dust-tight enclosure (NEMA Type 1-A) is similar to the Type 1 enclosure, but with the addition of a gasket around the cover. A NEMA Type 1-A enclosure is suitable for general-purpose application indoors and provides additional protection against dust, although it is not dust-tight.	Same as NEMA Type 1, but in locations where a small amount of dust is prevalent.	Same as NEMA Type 1.
1-B	General Purpose, Flush Mounting	A flush-type enclosure (NEMA Type 1-B) is similar to the Type 1 enclosure, but is designed for mounting in a wall and is provided with a cover that also serves as a flush plate.	Same as NEMA Type 1, but for flush-type mounting applications.	Same as NEMA Type 1 where flush (versus surface) mounting is desired.
2	Drip-tight	A drip-tight enclosure (NEMA Type 2), also referred to as drip-proof, is similar to the Type 1 general-purpose enclosure, but with the addition of drip shields or their equivalent. A Type 2 enclosure is suitable for application where condensation may be severe.  Note: Drip-tight apparatus may be semi-enclosed apparatus if it is provided with suitable protection integral with the apparatus, or so enclosed as to exclude effectively falling solid or liquid material.	Locations where condensation may be severe.	No typical offshore applications.
3	Weather-tight	A weather-tight enclosure (NEMA Type 3) is designed for use outdoors to provide protection against weather hazards such as rain and sleet. A NEMA Type 3 enclosure is suitable for application outdoors.	Outdoors where it is necessary to provide protection against weather hazards, such as rain and sleet.	Refer to NEMA Type 12 applications.
3R	Weather-resistant	A weather-resistant enclosure (NEMA Type 3R) is designed for use outdoors to provide protection against rain. Rain will not readily interfere with operation of internal components. NEMA Type 3R provides less protection than Type 3.	Same as NEMA Type 3, but in less severe application.	Same as NEMA Type 3.
4	Water-tight	A water-tight enclosure (NEMA Type 4) is designed for outdoor use and is required to meet the hose test as follows: NEMA Type 4 Enclosures shall be tested by subjection to a stream of water. A hose with a 1-in. nozzle shall be used and shall deliver at least 65 gal/min. The water shall be directed on the enclosure from a distance of not less than 10 ft and for a 5-minute period. During this period, it may be directed in one or more directions as desired. There shall be no leakage of water into the enclosure under these conditions.	Outdoor or indoor locations where enclosed equipment might be subjected to splashing or dripping water. Not suitable for submersion in water.	Equipment enclosures and junction boxes subject to wind-driven rain or hose washdown.

**Table 11—NEMA Enclosures (Continued)**

NEMA Type No.	Type of Enclosure	Characteristics	Intended Use	Typical Offshore Applications
4X	Water-tight	A water-tight corrosion-resistant (NEMA Type 4X) enclosure is similar to the Type 4 enclosure but is manufactured from corrosion-resistant materials, such as glass polyester or stainless steel.	Same as NEMA Type 4, but designed for a more corrosive environment.	Same as NEMA Type 4.
5	Dust-tight	A dust-tight (NEMA Type 5) enclosure is provided with gaskets and is suitable for application in locations where it is desirable to exclude dirt.	In locations where it is necessary to protect the enclosed equipment against injurious accumulation of dust or lint.	No typical offshore applications.
6, 6P	Submersible	A submersible enclosure is suitable for applications where the equipment may be subject to occasional temporary submersion (NEMA Type 6) and prolonged submersion (NEMA Type 6P) in water. The design of the enclosure will depend upon the specified conditions of pressure and time.	Locations where the equipment is subject to submersion in water.	Junction boxes installed in the splash zone.
7	Explosion-proof Class I	An explosionproof enclosure (NEMA Type 7) is designed to meet the application requirements in <i>NEC</i> Art. 500 for Class I locations and is designed in accordance with the latest specifications of Underwriters' Laboratories for particular groups of gases. Certain NEMA 7 enclosures are approved for several groups (such as Groups B, C, and D), while others may be approved only for a particular group (such as Group D). NEMA 7 enclosures are not necessarily suitable for outdoor use.	Locations classified as Class I, Division 1 or 2 hazardous locations.	Widely used in hazardous (classified) locations when arcing or high-temperature devices are utilized.
8	Explosion-proof Class I	Explosionproof, oil-filled, Class I. An explosionproof, oil-filled enclosure (NEMA Type 8) is designed to meet the application requirements in <i>NEC</i> Art. 500 for Class I locations and is designed in accordance with the latest specifications of Underwriters' Laboratories for specific gases. The apparatus is immersed in oil.	Same as NEMA Type 7.	Not widely utilized offshore, but suitable for same areas as NEMA Type 7.
9	Dust-ignition Proof, Class II	A dust-ignition-proof enclosure (NEMA Type 9) is designed to meet the application requirements in <i>NEC</i> Art. 500 for Class II locations and is designed in accordance with the latest specifications of Underwriters' Laboratories for particular dusts.	Locations classified as Class II hazardous locations (containing combustible dust).	No typical offshore applications.
10	Dust-ignition Proof, Class II	A Type 10 enclosure is designed to meet the latest requirements of the Bureau of Mines and is suitable for applications in coal mines.	Locations required to meet the latest requirements of the Bureau of Mines.	No typical offshore applications.
11	Acid-and-fume Resistant, Oil-immersed	An acid-and fume-resistant (NEMA Type 11) enclosure is suitable for applications indoors where the equipment may be subject to corrosive acid or fumes. The apparatus is immersed in oil.	Locations where acid or fumes are present.	No typical offshore applications.

**Table 11—NEMA Enclosures (Continued)**

<b>NEMA Type No.</b>	<b>Type of Enclosure</b>	<b>Characteristics</b>	<b>Intended Use</b>	<b>Typical Offshore Applications</b>
12	Dust-tight and Drip-tight	A dust-tight and drip-tight (NEMA Type 12) enclosure is provided with an oil-resistant synthetic gasket between the case and the cover. To avoid loss, any fastener parts are held in place when the door is opened. There are no holes through the enclosures for mounting or for mounting controls within the enclosure and no conduit knockouts or conduit openings. Mounting feet or other suitable means for mounting are provided. A NEMA Type 12 enclosure is suitable for industrial application in locations where oil or coolant might enter the enclosure. NEMA Type 12 enclosures are not suitable for outdoor use, but may be modified to meet Type 3 requirements with the addition of a drip shield. Enclosures carrying a NEMA 3.12 rating are superior to those carrying only a NEMA 3 rating.	Indoor locations where oil or coolant might enter the enclosure.	Indoors in areas protected from the environment, or outdoors when modified, to meet NEMA Type 3 requirements.
13	Oil-tight and Dust-tight	An oil-tight and dust-tight (NEMA 13) enclosure is intended for use indoors primarily to house pilot devices such as limit switches, push buttons, selector switches pilot, lights, etc., and to protect these devices against lint and dust, seepage, external condensation, and spraying of water, oil or coolant. They have oil-resistant gaskets and, when intended for wall or machine mounting, have mounting means external to the equipment cavity. They have no conduit knockouts or unsealed openings providing access into the equipment cavity. All conduit openings have provision for oil-tight conduit entry.	Indoor locations where spraying oil or coolant might enter the enclosure.	Indoors in areas protected from the environment for control panels.

**Table 12—Degree of Protection of Enclosures in Accordance with IEC 60529**

<b>First Number Degree of Protection Against Solid Objects</b>		<b>Second Number Degree of Protection Against Water</b>	
0	Nonprotected.	0	Nonprotected
1	Protected against a solid object greater than 50 mm, such as a hand.	1	Protected against water dripping vertically, such as condensation.
2	Protected against a solid object greater than 12 mm, such as a finger.	2	Protected against dripping water when tilted up to 15 degrees.
3	Protected against a solid object greater than 2.5 mm, such as wire or a tool.	3	Protected against water spraying at an angle of up to 60 degrees.
4	Protected against a solid object greater than 1.0 mm, such as wire or thin strips.	4	Protected against water splashing from any direction.
5	Dust-protected. Prevents ingress of dust sufficient to cause harm.	5	Protected against jets of water from any direction.
6	Dust-tight. No dust ingress.	6	Protected against heavy seas or powerful jets of water. Prevents ingress sufficient to cause harm.
		7	Protected against harmful ingress of water when immersed between a depth of 150 mm to 1 m.
		8	Protected against submersion. Suitable for continuous immersion in water.

NOTE The IP classification system designates, by means of a number, the degree of protection provided by an enclosure against impact or dust or water ingress. The IP classification should not be construed as indicating corrosion resistance.

**6.11.1.7** Electrical equipment subject to submersion should be manufactured to meet at least a NEMA Type 6 or 6P or IP 67 degree of protection, as appropriate for the service intended.

**6.11.1.8** Each enclosure should be selected such that the total rated temperature of the equipment inside the enclosure is not exceeded.

**6.11.1.9** Equipment enclosures for interior locations not subject to dripping liquids or falling solid particles should be manufactured to at least NEMA Type 1 or IP 10, as appropriate for the service intended. Most consumer products [e.g. personal computers, copy machines, facsimile (fax) machines and televisions] are not NEMA-rated but are permissible in such interior locations.

## **6.11.2 Arc Flash Considerations**

**6.11.2.1** The electrical power distribution system should be designed or operated to prevent exposure to personnel during operations, maintenance, or repair activities to excessive electrical incident energy. This should be demonstrated by the incident energy study as recommended in NFPA 70E. Proper design application of differential relays, ground fault protection, instantaneous overcurrent relaying, relay zone interlocking, and current limiting fuse applications, can be used to achieve reduced levels of electrical incident energy.

**6.11.2.2** It is recommended that adequate personal protective equipment (PPE), electrical safety equipment, and training be provided to personnel who work on or operate energized electrical equipment.

## **6.12 Working Space About Electrical Equipment and Means of Access**

### **6.12.1 General**

Working space is not required in back of assemblies such as dead-front switchboards or motor control centers where there are no renewable or adjustable parts such as fuses or switches on the back and where all connections are accessible from locations other than the back. Where rear access is required to work on de-energized parts on the back of enclosed equipment, a minimum working space of 30 in. (762 mm) horizontally shall be provided. In all cases, the work space shall permit at least a 90 degree opening of doors or hinged panels. Working space required by this section shall not be used for storage. When normally enclosed live parts are exposed for inspection or servicing, the working space, if in a passageway or general open space, shall be suitably guarded, barricaded, or otherwise blocked to restrict entry of unauthorized personnel.

### **6.12.2 Working Space About Electrical Equipment (600 Volts, Nominal, or Less)**

**6.12.2.1** Sufficient access and working space shall be provided and maintained about all electrical equipment to permit ready and safe operation and maintenance of such equipment. The provisions of *NEC* 110.26 C, D, E, and F should be followed.

**6.12.2.2** *Working Clearances.* The dimension of the working space in the direction of access to live parts operating at 600 Volts, nominal, or less to ground and likely to require examination, adjustment, servicing, or maintenance while energized shall not be less than indicated in Table 14. Distances should be measured from the live parts if such are exposed or from the enclosure front or opening if such are enclosed. Concrete, brick, or tile walls should be considered as grounded. Where electrical equipment is installed facing other electrical equipment, Working Condition 3 as shown in Table 13 should be assumed.

**6.12.2.3** In addition to the dimensions shown in Table 14 the work space shall not be less than 30 in. (762 mm) wide in front of the electrical equipment. The work space should be clear and extend from the floor or platform to the height required by this section. In all cases, the work space should permit at least a 90 degree opening of equipment doors or hinged panels. Equipment of equal depth should be permitted within the height requirements of this section.

**Table 13a—Selection of IEC 60529 IP Rated Enclosures to Meet NEMA Requirements**

NEMA Type	Definition	IP	Definition
1	General purpose, indoor.	20	Protection from solid foreign objects $\geq 12.5$ mm diameter.
2	Suitable where severe condensation present.	22	Protection from solid foreign objects $\geq 12.5$ mm diameter and against dripping water, spillage, (not rain) when enclosure is tilted up to 15 degrees.
3	Weather-tight against rain and sleet.	55	Dust-proof and protected against water jets.
3R	Rain-tight, less than NEMA 3.	24	Dust-tight and protection from splashing water.
4	Water-tight. Resistant to direct water jet spray.	66	Dust-tight and protection from powerful water jets.
4X	Same as NEMA 4, although corrosion resistant; stainless, nonmetallic.		
5	Dust-tight.	53	Dust-proof and protected against spraying water (not rain).
6	Limited submersion in water.	67	Protected against effects of immersion not below 1 m depth.
7	Explosionproof. Contains gaseous internal ignition.		
12	Dust-tight and Drip-proof.	54	Dust-proof and protected against splashing water (not rain).
13	Oil-tight and Dust-tight. Constructed with special gasketing to resist oil and liquid chemical penetration.	54	Dust-proof and protected against splashing water.
NOTE This table can only be used to determine IP rated enclosures required to meet NEMA specified enclosure designations.			

**Table 13b—Selection of NEMA Enclosures to Meet IP Designations**

NEMA Type No.	IP First Characteristic Numeral						IP Second Characteristic Numeral							Max IP Designation
	1	2	3	4	5	6	1	2	3	4	5	6	7	
1	X	0	0	0	0	0	0	0	0	0	0	0	0	IP10
2	X	0	0	0	0	0	X	0	0	0	0	0	0	IP11
3	X	X	X	X	X	0	X	X	X	X	0	0	0	IP54
3R	X	0	0	0	0	0	X	X	X	X	0	0	0	IP14
3S	X	X	X	X	X	0	X	X	X	X	0	0	0	IP54
4	X	X	X	X	X	0	X	X	X	X	X	X	0	IP56
4X	X	X	X	X	X	0	X	X	X	X	X	X	0	IP56
5	X	X	X	X	X	0	X	X	0	0	0	0	0	IP52
6	X	X	X	X	X	X	X	X	X	X	X	X	X	IP67
6P	X	X	X	X	X	X	X	X	X	X	X	X	X	IP67
12	X	X	X	X	X	X	X	X	X	X	X	0	0	IP52
12K	X	X	X	X	X	X	X	X	X	X	X	0	0	IP52
13	X	X	X	X	X	0	X	X	X	X	0	0	0	IP54

NOTE 1 This table can only be used to determine NEMA enclosures required to meet IP specified enclosure designations.

NOTE 2 "X" indicates that the NEMA type enclosure is judged to comply with the requirements for the corresponding characteristic numerals of IEC 60529.

NOTE 3 "0" indicates that the NEMA type enclosure is judged not satisfy the requirements corresponding to the characteristics numerals of IEC 60529.

EXAMPLE 1: IP 56 enclosure requirements can be satisfied with the following NEMA enclosure types: NEMA 4 and 4X.

**Table 14—Working Clearances**

Minimum Clear Distance (ft)			
Nominal Voltage to Ground	Condition 1	Condition 2	Condition 3
No greater than 30 Volts RMS, 42.5 Volts peak, or 50 Volts DC* (except for panelboards and switchboards) <b>*Departure from the NEC</b>	1 1/2	1 1/2	2
0 – 30 for panelboards or switchboards	3	3	3
31 – 150	3	3	3
151 – 600	3	1/2	4
<p>NOTE 1 Where the "Conditions" are as follows:</p> <ul style="list-style-type: none"> <li>a) Condition 1. Exposed live parts on one side and no live or grounded parts on the other side of the working space, or exposed live parts on both sides effectively guarded by suitable wood or other insulating materials. Insulated wire or insulated busbars operating at not over 300 Volts should not be considered live parts.</li> <li>b) Condition 2. Exposed live parts on one side and grounded parts on the other side.</li> <li>c) Condition 3. Exposed live parts on both sides of the work space (not guarded as provided in Condition 1) with the operator in between.</li> </ul> <p>NOTE 2 These clearances do not apply to self-contained instruments operating at voltages no greater than 30 Volts RMS, 42.5 Volts peak, or 50 Volts DC. This is a departure from the NEC.</p> <p>NOTE 3 This section is intended to address only the issue of electrical safety from the standpoint of electrical shock. For guidance on safe work practices related to electrical flash refer to NFPA 70E. Minimum clearances for adequate space to maintain electrical equipment should follow good engineering practice. Panelboards operating at 30 Volts RMS, 42.5 Volts peak, or 50 Volts DC or less do not present a hazard of electrical shock, but additional clearance is provided for other reasons.</p>			

### 6.12.3 Working Space About Electrical Equipment (Over 600 Volts, Nominal)

The applicable sections of NEC 110.III (Over 600 Volts nominal) shall be followed.

## 6.13 Additional Requirements for Floating Facilities

### 6.13.1 Inclination of a Facility

**6.13.1.1** All electrical equipment should be designed and installed to operate under the following two conditions:

- a) 15 degree static list at 7.5 degree static trim;
- b) 22.5 degree dynamic roll at 7.5 degree static trim.

**6.13.1.2** All emergency installations should be designed and installed to operate when the facility is at 22.5 degree list and 10 degree trim. In addition, emergency generators should also comply with 5.6.5.

**6.13.1.3** Mercury and float switches, loose parts, and gravity sensitive mechanisms are examples of devices that typically require additional consideration for vessel movement.

## **7 Electric Motors**

### **7.1 General**

**7.1.1** Electric motors are selected for the load requirements and the voltage, phase, and frequency of the power system. The motor design and construction should be suitable for both the load application and environmental conditions. For most applications, three-phase squirrel cage induction motors are recommended. Motors should be designed and constructed to meet NEMA dimensional and performance standards. It is recommended that motors comply with IEEE 841, NEMA MG-1, API 541, API 546, or API 547, as applicable. It should be noted that the scopes of these standards may overlap. The user should exercise good engineering judgment in applying these standards.

**7.1.2** AC motors operated on adjustable speed drives (non-sine wave power), in addition to the requirements of this section, should be carefully matched to the drive and load for optimum performance. See the special considerations in API 541 and IEEE 1566 for adjustable speed drive applications. DC motors are considered special cases and are not included in the scope of this section except where specifically referenced.

### **7.2 Selection**

#### **7.2.1 Three-phase Motor Voltages**

The normally recommended voltage for AC three-phase integral horsepower motors operated on 480-Volt systems is 460 Volts. Motors rated for 200 Volts, 230 Volts, or 575 Volts are recommended for supply systems voltages of 208 Volts, 240 Volts, or 600 Volts, respectively. Where motors larger than 200 HP are used, 2300 or 4000V Volt motors are usually preferable. For motors 5000 HP and larger higher voltages should be considered. In view of the problems of hazardous (classified) locations and severe environmental conditions on offshore platforms, special consideration should be given to all aspects of the installation before using motors and related controllers of voltages above 600 Volts.

#### **7.2.2 Single-phase Motor Voltages**

Single-phase motors, normally limited to fractional horsepower loads, usually are rated at 115 or 200/230 Volts when driving fixed equipment. For portable motors, 115 Volts is preferred.

#### **7.2.3 Supply Voltage**

The supply voltage and frequency should be as near the nameplate rating as practical and should not deviate more than 10 % in voltage and 5 % in frequency, above or below rating. The sum of voltage and frequency deviations may total 10 % provided the frequency deviation does not exceed 5 %.

#### **7.2.4 Motor Enclosures**

**7.2.4.1** Motor enclosures should be selected both to provide adequate protection from the environment and also to satisfy the area classification requirements.

**7.2.4.2** In Class I, Zone 2 locations, motors having type of protection “n” approved for the locations in which they are used, or totally enclosed, open drip-proof, or NEMA weather protected Type I or Type II motors that have no arcing or high-temperature devices may be used. Note that most single-phase motors have a centrifugal switch, which is an arcing device. All arcing or high-temperature devices shall be approved for use in Class I, Zone 2 hazardous locations or provided with suitable enclosures (reference IEEE 303 for additional requirements). Totally enclosed motors (IP44 or higher) generally are preferred to open motors because the insulation of totally enclosed motors is not continuously exposed to the salt-laden air. For improved resistance to corrosion, “chemical type” motors are recommended in preference to standard motors for integral horsepower motors in the NEMA frame sizes. These totally enclosed motors normally are available with all cast metal parts, noncorrosive and nonsparking cooling fans, corrosion-



resistant hardware, stainless steel nameplates, and paint coatings on both the interior and exterior parts. In larger sizes, totally enclosed fan-cooled (TEFC or IP44/54), totally enclosed water-air-cooled (TEWAC or IP54), or totally enclosed air-to-air cooled (TEAAC or IP54) motors with sealed insulation systems are recommended.

**7.2.4.3** In Class I, Zone 0 locations, it is recommended that installation of motors and related electrical apparatus be avoided. When installed in Zone 0 locations motors shall be of the submersible type and immersed in liquid during operation. Submerged pump motors should be provided with low liquid level protection and either motor undercurrent protection or pump discharge pressure sensors to activate if the pump loses suction. These sensors should automatically shut down power to the motor and activate audible and visual alarms.

**7.2.4.4** When motors requiring a positive-pressure ventilation system compliant with the requirements of NFPA 496 are installed within a hazardous location, they should be provided with a forced ventilation system for cooling and pressurization, with air intakes drawing from an unclassified location, preferably outboard. The cooling air shall be exhausted into an unclassified area or through a spark arrestor type assembly into a Zone 2 location to prevent the discharge of sparks into an area where flammable vapors could be anticipated under abnormal conditions.

**7.2.4.5** In Class I, Zone 1 locations, motors shall be approved to meet one of the following specific methods of construction: Flameproof (protection type "d"), Increased Safety (protection type "e"), pressurized (protection type "p"), or a special submerged unit as referenced in 7.2.4.2. Alternatively, motors in Class I, Zone 1 locations may either be explosionproof and listed for use in a Class I, Division 1 location, or employ one of the protection techniques listed in *NEC* Article 501.125(A) (2), (3), or (4) for Class I, Division 1 locations.

## **7.2.5 Bearings**

### **7.2.5.1 Horizontal Motors**

Antifriction-type, grease-lubricated bearings are recommended for horizontal motors in the NEMA frame sizes and should be evaluated for motors as large as 250 HP (500 HP at 1200 rpm and less). Oil-lubricated sleeve bearings frequently are used for larger horizontal motors. Grease-lubricated anti-friction bearings should be designed with seals or shields to permit long periods of operation without regreasing; however, it is recommended that motors be equipped with grease fill and drain holes to permit regreasing in the field.

### **7.2.5.2 Vertical Motors**

Thrust bearings in vertical motors normally are of the ball or roller type. Grease lubrication is generally acceptable for normal thrust motors; however, oil lubrication is recommended for high thrust motors in the larger sizes. The up-and-down thrust requirements should be defined when motors are expected to carry thrust loads from driven equipment.

## **7.2.6 Temperature Considerations**

Electric motors normally are designed to operate at their nameplate rating in ambient temperatures up to 40 °C (104 °F). Where motors are expected to be operated continuously in higher ambient temperatures, consideration should be given to derating the motor or using a motor specially designed for the higher temperature. Special attention should be given to the selection of the bearing lubricants if the motor is to operate in unusually high or low temperatures (see also 6.7.12).

## **7.2.7 Torque Characteristics**

Motor torque characteristics should be selected both to match load requirements and also to consider limitations in generating capacity. Normal-starting torque (NEMA design B) motors should be suitable for low-starting torque loads (such as centrifugal pumps and fans). High-starting torque (NEMA design C) motors may be needed for loads requiring high-starting torque (such as positive displacement pumps and compressors).

### 7.2.8 Insulation

Most standard NEMA frame motors are fabricated using non-hygroscopic NEMA Class F or H insulation. In totally enclosed motors, the normal insulation can be expected to provide satisfactory service. If open drip proof or weather-protected motors are selected, it is recommended that the insulation be a sealed system. Motors with NEMA Class F insulation and with a NEMA Class B rise at rated motor horsepower are available in most motor sizes and types and are recommended to provide an increased service factor and longer insulation life.

### 7.2.9 Locked Rotor kVA

Three-phase induction motors normally are designed for a starting kVA of 5 to 6 times the horsepower rating. This starting kVA corresponds to NEMA locked rotor Code F and Code G and is suitable for most offshore applications. It may be desirable that large motors be specified with lower inrush currents to minimize the effects of starting on the power source. Consult the motor manufacturer for specific details.

### 7.2.10 Efficiency

New installations should consider the use of energy efficient motors. For a given horsepower rating and speed, the efficiency of a motor is primarily a function of load. The full load efficiency generally increases as the rated horsepower and/or speed increase. Also, efficiency increases with a decrease in slip (difference between synchronous speed and full-load speed of an induction motor, divided by the synchronous speed). High slip motors usually yield higher overall efficiency for applications involving pulsating, high inertia loads. Reference NEMA MG 10 for additional guidance. Generally, the inrush current on high efficiency motors is higher than that for standard motors.

## 7.3 Motor Space Heaters

For increased reliability, a motor can be equipped with space heaters or a low-voltage (usually 24 Volts to 32 Volts AC) circuit to keep the motor windings dry while not in operation. For motors located in hazardous (classified) locations, space heaters should operate with surface temperatures not exceeding requirements of the *NEC* for the flammable gas or vapor that could be present. It is recommended that motors 50 HP and larger be provided with space heaters or other anticondensation systems. It is recommended that for exposed insulation systems such as WPI, WP11 and Open Drip Proof machines additional space heaters be installed to provide more heat than is normally provided for onshore applications.

## 7.4 Motor Control

### 7.4.1 General

Most AC motors should be controlled by either a manual or a magnetic starter (or controller) adequately sized for both the starting inrush and the continuous load currents. The starter should open all phases simultaneously and provide overload protection in each phase. Magnetic motor starters normally are installed together with a circuit breaker or a fused switch to provide both short-circuit protection and a means of isolating the starter from the power source. Non-automatically started fractional horsepower motors may be protected by an internal temperature switch.

Caution—When motors utilizing type “e” protection (i.e. increased safety motors) are installed, the motor and its controller shall be installed in accordance with *NEC* 505.22.

### 7.4.2 Motor Starting Methods

Full voltage (across-the-line) starters are the simplest and should be satisfactory for most applications. If the motor nameplate horsepower is greater than 20 % of the generator's nameplate kVA, a reduced voltage starting method should be considered to avoid undesirable voltage dips on the system during starting. Several methods of reducing motor starting current are as follows:

- a) part winding starting;

- b) Wye-Delta starting;
- c) resistance reduced voltage starting;
- d) solid state reduced voltage starting;
- e) autotransformer reduced voltage starting;
- f) Adjustable Speed Drives.

### 7.4.3 Starter Sizing

Full voltage motor starters for AC induction motors should be sized according to NEMA recommendations listed in Table 15.

**Table 15—NEMA Motor Starter Sizing**

NEMA Size	Maximum Motor Size (HP)				
	Single-phase		Three-phase		
	115 V	230 V	200 V	230 V	460/575 V
0	1	2	3	3	5
1	2	3	7 1/2	7 1/2	10
2	3	7 1/2	10	15	25
3	7 1/2	15	25	30	50
4			40	50	100
5			75	100	200
6			150	200	400

### 7.4.4 Overload Protection

Motor starters should be equipped with an overload relay in each phase. These relays should be selected to de-energize the starter for continuous loads exceeding 115 % of rated full load motor current for motors with a service factor of 1.0 and 125 % of rated full load motor current for motors with a service factor of 1.15 or more. For most applications, manually reset overload relays are preferred to automatic reset. Solid state overload protection senses true RMS current rather than temperature; sensing true RMS current provides for more accurate overload protection and does not require ambient compensation. For overload device settings above 115 % in Zone 2 applications, it is recommended that sound engineering judgment be applied considering the AIT of the particular gas or vapor involved and the motor internal and external temperatures.

### 7.4.5 Short Circuit Protection

Combination motor starters are equipped with either a circuit breaker or a fused switch to provide short circuit protection. Magnetic-only circuit breakers or thermal-magnetic circuit breakers with adjustable magnetic trip are recommended because the adjustable trip feature permits the breaker to be set to protect the motor circuit at lower fault levels. Circuit breakers and fuses should be sized in accordance with the NEC 430.52. The interrupting capacity of breakers and fuses should exceed the maximum available fault current. Consideration should be given to providing single phase protection on motor controllers that utilize fused disconnect switches. Large or critical motor applications may utilize multifunction relays.

### 7.4.6 Control Methods

**7.4.6.1** To provide safety, each motor should be controlled by a separate starter in an individual enclosure or in a separate compartment of a motor control center. A common enclosure may be used for more than one starter when several motors are related to a common load and operated as a group. If the motor starter is not in sight of the motor, the starter should have provisions to either lock the disconnect in the open position, or have a manually operable switch within sight of the motor location that will disconnect the motor from its source of supply. It is recommended that low voltage motor control centers comply with UL 845 and medium voltage motor control centers comply with UL 347.

**7.4.6.2** The installation of a few motors usually is most practically controlled by individual motor starters placed on a common switchrack or in an environmentally controlled room. Where a number of motors are connected to a system, a motor control center located in an environmentally controlled room should be considered.

**7.4.6.3** Where electric power generating systems are limited in capacity, it may be necessary to design motor controls to prevent simultaneous starting of several motors, particularly upon resumption of power following a shutdown.

### 7.4.7 Starter Enclosures

**7.4.7.1** Motor starters installed in Class I, Zone 1 and 2 locations shall be listed for the applicable location.

**7.4.7.2** All motor starters shall be enclosed per 6.11.

### 7.4.8 Identification of Controllers

**7.4.8.1** Each motor controller should be marked in accordance with *NEC* 430.8. Each motor controller should be externally marked to identify the specific load served unless located and arranged such that its load is evident. These markings should be consistent with the markings on the loads. In addition, motor controllers that are not part of a Motor Control Center (MCC) should be externally marked to indicate their source of power.

**7.4.8.2** Motor control centers should be marked in accordance with *NEC* 430.98.

**7.4.8.3** Motor Control Centers (MCC) or individual Motor Controllers shall have a warning label indicating potential electric arc flash hazard. Consider labeling the equipment with the potential amount of incident energy and/or the level of arc flash PPE required. Refer to NFPA 70E for calculation methods and typical examples. Refer to 6.11.2 for further information.

### 7.4.9 Documentation

Adequate documentation is recommended to facilitate proper operation and maintenance. It may be useful to have elementary drawings stored in the vicinity of the motor controller.

## 8 Transformers

### 8.1 General

Power transformers typically are used on offshore production platforms to provide various transmission and utilization voltage levels. Power transformers should be designed and constructed in accordance with ANSI C57 standards as a minimum. In addition to power transformers, small control transformers are frequently utilized in control circuits. Instrument transformers and both potential transformers (PTs) and current transformers (CTs) are frequently utilized for instrumentation circuits. On systems containing nonlinear loads, which generate harmonics, K-factor rated transformers should be considered. The K-factor ratings should be selected based on the magnitude of the harmonic

current present and the maximum temperature rise as calculated by the methods in ANSI/IEEE C57.110. As K-factor ratings increase, transformers become larger and heavier. Typical nonlinear loads include lighting ballasts, ASDs, DC drives, computers, and UPS systems.

## **8.2 Selection**

### **8.2.1 Three-phase Versus Single-phase Units for Three-phase Systems**

When transformers are required in three-phase systems, either three-phase transformers or separate single-phase transformers can be utilized. A disadvantage of utilizing a single three-phase transformer is that the entire unit should be replaced if any one of the windings fails. Advantages of three-phase transformers are higher efficiency, less weight, and small physical size.

### **8.2.2 Dry-type Versus Liquid-filled Units**

**8.2.2.1** For most typical offshore installations, dry-type, self-cooled transformers usually are more practical for sizes through 112.5 kVA at 600 Volts. Voltage ratings may be increased to 5,000 Volts with sound engineering. Liquid-filled, self-cooled transformers usually are more practical for higher voltages and larger kVA capacities. For some applications, high fire point liquid-insulated transformers should be considered.

**8.2.2.2** The presence of polychlorinated biphenyls (PCBs) in transformers is regulated in accordance with the U.S. Environmental Protection Agency regulations—in particular, Title 40 *CFR* Part 761. Equipment containing PCB liquids requires special labeling, inspection, maintenance, record keeping, storage and disposal.

### **8.2.3 Special Offshore Considerations**

**8.2.3.1** When transformers are installed in buildings or other protected areas, standard transformers can be utilized satisfactorily. However, to achieve high reliability and minimize maintenance when transformers are exposed to the marine environment, the following features should be considered for offshore facilities:

- a) Permanently attached nameplates of corrosion resistant material. Nameplates shall provide the connection diagram, the name of the manufacturer, rated kilovolt-amperes, frequency, primary and secondary voltages, percent impedance, class of insulation, and the temperature rise for the insulation system;
- b) High-quality exterior coating for the entire enclosure, including mounting brackets and other peripheral components, to resist corrosion, unless the components are of corrosion-resistant materials.

**8.2.3.2** For dry transformers:

- a) Totally Enclosed Nonventilated enclosures (TENV) are recommended for outdoor locations, but Totally Enclosed Ventilated enclosures (TEV) are suitable for most indoor locations;
- b) flexible, multistrand copper primary and secondary lead wires with high-temperature insulation that is resistive to the corrosive effects of salt water and alkaline mud;
- c) Class H insulating material;
- d) full load temperature rise not exceeding 115 °C (239 °F);
- e) vacuum pressure impregnated (VPI) core and coil;
- f) copper coil material, if aluminum coils are utilized, special precautions should be taken at terminations.

**8.2.3.3** For liquid-filled transformers:

- a) full load temperature rise not to exceed 55 °C (131 °F) OA;
- b) low oil-level indication;
- c) high oil-temperature indication;
- d) field replaceable cooling fin assemblies, if provided with cooling fins. Replaceable cooling fin assemblies made of painted 304 stainless steel should be considered;
- e) where aluminum windings are utilized, the winding to terminal pad connection should be oil-immersed.

**8.3 Installation****8.3.1 General**

It is recommended that transformers be installed in accordance with the *NEC*, particularly Article 450. ANSI C57.12.70 gives standard terminal markings and connections.

**8.3.2 Special Considerations**

**8.3.2.1** If liquid-filled transformers are utilized, it is recommended that such be installed outdoors. All liquid-filled transformers should be provided with adequate curbing to confine any transformer liquid spilled to prevent pollution and to confine any burning oil. Other design considerations may be made when low flammability biodegradable oil filled transformers are used.

**8.3.2.2** Transformers installed in Zone 1 locations shall be approved for the location or installed in accordance with the requirements for transformers installed in Class I Division 1 locations per *NEC* Art 501. It may be practical to install small control transformers in flameproof or explosionproof enclosures. Special precautions should be taken to properly dissipate heat without exceeding the devices' ratings. Reference also paragraph 4.2 for surface temperature and other considerations. Ordinary location transformers are permitted in Zone 2 locations, provided the accessory devices (such as fans and alarm switches) are suitable for the location. Standard transformers are permitted in Zone 2 locations, provided the accessory devices (such as fans and alarm switches on liquid-filled transformers) are suitable for the location.

**8.4 Connections****8.4.1 General**

Three-phase transformer banks can be connected in four basic configurations:

- a) Wye-Wye (also referred to as Star-Star);
- b) Wye-Delta;
- c) Delta-Delta;
- d) Delta-Wye.

The Delta-Wye, Wye-Delta, and Delta-Delta connections are recommended for most three-phase transformer applications. In four-wire systems, the Wye connection provides a neutral to serve single-phase loads.

## 8.4.2 Common Connections

Specific characteristics of the five most common three-phase transformer connections are given below.

### 8.4.2.1 Delta-Wye and Wye-Delta

**8.4.2.1.1** The Delta-Wye connection is suitable for three-wire primary systems and three- or four-wire secondary systems. The four-wire secondary system can serve single-phase, line-to-neutral loads and three-phase loads. The three-wire Wye secondary system can serve single-phase, line-to-line loads and three-phase loads.

**8.4.2.1.2** The Wye-Delta connection is suitable for systems serving line-to-line single-phase and three-phase loads. Single-phase loads requiring a grounded neutral can be served by grounding a center tap of one winding; however, such loads do unbalance the transformer's phase balance.

**8.4.2.1.3** The Delta connection stabilizes the neutral of the Wye and eliminates third harmonic currents in the supply line. The neutral in the Wye connection makes any type of system grounding convenient, see 6.10.2.

### 8.4.2.2 Delta-Delta

The Delta-Delta connection is suitable for three-phase three-wire primary and secondary systems feeding three-phase loads. Single-phase loads can be served as explained in 8.4.2.1.2. The secondary may be operated ungrounded or grounded; a grounding transformer should be provided, however, if it is desired to obtain equal line-to-ground voltages. If three single-phase transformers are used to form a three-phase system, all three transformers should have identical voltage ratios, polarities, and impedances to prevent undesirable circulating currents. An advantage of the Delta-Delta connection is that it can be operated with two transformers in the Open-Delta connection if one transformer fails (reference also 8.4.2.4). A disadvantage of ungrounded Delta-Delta connections is that arcing ground faults can generate abnormally high voltages.

### 8.4.2.3 Wye-Wye

The Wye-Wye connection is not recommended. Serious damage can occur to both loads and to the transformer itself unless Delta tertiary windings or other provisions are made to accommodate the third harmonic currents produced by the Wye-Wye connection. Third harmonic currents can be as much as 50 % to 60 % of the fundamental exciting currents without such provisions.

### 8.4.2.4 Open-Delta

A variation to the Delta connection is the Open-Delta connection. Although this is not recommended as a design standard for power circuits, the Open-Delta connection often can be utilized as an expediency measure if one of the three single-phase units in a three-phase bank faults. This connection is identical to a standard Delta connection, except one of the windings is absent. The Open-Delta system is capable of 57.7 % of the kVA load of the original transformer bank.

## 8.5 Protection

### 8.5.1 Lightning Protection

Lightning protection normally is not required for transformers installed offshore. However, transformers should be protected if the incoming line sections are connected to circuits exposed to lightning strikes. Circuits connected to open wire power lines through power transformers or metal-sheathed cable generally are not considered exposed if adequate protection is provided on the line side of the transformer or at the junction of the metal-sheathed cable and the open wire power lines. Electrical systems confined entirely to the interior of a building or completely enclosed in metallic enclosures, raceways, or sheaths are not considered exposed to lightning.

## 8.5.2 Overcurrent and Fault Protection

**8.5.2.1** All transformers should be provided with overcurrent protection in accordance with the *NEC* Article 450. It is noted that transformers over 600 Volts and those 600 Volts or less are considered separately and differently. Also, it is cautioned that the requirements for sizing fuses and for sizing circuit breakers are different.

**8.5.2.2** It is recommended that all transformers rated 5000 kVA and larger be provided with differential protection.

**8.5.2.3** It is recommended that all liquid-filled transformers rated 5000 kVA and larger be protected by a sudden pressure relay to detect internal arcing faults.

**8.5.2.4** When the electrical system is ungrounded, a ground-fault detection system is required.

**8.5.2.5** When the electrical system is high-resistance grounded, a ground-fault detection system with alarms is required.

**8.5.2.6** When the electrical system is low-resistance grounded, ground-fault protective devices should be provided to open the transformer secondary breaker if coordinated downstream devices do not clear the fault. If the secondary breaker is located remote from the transformer, then consideration should be given to tripping the primary protective device upon ground fault detection coordinated with the downstream devices.

**8.5.2.7** When the electrical system is solidly grounded and the transformer secondary protective device is rated 1000 amperes or greater, ground fault protective devices should be provided to open the transformer secondary breaker if coordinated downstream devices do not clear the fault.

NOTE See IEEE Std 142 for additional information on transformer grounding.

## 9 Lighting

### 9.1 General

Lighting is provided for offshore installations for two distinct purposes. One of the purposes of lighting is to provide safety to operating personnel, requiring relatively low levels of lighting. The other purpose is to ensure effective and efficient job performance, normally requiring higher lighting levels than those levels required for safety alone. This section discusses lighting levels for both purposes, as well as equipment selection and installation practices. Glare, color, contrast and other factors that may be considered in the design of lighting systems are beyond the scope of this recommended practice.

### 9.2 Lighting Levels

#### 9.2.1 General

Lighting systems should be designed to give slightly more than desired light initially to allow for lamp deterioration and dirt accumulation on the fixture lens. The lighting system should be designed to provide the desired quantity of light at the particular location and in the proper visual plane (horizontal, vertical, or oblique angle).

#### 9.2.2 Levels for Efficiency of Visual Operations

The illumination values in Table 16 are typical examples of recommended minimum maintained lighting levels for the designated areas for efficiency of visual operations (adapted from the *IES Lighting Handbook*). The minimum recommended levels of illumination for safety in various locations are given in Table 17. As recommended by IES, the levels of illumination for safety are divided into two primary areas, dependent upon the hazard requiring visual detection—slight or high. Also, these two areas are divided according to the normal activity level—low or high. The minimum recommended levels of illumination for safety based on various types of hazards are given in Table 16A.



**Table 16—Minimum Recommended levels of Illumination for Efficient Visual Tasks**

Area	Minimum Lighting Level (Foot-candles)
Offices, General	50
Offices, Desk Area	70
Recreation Rooms	30
Bedrooms, General	20
Bedrooms, Individual Bunk Lights	70
Hallways, Stairways, Interior	10
Walkways, Stairways, Exterior	2
Baths, General	10
Baths, Mirror	50
Mess Halls	30
Galleys, General	50
Galleys, Sink, and Counter Areas	100
Electrical Control Rooms	30
Storerooms, Utility Closets	5
Walk-in Freezers, Refrigerators	5
TV Rooms (lights equipped with dimmers)	Off to 30
Work Shops, General	70
Work Shops, Difficult Seeing Task Areas	100
Compressor, Pump and Generator Buildings, General	30
Entrance Door Stoops	5
Open Deck Areas	5
Panel Fronts	10
Wellhead Areas	5

**Table 16A—Minimum Recommended Levels of Illumination for Hazard Recognition**

Hazard Requiring Visual Detection	Slight Hazard		High Hazard	
Normal Activity Level	Low	High	Low	High
Foot-candles	0.5	1.0	2.0	5.0
NOTE Under loss of power conditions, where lighting is provided by battery powered fixtures, a minimum of 0.1 foot-candles for means of egress is recommended. This is consistent with the requirements of NFPA 101.				

**Table 17—Minimum Recommended Levels of Illumination for Safety**

Area	Minimum Lighting Level (Foot-candles)
Stairways	2.0
Survival Craft and Rescue Boat	2.0
Water surface below Survival Craft and Rescue Boat	0.5
Offices	1.0
Exterior Entrance	1.0
Compressor and Generator Rooms	5.0
Electrical Control Rooms	5.0
Open Deck Areas	0.5
Personnel Landings	1.0
Lower Catwalks	2.0

### 9.3 Fixture Selection and Installation

#### 9.3.1 General

Fixture selection for offshore use involves choosing which type lamp (fluorescent, high pressure sodium, incandescent, metal halide, etc.) should be used, determining the degree of ingress protection required (based on the environment in which the fixture will be installed), matching the fixture with the area classification of the location where the fixture will be installed, and selecting the most appropriate NEMA beam spread.

#### 9.3.2 Lamp Selection

Various types of lamps are utilized for offshore lighting. Application considerations of several types are discussed below.

##### 9.3.2.1 Fluorescent

Fluorescent fixtures often are a good selection for lighting building interiors and areas with low headroom because of high lamp efficacy (lumens/watt), long lamp life, and low profile. Fluorescent fixtures provide “instant on” lighting; long lamp life, good lumen maintenance and fixtures with high ingress protection are available. A key consideration in selecting fluorescent lighting fixtures relates to extremes in ambient temperature. Temperatures below 0 °C (32 °F) can cause starting problems and a significant decrease in light output. High ambient temperatures [in excess of 40 °C (104 °F)] can cause a significant decrease in light output. Self-ballasted compact fluorescent lamps when used as replacement for incandescent lamps may result in certification issues and may pose a risk when used in Zone 1 fixtures and therefore should not be used.

##### 9.3.2.2 Incandescent

Incandescent fixtures are seldom recommended for general area lighting offshore because of the lamp’s relatively short life, low efficacy, and susceptibility to vibration. When incandescent lamps are used, the long-life type lamp is recommended. Incandescent lamps provided “instant on” lighting and may be an appropriate choice for extremely high or low ambient temperatures.

### 9.3.2.3 Mercury Vapor

Mercury vapor light fixtures are not recommended for new construction. These fixtures are no longer available due to environmental considerations.

### 9.3.2.4 Metal Halide

Metal halide lamps are high efficiency lamps with white light. The pulse start type lamps provide a faster restrike time and longer life than the switch start type lamps. Probe Start metal halide ballast systems were banned by the U.S. Energy Independence & Security Act in 2009 and are therefore not suitable for new installations. These are replaced by Pulse start lamps that provide improved lamp life; lumen maintenance and efficacy over probe start lamps. The hot restrike time of Probe Start Metal halide is approximately 3 minutes to 5 minutes (which is greatly improved over the 15 minutes of Probe Start lamps). Alternative egress or standby lighting may be necessary in critical areas. These lamps are used where “white light” is desired.

### 9.3.2.5 High-Pressure Sodium

High-pressure sodium lamps provide higher efficiency and longer life than metal halide, however the color rendition index is significantly lower than metal halide. The use of “dual arc tube” HPS lamps is suggested to reduce maintenance costs and to provide a hot restrike.

### 9.3.2.6 Induction

Induction Light sources should be considered for general lighting because of their extremely long life, high color rendition, and instant-on capabilities and resistance to vibration. While Induction lamps are typically available in wattages below 200W and are a good choice as replacements or alternatives for low wattage metal halide and HPS lighting. Limited wattage availability does minimize use of this light source over long distances.

### 9.3.2.7 LED (Light Emitting Diode)

LED Light sources should be considered due to their increased energy efficiency, superior color rendition, higher fixture efficacy and extremely long life. LED light sources provide increased visibility for less wattage. Colored LED light sources are superior choices for obstruction, warning, and navigation lighting due to their long life and minimal lumen depreciation. Users need to be aware of ambient temperature conditions when using LED lighting systems. High ambient temperatures can greatly reduce the life of a unit. In low ambient locations exposed to rain, snow and sleet, the LED fixture may not generate sufficient heat to prevent or shed the buildup of ice on the lens that can impair the light output.

## 9.3.3 Special Considerations

The following factors should be considered when selecting lighting fixtures for offshore platforms.

**9.3.3.1** It is desirable that lighting fixtures include all of the following features:

- a) corrosion-resistant materials;
- b) captive screws;
- c) adequately sized threaded conduit or cable entrances;
- d) capacitors capable of withstanding the high humidity.

**9.3.3.2** Where practicable, lighting fixtures should be installed for easy access by maintenance personnel without the use of portable ladders. If poles are used, the laydown or swivel type should be considered.

**9.3.3.3** Lighting fixtures installed in hazardous (classified) locations shall be approved for the area, as listed below.

**9.3.3.3.1** Installation of lighting fixtures in Class I, Zone 0 locations shall be avoided. Fixtures installed in Zone 0 areas shall be through-bulkhead type or shall be intrinsically safe, employing type of protection “ia”.

**9.3.3.3.2** In Class I, Zone 1 locations, lighting fixtures shall employ one or more of the following specific methods of construction:

- a) flameproof (protection type “d”);
- b) increased Safety (protection type “e”);
- c) powder filling (protection type “q”).
- d) explosionproof fixtures listed for use in a Class I, Division 1 location.

**9.3.3.3.3** In Class I, Zone 2 locations, fixtures having types of protection “nA” and/or “nR” and approved for the location may be used. Alternatively, fixtures listed for use in a Class I, Division 1 or 2 locations may be utilized in Zone 2 locations.

**9.3.3.4** Wiring with high-temperature insulation should be utilized inside fixtures for interconnections. This is particularly important when installing flameproof or explosionproof pendant-type fixtures of most designs, see also 6.7.5.

**9.3.3.5** Flexible cushion hangers or flexible fixture supports are desirable on pendant fixtures to reduce vibration (and thus increase lamp life), also see *NEC* Articles 501.130(A)(3) and 501.130(B)(3). All fixtures should be physically protected or installed out of the way of moving objects. It usually is desirable to provide globes on pendant and ceiling fixtures. Guards are recommended for fixtures subject to mechanical damage.

#### **9.3.3.6 Restricted Breathing Lighting Fixtures**

Restricted Breathing (nR) protection is an approved method by the *NEC* for Zone 2 applications. The hazard is “restricted” to the outside of the housing, so internal components are no longer considered a source of ignition. The benefit of nR and the better T ratings allow higher wattage fixtures for better illumination. The fixture design is based on enhanced ingress protection that limits the air exchange of the unit during heating (on) and cooling (off) cycles. This allows the T-Code ratings to be based on the external temperature of the fixture in contrast to a standard Zone I, which is based on internal temperatures. Care should be taken when installing and maintaining Restricted Breathing fixtures to ensure the globe (if used) is tightened beyond hand tight and that any torque requirements for closing fasteners as identified by the manufacturer are maintained.

#### **9.3.3.7 Remotely Mounted Ballasts**

**9.3.3.7.1** Remotely mounted ballasts are sometimes desirable. They can be installed at convenient locations for ease of maintenance and away from high-temperature areas (i.e. ceilings of compressor buildings) for extended life. However; there are maximum distances for remote mounted ballast applications.

**9.3.3.7.2** If it is desirable to separate high-pressure sodium lamps from their ballasts, the manufacturer should be consulted for maximum distances allowed.

**9.3.3.7.3** Metal halide lamps will not re-light immediately after a brief power interruption. Where continuity of lighting is important, they should be supplemented with another type of lamp (e.g. high-pressure sodium or fluorescent). Fluorescent lamps relight immediately. High-pressure sodium lamps re-light to partial lumen output rapidly after brief power outages. Use of high-pressure sodium lamps with dual arc tubes or with instant restrike ballasts will give instant return to 30 % to 50 % brilliance after momentary power dips and will ultimately return to full brilliance.

**9.3.3.7.4** Components for high pressure sodium ballasts that shut off at the end of lamp life are available. This reduces ballast failure from continued restrike attempts.

**9.3.3.7.5** The stroboscopic effect inherent with fluorescent and HID lighting should be considered before installing these fixtures in areas with rotating machinery. The effect can be overcome by connecting fixtures within the same room on two or more phases of a three-phase power supply. There is no stroboscopic effect with Induction or incandescent lamps.

**9.3.3.7.6** When berth lights are selected, consideration should be given to minimizing horizontal projections so that the lights will not be covered with bedding.

## **9.4 Standby Lighting**

### **9.4.1 General**

Standby lighting systems may be desirable for certain offshore locations during times of power failure.

### **9.4.2 Recommended Locations**

Generally, it is recommended that standby lighting systems be provided in buildings where personnel are quartered or assembled and, also, in other buildings or areas where personnel utilize power tools or other equipment that would subject such personnel to danger if illumination were suddenly extinguished. In addition, egress lighting systems may be desirable for personnel evacuation from manned platforms and for illuminating shut-down controls.

### **9.4.3 System Recommendations**

**9.4.3.1** The egress lighting system may be separate from or an integral part of the regular lighting system. Where loss of regulator lighting presents a danger to personnel, egress lighting should be provided automatically.

**9.4.3.2** *Duration.* Where permanently installed, standby lighting should be designed with battery capacity for 1.5 hours of operation or connected to a standby or emergency power source capable of 1.5 hours of continuous operation.

**9.4.3.3** *Additional Duration.* Where emergency or standby generators are not provided to augment the 1.5 hour duration, consideration should be given to supplementing permanently installed lighting systems with additional duration capacity. This can be achieved by greater battery capacity, chemical light sources, hand lanterns, etc. Such additional duration lighting may be fixed or portable but, if employed, should be capable of providing silhouette lighting for 8 hours or more which is adequate to allow personnel to move about stairways, hallways, exit areas, rest rooms, and power generating spaces.

### **9.4.4 Lighting Circuits**

#### **9.4.4.1 General**

Lighting for engine rooms, boiler rooms, living quarters areas accommodating more than 25 persons, and enclosed machinery spaces should be supplied from two or more branch circuits.

NOTE One of these branch circuits may be a standby or an emergency lighting circuit.

#### **9.4.4.2 Lighting Branch Circuits**

**9.4.4.2.1** Lighting branch circuits should be dedicated to lighting loads.

**9.4.4.2.2** Lighting branch circuits should be protected by overcurrent devices rated at 20 amperes or less, except nonswitched lighting branch circuits up to 30 amperes.

#### **9.4.4.3 Lighting of Survival Craft and Rescue Boats**

During preparation, launching, and recovery, each survival craft and rescue boat, its launching appliance, and the area of water into which it is to be launched or recovered shall be adequately illuminated by lighting supplied from the emergency power source. Minimum illumination levels around the survival craft and rescue boat should comply with those specified in Table 17. A minimum of 0.5 foot-candles should be considered adequate for the water surface below. It is recommended that fixtures provided for water surface illumination be designed or arranged to minimize glare. The arrangement of circuits should be such that the lighting for adjacent launching stations for survival craft or rescue boats is supplied by different branch circuits.

### **9.5 Lighting for Helicopter Operations**

#### **9.5.1 Perimeter Lights**

Helideck perimeter lights should be installed in accordance with the lighting section of API 2L, section 5.10 "Lighting" (duplicated below for the convenience of the reader), except as modified herein. Perimeter lights are recommended only on manned facilities.

#### **9.5.2 Excerpts from API Recommended Practice 2L**

##### ***Lighting***

*For night use, perimeter lights should be used to delineate the heliport flight deck. Alternating yellow and blue omnidirectional lights of approximately 30 watts to 60 watts should be spaced at intervals to adequately outline the flight deck. A minimum of eight lights is recommended for each heliport. Adequate shielding should be used on any floodlighting that could dazzle the pilot during an approach for landing. Obstructions that are not obvious should be marked with omnidirectional red lights of at least 30 watts. Where the highest point on the platform exceeds the elevation of the flight deck by more than 50 ft (15 m), an omnidirectional red light should be fitted at that point, with additional such lights fitted at 35 ft (10 m) intervals down to the elevation of the flight deck. An emergency power supply should provide power to the perimeter and obstruction lighting and to lighting along the heliport access and egress routes. Flight deck lights should be outboard of the flight deck and should not extend over 6 in. (15 cm) above the deck surface. They should be guarded, have no exposed wiring, and be located so as not to be an obstruction. Any inboard lighting should be flush mounted.*

#### **9.5.3 Hazardous (Classified) Location Lighting**

If perimeter lights are located in an area classified by API 505, they should be approved for the area\_classification of location; otherwise, weather-tight fixtures are recommended.

#### **9.5.4 Emergency Power Requirements.**

An emergency power supply, where provided on the facility, should provide power to the perimeter and obstruction lighting and to lighting along the heliport access and egress routes.

#### **9.5.5 Aircraft Warning Lights**

**9.5.5.1** All platforms and drilling rigs with cranes that can reach the flight deck or create an obstruction (see 9.5.2 for the definition of "obstruction") to helicopters on approach or departure should be equipped with an aircraft warning light, mounted on the crane. It is preferred that the light be automatically activated when the crane engine is running or the boom is out of the cradle, enabling the pilot to determine the crane's status.

**9.5.5.2** On unmanned structures where the work area, crane area, and helideck occupy the same deck level, and when crane usage can be classified as infrequent, a "portable" aircraft warning light (suitable for outdoor service) is permitted in lieu of a fixed aircraft warning light. The light may be powered from either dry cells or rechargeable batteries. The units should be located by operations personnel approximately in the middle of the flight deck when the crane boom is out of its cradle and promptly removed when the boom is returned to its cradle. All portable aircraft warning light packages not suitable for hazardous (classified) areas should be permanently labeled "WARNING—SOURCE OF IGNITION WHEN IN USE."

**9.5.5.3** It may be desirable to install a manually switched aircraft warning light located at the helideck so that the light can be activated whenever a safety hazard exists that would affect helicopter operations. This light is sometimes referred to as a wave-off light.

## **9.5.6 General Lighting of Helidecks**

**9.5.6.1** Offshore helidecks designated as overnight bases for field helicopters should be equipped with general area lighting for the performance of daily maintenance checks. Lighting fixtures used for this purpose and installed on the deck proper shall in no case extend greater than 6 in. (152 mm) above the flight deck surface. Each facility should be reviewed on a case-by-case basis to ascertain the need for such lighting.

**9.5.6.2** If adjacent structural supports at higher elevations (such as communications towers) are available for mounting lighting fixtures, HID fixtures remotely mounted on such supports are recommended for general area lighting.

**9.5.6.3** When general lighting is required and adjacent structural supports are not available, fluorescent fixtures are recommended due to their low profile, high efficiency, and reduced glare.

**9.5.6.4** Lighting levels of 5 ft-candles to 10 ft-candles (50 Lux to 100 Lux) are recommended when general lighting is required.

## **10 Battery-powered DC Supply Systems**

### **10.1 General**

**10.1.1** Battery-powered supply systems are utilized offshore primarily for the following reasons:

- a) provide continuous power, not interrupted by generator failures and shutdowns;
- b) provide standby power during generator failures and shutdowns;
- c) serve as buffers between electronics equipment and generating equipment;
- d) provide power to equipment designed for DC input power.

### **10.2 Specific Applications**

#### **10.2.1 Continuous Power Applications**

##### **10.2.1.1 Controls**

It generally is recommended that electrical control systems be powered by a DC source since most such systems are designed "normally energized" (commonly referred to as "fail-safe"); this avoids unnecessary equipment shutdown with temporary losses in AC power. Also, continuous power frequently is necessary to eliminate step input functions to controllers—often causing step output functions to process loops.

### 10.2.1.2 Instrumentation

Many instrumentation circuits utilize DC power for simplicity in reducing the effects of magnetic coupling of continuous and transitory extraneous signals into instrumentation loops.

### 10.2.2 Standby Power Applications

**10.2.2.1** Because the majority of electrical power utilized offshore is self-generated and alternate sources of power are not always readily available, many safety systems and other critical loads require standby power. Unique weather conditions offshore, particularly hurricanes, occasionally prevent personnel from visiting isolated structures for several continuous days. In these instances, standby DC systems are particularly attractive.

**10.2.2.2** It is recommended that AC-powered equipment operated by DC to AC inverters be avoided whenever DC-powered equipment can be utilized directly. The elimination of inverters reduces the number of components subject to failure, thereby improving reliability. Inverters are also less efficient and require larger batteries.

### 10.2.3 Buffer Applications

DC power systems often are installed to serve as buffers between power generators and electronic equipment, reducing the equipment's exposure to transients and short periods of time when AC power is off-frequency or off-voltage.

## 10.3 Batteries

### 10.3.1 Rechargeable (Secondary) Versus Nonrechargeable (Primary)

For most applications, rechargeable batteries are recommended over nonrechargeable batteries. Comparisons between the two types are given below:

- a) *Discharge Rate.* Nonrechargeable batteries normally are severely limited in discharge capacity, while rechargeable batteries capable of providing hundreds of amperes (for limited time periods) may be procured.
- b) *Volume and Weight.* Rechargeable batteries usually are smaller and lighter for the same voltage and ampere-hour capacity.
- c) *Internal Resistance.* Internal resistance is much higher for nonrechargeable batteries, which may be an advantage or a disadvantage, depending on the application.
- d) *Hydrogen Production.* Nonrechargeable batteries produce no hydrogen, while rechargeable batteries do. See 10.3.4.2.
- e) *Charging Power Required.* Rechargeable battery systems require AC power for conventional battery chargers, solar cells, windmill-driven DC generators, or similar provisions if the batteries are to be recharged on location.
- f) *Reliability.* With proper maintenance, overall reliability is approximately the same for the two types of batteries.
- g) *Maintenance.* While nonrechargeable batteries need only be checked periodically for proper voltage, rechargeable batteries require periodic cleaning and distilled, deionized water additions.

### 10.3.2 Typical Uses

**10.3.2.1** Typical uses for nonrechargeable batteries are for aids-to-navigation equipment and small supervisory control and remote monitor systems at isolated locations without AC power.



**10.3.2.2** Typical uses for rechargeable batteries are for electrical safety systems, communications equipment, engine cranking and control, and standby lighting systems.

### **10.3.3 Types of Batteries**

Numerous types of batteries are available. A comparison of batteries by cell type is shown in Table 18.

### **10.3.4 Special Considerations**

#### **10.3.4.1 Corrosion**

It is recommended that lead-acid batteries vented to the enclosure not be installed in small enclosures with electronics equipment, as contamination of the electronics equipment may result from corrosive gases produced by the batteries.

#### **10.3.4.2 Hydrogen Venting**

All rechargeable type batteries release hydrogen to the atmosphere in varying degrees; even battery types commonly referred to as sealed batteries, or valve regulated lead acid (VRLA) batteries, normally contain pressure relief devices and thus may vent hydrogen under overcharge conditions. Large rechargeable batteries can produce enough hydrogen to create a flammable mixture under certain conditions. All rechargeable battery systems should be installed such that hydrogen cannot collect in sufficient quantity to create a hazard. This may require that batteries inside buildings be installed in enclosures vented to the outside. It is recommended that the minimum ventilation levels specified by API 505 be maintained to ensure that the interiors of battery enclosures remain unclassified.

#### **10.3.4.3 Rooms and Enclosures**

**10.3.4.3.1** Enclosures normally are recommended both to provide protection against the environment and also to ensure that falling objects do not accidentally short the batteries. In addition to being deleterious to the batteries, shorts could cause arcs capable of igniting hydrogen-air or hydrocarbon-air mixtures. In addition, the following design considerations apply.

**10.3.4.3.2** Since the batteries may be the source of the flammable gas mixture in the battery room, it is impossible to separate the batteries from the source of the flammable gas. Installation of electrical equipment in dedicated battery rooms should be limited to the batteries, associated battery system wiring, and lighting for the space. All electrical equipment installed in such spaces, except for the batteries and battery leads, should be suitable for use in a Class I, Zone 1, Group IIC hazardous (classified) location.

**NOTE** Dedicated battery rooms are rooms large enough to accommodate the entry of personnel and whose sole purpose is for the enclosure of large banks of batteries and typically are directly ventilated with artificial ventilation systems such as fans. Other rooms where batteries may be installed along with other equipment, such as communications equipment, but where evolved hydrogen is removed from the room by suitable means (such as direct ventilation of individual cells or battery boxes in which they are installed) are not subject to these restrictions.

**10.3.4.3.3** Installation of electrical equipment in the vicinity of battery room power ventilation discharge openings should be avoided. Any electrical equipment installed within 18 in. (457 mm) of such openings should be suitable for use in a Class I, Zone 1, Group IIC hazardous (classified) area.

**10.3.4.3.4** All battery boxes installed on open decks should be weather-tight and constructed of corrosion-resistant materials such as fiberglass or hot-dipped galvanized steel. In battery rooms, consideration should be given to utilizing coating systems or materials that are impervious to the corrosive effects of battery electrolyte and emitted gasses. It is recommended that battery boxes be vented to dissipate heat and to disperse hydrogen gasses. For additional information on battery box ventilation requirements reference API 505, section 8.2.6.

**Table 18—Comparison of Batteries by Cell Type**

Type	Projected Useful Life (Years)	Projected Cycle Life (Number of Cycles)	Wet Shelf Life (Months)	Comments
Primary	1 to 3	1	12	<ul style="list-style-type: none"> <li>Least maintenance.</li> <li>Periodic replacement.</li> <li>Cannot be recharged.</li> </ul>
SLI (Starting, Lighting & Ignition) (Automotive Type)	1½ to 2	50 to 100	2 to 3	<ul style="list-style-type: none"> <li>High hydrogen emission.</li> <li>High maintenance.</li> <li>Not recommended for float service or deep discharge.</li> <li>Low shock tolerance (Flat Plate Design). Susceptible to damage from temperatures &gt;27 °C (80 °F).</li> </ul>
Lead Antimony	8 to 15	600 to 800	4	<ul style="list-style-type: none"> <li>High hydrogen emission (increases with age).</li> <li>Periodic equalizing is required for float service and full recharging.</li> <li>Low shock tolerance. Susceptible to damage from temperature above 27 °C (80 °F).</li> </ul>
Lead Calcium	8 to 15	40 to 60	6	<ul style="list-style-type: none"> <li>Low hydrogen emission if floated at 2.17 Volts per cell. Periodic equalizing charge is not required for float service if floated at 2.25 Volts per cell. However, equalizing is required for recharging to full capacity. When floated below 2.25 Volts per cell equalizing is required. Susceptible to damage from deep discharge and temperatures &gt;27 °C (80 °F).</li> <li>Low shock tolerance.</li> </ul>
Lead Selenium	20+	600 to 800	6	<ul style="list-style-type: none"> <li>Low hydrogen emission if floated at 2.17 Volts per cell.</li> <li>Periodic equalizing charge is not required for float service if floated at 2.23 Volts per cell. However, equalizing is required for recharging to full capacity. When floated below 2.23 Volts per cell equalizing is required.</li> <li>Low shock tolerance (Flat plate design). Susceptible to damage from temperatures &gt;32 °C (90 °F).</li> </ul>
Lead Plante <sup>a</sup> (Pure Lead)	20+	600 to 700	4	<ul style="list-style-type: none"> <li>Moderate hydrogen emission if floated at 2.17 Volts per cell.</li> <li>Periodic equalizing is required for float service and full recharging. Susceptible to damage from temperatures &gt;32 °C (90 °F).</li> </ul>
Nickel Cadmium (Ni-Cad)	25+	1000+	120+	<ul style="list-style-type: none"> <li>Low hydrogen emission if floated at 1.40 Volts per cell. Periodic equalizing charge is not required for float service, but is required for recharging to full capacity. High shock tolerance.</li> <li>Can be deep cycled. Least susceptible to temperature &lt;43 °C, (110 °F).</li> <li>Can remain discharged without damage.</li> </ul>

<sup>a</sup> Cycle life is the number of cycles at which time a recharged battery will retain only 80 % of its original ampere-hour capacity. A cycle is defined as the removal of 80 % of the rated battery ampere-hour capacity.

<sup>b</sup> Wet shelf life is defined as the time that an initially fully charged battery can be stored at 25 °C (77 °F) until permanent cell damage occurs.

<sup>c</sup> Float voltages listed are for 25 °C (77 °F).

**10.3.4.3.5** Where power ventilation systems are installed in battery rooms, consideration should be given to installing alarms or safety interlocks that activate upon loss of ventilation in the room.

**10.3.4.3.6** Provisions should be furnished to disconnect battery charging systems when a loss of room ventilation is detected, if the maximum battery charger output is greater than 2 kW.

#### **10.3.4.4 Rechargeable Batteries**

Rechargeable batteries should be stored and installed on electrically nonconductive surfaces and stored in cool dry locations. If extended storage of rechargeable batteries (except nickel cadmium) is anticipated, it is recommended that the batteries either be supplied dry-charged (batteries shipped without electrolyte) or be maintained in a fully charged state with a suitable charger.

#### **10.3.4.5 Hazardous (Classified) Locations**

It is recommended that batteries be installed in unclassified locations whenever possible. Batteries should not be installed in areas classified as Zone 0 or Zone 1 because of adjacent potential sources of release.

#### **10.3.4.6 Battery Disconnects**

It is recommended that rechargeable batteries be provided with suitable disconnect switches allowing maintenance personnel to remove all electrical loads from the batteries prior to removing battery leads or performing maintenance on the battery-powered equipment when:

- a) the batteries are located in a hazardous (classified) locations;
- b) the batteries furnish power to equipment in hazardous (classified) locations;
- c) the battery charger maximum output is greater than 2 kW.

#### **10.3.4.7 Other Battery Considerations**

**10.3.4.7.1** Batteries should be arranged to provide sufficient working space for inspection and maintenance.

**10.3.4.7.2** The fumes given off by rechargeable batteries are corrosive. Wiring and its insulation should be of the type that will withstand corrosive action. Wiring methods, racks, and trays should be designed to be corrosion resistant. All energized exposed battery components should have mechanical protection to prevent shorting and inadvertent personnel contact.

**10.3.4.7.3** Battery overcharging produces heat which in turn causes gassing and loss of water. A battery should not be allowed to reach temperatures over 43 °C (110 °F), because heat causes a shedding of active materials from the plates that will eventually form a sediment buildup in the bottom of the case and short circuit the plates and the cell.

**10.3.4.7.4** Because mixtures of oxygen and hydrogen are highly explosive, flame or sparks should never be allowed near a cell, especially if the filler cap is removed.

**10.3.4.7.5** It is recommended that batteries be selected with an initial capacity of 125 % of the required load.

### **10.4 Battery Chargers**

**10.4.1** When specifying battery chargers for offshore use, all of the following features should be considered.

- a) *Frequency and Voltage Tolerance.* It is recommended that chargers installed offshore be capable of tolerating voltage variations of  $\pm 10$  % and frequency variations of  $\pm 5$  %.

b) *Output Voltage.* Since the recharge voltage required varies with the ambient temperature and the particular type of battery used, the charger should be selected for the particular type of batteries being used and the anticipated ambient temperature range. It is recommended that the output voltage be adjustable.

c) *Size.* The minimum charger output current rating can be calculated according to the following equation.

$$C = L + \frac{AH \times BR}{T} \quad (3)$$

where

$C$  is charger size in amperes;

$L$  is connected load in amperes;

$AH$  is capacity of batteries in ampere-hours;

$T$  is desired recharge time in hours;

and the value for  $BR$  is one of the following;

$BR$  is 1.10 for lead calcium batteries;

$BR$  is 1.20 for sintered/PBE plate NiCad batteries;

$BR$  is 1.25 for lead antimony batteries;

$BR$  is 1.40 for pocket plate NiCad batteries.

d) *Enclosure.* The enclosure should be suitable for both the area classification and the environment. If flameproof or explosionproof or nonventilated enclosures are used, care should be taken to ensure proper heat dissipation.

e) *Area Classification.* If chargers are to be installed in hazardous (classified) locations, they shall be suitable for such areas.

f) *Equalization.* Certain types of batteries require equalizing charges on a periodic basis to ensure that all battery cells are fully recharged. Equalizing voltages could be as high as 110 % of the nominal float voltage. This higher voltage could be deleterious to connected equipment. Consideration should be given to the installation of the following:

1) counter-EMF cells;

2) dropping diode circuit;

3) DC-DC converters;

4) a reduction in the number of cells when the connected equipment will operate at the reduced voltage;

5) other effective means of protecting the load. If equalizing is desired, timers are available to automatically provide the proper frequency and duration of equalization.

g) *Regulation.* It is recommended that battery chargers be capable of maintaining their output voltage within  $\pm 1$  % from no load to full load current.

- h) *Current limiter.* It is recommended that chargers be provided with output current limiters.
- i) *Filtering.* For circuits powering electronics equipment (particularly solid state), 30-millivolt filtering (or less) is recommended for batteries of 48 Volts or less, and 100-millivolt filtering (or less) is recommended for batteries over 48 Volts. Output filters that prevent damage to electronics loads when the battery charger powers the loads directly with the batteries disconnected should be considered. For battery systems supplying other loads, such as engine cranking batteries, millivolt filtering is not usually necessary. When applying a battery charger which is rated to fully charge a battery in less than four hours the battery charger manufacturer should be advised of such in that filtering may be required to maintain output ripple of 30 millivolts or less.
- j) *Meters.* It is recommended that both an output ammeter and an output voltmeter be provided. For certain applications, AC input meters may be desirable.
- k) *Alarms.* Alarm outputs may be useful for the following conditions:
  - 1) low DC voltage;
  - 2) high DC voltage;
  - 3) AC power failure;
  - 4) ground indication;
  - 5) charger failure.
- l) *Input power.* Normally 120-volt, single-phase input power is recommended, but higher voltage chargers, three-phase chargers, or both, are available for larger sizes.
- m) *Transient suppression.* It is recommended that transient suppressers be provided on the AC input and the DC output.
- n) *Environmental considerations.* The following options are recommended when available:
  - 1) hermetically sealed relays;
  - 2) conformally coated printed circuit cards;
  - 3) environmentally sealed or hermetically sealed switches and circuit breakers;
  - 4) corrosion-resistant enclosures and hardware.
- o) *Blocking diode.* A blocking diode is recommended in the output of the charger.

## 10.5 Uninterruptible Power Supply (UPS) Systems

Uninterruptible power supply (UPS) systems are used offshore to supply AC power to computers, process controllers, and other critical loads during primary power failure. When specifying UPS systems for offshore use, the following features should be considered.

### 10.5.1 General

It is recommended that the UPS consist of a rectifier/charger, inverter, static switch, manual bypass switch, and batteries.

### 10.5.2 Recommended Performance Criteria

To ensure reliable operation the following minimum performance criteria are recommended:

- a) The UPS should be capable of tolerating various input frequency variations of  $\pm 5\%$  and input voltage variations of  $\pm 10\%$ .
- b) The output voltage should be within  $\pm 5\%$  of rated voltage and output frequency should be within  $\pm 1\%$  of rated frequency from no load to full load.
- c) The UPS should be capable of supplying the rated load kVA at power factors ranging from 0.75 lagging to 0.8 leading.
- d) It is recommended that UPS systems operate at rated output without any adverse affect in an ambient temperature of  $0\text{ }^{\circ}\text{C}$  ( $32\text{ }^{\circ}\text{F}$ ) to  $40\text{ }^{\circ}\text{C}$  ( $104\text{ }^{\circ}\text{F}$ ).
- e) Total harmonic distortion impressed on the primary power supply should be limited to  $5\%$ .

### 10.5.3 Current Limiters

It is recommended that UPS systems be provided with output current limiters.

### 10.5.4 Enclosure

The enclosure should be suitable for both the area classification and environment. If nonventilated enclosures are used, care should be taken to ensure proper heat dissipation.

### 10.5.5 Area Classification

If a UPS system is installed in a hazardous (classified) location, it shall be suitable for the area.

### 10.5.6 Rectifier/Charger

It is recommended that the rectifier/charger meet the basic requirements as outlined in 10.4.

### 10.5.7 Protection Against Internal Faults

The rectifier/charger should have protection against an internal failure draining the battery.

### 10.5.8 Inverter

**10.5.8.1** The inverter should automatically shut down for low DC input voltage equal to battery minimum voltage.

**10.5.8.2** The inverter should be designed so that the batteries can be disconnected from the system and the system will operate satisfactorily with the rectifier/charger and inverter units only.

### 10.5.9 Static Bypass Switch

**10.5.9.1** The static bypass switch should be supplied with suitable sensing and alarm circuitry to automatically transfer the load to the alternate power supply. Switch transfer time should be  $\frac{1}{4}$  cycle maximum.

**10.5.9.2** It is recommended that provisions for initiation of a manual transfer and retransfer be furnished. An interlocking synchronization check system should be included to prohibit completion of transfer if the systems are not synchronized.

### **10.5.10 Meters**

It is recommended that the following meters be included:

- a) DC input voltmeter;
- b) DC input ammeter;
- c) AC output voltmeter;
- d) AC output ammeter.

### **10.5.11 Alarm and Status Indications**

It may be desirable to provide a means for remote alarm and status indications as well as a local indication. Alarm and status outputs may be useful for the following conditions:

- a) DC input low voltage;
- b) synchronization verification (if applicable);
- c) inverter output failure;
- d) alternate AC supply available;
- e) inverter available;
- f) static bypass switch in alternate position;
- g) static bypass switch in normal position;
- h) static bypass switch malfunction.

## **11 Special Systems**

### **11.1 Electrical Platform Safety Control Systems**

#### **11.1.1 General**

A Platform Safety Control System is an arrangement of safety devices and emergency support systems to effect platform shutdown. The control medium for these devices and systems may be pneumatic, hydraulic, electric, or a combination thereof. API 14C covers in detail the basic safety systems on offshore platforms. IEC 61511/ISA-S84.00.01 (2004) is sometimes utilized where permitted by the authority having jurisdiction. This Standard is a performance-based Standard that requires a level of safety performance, using Safety Integrity Level (SIL) as a metric. The target SIL is based on the amount of risk inherent in the operation of the Platform.

#### **11.1.2 Design**

**11.1.2.1** It generally is recommended that electrical controls for platform safety control systems and other safety systems (e.g. gas and fire detection systems) be installed normally energized (commonly referred to as fail-safe). This means that power is supplied continuously during normal operations to end devices (such as solenoid valves) that provide corrective action if certain undesirable conditions (e.g. specific combustible gas concentrations) are detected. Under these conditions, interruption of power due to either deliberate end devices actuation or loss of power to the end device will initiate corrective action (e.g. equipment shutdown). Fire detection systems utilizing

supervised circuits may be installed in a normally de-energized configuration where the normally de-energized component is contained in a supervised circuit. The circuit supervision provides an additional level of protection in lieu of a "fail-safe" design and loss of power will initiate an alarm but corrective action will not be initiated. Obviously, special consideration should be given to systems where unwarranted shutdowns (such as those caused by coil failure of an energized solenoid valve) could create potentially hazardous situations (i.e. shutdown of emergency generator or battery systems).

**11.1.2.2** Circuit breakers with either shunt-trip or low-voltage release options often are used to initiate corrective action, e.g. disconnecting electrical power from a specific building. Both methods are acceptable. The source of power used to operate low-voltage release or shunt-trip devices should be either monitored by the safety system, with visual or audible alarms (as most appropriate for the particular location) actuated upon power source failure), or obtained from the source side of the feeder or branch circuit breaker that is to be de-energized by the trip device. If the feeder or branch circuit is already de-energized, it is not necessary that control power be available to de-energize the circuit.

**11.1.2.3** Supervised circuits provide an alternate method of ensuring proper operation of safety systems (e.g. fire detection systems and certain programmable logic controller outputs). Supervised circuits have a current-responsive device to indicate a break in the circuit, and, in some cases, to indicate an accidental ground. Such technique is also referred to as "protective signaling." Detected failures should cause the activation of audible or visual alarms (as most appropriate for the particular location).

**11.1.2.4** Loss of external power (not integral to manufactured equipment) to safety systems requires activation of visual or audible alarms (as most appropriate for the particular location). As an alternative to an alarm, suitable corrective action in accordance with API 14C is acceptable. Visual or audible alarms (as most appropriate for the particular location) should be provided on safety systems (e.g. gas and fire detection systems) to indicate a system malfunction if the systems have an output (e.g. relay contacts) indicating a malfunction in the system.

**NOTE** It is desirable to provide a test means that will allow safety systems to be tested and calibrated without initiating corrective action, but it should be evident to personnel that the system is in the test (bypass) mode.

### **11.1.3 Power Supplies**

**11.1.3.1** Electrical safety control systems should have reliable power sources, either AC or DC.

**11.1.3.2** A DC-powered system is the preferred means of supplying power to safety control systems. DC systems are discussed in Section 10.

**11.1.3.3** An AC system is usually powered through a battery charger-inverter system. In a battery charger-inverter system, the inverter provides standby power from batteries in the event of failure of the normal power source.

### **11.1.4 Equipment Selection**

**11.1.4.1** It is recommended that printed circuit boards be conformally coated to resist moisture and fungus damage, be built to withstand vibration, and have gold plated connectors.

**11.1.4.2** It is recommended that electronics units (AC or DC) be capable of tolerating voltage variations of  $\pm 10\%$  and frequency variations of  $\pm 5\%$ . Special filtering of noise/transients should be considered when electronics equipment is operated directly from AC supplies.

**11.1.4.3** Radio Frequency Interference (RFI):

**11.1.4.3.1** Most electronics equipment is susceptible to electromagnetic interference (EMI), especially RFI, which can cause malfunctions, false alarms, zero drift, and erroneous signals. Where EMI is anticipated, suitable apparatus immune to such interference should be selected.



**11.1.4.3.2** In areas subjected to EMI, it is recommended that properly grounded, shielded interconnecting cables (or wire and conduit) be used and enclosures (if of conductive material) be adequately grounded. It is recommended that cable shields be grounded at one point only, the controller end, unless otherwise specified by the manufacturer.

**11.1.4.4** Unless equipment is installed in an environmentally controlled room, it is recommended that relays, circuit breakers, and switches be hermetically sealed when available.

**11.1.4.5** Electronics packages not installed inside environmentally controlled equipment rooms should be constructed to provide protection against the environment and be suitable for the area. Housing material and mounting hardware should be corrosion resistant.

**11.1.4.6** Any viewing windows should be resistant to deterioration by ultraviolet radiation.

**11.1.4.7** Equipment should be suitable for the area in which it is installed (Zone 0, Zone 1, Zone 2, or unclassified).

### **11.1.5 Equipment Installation**

**11.1.5.1** It is recommended that electronics units and sensors be located in areas as free from vibration as possible. Vibration-damping devices should be considered where applicable.

**11.1.5.2** Signal cables should be provided with properly grounded shields to prevent interference from extraneous signals.

**11.1.5.3** A standby power supply should be provided in accordance with recommendations in 11.1.3.

**11.1.5.4** Whenever possible, it is recommended that electronics equipment be installed in environmentally controlled rooms.

**11.1.5.5** Platform safety systems installed specifically to provide personnel protection should include audible alarms. Audible alarms installed in buildings should be audible throughout. In high noise areas, it may be desirable to install visual alarms in lieu of, or in addition to, audible alarms.

## **11.2 Gas Detection Systems**

### **11.2.1 General**

**11.2.1.1** Gas Detection Systems are safety systems, and should meet the requirements of 11.1. Gas Detectors are available using different technologies. Many detectors provide a 4-20mA (or other equivalent means) output that indicates the status of the device, the integrity of the circuit, and the gas concentration. For all systems, consideration should be given to supervising field wiring to monitor the integrity of the circuit as detailed in 11.1.2.3.

**11.2.1.2** Combustible gas detection systems are used on offshore production platforms to detect combustible gas leaks in equipment and piping, to warn personnel of such leaks, and to initiate remedial action.

**11.2.1.3** Hydrogen sulfide (H<sub>2</sub>S) gas detection systems are used where necessary on offshore platforms to detect hydrogen sulfide concentrations in the atmosphere resulting from leaks in equipment and piping, to warn personnel of possible toxic concentrations, and to initiate remedial action.

**11.2.1.4** Sensor placement is outside the scope of this document. Recommended practices for sensor location and operation of combustible gas detectors are presented in API 14C.

**11.2.1.5** A combustible gas detection system may be used as a protection technique to allow the installation and use of electrical equipment in specific hazardous (classified) location applications. Any gas detection equipment utilized as a protection technique shall meet all of the following requirements.

- a) The gas detection equipment and installation shall meet all the requirements in API 505, section 6.8.
- b) The type of detection equipment, its listing, installation location(s), alarm and shutdown criteria, and calibration frequency shall be documented. The specific details of the application of this protection technique shall be documented on the facility area classification drawings and other documentation.
- c) The gas detection equipment used shall be approved for Class I, Zone 1, for the appropriate gas classification group(s), and for the detection of the specific gas or vapor to be encountered.
- d) The gas detection system shall not utilize any portable type equipment or temporary installation methods.
- e) The gas detection equipment shall not be a "line of sight" type and only point type sensors can be used. The system may be augmented with this type equipment but "line of sight" gas detection equipment shall not be the basis for this protection technique.
- f) The applications for the use of combustible gas detection systems as a protection technique shall be limited to the following.
  - 1) Inadequate Ventilation: A location, enclosed space, or building that is classified as Class I, Zone 1 due to inadequate ventilation that is provided with a combustible gas detection system will be allowed to utilize electrical equipment, installation methods, and wiring practices suitable for Class I, Zone 2 installations.
  - 2) Interior of a Building: Any building or enclosure that does not contain a source of flammable gas or vapors that is located in, or with an opening into, a Class I, Zone 2 classified (hazardous) location that is provided with a combustible gas detection system will be allowed to utilize electrical equipment, installation methods, and wiring practices suitable for unclassified installations.
  - 3) Interior of a Control Panel: Inside the interior of a control panel containing instrumentation or other equipment utilizing or measuring flammable gases, liquids, or vapors that is provided with a combustible gas detection system will be allowed to utilize electrical equipment, installation methods, and wiring practices suitable for Class I, Zone 2 installations.

**11.2.1.6** Note: For further information on the uses of combustible gas detection systems as a protection technique, see ANSI/ISA-TR12.13.03-2009, Guide for Combustible Gas Detection as a Method of Protection.

## **11.2.2 Equipment Selection**

**11.2.2.1** It is recommended that units have a 4-20 mA output and a minimum of two adjustable set points, preferably with the set points selected being visually indicated.

**11.2.2.2** Separate function indications are recommended for:

- a) power (normal);
- b) malfunction;
- c) low-level alarm;
- d) high-level alarm.

**11.2.2.3** Systems using parallel sensors that yield additive readings should not be used.

**11.2.2.4** Sensor heads should be constructed of corrosion-resistant materials.

**11.2.2.5** Equipment enclosures should be provided with windows for viewing any indicators.

**11.2.2.6** Combustible gas detection instruments should be approved by a nationally recognized testing laboratory (NRTL) as meeting the minimum performance requirements of ANSI/ISA-12.13.01. Where intelligent sensors are utilized, direct connection to the control system may be considered in lieu of a separate controller if equivalent sensor monitoring is provided by the control system.

**11.2.2.7** Hydrogen sulfide detection instruments should be approved by a nationally recognized testing laboratory (NRTL) as meeting the minimum performance requirements of ISA-92.00.01. Where intelligent sensors are utilized, direct connection to the control system may be considered in lieu of a separate controller if equivalent sensor monitoring is provided by the control system.

**11.2.2.8** To better ensure proper application, it is recommended that an environmental and application checklist (similar to the examples shown in Annex B, ANSI/ISA-RP12.13.02 and ISA-RP92.0.02, Part II) be provided by users to prospective vendors of gas detection instruments.

### **11.2.3 Equipment Installation**

**11.2.3.1** If the monitored area contains a source of hydrocarbons, it is recommended that combustible gas detection control units be installed outside the monitored area to permit personnel to determine gas concentration levels without entering the monitored area. When gas detection control units are installed inside an area that contains a source of hydrocarbons, it is recommended that audible or visual alarms (as most appropriate for the particular location) be installed to indicate the presence of gas to personnel before they enter the monitored area.

**11.2.3.2** Visual or audible alarms (as most appropriate for the particular location) should be provided on gas detection systems if levels of gas concentration corresponding to the lower and upper set points are detected. Some form of automatic corrective action may be desirable if concentrations reach the upper set point; reference API 14C for recommended set points and corrective actions.

**11.2.3.3** It is recommended that combustible gas detection equipment be installed, operated, and maintained in accordance with ANSI/ISA-RP12.13.02.

**11.2.3.4** It is recommended that hydrogen sulfide detection equipment be installed, operated, and maintained in accordance with ISA-RP92.0.02, Part II. Reference also API 55.

## **11.3 Fire Detection Systems**

### **11.3.1 General**

In addition to pneumatic fire loop systems, electrical fire (flame, heat and smoke) detection systems are commonly used on offshore production platforms. Recommended practices for the installation and operation of electrical fire detectors are presented in API 14C and API 14G. This section discusses some additional electrical considerations for the selection and installation of such equipment.

### **11.3.2 Equipment Selection**

**11.3.2.1** For centralized control units, separate function lights are recommended for:

- a) power (normal);
- b) malfunction;
- c) alarm(s).

**11.3.2.2** Self-contained battery-powered smoke (ionization or photoelectric) detectors with audible alarms are adequate for small isolated buildings.

**11.3.2.3** Audible/visual fire alarm signals should be distinctive from any other signal on the facility.

### **11.3.3 Equipment Installation**

**11.3.3.1** Smoke detectors should be installed away from galley areas to avoid nuisance alarms.

**11.3.3.2** Rate-of-rise heat detectors should not be installed near outside doorways in heated or air conditioned buildings to avoid nuisance alarms caused by rapid temperature variations.

**11.3.3.3** Ultraviolet (UV) flame detector sensors should be positioned and aimed to minimize the possibility of activation from extraneous ultraviolet sources such as welding arcs.

**11.3.3.4** Consideration should be given to the installation of a "bypass" or "test" switch to be used for maintenance purposes. Where employed, the switch could provide audible or visual indication that the fire detection system is in the bypass or test mode. Bypass switches for inerting system release solenoids should also be provided to prevent the accidental release of the inerting agent during repair or maintenance operations.

**11.3.3.5** For all systems, consideration should be given to supervising field wiring to monitor the integrity of the circuit.

## **11.4 Aids-to-Navigation Equipment**

### **11.4.1 General**

**11.4.1.1** To minimize collisions between seagoing vessels and offshore facilities, U.S. Coast Guard (USCG) regulations (reference 33 *CFR* Subchapter C, Part 67) require that offshore platforms and structures install and maintain aids-to-navigation equipment (obstruction lights and fog signals). The term "structures" includes all fixed structures, temporary or permanent, for which a Corps of Engineers' permit is issued. It includes all drilling platforms, Mobile Offshore Drilling Units (MODUs) when attached to the bottom, production platforms, quarters platforms, pipe line riser platforms, manifold platforms, loading platforms, boat landings, caissons, well protective structures, tank battery barges submerged on station, drilling barges submerged on location, breakwater barges submerged on location, artificial islands and all other piles, pile clusters, pipes, or structures erected in the waters.

**11.4.1.2** The USCG District Commander will assign structures to Class A, B, or C as part of processing an application for a permit to establish and operate obstruction lights and sound signals. When assigning a structure to a class, the District Commander will take into consideration whether a line of demarcation has been prescribed, and matters concerning, but not necessarily limited to, the dimensions of the structure and the depth of water in which it is located, the proximity of the structure to vessel routes, the nature and amount of vessel traffic, and the effect of background lighting. If a line of demarcation has been prescribed, the District Commander will assign those structures seaward of the line of demarcation to Class A. All structures shoreward of the line of demarcation will be assigned to either Class B or Class C, unless the District Commander determines under 33 *CFR* 67.05-25 that the structure

should be assigned to Class A because of the structure's proximity to a navigable channel, fairway or line of demarcation. If a line of demarcation has not been prescribed, the District Commander will assign a structure to Class A, B, or C as he or she deems appropriate. The "line of demarcation" means the dividing line used administratively to distinguish between the areas in which structures shall conform to Class "A" and Class "B" or "C" requirements. In general, structures the farthest from shore are likely to be assigned to Class "A" and required to have obstruction lights and sound signals that can be detected from the farthest distance. Structures closest to shore are likely to be assigned to Class C and, while subject to requirements to ensure that they are also detectable from a safe distance away, will be required to have the least powerful obstruction lights or sound signals.

**11.4.1.3** The obstruction lights on Class C, B, and A structures are required to have sufficient candlepower as to be visible at a distance of at least 1, 3, and 5 nautical miles, respectively. In general, the obstruction lights on Class B and Class A structures are required to be displayed not less than 20 ft (6 m) above mean high water. The number and arrangement of obstruction lights depends on the size and type of structure. Obstruction lights shall display a quick-flash characteristic of approximately 60 flashes per minute, unless prescribed otherwise in the permit issued by the District Commander. All obstruction lights are required to be powered from a reliable power source, including auxiliary power sources as necessary. Class C structures require obstruction lights only; unless a sound signal is required by the District Commander.

**11.4.1.4** The sound signals on Class B and Class A structures are to be rated for at least one-half nautical mile and 2 nautical miles, respectively. The sound signal should be audible over 360 degrees in a horizontal plane at all ranges up to and including the required rated range and be located at least 10 ft (3 m) but not more than 150 ft (46 m) above mean high water. All sound signals are required to be "approved" by the USCG.

#### **11.4.2 Aids-to-Navigation Equipment**

Aids-to-navigation equipment should be suitable for the area in which it is installed. Installation in unclassified locations is recommended whenever possible to facilitate maintenance.

#### **11.4.3 Equipment Installation**

Consideration should be given to location of aids-to-navigation lights taking into account maintenance access and expected vibration at the chosen location. Due to varying requirements between USCG districts, it is recommended that advice be obtained from individuals familiar with the requirements of the particular district involved before actually designing an aids-to-navigation system.

#### **11.4.4 Wiring Methods**

Circuits supplying power to aids-to-navigation equipment should be in accordance with Section 6. To properly consider voltage drop and to minimize wire size, the following recommendations are offered:

- a) It is recommended that the voltage drop to any obstruction light or fog signal be limited to a maximum of 2.5 %. This may be accomplished by increased conductor size, higher voltage battery supply systems and individual voltage regulators at each light or fog signal, or other methods.
- b) Looped or radial systems provide less voltage drop and higher reliability, compared to a branched network.
- c) If wiring splices are required, they should be water-tight and low resistance, preferably soldered, to prevent excessive voltage drops.
- d) It is recommended that all wiring in junction boxes, battery boxes, solar panel junction boxes and control panel cabinets, be properly marked with positive (+) and negative (–) markers as well the synchronization wire (SYNC).

## **11.5 Communications Equipment**

### **11.5.1 General**

Communications equipment is a vital part of offshore platform installations, for on-the-platform communication between strategic locations, for conducting daily operations with boats, planes, helicopters, and shore bases, and for emergencies. Selection and placement of this equipment is thus very important. The equipment should be durable and reliable and located so that it will not interfere with or endanger normal operations on the platform.

### **11.5.2 Hazardous (classified) Locations**

The placement of communications equipment in hazardous (classified) locations should be avoided. Most communications equipment is not designed to meet the requirements of Zone 0, Zone 1, or Zone 2 locations. Communications equipment located in hazardous (classified) locations shall be intrinsically safe or otherwise suitable for the area.

### **11.5.3 Environmental Protection**

It is always desirable, and at times essential, to provide a controlled environment for communications equipment. High temperatures, high humidity, and salt air are highly deleterious to communications equipment.

### **11.5.4 Antennas**

Antennas should be located in unclassified locations when possible. The elevation required for an antenna to provide a good communication path normally will result in its location in an unclassified location. The antenna location shall not pose an obstruction to helicopter landing areas, platform cranes, or other platform operations. The antenna feed lines should be protected from possible physical damage.

### **11.5.5 Emergency Communications Equipment**

Emergency communications equipment for use on manned facilities may consist of either hand-held radios or a paging system(s). The power supply for paging systems should operate as required in 11.16.2.10.2. Hand-held radios used in emergency service should have battery power designed for at least four hours of operation.

## **11.6 Heat Trace Systems**

Electrical heat trace systems are utilized offshore to prevent hydrate formation, to maintain temperatures of sample lines, to heat lubricating fluids, to prevent the freezing of water piping, and for other similar applications. Heat trace systems typically utilize cables other than those described by 6.4. Systems utilized in hazardous (classified) locations should be suited for the specific location as determined by a nationally recognized testing laboratory and installed in accordance with the manufacturer's recommendations. Please refer to IEEE Std 515.

## **11.7 Fire Pumps**

### **11.7.1 General**

**11.7.1.1** Some recommended practices in this section are departures from the *NEC*.

**11.7.1.2** Reference API 14G.

## 11.7.2 Electric Pumps

**11.7.2.1** All electric fire pumps should be installed with a wiring system that meets the requirements of 6.7.8. This wiring system includes all feeder and control cables. It is recommended that installations provide dedicated feeders to the fire pump motors.

**11.7.2.2** Fire pump cables should be supported and secured with stainless steel or other flame-resistant materials.

**11.7.2.3** It is recommended that thermal protectors (heaters) in motor starters supplying fire pumps be one size larger than normal for a motor of similar horsepower and voltage. In some cases, it may be desirable to install even larger heaters, or bypass the heaters. It is recommended that fire pump controllers be NRTL listed in accordance with NFPA 20.

## 11.7.3 Diesel Engine-driven Fire Pumps

All control wiring not installed in a fail-safe manner and associated with starting diesel engines driving fire pumps should utilize wiring methods as described by 11.7.2.1 and 11.7.2.2.

## 11.8 Adjustable Speed Drives (Variable Frequency Drives)

### 11.8.1 General

**11.8.1.1** Static power converters are used to rectify AC to DC, as phase-controlled rectifiers on variable speed DC drives, and as frequency changers for variable speed AC drives. When static power converters constitute a sizable portion of a total electrical system, the harmonics they produce can cause excessive heating in motors, capacitors, transformers and other electrical equipment. In addition, the harmonics may adversely affect electronic devices that are frequency sensitive.

**11.8.1.2** Effective application of adjustable speed drive (ASDs) can present unique challenges to the application engineer. A detailed understanding of ASD operation, motor performance, load characteristics, and potential application and installation considerations is essential to proper application success. Drive manufacturer migration to insulated gate bipolar transistors (IGBTs) as output devices demands a more careful selection of motors and cables. Because the ASD affects the operating characteristics of a motor, a load that will easily start across the line may have difficulty starting when an adjustable frequency controller is applied. The traditional solutions for high-starting-torque loads, such as NEMA Design C and NEMA Design D motors, are not generally good choices for ASD applications. Under variable frequency conditions, the NEMA Design A motor may have higher starting torque than NEMA Designs C or D. The introduction of an ASD can introduce additional operating concerns, such as increased motor temperature, premature installation failure, and objectionable harmonic currents, if the equipment is not selected and installed properly.

### 11.8.2 Relationship of Torque, Horsepower, and Current

**11.8.2.1** Torque and horsepower are related. To accurately determine the motor torque requirements for a given application, there are four variables that need to be addressed. The first is the breakaway torque needed to begin rotation. The second is the torque needed to accelerate. The third is the torque required to sustain rotation at fixed speed. The last variable is the torque, if any, necessary to decelerate the load.

**11.8.2.2** Load torque is given by the following equation:

$$T = \frac{HP \times 5250}{S} \quad (4)$$

where

$HP$  is horsepower of the load;

$T$  is torque in foot-pounds at the load;

$S$  is speed in rpm.

**11.8.2.3** To fully understand the issue associated with motor starting on an adjustable frequency controller, one should be aware of the interaction of torque, horsepower, and current. As an induction motor is started across the line, the initial inrush current will approach six to ten times its normal running full load current. This initial current produces significant breakaway or starting torque acceleration. Depending on the motor design, the starting torque can be as high as 300 % of rated full load torque but more commonly is closer to 150 %.

**11.8.2.4** A motor starting under the control of an adjustable frequency controller normally is limited to 150 % of the controller's rated full load current. This current limitation can produce a corresponding torque limitation. By applying a properly sized (perhaps oversized) adjustable frequency controller to a specific motor, it is possible to produce more starting torque using the drive than is possible starting the same motor across the line. Some drive manufacturers produce drives that produce this higher starting torque capability without the need to oversize the drive.

### **11.8.3 Three Major ASD Technologies**

#### **11.8.3.1 Variable Voltage Inverter (VVI)**

The variable voltage inverter consists of a rectifier front end that produces a variable DC voltage on the DC link bus. This controlled DC voltage is inverted at the prescribed frequency using sequential firing of the output switching devices to produce a six-step waveform.

#### **11.8.3.2 Current Source Inverter (CSI)**

A large reactor in the DC link bus characterizes the current source inverter. This reactance is intended to provide impedance to any rapid changes in current, making current the controlled variable with voltage changing as necessary to maintain the current. In general, CSI inverters require motors with matched characteristics to be connected.

#### **11.8.3.3 Pulse Width Modulated Inverter (PWM)**

The PWM design is the technology most commonly used today. It is characterized by pulse output waveforms of varying width to form a sinusoidal-type waveform of variable frequency and RMS voltage. Early designs of PWM drives used gate turnoff transistors (GTOs) and bipolar junction transistors (BJTs) as output devices; however, there has been a migration to insulated gate bipolar transistor (IGBT) technology. PWM technology, especially IGBT technology, is better able to produce high torque at low speeds.

### **11.8.4 Load Considerations**

In the application of adjustable frequency controllers, the first important consideration is the type of load (including its characteristics). Loads generally may be grouped into the following four categories.

#### **11.8.4.1 Variable Torque Loads**

With variable torque loads, torque is a function of speed. Typical examples are centrifugal pumps and fans. As the speed decreases, torque typically will decrease as a square of the speed, and horsepower will decrease with the



cube of the speed, see Figure 11. Variable torque characteristics are the result of affinity laws, which relate to centrifugal loads. A summary of the laws that relate to speed follows:

- a) flow is directly proportional to speed;
- b) head is directly proportional to the square of the speed;
- c) horsepower is directly proportional to the cube of the speed.

#### 11.8.4.2 Constant Torque Loads

With constant torque loads, torque is not a function of speed. Typical examples of constant torque loads are traction drives, conveyors, positive displacement pumps, and centrifuges. As the speed is changed, the load torque remains constant and the horsepower changes in direct proportion to the speed, see Figure 12.

#### 11.8.4.3 Constant Horsepower Loads

With constant horsepower loads, torque is a function of speed. As speed increases, torque decreases inversely, and horsepower remains relatively constant. Typically, constant horsepower loads are operated above base speed. Typical examples of constant horsepower loads are grinders and lathes, see Figure 13.

#### 11.8.4.4 Impact Loads

With impact loads, torque loading pulsates. Typical examples of impact loads are punch presses, reciprocating compressors, shakers, and oil well, sucker-rod-type pumps. Such applications require that motors produce sufficient accelerating torque to complete each stroke cycle, see Figure 14.

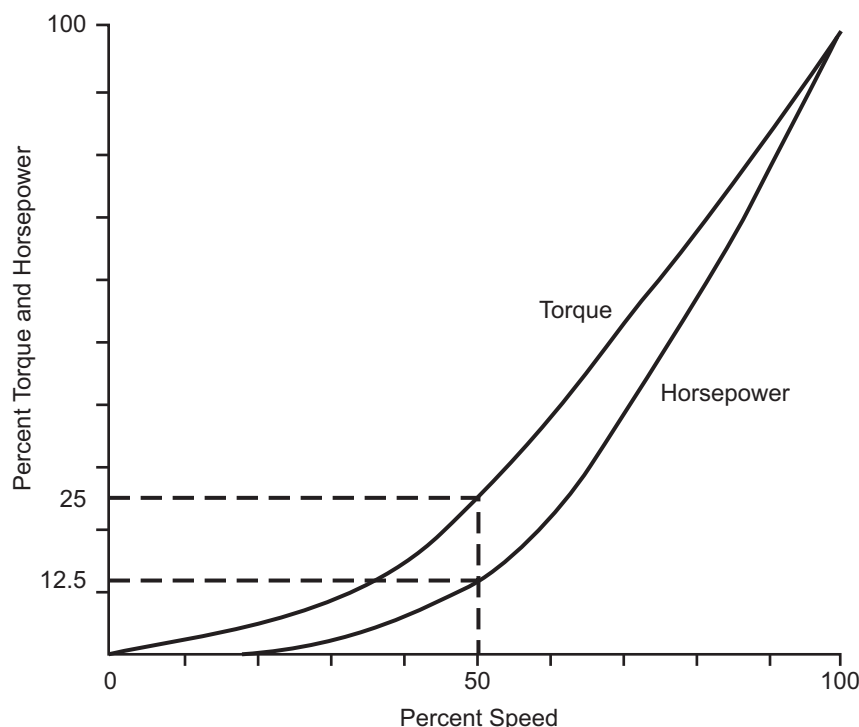


Figure 11—Typical Speed Torque Curve for Variable Torque Load

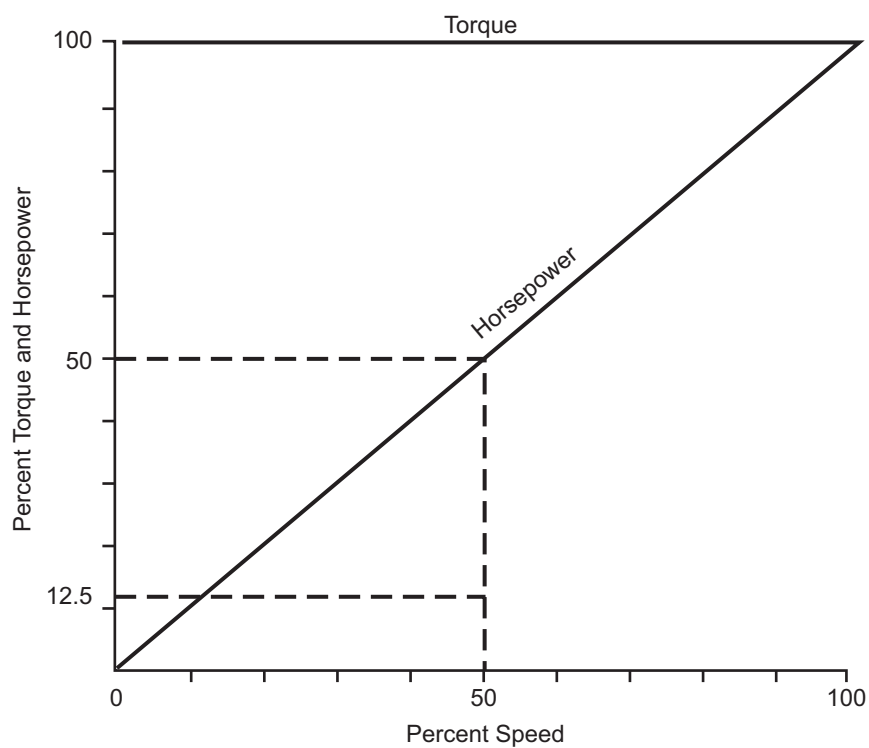


Figure 12—Typical Speed Torque Curve for Constant Torque Load

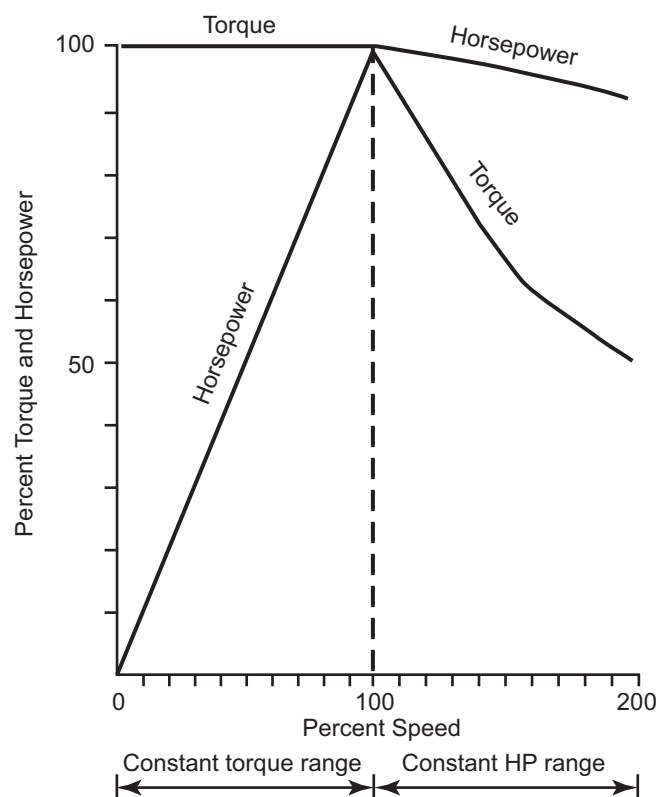
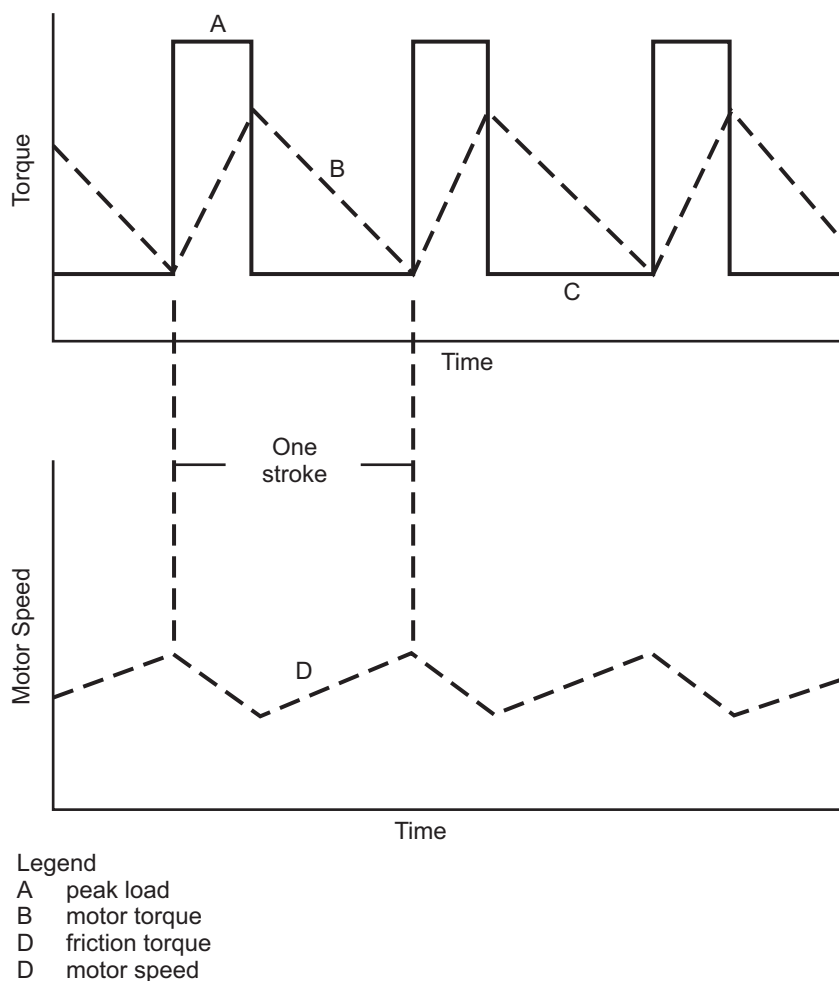


Figure 13—Typical Speed Torque Curve for Constant Horsepower Load



**Figure 14—Typical Speed Torque Characteristics for Impact-type Loads**

#### 11.8.4.5 Application Considerations

**11.8.4.5.1** Applications of ASDs to centrifugal loads are relatively simple except that the maximum speed should be limited to the speed at which the maximum horsepower available from the motor occurs; the torque available to produce that horsepower is limited by the maximum current the drive is able to produce.

**11.8.4.5.2** When controlling constant torque loads, the ability of a motor to operate at reduced speed and full load current for extended periods of time may be limited due to insufficient cooling of the motor at low speed: the fan that normally cools the motor is also running at a slow speed and possibly not capable of cooling the motor sufficiently.

#### 11.8.5 Inverter Duty Versus IGBT Inverter Duty

Inverter duty rated motor specifications historically address the thermal issues of the drive application related to harmonic heating and insufficient cooling at low speeds. Different motor manufacturers interpret inverter duty to mean different things. Inverter duty may not connote any motor ability to handle increased reflected wave voltage stress resulting from IGBT drive application. As most drive manufacturers today are migrating to IGBT type drives, the recommended 460 Volt motor is the NEMA MG1 Part 31 motor, which has a 1600V corona-inception voltage (CIV)

rating. This motor design is able to handle the reflected wave voltages available on IGBT-type inverters. For existing motor applications or motors not rated 1600V CIV, recommended solutions would include application of filters, output reactors at motor or at the drive, or the application of impedance-matching terminators at or near motor terminal box.

### **11.8.6 Cable Considerations for ASDs**

**11.8.6.1** Motor lead cables for ASD applications require special consideration because of harmonics, electromagnetic interference (EMI), reflected wave voltages, common mode current, and induced voltages in adjacent cables. Cable should be selected to minimize net induced ground currents into the system ground, to minimize common-mode current, to minimize motor-frame-standing voltage (minimize potential bearing currents), to minimize cross-talk between adjacent cables, and to provide the best connection of sheath/shield and ground.

**11.8.6.2** Depending on the nominal voltage rating and the reflected voltage (which can be up to three times nominal voltage), over insulated conductor ratings should be considered. Selection of the insulation thickness will also be dependent on the switching frequency, length of cable installed, and life expectancy of the installation. Reducing the capacitance of the cable reduces common mode current. It is recommended that the insulation material used on these cables have a dielectric constant less than 3.0 to reduce cable capacitance. In order to reduce voltage imbalances, the cable should have sectioned grounding conductors, one in each interstice. Motor lead cables for certain ASD manufacturers' applications should have an overall non-ferrous shield or armor with a recommended minimum coverage of 100 %. The ASD manufacturer should be consulted concerning this shielding or armor coverage requirement. The purpose of this overall shield or armor is to provide a low impedance ground path close to the cable core and contain EMI emissions.

**11.8.6.3** Voltage drop on motor lead cables for ASD applications require special consideration when loads with high starting torques are involved.

**11.8.6.4** Where Type MC cable is used, a continuous corrugated non-ferrous sheath and three segmented grounding conductors, one in each interstice is recommended. Where marine shipboard cable is used, a combination non-ferrous braid plus tape shield and three segmented grounding conductors, one in each interstice, is recommended. Conductors with PVC insulations are not recommended for ASD installations PVC insulation is susceptible to degradation due to moisture and voltage stress.

**11.8.6.5** It is recommended that control cables be shielded if they are routed in close proximity to or in the same cable tray with the ASD power feeders that do not meet the requirements in 11.8.6.4.

### **11.8.7 AC Power Source Considerations**

ASDs are designed to operate on 3-phase supply systems whose line voltages are symmetrical. An isolation transformer is recommended where potential exists for phase-to-ground voltages in excess of 125 % of nominal or where the supply ground is tied to another system or equipment that could cause the ground potential to vary with operation.

### **11.8.8 Branch Circuit Ratings**

The branch circuit or feeder sizing for an ASD should be based on the input current rating of the ASD as opposed to the motor full load current value. The ASD manufacturer's user manual should be consulted as well as the *NEC*. [See *NEC* 430.2, *NEC* 430.6, 430.22, 430.113, 430.122, and 430.128.]

### **11.8.9 Line Voltage Ratings**

The AC line voltage supply to the ASD should be within 10 % of the utilization voltage. Deviations greater than 10 % may cause malfunctions.

### **11.8.10 Transient Overvoltages**

Overvoltage transients may have an effect on ASDs, depending on the magnitude of the transient and the type of ASD design. In most cases, isolation transformers are not necessary for PWM-type ASDs.

### **11.8.11 Transient Line Notching**

Depending on the installation, voltage notching created by ASDs normally is not significant in PWM-type designs using diode front ends. ASDs employing SCR front ends may require isolation transformers or reactors.

### **11.8.12 Line Harmonics**

Line harmonics can be a significant application consideration where the kVA supplied to adjustable frequency drives is in excess of 40 % of the available kVA of the supply system. Use of isolation transformers, line reactors, and filters normally will become necessary. Careful consideration should also be given to the types of governors and regulators used on generation equipment. Filters or isolation transformers should be used ahead of governors and regulators. Harmonic analysis software is useful in analyzing system harmonics.

### **11.8.13 Line Power Factor**

For PWM type ASDs with diode front ends, the displacement power factor normally will be high (usually in excess of 0.95).

### **11.8.14 Line Frequency**

Consult the ASD manufacturer's manual for proper application. Deviations greater than the specified tolerance may cause ASD malfunctions.

### **11.8.15 Environmental Considerations**

Environmental considerations are important for successful ASD installations. The following conditions should be reviewed.

#### **11.8.15.1 Ambient Temperature**

ASDs normally can be operated in ambient temperatures of 0 °C (32 °F) to 40 °C (104 °F) without derating. Manufacturers can furnish supply derating curves for higher rating temperatures. Large ASDs, isolation transformers, and line reactors may contribute significant heat load to air-conditioned spaces.

#### **11.8.15.2 Humidity Considerations**

ASDs normally can operate satisfactorily in the range of 5 % to 95 % humidity if it is noncondensing.

### **11.8.16 Enclosure Considerations**

**11.8.16.1** ASDs should be suitable for the environmental conditions in which they are applied. NEMA has established standards for electrical enclosure construction. Refer to 6.11 for additional information on electrical enclosures. A wide range of ASDs in enclosures for hazardous locations is normally not available. The use of a flameproof or explosionproof motor with an ASD may be required for certain hazardous locations. Normally, ASDs should be located in unclassified locations.

**11.8.16.2** A flameproof or explosionproof motor will operate with its surface temperatures at safe levels for the approved hazardous locations when applied, fully loaded, at nameplate voltage on sine wave power. When a motor is controlled by an ASD, additional heat may be produced in the motor and raise its surface temperature. To apply a

flameproof or explosionproof motor to a specific ASD with a NRTL listing, the motor should be tested with the specific type of ASD to ensure that the motor operates within the allowable surface temperature range for the specifically defined hazardous (classified) location.

### **11.8.17 ASD Grounding**

**11.8.17.1** In addition to the *NEC* requirements, it is important to follow the manufacturer's recommendations for grounding, also see 6.10.

**11.8.17.2** Manufacturers provide specific information regarding communication grounding, which normally is separate from power equipment grounding. Common mode chokes and shielding are sometimes also required. Specific attention should be paid to the recommendations given by the ASD manufacturer.

## **11.9 Submarine Cables**

Submarine cables are used to supply electrical power and communications from central offshore generating stations and land-based (utility and self-generated) generation/distribution systems to offshore platforms and from platform generation stations to platforms without primary generation. Distribution is normally at 2400 Volts, 4160 Volts, 13800 Volts, and 34500 Volts, although higher voltages are occasionally used. In general, submarine cables are custom designed and engineered for specific applications. Typical submarine cables are provided with steel armor wires to offer mechanical protection and strength. Normally, the armor wires are protected from corrosion by either an overall jacket or individual coatings. Frequently, communication, control, and grounding conductors are provided in the interstices of the power conductors. For additional information regarding the design, installation, and repair of submarine cables refer to IEEE-1120.

## **11.10 Electric Oil-immersion Heaters**

**11.10.1** Excluding lube oil service, each oil-immersion heater should have all of the following:

- a) an operating thermostat;
- b) heating elements that have no electrical contact with the oil;
- c) a high-temperature limiting device that:
  - 1) opens all conductors to the heater;
  - 2) is manually reset;
  - 3) actuates at a temperature below the flash point of the oil.
- d) Either a low-fluid-level device that opens all conductors to the heater if the operating level drops below the manufacturer's recommended minimum safe level, or a flow device that opens all conductors to the heater if there is inadequate flow.

## **11.11 Electric Power-operated Boat Winches for Survival Craft**

Boat winches shall be designed in accordance with USCG requirements, 46 *CFR*, Subchapter J, 111.95, reproduced as Annex C for the convenience of the reader.

## **11.12 Electric Power-operated Water-tight Doors**

Electrical power and control systems for water-tight doors installed in the hull sections of floating production facilities shall be designed in accordance with USCG requirements, 46 *CFR*, Subchapter J, 111.97, reproduced as Annex D for the convenience of the reader.

## **11.13 Hull Mechanical Systems Controls**

**11.13.1** Enclosed areas of floating production facilities below the lowest production deck (hull spaces) require special design considerations because of the hazards to personnel inherent in such areas. Examples of hazards associated with such areas include the following:

**11.13.1.1** Natural ventilation typically is not available in these areas. Forced mechanical ventilation is required for safe personnel access.

**11.13.1.2** Access and egress means typically are limited to ladders or enclosed manways. Rapid exit, particularly under emergency conditions, is difficult.

**11.13.1.3** Because of the enclosed nature of these spaces, small fires can quickly fill a hull compartment with toxic smoke.

**11.13.2** To mitigate the unique hazards associated with hull areas, it is recommended that the following controls be provided for hull mechanical systems;

**11.13.2.1** Each power ventilation fan should be provided with at least two shutdown stations for stopping the fan motor, with one located adjacent to, but outside of, the space, and the other located remotely.

**11.13.2.2** Other hull machinery systems, such as fuel oil pumps and purifiers and chemical transfer pumps, should be provided with a shut-down station for the equipment (e.g. oil pumps) located adjacent to, but outside of, the space. Additional shut-down stations may be appropriate, depending on the application.

**11.13.2.3** The shut-down stations described in 11.13.2.1 and 11.13.2.2 should be clearly marked as to their functions, be readily accessible to operators, and be appropriately grouped for each space to facilitate corrective action during emergency conditions.

**11.13.3** The Integrated Marine Monitoring System (IMMS) & Tendon Tension Monitoring System is as follows.

**11.13.3.1** The primary purpose of the data collected from the IMMS system are for field performance verification of the Deep Water floating facilities. The IMMS is designed to monitor, log, and display environmental parameters such as air-gap, deep current profiles, near surface current speed and direction, wind speed and direction, air temperature, and barometric pressure. It also performs the same functions for facility response parameters such as trim and list, six degree of freedom (6-DOF) motion, position, draft, mooring line or tendon tension, ballast level, and void space integrity

**11.13.3.2** Typical hardware for an IMMS system is as follows.

- a) Air Gap Wave Sensor—monitoring wave height and direction with correction for hull presence;
- b) Deep Current Profiler and Surface Current Measurement System;
- c) Meteorological Data Station—temperature and barometric pressure;
- d) Wind Speed and Direction Monitoring System;
- e) Globally Corrected Global Positioning System (GCGPS) included with wind speed and direction system;
- f) Precision Inclination and 6 Degree of Freedom (6-DOF) Motion Package;
- g) Tension monitoring devices integrated into the mooring or tendon system.

**11.13.3.3** Deep Water floating facilities that are equipped with a IMMS shall have a power supply and backup system that complies with USCG 46 *CFR* 112.15. Consideration should be given to providing backup Emergency Generator AC power to these systems during hurricane evacuations so that these systems can continue to collect and store required data. It is recommended that the IMMS system have 7 days of uninterrupted power supplied during hurricane evacuations. BSEE normally requires a mooring test insert be removed on a regular basis for testing purposes however if mooring tension are continuously monitored, the frequency of insert removal may be reduced.

#### **11.13.4 Hull Elevator**

Hull Elevators electrical system design shall comply with ANSI/ASME A17.1 and ASME 17.5.

#### **11.13.5 Alarms for Loss of Mechanical Ventilation**

Alarms should be provided in a location normally occupied by personnel to annunciate the loss of mechanical ventilation that is required by either of the following:

- a) the authority having jurisdiction;
- b) API 505 to establish or maintain area classification.

#### **11.14 Cargo Tanks on Floating Facilities**

A cargo tank is defined by API 505 as a Class I, Zone 0 location. Cargo tanks shall not contain any electrical equipment except the following: a) Type “ia” Intrinsically safe equipment, and b) Submerged cargo pump motors and their associated cable. Submerged cargo pumps shall be provided with low liquid level, motor current, or pump discharge pressure sensors to activate if the pump loses suction. These sensors should automatically shut down power to the motor and activate audible and visual alarms.

#### **11.15 Cargo Handling Rooms on Floating Facilities**

**11.15.1** Cargo handling rooms are classified Class I, Zone 1 or occasionally Zone 0 in accordance with API 505, depending on the conditions.

**11.15.2** Flameproof or explosionproof lighting fixtures and their associated wiring may be used in those rooms classified as Class I, Zone 1, where all of the following conditions apply:

- a) continuous ventilation with a minimum of 20 air changes per hour is provided;
- b) loss of ventilation is alarmed in accordance with 11.13.4;
- c) combustible gas detection systems are installed and maintained in accordance with API 505, section 6.8.

**11.15.3** In cargo handling rooms classified Class I, Zone 0 and not meeting the requirements of 11.15.2 a), b), and c), lighting should be accomplished via fixed glass lenses in the bulkhead or overhead complying with 46 *CFR*, Subchapter J, Subpart 111.105, reproduced as Annex E for the convenience of the reader.

#### **11.16 General Alarm System**

##### **11.16.1 Fixed Platforms**

**11.16.1.1** Offshore platforms that are manned (see 3.2.64) are required by the USCG (Title 33, *CFR* Part 146.105) to have general alarm systems (general emergency alarm system; SOLAS). Systems are required for temporary quarters buildings as well as permanent bunkhouses.



**11.16.1.2** General alarm systems shall be audible in all parts of the platform. When two or more platforms are bridge-connected, the entire complex is considered one platform, and the system shall be audible in all parts of all bridge-connected platforms. Also, when a drilling rig is on a platform, the system shall be audible throughout the rig as well as the platform.

**11.16.1.3** An emergency signal that is an intermittent tone shall be provided. Intermittent tones shall last a minimum of 15 seconds, but it is recommended that the tone sound until manually silenced.

**11.16.1.4** An abandon signal that is a continuous tone shall be provided.

**11.16.1.5** All general alarm sounding devices (bells, sirens, etc.) shall be identified by a sign at each device in red letters at least 1 in. (25 mm) high with a sharp contrasting background: "GENERAL ALARM—WHEN ALARM SOUNDS GO TO YOUR STATION."

**11.16.1.6** Push-button stations shall be provided at points of access and egress to the structure.

**11.16.1.7** General alarm pushbutton stations shall be identified by red letters at least one inch high with a contrasting background: "GENERAL ALARM."

**11.16.1.8** It may be desirable to initiate shut-in/isolation action simultaneously with the abandon signal.

**11.16.1.9** A paging and alarm system is recommended. A general alarm supplemented by verbal instructions over the public address (PA) system will enhance safety. These instructions may be automatically generated by an electronic voice synthesizer or vocalized by operations personnel.

**11.16.1.10** *Alarm Tones*—Table 19 provides one possible combination of tones for five-tone general alarm systems.

**Table 19—Possible combination of Tones for Fixed Platforms**

Priority	Condition	Tone
1	Abandon	Siren
2	Emergency	Yelp
3	Safety System Alarms	Warble
4	Process Alarms	Steady
5	Special Alarms	Pulse

**11.16.1.11** *Power Supply*—It is recommended that the general alarm system be powered from one or more power supplies dedicated to the general alarm system and, where applicable, the associated paging system when an integrated paging and alarm system is installed. The general alarm system shall be provided with a backup power source for 18 hours after the loss of the primary power system. Upon loss of power to the system from the primary power source, the system should be automatically supplied from the backup power source. If an engine generator is used as the backup power source, a transitional power source should be provided with a minimum of 30 minutes capacity at full load.

## **11.16.2 Floating Facilities**

**11.16.2.1** Floating offshore platforms that are manned (see 3.2.64) are required by the USCG (Title 46, *CFR* Part 113.25) to have general alarm systems (general emergency alarm system; SOLAS) that provide both emergency and abandon alarm signals. Systems are required for temporary quarters buildings as well as for permanent bunkhouses.

**11.16.2.2** General alarm systems shall be audible in all parts of the platform. When a drilling rig is on a platform, the system shall be audible throughout the rig as well as the platform. As a minimum, the general alarm system should be designed for sound levels clearly audible above normal facility background noise. Consideration should be given to automatic volume adjustment of individual speakers in areas with changing ambient noise levels, to permit consistent audio coverage. In areas where the general alarm system cannot be heard because of high ambient noise (e.g. in compressor buildings), red flashing lights should be installed to augment the audible emergency signal. These lights should be activated whenever the audible emergency signal is activated and should be designed and positioned to be clearly visible above normal background lighting from any location within the space. In accordance with the USCG (Title 46, *CFR* Part 113.25-12), the minimum sound pressure levels for the emergency alarm tone in interior and exterior spaces shall be 80 dB (A) and at least 10 dB (A) above ambient noise levels existing during normal equipment operation in moderate weather.

**11.16.2.3** The emergency signal shall provide an intermittent tone. Intermittent tones shall last a minimum of 15 seconds, but it is recommended that the tone sound until manually silenced.

**11.16.2.4** The abandon signal shall provide a continuous tone.

**11.16.2.5** All general alarm sounding devices (bells, sirens, etc.) shall be identified by a sign at each device in red letters at least 1 in. (25 mm) high with a sharp contrasting background: "GENERAL ALARM—WHEN ALARM SOUNDS GO TO YOUR STATION."

**11.16.2.6** General alarm push-button stations shall be provided, as a minimum, at the following locations:

- a) each survival craft embarkation location;
- b) each continuously manned control room;
- c) each emergency command center, where provided;
- d) each driller's console, on platforms where a drilling rig is installed.

**11.16.2.7** General alarm push-button stations shall be identified by red letters at least 1 in. (25mm) high with a contrasting background: "GENERAL ALARM."

**11.16.2.8** It may be desirable to initiate shut-in/isolation action simultaneously with the abandon signal.

**11.16.2.9** It is recommended that the general alarm system be integral to the facility's paging and alarm system. On floating facilities, this system should be designed such that all components common to the entire system (e.g. tone generators, central power supplies, amplifiers) have one or more on-line backups installed, such that failure of any single component will not disable the entire general alarm system. A general alarm supplemented by verbal instructions over the PA system will enhance safety. These instructions may be automatically generated by an electronic voice synthesizer or vocalized by operations personnel. Where it is not desirable to integrate the general alarm system into the paging and alarm system, a conventional bell and red flashing light system is acceptable.

**11.16.2.10** Power supply:

**11.16.2.10.1** It is recommended that the general alarm system be powered from one or more power supplies dedicated to the general alarm system and, where applicable, the associated paging system when an integrated paging and alarm system is installed. The battery charger(s) for this system should be powered from the emergency generator switchboard as recommended in 5.6.3.2.

**11.16.2.10.2** The general alarm system shall be provided with a backup power source for 18 hours after the loss of the primary power system. Upon loss of power to the system from the primary power source, the system shall be automatically supplied from the backup power source. If an engine generator is used as the backup power source, a transitional power source shall be provided with a minimum of 30 minutes capacity at full load.

**11.16.2.11** Power distribution—Reliable and uninterrupted power to the general alarm system is vital during emergency situations on floating facilities. As a minimum, general alarm power distribution systems should conform to the following recommendations.

**11.16.2.11.1** Main overcurrent devices installed on general alarm system power supplies shall be sized for at least 200 % of the total system connected load at maximum system load.

**11.16.2.11.2** On facilities divided into vertical fire zones by main vertical fire bulkheads, at least one general alarm power feeder circuit shall be provided for each vertical fire zone. On facilities not divided into fire zones by vertical fire bulkheads, the facility should be divided into areas not exceeding 120 ft. (37 m) in any horizontal direction, with at least one power feeder provided for each area. Overcurrent devices installed on general alarm power feeders should be sized for at least 200 % of the total load connected to the circuit and should not exceed 50 % of the rating of the main overcurrent device described in 11.16.2.11.1.

**11.16.2.11.3** Each general alarm power feeder should supply one or more fused branch circuit distribution panels. Each branch circuit fuse should be sized so as not to exceed 50 % of the rating of the feeder overcurrent device described 11.16.2.11.2. The number of general alarm devices supplied by each branch circuit shall be limited to one deck level within a vertical fire zone. The intent of this requirement is to ensure that the alarm signal is audible or visible with the loss of any single circuit.

**11.16.2.12** *Signal Redundancy*—Certain types of integrated paging and alarm systems are designed to be installed in a series (daisy chain) configuration, with communication and alarm wiring looped from one station to the next. When such systems are utilized for the facility general alarm system, it is recommended that the system be configured in a closed-loop design such that damage to any single portion of the signal loop will not render portions of the alarm system inoperative.

**11.16.2.13** *Alarm Tones*—Table 20 provides one possible combination of tones for five-tone general alarm systems:

**Table 20—One Possible Combination of Tones for Floating Facilities**

Priority	Condition	Tone
1	Abandon	Siren
2	Emergency	Yelp
3	Safety System Alarms	Warble
4	Process Alarms	Steady
5	Special Alarms	Pulse

## **11.17 Cathodic Protection**

### **11.17.1 General**

Corrosion of offshore structures and associated pipelines due to galvanic action can be retarded or prevented by impressing a low DC voltage on them, making them slightly negative with respect to earth. The structures and pipelines are made the cathode, expendable metal the sacrificial anode, and the earth/ocean the electrolyte of the battery formed by the structures, the sacrificial anode, and the earth/ocean. Protection by this method is referred to as cathodic protection. The imposed voltages are so low that electrical shock hazards normally do not exist. Likewise, the imposed voltages and resulting currents typically are not high enough to create incensive energy levels. However, some larger cathodic protection systems can operate at incensive levels.

### 11.17.2 Sacrificial Anode Systems

One type of cathodic protection system is the sacrificial galvanic anode system. In this system, sacrificial galvanic anodes (typically aluminum, zinc, or magnesium) are attached via electrical conductors to the metal being protected (that is, structures or pipelines). No external source of electrical power is required since the galvanic voltage produced by the dissimilar metals as the driving force. This method utilizes the lowest voltage (less than 2 Volts) of the cathodic protection methods, and currents normally are low. However, with larger anodes, incensive levels of voltage and current can be produced. The anodes usually are attached to the structures at levels 10 ft (3 m) or less above the water line, so hazardous (classified) locations are seldom involved.

### 11.17.3 Impressed Current Systems

The second type of cathodic protection system, the impressed current system, typically utilizes rectifiers powered by AC power to produce the DC voltage necessary to make the structure (or pipeline) negative with respect to earth. Voltages typically are less than 50 Volts DC, and currents normally are significantly higher than currents of sacrificial anode systems. The negative side of the rectifier is connected to the structure and the positive side of the rectifier is connected to anodes suspended in the water (or, occasionally, buried) in a pattern as required for good current distribution. Normally, one conductor leaves the rectifier and is interconnected to the applicable anodes, either with connections made in junction boxes or spliced to the cable. The junction box method is preferred to facilitate the measurement of the currents to the individual anodes (for verification of operation and maintenance).

### 11.17.4 AC Portions of Impressed Current Systems

It is recommended that the AC wiring and the rectifier of impressed current systems meet the requirements of electrical systems prescribed by this recommended practice—including the hazardous (classified) area requirements, as applicable. It is permissible to supply AC power by a dedicated switch or circuit breaker that is capable of being locked in the “on” position. A visual and audible alarm indicating loss of power should be provided.

### 11.17.5 DC Portions of All Systems

**11.17.5.1** It is recommended that conductors for DC cathodic wiring not be smaller than No. 12 AWG to minimize the possibility of breakage, which would disrupt protection and also could produce an ignition-capable arc. Such conductors should be insulated with materials such as high molecular weight polyethylene (HMWPE) that are resistant to mechanical damage. Splices, taps, and connections are permitted in DC wiring provided both following conditions are met:

- a) a) The splice or tap is made by welding, by a positive compression tool, by crimping and soldering, or by means of a copper, bronze, or brass (or other suitable material) cable connector.
- b) The splice or tap is effectively sealed against moisture by taping or by some other method that is at least as effective as the original insulation of the conductor (for example, resin splicing, heat shrink or cold shrink), or the splice or tap is made in a suitable enclosure.

**11.17.5.2** Connections to the structure (or piping) should be made by means of:

- a) a welded stud, exothermic welding, or other permanent means;
- b) a clamp constructed of the same material as the metal to which it is attached;
- c) a clamp constructed of material that is anodic to the material to which it is attached.

**11.17.5.3** DC conductors should be protected from damage by physical means (for example, pipe, conduit, or angle iron) or by location (for example, by placing it inside the webs of beams). DC conductors should not be installed in Class I, Zone 1 locations, unless the wiring method meets the requirements for such location, as specified by this recommended practice. DC conductors in Zone 2 locations are suitable if installed in accordance with the requirements given in this section.

### **11.17.6 Operating Voltage**

When a cathodic protection system has a maximum available voltage of more than 50 Volts, the voltage difference between any exposed point on the protected system and a point 1 m (3 ft) away should not exceed 10 Volts.

## **11.18 Subsea Electrical Systems**

A Subsea electrical system is comprised of cables, umbilicals, and specific subsea electrical equipment (motor operated valves, transformers, etc). For additional information refer to the International Marine Contractors Association (IMCA) Code of practice for the safe use of electricity underwater (AODC 035).

### **11.18.1 Subsea Definitions**

**11.18.1.1 Submarine Cable**—A power and/or communications cable connecting a power and/or communications system onshore to an offshore platform or connecting two or more offshore platform systems where both ends of the cable are dry and are connected above water and is not intended to contain hydraulic control tubing. Also see 11.9.

**11.18.1.2 Power Umbilical**—A power cable connecting an onshore system or an offshore platform system to a subsea device(s) or load(s) such that one end is underwater.

**11.18.1.3 Composite umbilical**—An umbilical containing several electrical power and control cables, fiber optics or hydraulic tubing that are each interconnecting a subsea facility to the surface facilities.

**11.18.1.4 Topside Umbilical Termination Assembly (TUTA)**—The breakout of cables and tubing from the umbilical.

**11.18.1.5 Hang – Off Termination Assembly**—Means for supporting the weight of a submarine cable or the umbilical typically at an offshore platform or vessel that primarily terminates and secures the armor wire and allows cable conductors to transition to a splice assembly or other connections.

**11.18.1.6 Subsea Umbilical Termination Assembly (SUTA)**—The structure at the subsea end of the umbilical that breaks out the cables and tubing from the umbilical and provides the means for connection

### **11.18.2 Subsea Umbilical Types**

Almost all umbilicals are composite umbilicals and interact with both electrical and non-electrical systems. Below are common types of subsea cables that interact in some way with the power system of the offshore platform.

**11.18.2.1 Well control**—A well control umbilical is generally a low power composite umbilical that supplies electric power (less than 2000V), communications, hydraulic power and chemicals to oil wells on the sea bottom. Often the electric power is isolated from platform ground.

**11.18.2.2 Power Transmission (Land to Platform, Platform to Platform)**—See *Submarine Cable* above.

**11.18.2.3 Subsea Processing**—Subsea processing umbilicals are generally a high power composite umbilical that supplies electric power (greater than 2000V), controls (under 2000V), communications, hydraulic power and chemicals to processing equipment on the sea bottom.

**11.18.2.4 Single circuit/single function**—A Single circuit/single function umbilical supplies power to discrete subsea loads such as a booster pump or a compressor. This type of umbilical may have two or more power circuits each connected to a single subsea load. Single circuit/single function umbilicals can be Direct Drive where the load is driven directly from the platform or can use transformers (topside and subsea) to reduce losses and maintain voltage regulation in the circuit.

**11.18.2.5 Subsea power distribution**—A Subsea power distribution umbilical supplies power to multiple subsea loads. Power is distributed on the sea floor. This type of umbilical may have two or more power circuits serving separate subsea distribution points.

### **11.18.3 Subsea Umbilical Design Considerations**

Subsea electrical systems and umbilicals are unique and require special design considerations. These include but are not limited to the following (for additional information reference API 17E).

**11.18.3.1 Voltage Drop**—The voltage drop for a subsea umbilical may be much higher than a typical land based power transmission system. Voltage drops of 25 % or more are common. These large voltage drops are tolerated because the equipment required to reduce the voltage drop would reduce reliability of the subsea system.

**11.18.3.2 Power Loss**—The power loss for a subsea umbilical may be much higher than a typical land based power transmission system. These power losses are tolerated because the equipment required to reduce the loss would reduce reliability of the subsea system.

**11.18.3.3 Thermal**—The subsea umbilical should be able to withstand operating in air for the distance from the surface of the sea to the TUTA. Sometimes the umbilical will travel all or part of the way in a enclosed tube or pipe.

**11.18.3.4 Umbilical Discharge**—Umbilicals used to provide power to the subsea boosting system are capacitive in nature and can hold an electrical charge for a long period of time after they are de-energized. A means of discharging the umbilical after de-energization shall be provided. Consideration should be given to slowly discharging the power cables in the umbilical through a resistive device for cable protection.

**11.18.3.5 Induced Voltage in Adjacent Power Circuits**—In situations where the subsea umbilical has two or more power circuits it may be possible (thru EMI/Crosstalk) for high voltage to be induced in an unused or open power circuit. CAUTION: when performing maintenance on any part of a power circuit of an umbilical, whether the adjacent power circuit in the umbilical is energized or not, the circuit shall be made safe in accordance with applicable safe work practices, prior to beginning work.

**11.18.3.6 Grounding**—Normal electrical equipment grounding practices should be employed on power cables within umbilicals. This should include armor wire grounding and high voltage cable shield grounding under normal operation. Equipment grounding could be isolated from the platform due to specific subsea equipment requirements. Complete engineering assessment should be preformed to ensure proper grounding.

**11.18.3.7 Circuit protection—Fault current path**—The path for phase to ground fault current should be determined and analyzed to verify that the expected fault current can be sustained until the protection system isolates the circuit and no damage is sustained by the cable sheaths or cable shielding materials.

**11.18.3.8 Circuit protection—EMI/Crosstalk**—In situations where the subsea umbilical has two or more power circuits it may be possible, thru EMI/Crosstalk, for one power circuit to influence another. An analysis should be preformed prior to manufacture of the umbilical to verify that it is fit for purpose and all circuits will function as designed.

## **12 Special Considerations**

### **12.1 Construction Practices**

#### **12.1.1 Corrosion Prevention**

Excessive corrosion of equipment will require maintenance or replacement. Corrosion is not only undesirable in terms of repair and replacement of equipment, but also will present a safety hazard if it is allowed to negate the effect of special enclosures that are required in hazardous (classified) locations. Corrosion also can cause malfunction of equipment that may be required to ensure safe conditions. Some of the measures that can be taken to minimize corrosion of conduits and electrical equipment are as described in the following sections.

**12.1.1.1** Provide and adequately maintain breathers and drains to prevent accumulation of moisture.

**12.1.1.2** Lubricate all threaded connections with an electrically conductive and anti-seize compound that will survive in the environment. Lubricants used on flame path surfaces of flameproof or explosionproof equipment should be suitable for the purpose and recommended by the equipment manufacturer.

**12.1.1.3** Provide space heating to prevent condensation of moisture.

**12.1.1.4** Select materials appropriate for the application.

**12.1.1.4.1** Uncoated aluminum is subject to corrosion when exposed to materials whose pH is less than 4.5 or greater than 8.5. Drilling fluids rarely fall below a pH of 8.5, and normally are in the range of 9.0 to 10.5. If aluminum is installed in areas subject to exposure to such materials, it should be adequately coated or otherwise protected.

**12.1.1.4.2** Prevent contact between dissimilar metals (such as between aluminum fittings, conduits, etc. and steel). The galvanic action can result in a rapid rate of corrosion in a salty atmosphere when moisture is present. Aluminum is anodic to steel and copper. Steel is anodic to copper.

**12.1.1.4.3** If stainless steel is used, Type 316 is more resistant to corrosion than Type 303 and Type 304.

**12.1.1.4.4** Aluminum is more resistant to corrosion as its impurities, particularly copper, decrease. The term copper-free aluminum is often used to denote low copper content aluminum. It is recommended that aluminum used offshore in areas not environmentally controlled contain 0.4 % or less copper. Additional information can be obtained from the Aluminum Association, Inc.

**12.1.1.4.5** Prevent contact between aluminum and fireproofing materials containing magnesium oxychloride. Rapid corrosion of aluminum can occur when moisture is trapped between aluminum and such fireproofing material.

**12.1.1.5** Install vapor-phase corrosion inhibitors inside nonventilated enclosures.

**12.1.1.6** Use oil-immersed equipment.

**12.1.1.7** Nylon cable straps and other similar materials should be carbon impregnated (black) if exposed to sunlight to prevent rapid deterioration.

**12.1.1.8** Use hermetically sealed and environmentally sealed contacts when practical.

## **12.1.2 Cable Support Systems**

### **12.1.2.1 General**

A cable support system is a unit or assembly of units or sections and associated fittings made of metal or other non-combustible material forming a rigid structural system used to support electrical cable. Commercially made cable trays are generally preferred for multiple cable runs. For small installations, standard pipe or conduit, or specially designed brackets or supports may be utilized.

### **12.1.2.2 Materials**

Recommended materials for cable trays include copper-free aluminum, stainless steel, and fiberglass. If fiberglass tray is used in hazardous (classified) locations then it should be of the conductive type to facilitate static discharge. Cable tray supports made of hot-dipped galvanized steel or painted pipe or structural steel are recommended.

### **12.1.2.3 Design**

Cable tray systems should be designed in accordance with Article 392 "Cable Trays" of the *NEC*. Trays should be selected, using manufacturer's data, to adequately support anticipated cable loads and to sustain wind loads. It is recommended that the rung spacing of open-type trays not exceed 12 in. Trays should be supported in accordance with the manufacturer's recommendations. If cable supports are used, cables should be individually secured to the supports at intervals to prevent excessive sag or strain on the cables. Bundling of cables on supports is not recommended. All electrically conductive cable support systems should be grounded.

### **12.1.2.4 Installation**

**12.1.2.4.1** Cables and cable trays should be installed an adequate distance from piping and structural members to allow for abrasive blasting and maintenance of such piping and members without damage to the cable system.

**12.1.2.4.2** Aluminum cable trays should be electrically insulated from steel supports to prevent galvanic corrosion.

**12.1.2.4.3** Cutting and welding of galvanized trays should be avoided.

**12.1.2.4.4** Cable support systems should be installed so as not to interfere with or be damaged by routine production operations, installation of workover rigs, etc., and should be accessible for maintenance.

## **12.2 Electronic Instrumentation**

Outlined below are some general recommendations that apply to any type of offshore electronic instrumentation.

**12.2.1** It is recommended that electronic equipment be placed in areas as free as possible from vibration and extreme temperatures. If practicable, it is preferable to install electronic equipment in an air-conditioned or environmentally controlled room that provides constant temperature, low humidity, increased cleanliness, personnel comfort, and less likelihood of exposure to hazardous gases. Experience has proven that such installations will experience increased performance stability, longer equipment life, and lower downtime.

**12.2.2** Sensors and end devices are critical to the successful operation of any electronic instrumentation or control system. End devices should be selected that are suitable for the area classification, environmental conditions and operating requirements. Particular attention should be given to both mechanical and electrical installation methods to provide dependable, long life performance. Screwed process connections should be carefully installed to avoid failures due to vibration.

**12.2.3** Electronic instrumentation circuits should be separated from power circuits when practical to avoid electrical interference.



## 12.3 Electrical Tools

**12.3.1** It is necessary at times to use portable electrical power tools on offshore platforms. Most portable electrical tools, whether cord connected or battery powered (cordless), are constructed with an open housing to allow adequate ventilation and contain a type of motor that creates sparks with sufficient energy to ignite a methane-air mixture. When using this type of electrical tool, precautions should be taken to ensure that a noncombustible atmosphere exists prior to use. Frequently, the use of portable electrical power tools requires a procedure described by an authorized hot work permit.

**12.3.2** An electrical tool that can be an ignition source should not be equipped with a flameproof or explosionproof type plug permanently attached to the power cord. To allow for use of these portable electrical tools in areas where only flameproof or explosionproof receptacles are installed, adapter cords should be provided that incorporate a flameproof or explosionproof plug on one end and a three-wire, grounded, nonflameproof or non-explosionproof receptacle on the other end.

**12.3.3** The nonflameproof or non-explosionproof receptacle should be the locking-type, or a means should be provided whereby the connection cannot accidentally be disconnected. These adapter cords should not be more than 2 ft long and should be used only under supervised conditions. Alternatively, the adapter cords can be longer than 2 ft provided the end of the cord connected to the general purpose receptacle is used only in unclassified locations or locations where work is being performed in accordance with the procedure described by an authorized hot work permit. Also, the adapter cords can be used in combination with an extension cord utilizing a flameproof or explosionproof receptacle on one end and a flameproof or explosionproof plug on the other end.

**12.3.4** It is recommended that any portable electrical tools kept offshore that do not have labels certifying their use in Class I, Zone 1 locations should be distinctly identified and permanently labeled "WARNING—SOURCE OF IGNITION WHEN IN USE."

**12.3.5** All portable electric power tools—except double-insulated tools—should be equipped with a three-wire cord containing a grounding conductor. The grounding conductor should be mechanically secured to the frame of the tool and to the grounding pin of the plug and shall be contained in the same jacket as the power conductors. Double-insulated power tools and appliances are not recommended for use offshore unless special supervision and maintenance precautions are taken to assure the integrity of the equipment.

## 12.4 Electrical Appliances

Electrical appliances are normally located in unclassified locations; however, some appliances on small platforms without quarters may be located in hazardous (classified) locations. In the latter case, the appliances should be suitable for the area classification and should be made of corrosion-resistant materials. Consideration should be given to the use of only Zone 1 or Zone 2 appliances on offshore platforms outside of environmentally controlled buildings to provide increased safety and to allow for subsequent relocation of the appliances or changes in production equipment.

## 12.5 Extension Cords

Extension cords are designed for, and should be used for, only temporary use. All other electrical connection should be made permanent by proper construction methods. All extension cords should include a grounding conductor within the cable jacket and should be equipped with either explosionproof or non-explosionproof (flameproof or nonflameproof), three-wire grounding receptacles and plugs (but not with one of each). The type of receptacle, plug, and cord will depend on the classification of the location in which it will be used. Reference 12.3.2 for adapter cords.

## 12.6 Electrical Equipment Buildings

Where practical, it is recommended that electrical and electronic equipment be installed in environmentally controlled rooms or buildings that are effectively sealed from the outside atmosphere. It is recommended that recirculating air conditioning systems be used. This approach provides optimum protection of the electrical equipment from contaminants in the offshore atmosphere and minimizes the possibility of flammable concentrations of hydrocarbons reaching the electrical equipment in the event of a catastrophic failure of hydrocarbon handling equipment.

## 12.7 Laboratory Buildings

As laboratory buildings often have unique purposes and applications, special considerations should be given with regards to the classification of the area and appropriate wiring methods to accommodate the electrical area classification.

**NOTE** Specific guidance is provided in the 2012 edition of API 500 as to the area classification of laboratory buildings and spaces that are used to analyze, store, or handle flammable and combustible materials. This guidance is based on the type, quantity, and frequency of use of these materials. This information is specifically applicable to Zone applications as well and will be incorporated in the next update to API 505.

## 12.8 Signs

Equipment operating at or containing live parts at voltage levels exceeding 600 Volts, nominal, should be provided with suitable signs alerting personnel of the higher voltage to reduce the possibility of electrical shock. Such signs should be located at the point of access to live parts.

## 12.9 Lockout and Tagout Procedures

To guard against electrical shock, injury from movement, or injury from power-driven equipment, individual facilities should develop proper lockout and tagout procedures so consideration can be given to local needs to assure the procedures are compatible with each facility's operations. Lockout and tagout procedures should comply with the requirements of NFPA 70E *Standard for Electrical Safety in the Workplace* and the authority having jurisdiction.

## 12.10 Portable Electronic Devices

Where portable electronic devices (e.g. pagers, cell phones, cameras, video equipment, and radios) are used in hazardous (classified) locations they should be either:

- a) approved for the location being used or;
- b) used in conjunction with a hot work or a gas-free work permit or;
- c) as permitted in ISA-RP12.12.03, *Recommended Practice for Portable Electronic Products Suitable for Use in Class I and II, Division 2, Class I Zone 2 and Class III, Division 1 and 2 Hazardous (Classified) Locations*.

## 12.11 Abandoned Raceways and Conductors

Abandoned conductors should either be removed or maintained in a manner that, if energized, would not cause an electrical fault or present an electrical shock hazard. Any abandoned conduit and other raceway (containing or not containing conductors) should be properly sealed to prevent the passage of flames and to minimize the passage of flammable gases and vapors from Zone 0 to Zone 1, Zone 1 to Zone 2, or Zone 2 to unclassified locations.

## 13 System Checkout

### 13.1 General

It is recommended that all electrical systems be thoroughly checked prior to first being energized for normal operation. A well-planned checkout will reduce both the probability of operational malfunctions and damage to equipment. The extent of any checkout program is based on the complexity of the electrical system; however, certain basic checks are considered good practice for all systems. The following items are recommended minimum checks that should be considered prior to operating an electrical system for the first time or following a lengthy shutdown.

### 13.2 Generators and Motors

**13.2.1** Check windings for dryness. It is recommended that space heating be operated for a sufficient time prior to start-up to assure dryness.

**13.2.2** Check stator insulation resistance to the motor or generator frame with an instrument applying a minimum of 500 Volts DC for LV machines and 5000 Volts DC for MV machines across the insulation for one minute. The suggested minimum insulation resistance for LV machines is 2.5 megohms and for MV machines is 15 megohms. If generators are to be operated in parallel, check their phase rotation and the synchronizing circuits for proper operation.

**13.2.3** Check motor starter overload relay heater elements for proper sizing.

**13.2.4** Check circuit breaker trip settings and fuse sizes.

**13.2.5** Jog motors to check for proper direction of rotation after first uncoupling any loads that might be damaged by reverse rotation.

**13.2.6** Check motor-to-load and generator-to-prime mover alignments.

**13.2.7** After motors and generators are started, check for abnormal line currents, vibration, and high bearing temperatures.

### 13.3 Instrumentation and Control Circuits

**13.3.1** Check all circuits for continuity.

**13.3.2** Check logic functions with normal voltage applied to the control circuits but, preferably, with the power circuits not energized.

**13.3.3** Check each sensor and end device individually for proper operation prior to incorporating same into the system.

## 14 Maintenance

Electrical installations should be maintained in accordance with NFPA 70B, *Recommended Practice for Electrical Equipment Maintenance*, during the life of the facility. Alternate maintenance plans based on local experience are also acceptable. An electrical preventive maintenance (EPM) program should be developed for each facility in order to reduce hazards to life and property that can result from failure or malfunction of electrical systems and equipment. For recommended electrical equipment inspection intervals reference Annex A.

## 15 Safety

The electrical safety requirements of NFPA 70E, *Standard for Electrical Safety in the Workplace*, should be followed during the installation, use, and maintenance of electrical systems. It is important that the personnel who perform the electrical work should be properly trained on the specific equipment being installed, maintained or tested. This includes understanding the functionality of the equipment, both electrically and mechanically, and having a thorough knowledge of electrical safety practices and procedures. Specific training is required for each class of electrical equipment, protective relaying devices, and the use of personnel protection equipment (PPE).

## Annex A (informative)

### Inspection Intervals

The inspection intervals in Table A.1 are offered to assist in developing an effective electrical maintenance program. The inspection time intervals shown are recommended until the location conducts sufficient inspections to develop a history/ database and understand the condition of the equipment. At that time, the intervals should be adjusted, based on the age and condition of the equipment, the risk associated with the failure of that equipment, weather, ambient temperature, and other site-specific conditions.

A determination of whether to inspect equipment in an energized condition or to first shut down the equipment, using suitable lockout and tagout procedures before inspection, should be made before initiating any inspection program for electrical equipment. Use of good engineering judgment is essential in making this determination. NFPA 70E, *Standard for Electrical Safety in the Workplace*, provides guidelines for proper selection and use of personal protective equipment, which may be required for certain inspections.

**Table A.1—Inspection Intervals**

Equipment	Inspection Intervals	
	Routine	Detailed
<b>Motors</b>		
AC Motors (MV/LV)	1 yr	3 – 4 yrs
Critical service	6 mos	3 – 4 yrs
Synchronous Motors	1 yr	3 – 4 yrs
DC Motors	3 mos	3 – 4 yrs
Brushes		1 yr
<b>Motor Controllers (Outdoor/Indoors)</b>		
Oil immersed (MV)	6 mos	4 – 6 yrs
Vacuum (MV)	6 mos	4 – 6 yrs
Air (MV)	6 mos	4 – 6 yrs
ASDs (MV/LV)	6 mos	1 – 4 yrs
Air (LV)	6 mos	4 – 6 yrs
Flameproof or Explosionproof	6 mos	3 – 4 yrs
MOVs	6 mos	3 – 4 yrs
Generator Sets	1 mo	4 yrs
Switchgear/MCCs (Outdoor/Indoor)	3 – 6 mos	3 – 6 yrs
Panelboards	1 yr	6 yrs
<b>Transformers</b>		
Oil-filled	6 mos	2 yrs
Oil analysis	2 yrs	2 yrs
Dry	1 yr	6 yrs

**Table A.1—Inspection Intervals (Continued)**

Equipment	Inspection Intervals	
	Routine	Detailed
UPS systems	1 yr	2 yrs
Check air filters	1 mo	
Battery chargers	1 mo	1 yr
Batteries		
Electrolyte level	1 mo	1 yr
Electrolyte sp gravity	1 mo	
Automatic Transfer Switches	6 mos	4 yrs
Surge Arrestors	1 yr	
Protective Relay Systems	6 mos	3 yrs
Grounding Systems	1 yr	
Heat Tracing Systems	1 yr	
Cathodic Protection System		
Sacrificial anodes	N/A	10 yrs
Impressed current	1 mo	1 yr

## **Annex B**

### **(informative)**

## **ABS Rules For Building and Classing Steel Vessels—1998, PART 4**

The following information was reprinted with ABS permission from ABS Rules and is included only for the convenience of the reader. It may reference other portions of ABS Rules that are not included. Users of this RP are cautioned that ABS rules are subject to change and the latest revision of the subject document should be referred to for actual design criteria.

### **4/5C2 Rotating Machines**

#### **4/5C2.1 General**

##### **4/5C2.1.1 Applications**

All rotating electrical machines of 100 kW and over are to be constructed and tested in accordance with the following requirements to the satisfaction of the Surveyor. All rotating electrical machines below 100 kW are to be constructed and equipped in accordance with good commercial practice, and will be accepted subject to a satisfactory performance test conducted to the satisfaction of the Surveyor after installation.

##### **4/5C2.1.2 Certification on Basis of an Approved Quality Assurance Program**

See 4/1.2.

##### **4/5C2.1.3 References**

- a) *Inclination*. For the requirements covering inclination for design condition, see 4/1.13.
- b) *Insulation Material*. For the requirements covering insulation material, see 4/5.13.
- c) *Capacity of Generators*. For requirements covering main generator capacity, see 4/5A2.1.2 and 4/5A2.5. For requirements covering emergency generator capacity, see 4/5A3.3.1.
- d) *Power Supply by Generators*. For requirements covering power supply by main or emergency generator, see 4/5A2.1.2 and 4/5A3.5.2 respectively.
- e) *Protection for Generator Circuits*. For requirements covering protection for generator, see 4/5A5.3, 4/5A5.5 and 4/5A5.7.
- f) *Protection for Motor Circuits*. For requirements covering protection for motor branch circuit, see 4/5A5.13.
- g) *Installation*. For requirements covering installation, see 4/5B2.3 for generators and 4/5B2.5 for motors.
- h) *Protection Enclosures and its Selection*. For requirements covering degree of the protection and the selection of equipment, see 4/5.15 and 4/5B2.1 respectively.

### 4/5C2.3 Testing and Inspection

#### 4/5C2.3.1 Applications

- a) *Machines of 100 kW and Over.* All rotating machines of 100 kW and over are to be tested in accordance with Table 4/5C.1 in the presence of and inspected by the Surveyor, preferably at the plant of the manufacturer.
- b) *Machines Below 100 kW.* For machines of less than 100 kW, the tests may be carried out by the manufacturer whose certificate of tests will be acceptable and is to be submitted upon request from the Bureau.

#### 4/5C2.3.2 Special Testing Arrangements

In cases where all of the required tests are not carried out at the plant of the manufacturer, the Surveyor is to be notified and arrangements are to be made so that the remaining tests will be witnessed.

#### 4/5C2.5 Insulation Resistance Measurement

The resistance is to be measured before the commencement of the testing and after completion of the testing for all circuits. Circuits or groups of circuits of different voltages above earth are to be tested separately. This test is to be made with at least 500 Volts DC and the insulation resistance in megohms of the circuits while at their operating temperatures is to be normally at least equal to:

The minimum insulation resistance of the fields of machines separately excited with voltage less than the rated voltage of the machine is to be of the order of one-half to one megohm.

#### 4/5C2.6 Overload and Overcurrent Capability

(1997)

##### 4/5C2.6.1 AC Generators

AC generators are to be capable of withstanding a current equal to 1.5 times the rated current for not less than 30 seconds.

##### 4/5C2.6.2 AC Motors

- a) *Overcurrent Capacity.* Three phase motors, except for commutator motors, having rated outputs not exceeding 315 kW and rated voltages not exceeding 1 kV are to be capable of withstanding a current equal to 1.5 times the rated current for not less than 2 minutes. For three-phase and single phase motors having rated outputs above 315 kW the overcurrent capacity is to be in accordance with the manufacturer's specification.
- b) *Overload Capacity.* Three-phase induction motors are to be capable of withstanding for 15 seconds, without stalling or abrupt change in speed, an excess torque of 60 % of their rated torque, the voltage and frequency being maintained at their rated values.
- c) *Overload Capacity for Synchronous Motors.* Three phase synchronous motors are to be capable of withstanding an excess torque as specified below for 15 seconds without falling out of synchronism, the excitation being maintained at the value corresponding to the rated load.

Synchronous (wound rotor) induction motors:	35 % excess torque
Synchronous (cylindrical rotor) motors:	35 % excess torque
Synchronous (salient pole) motors:	50 % excess torque

When automatic excitation is used, the limit of torque values are to be the same as with the excitation equipment operating under normal conditions.



## **4/5C2.7 Dielectric Strength of Insulation**

### **4/5C2.7.1 Application**

The dielectric test voltage is to be successively applied between each electric circuit and all other electric circuits and metal parts earthed and for direct-current (DC) rotating machines between brush rings of opposite polarity. Interconnected polyphase windings are to be considered as one circuit. All windings except that under test are to be connected to earth.

### **4/5C2.7.2 Standard Voltage Test**

The insulation of all rotating machines is to be tested with the parts completely assembled and not with the individual parts. The dielectric strength of the insulation is to be tested by the continuous application for 60 seconds of an alternating voltage having a frequency of 25 to 60 Hz and voltage in Table 4/5C.2.

### **4/5C2.7.3 Direct Current Test**

A standard voltage test using a direct current source equal to 1.7 times the required alternating-current voltage will be acceptable.

## **4/5C2.9 Temperature Ratings**

### **4/5C2.9.1 Temperature Rises**

- a) *Continuous Rating Machines.* After the machine has been run continuously under a rated load until steady temperature condition has been reached, the temperature rises are not to exceed those given in Table 4/5C.3.
- b) *Short-time Rating Machines.* After the machine has been run at a rated load during the rated time, followed by a rest and de-energized period of sufficient duration to re-establish the machine temperatures within 2 °C (36 °F) of the coolant, the temperature rises are not to exceed those given in Table 4/5C.3. At the beginning of the temperature measurement, temperature of the machine is to be within 5 °C (41 °F) of the temperature of the coolant.
- c) *Periodic Duty Rating Machines.* The machine has been run at a rated load for the designed load cycle to be applied and continued until obtaining the practically identical temperature cycle. At the middle of the period causing the greatest heating in the last cycle of the operation, the temperature rises are not to exceed those given in Table 4/5C.3.
- d) *Non-periodic Duty Rating Machines.* After the machine has been run continuously or intermittently under the designed variations of the load and speed within the permissible operating range until reaching the steady temperature condition, the temperature rises are not to exceed those given in Table 4/5C.3.
- e) *Insulation Material Above 180 °C (356 °F).* Temperature rises for insulation materials above 180 °C (356 °F) will be considered in accordance with 4/5.13.6.

### **4/5C2.9.2 Ambient Temperature**

These final temperatures are based on an ambient temperature of 50 °C (122 °F). Where provision is made for insuring an ambient temperature being maintained at 40 °C (104 °F) or less, as by air cooling or by locating the machine outside of the boiler and engine rooms, the temperature rises of the windings maybe 10 °C (50 °F) higher. The ambient temperature is to be taken in at least two places within 1.83 m (6 ft) of the machine under test and by thermometers having their bulbs immersed in oil contained in an open cup.

## **4/5C2.11 Construction and Assemblies**

### **4/5C2.11.1 Enclosure, Frame and Pedestals**

Magnet frames and pedestals may be separate but are to be secured to a common foundation.

### **4/5C2.11.2 Shafts and Couplings**

Rotating shaft, hollow shaft, and coupling flange with bolts are to comply with 4/3.19, 4/7.21, 4/7.31. Plans to be submitted are given in 4/317 and 4/4.3.

### **4/5C2.11.3 Circulating Currents**

Means are to be provided to prevent circulating currents from passing between the journals and the bearings, where the design and arrangement of the machine is such that damaging current may be expected. Where such protection is required, a warning plate is to be provided in a visible place cautioning against the removal of such protection.

### **4/5C2.11.4 Rotating Exciters**

Rotating exciters are to conform to all applicable requirements for generators.

### **4/5C2.11.5 Insulation of Windings**

Armature and field coils are to be treated to resist oil and water.

### **4/5C2.11.6 Protection Against Cooling Water**

Where water cooling is used, the cooler is to be so arranged to avoid entry of water into the machine, whether through leakage or from condensation in the heat exchanger.

### **4/5C2.11.7 Moisture-condensation Prevention**

When the weight of the rotating machine, excluding the shaft, is over 455 kg (1000 lb), it is to be provided with means to prevent moisture condensation in the machine when idle. Where steam-heating coils are installed for this purpose, there are to be no pipe joints inside the casings. See item 7 in Table 4/5C.7 for space heater pilot lamp for alternating-current generators.

### **4/5C2.11.8 Terminal Arrangements**

Terminals are to be provided at an accessible position and protected against mechanical damage and accidental contact for earthing, short-circuit or touching. Terminal leads are to be secured to the frame and the designation of each terminal lead are to be clearly marked. The ends of terminal leads are to be fitted with connectors. Cable glands or similar are to be provided where cable penetrations may compromise the protection property of terminal enclosures.

### **4/5C2.11.9 Nameplates**

Nameplates of corrosion-resistant material are to be provided in an accessible position of the machine and are to indicate at least the information as listed in Table 4/5C.4a.

## **4/5C2.13 Lubrication**

Rotating machines are to have continuous lubrication at all running speeds and all normal working bearing temperatures, with the vessel's inclinations specified in 4/1.13. Unless otherwise approved, where forced lubrication

is employed, the machines are to be provided with means to shut down their prime movers automatically upon failure of the lubricating system. Each self-lubricating sleeve bearing is to be fitted with an inspection lid and means for visual indication of oil level or an oil gauge.

#### **4/5C2.15 Turbines for Generators**

Steam- and gas-turbine prime movers driving generators are to meet the applicable requirements in Section 4/3 and in addition are to comply with the following requirements.

##### **4/5C2.15.1 Operating Governor**

An effective operating governor is to be fitted on prime movers driving main or emergency electric generators and is to be capable of automatically maintaining the speed within the following limits. Special consideration will be given when an installation requires different characteristics.

a) *Momentary Speed Variations* (1998). The momentary speed variations, when running at the following loads, is to be within 10% of the rated speed when:

- 1) (1998) the full load (equal to rated output) of the generator is suddenly thrown off;
- 2) 50 % of the full load of the generator is suddenly thrown on followed by the remaining 50 % load after an interval sufficient to restore the speed to steady state;
- 3) the speed is to return to within 1 % of the final steady state speed in no more than 5 seconds.

a) *Speed Variations in Steady State*. The steady state speed variation is to be within 5 % of the rated speed at any loads between no load and the full load.

b) *Emergency Generator Prime Movers* (1998). Prime movers driving emergency generators are to be able to maintain the speed within the limits in 4/5C2.15.1a and 4/5C2.15.1b when the full load of the emergency generator is suddenly thrown on.

##### **4/5C2.15.2 Overspeed Governor**

In addition to the normal operating governor an overspeed governor is to be fitted which will trip the turbine throttle when the rated speed is exceeded by more than 15 %. Provision is to be made for hand tripping. See 4/5C2.13 for pressure-lubricated machines.

##### **4/5C2.15.3 Exhaust Steam to the Turbines**

If exhaust steam is admitted to the turbine, means are to be provided to prevent water entering the turbine. An automatic shutoff is to be provided for auxiliary exhaust when exhaust steam is admitted to the turbine lower stages; this shut-off is to be controlled by the governor and is to function when the emergency trip operates.

##### **4/5C2.15.4 Extraction of Steam**

Where provision is made for extraction of steam, approved means are to be provided for preventing a reversal of flow to the turbine.

##### **4/5C2.15.5 Power Output of Gas Turbines**

To satisfy the requirements of 4/5A2.1 the required power output of gas turbine prime movers for ship's service generator sets is to be based on the maximum expected inlet air temperature.

#### **4/5C2.17 Diesel Engines for Generators**

Diesel-engine prime movers are to meet the applicable requirements in Section 4/4 and in addition are to comply with the following requirements.

##### **4/5C2.17.1 Operating Governor**

An effective operating governor is to be fitted on prime movers driving main or emergency electric generators and is to be capable of automatically maintaining the speed within the following limits. Special consideration will be given when an installation requires different characteristics.

- a) *Momentary Speed Variations* (1998). The momentary speed variations, when running at the following loads, is to be within 10% of the rated speed when:
- 1) (1998) the full load (equal to rated output) of the generator is suddenly thrown off, and
  - 2) 50 % of the full load of the generator is suddenly thrown on followed by the remaining 50 % load after an interval sufficient to restore the speed to steady state.
  - 3) The speed is to return to within 1 % of the final steady state speed in no more than 5 seconds.
  - 4) (1998) The application of electrical load in more than two steps can be used where the system design provides for incremental grouping of loads with due consideration for automatically switched loads, critical recovery loads following a blackout, and emergency transfer of loads from a troubled generator set to the surviving sets operating in parallel (see Figure 4/5C.1). The details of load management system are to be described fully in the design documentation and its satisfactory operation is to be demonstrated to the Surveyor during the vessel's trial. In this case, due consideration is to be given to the power required for the electrical equipment to be automatically switched on after black-out and to the sequence in which it is connected. This applies analogously also for generators to be operated in parallel and where the power has to be transferred from one generator to another in the event that any one generator has to be switched off.
- b) *Speed Variations in Steady State* (1998). The steady state speed variation is to be within 5 % of the rated speed at all loads between no load and full load.
- c) *Emergency Generator Prime Movers* (1998). Prime movers driving emergency generators are to be able to maintain the speed within the limits in 4/5C2.17.1a and 4/5C2.17.1b when the full load of the emergency generator is suddenly thrown on. Where loads are applied in multiple steps, the first applied load is not to be less than the required emergency load (see 4/5A3.3.1) or 4/5C2.17.1a4 whichever is the greater. Where loads are applied in multiple steps, the first applied load is not to be less than the sum of all emergency loads that are automatically connected.

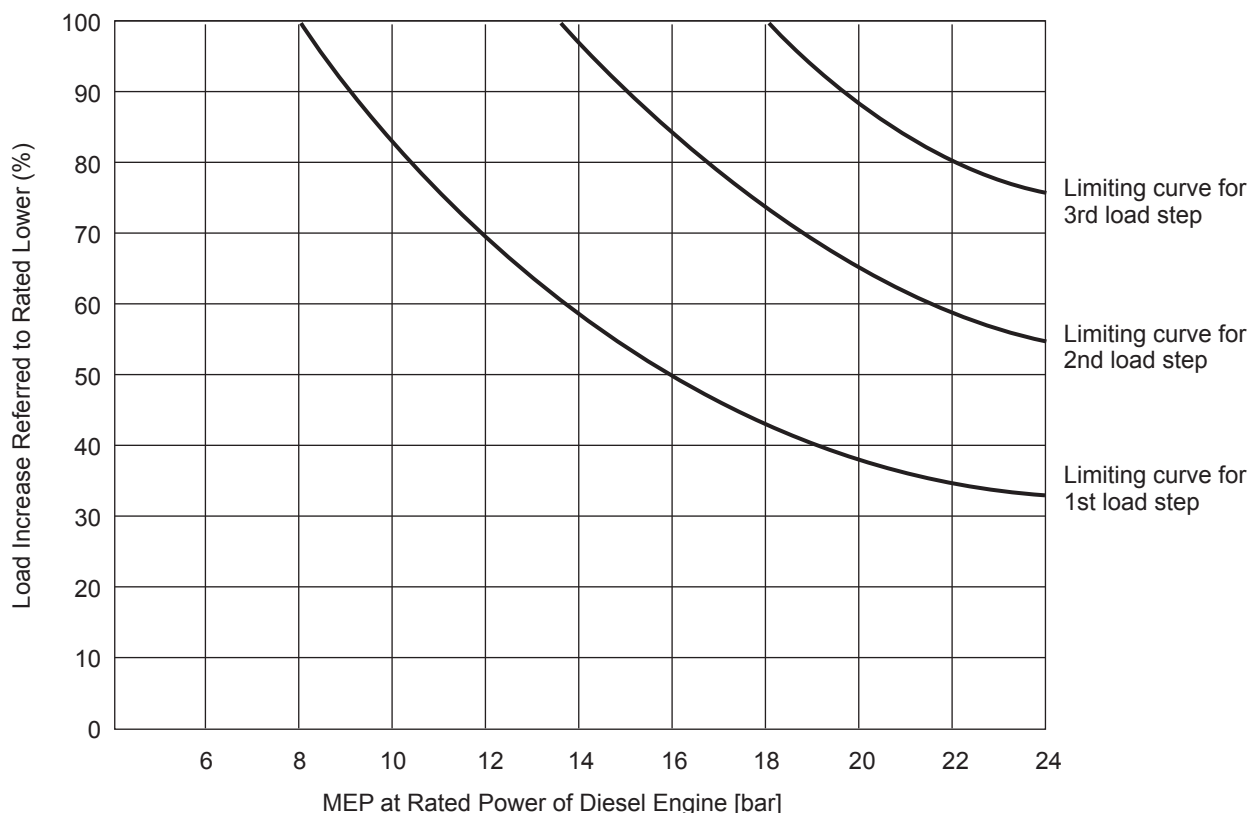
##### **4/5C2.17.2 Overspeed Governor**

In addition to the normal operating governor each auxiliary diesel engine having a maximum continuous output of 220 kW and over is to be fitted with a separate overspeed device so adjusted that the speed cannot exceed the maximum rated speed by more than 15 %. Provision is to be made for hand tripping. See 4/5C2.13 for pressure-lubricated machines.

#### **4/5C2.19 Alternating-current (AC) Generators(1997)**

##### **4/5C2.19.1 Control and Excitation of Generators**

Excitation current for generators is to be provided by attached rotating exciters or by static exciters deriving their source of power from the machine being excited.



**Figure 4/5C.1—Limiting Curves for Loading 4-stroke Diesel Engines Step by Step from No-load to Rated Power as Function of the Brake Mean Effective Pressure**

#### 4/5C2.19.2 Voltage Regulation

- a) *Voltage Regulators.* A separate regulator is to be supplied for each AC generator. When it is intended that two or more generators will be operated in parallel, reactive-droop compensating means are to be provided to divide the reactive power properly between the generators.
- b) *Steady Conditions.* Each AC generator for ship's service driven by its prime mover having governor characteristics complying with 4/5C2.15.1 or 4/5C2.17.1 is to be provided with an excitation system capable of maintaining the voltage under steady conditions within plus or minus 2.5 % of the rated voltage for all loads between zero and rated load at rated power factor. These limits may be increased to plus or minus 3.5 % for emergency sets.
- c) *Short Circuit Conditions.* Under steady-state short circuit conditions, the generator together with its excitation system is to be capable of maintaining a current of not less than 3 times its rated full load current for a period of 2 seconds or of such magnitude and duration as required to properly actuate the associated electrical protective devices.

#### 4/5C2.19.3 Parallel Operation

For AC generating sets operating in parallel, the following requirements are to be complied with. See also 4/A.5.5.2 for protection of AC generators in parallel operation.

- a) *Reactive Load Sharing.* The reactive loads of the individual generating sets are not to differ from their proportionate share of the combined reactive load by more than 10 % of the rated reactive output of the largest generator, or 25 % of the rated reactive output of the smallest generator, whichever is the less.

- b) *Load Sharing.* For any load between 20 % and 100 % of the sum of the rated output (aggregate output) of all generators, the load on any generator is not to differ more than 15 % of the rated output in kilowatt of the largest generator or 25 % of the rated output in kilowatt of the individual generator in question, whichever is the less, from its proportionate share of the combined load for any steady state condition. The starting point for the determination of the foregoing load-distribution requirements is to be at 75 % of the aggregate output with each generator carrying its proportionate share.
- c) *Facilities for Load Adjustment.* Facilities are to be provided to adjust the governor sufficiently fine to permit an adjustment of load not exceeding 5 % of the aggregate output at normal frequency.

#### **4/5C2.21 Direct-current (DC) Generators**

##### **4/5C2.21.1 Control and Excitation of Generators**

- a) *Field Regulations Means.* are to be provided at the switchboard to enable the voltage of each generator to be adjusted separately. This equipment is to be capable of adjusting the voltage of the DC generator to within 0.5 % of the rated voltage at all loads between no-load and full-load.
- b) *Polarity of Series Windings.* The series windings of each generator for two wire DC system are to be connected to negative terminal of each machine.
- c) *Equalizer Connections.* See 4/5C4.15.3.

##### **4/5C2.21.2 Voltage Regulation**

- a) *Shunt or Stabilized Shunt-wound Generator.* When the voltage has been set at full-load to its rated value, the removal of the load is not to cause a permanent increase of the voltage greater than 15 % of the rated voltage. When the voltage has been set either at full-load or at no-load, the voltage obtained at any value of the load is not to exceed the no-load voltage.
- b) *Compound-wound Generator.* Compound-wound generators are to be so designed in relation to the governing characteristics of prime mover, that with the generator at full-load operating temperature and starting at 20 % load with voltage within 1% of rated voltage, it gives at full-load a voltage within 1.5 % of rated voltage. The average of ascending and descending voltage regulation curves between 20 % load and full-load is not to vary more than 3 % from rated voltage.
- c) *Automatic Voltage Regulators.* Ship's service generators which are of shunt type are to be provided with automatic voltage regulators. However, if the load fluctuation does not interfere with the operation of essential auxiliaries, shunt-wound generators without voltage regulators or stabilized shunt-wound machines may be used. An automatic voltage regulators will not be required for the ship's service generators of approximately flat-compounded type. Automatic voltage regulators are to be provided for all service generators driven by variable speed engines used also for propulsion purposes, whether these generators are of the shunt, stabilized shunt or compound-wound type.

##### **4/5C2.21.3 Parallel Operation**

For DC generating sets operating in parallel, the following requirements are to be complied with. See also 4/A.5.7.2 for protection of DC generators in parallel operation.

- a) *Stability.* The generating sets are to be stable in operation at all loads from no-load to full-load.
- b) *Load Sharing.* For any load between 20 % and 100 % of the sum of the rated output (aggregate output) of all generators, the load on any generator is not to differ more than 12 % of the rated output in kilowatt of the largest generator or 25 % of the rated output in kilowatt of the individual generator in question, whichever is the less, from

its proportionate share of the combined load for any steady state condition. The starting point for the determination of the foregoing load-distribution requirements is to be at 75 % of the aggregate output with each generator carrying its proportionate share.

- c) *Tripping of Circuit Breaker.* DC generators which operate in parallel are to be provided with a switch which will trip the generator circuit breaker upon functioning of the overspeed device.

## **Annex C** (informative)

### **USCG Requirements, 46 CFR, Subchapter J, 111.95**

#### **Subpart 111.95—Electric Power-Operated Boat Winches**

##### **§ 111.95-1 Applicability.**

(a) The electric installation of each electric power-operated boat winch must meet the requirements in this subpart, except that limit switches must be adapted to the installation if there are no gravity davits.

(b) The provisions of this subpart supplement the requirements for boat winches in other parts of this chapter under which vessels are certificated and in subchapter Q, Equipment approvals.

[CGD 74–125A, 47 FR 15236, Apr. 8, 1982, as amended by CGD 94–108, 61 FR 28283, June 4, 1996]

##### **§ 111.95-3 General requirements.**

(a) Each electrical component (e.g. enclosure, motor controller, or motor) must be constructed to the appropriate NEMA or IEC degree of protection requirement for the service and environment in which it is installed.

(b) Each main line emergency disconnect switch, if accessible to an unauthorized person, must have a means to lock the switch in the open-circuit position with a padlock or its equivalent. The switch must not lock in the closed-circuit position.

[CGD 94–108, 61 FR 28283, June 4, 1996]

##### **§ 111.95-7 Wiring of boat winch components.**

(a) If the motor controller of a boat winch power unit is next to the winch, the main line emergency switch must disconnect all parts of the boat winch power unit, including the motor controller and limit switches, from all sources of potential. Other power circuit switches must be connected in series with the main line emergency switch and must be ahead of the motor controller. The main line emergency switch must be the motor and controller disconnect required by Subpart 111.70 and must have a horsepower rating of at least that of the winch motor.

(b) If the motor controller of a boat winch power unit is remote from the winch, there must be a switch at the controller that can disconnect the entire winch electric installation from all sources of potential. The switch must be in series with and on the supply side of the main line emergency switch.

(c) Each davit arm limit switch, whether connected in the power circuit or in the control circuit, must disconnect all ungrounded conductors of the circuit controlled.

(d) If one motor is used with two winches, there must be a main line emergency switch, a clutch interlock switch, and a master switch for each winch, except that a single main line emergency switch located as required by paragraph (e) of this section may be used for both winches. The main line emergency switches must be connected, in series, ahead of the motor controller. The master switches must be connected in parallel and each, in series, with the corresponding clutch interlock switch for that winch. Each clutch interlock switch must open the circuit to its master switch, except when the power unit is clutched to the associated winch. There must be a means to prevent the power unit from being clutched to both winches simultaneously.



(e) The main line emergency disconnect switch must be adjacent to the master switch, within reach of the winch operator, accessible to the person in charge of the boat stowage, and for gravity davit installations, in a position from which the movement of boat davit arms can be observed as they approach the final stowed position.

[CGD 74–125A, 47 FR 15236, Apr. 8, 1982, as amended by CGD 94–108, 61 FR 28283, June 4, 1996]

## **Annex D** (informative)

### **USCG Requirements, 46 CFR, Subchapter J, 111.97**

#### **Subpart 111.97—Electric Power-Operated Watertight Door Systems**

##### **§ 111.97-1 Applicability.**

This subpart applies to electric power-operated watertight door systems required under Subpart H of Part 170 of this chapter.

[CGD 79–023, 48 FR 51008, Nov. 4, 1983]

##### **§ 111.97-3 General requirements.**

Each watertight door operating system must meet Subpart H, §170.270 of this chapter.

[CGD 74–125A, 47 FR 15236, Apr. 8, 1982, as amended by USCG–2000–7790, 65 FR 58462, Sept. 29, 2000]

##### **§ 111.97-5 Electric and hydraulic power supply.**

(a) Each electric motor-driven door operating system must have the same source of power as the emergency lighting and power system.

(b) The temporary emergency power source and the final emergency power source must each be capable of operating all doors simultaneously or sequentially as allowed by §170.270(c) of this chapter.

(c) The power supply for each hydraulically operated watertight door system that uses a hydraulic system common to more than one watertight door must be an accumulator tank with enough capacity to open all doors once and to close all doors two times and be supplied by one or more motor-driven hydraulic pumps that can operate from the final source of the emergency lighting and power system.

(d) The motor-driven hydraulic pumps must automatically maintain the accumulator tank pressure within the design limits, be above the uppermost continuous deck, and be controlled from above the uppermost continuous deck.

(e) The accumulator tank capacity required in paragraph (c) of this section must be available when the accumulator tank pressure is at the automatic pump “cut-in” pressure.

(f) The source of power for each hydraulically operated watertight door system using an independent hydraulic system for each door operator must meet paragraphs (a) and (b) of this section.

(g) The power supply for other types of watertight door operators must be accepted by the Commandant.

[CGD 74–125A, 47 FR 15236, Apr. 8, 1982, as amended by CGD 94–108, 61 FR 28283, June 4, 1996; USCG–2000–7790, 65 FR 58462, Sept. 29, 2000]

##### **§ 111.97-7 Distribution.**

(a) Each distribution panelboard for a watertight door system must be above the uppermost continuous deck and must have means for locking.

(b) Each feeder supplying a watertight door operating system must be above the uppermost continuous deck.

(c) Each watertight door operating system must have a separate branch circuit.

**§ 111.97-9 Overcurrent protection.**

Overcurrent devices must be arranged to isolate a fault with as little disruption of the system as possible. The relationship between the load and the rating or setting of overcurrent devices must meet the following:

- (a) The rating or setting of each feeder overcurrent device must be not less than 200 percent of its maximum load.
- (b) The rating or setting of a branch circuit overcurrent device must be not more than 25 percent of that of the feeder overcurrent device.

## **Annex E**

### **(informative)**

## **USCG Requirements, 46 CFR, Subchapter J, Subpart 111.105**

### **Subpart 111.105—Hazardous Locations**

#### **§ 111.105-1 Applicability; definition**

This subpart applies to installations in hazardous locations as defined in NFPA NEC 2002 and in IEC 60079-0 (both incorporated by reference; see 46 *CFR* 110.10-1). As used in this subpart, "IEC 60079 series" means IEC 60079-0, IEC 60079-1, IEC 60079-2, IEC 60079-5, IEC 79-6, IEC 60079-7, IEC 60079-11, IEC 60079-15, and IEC 79-18 (all incorporated by reference; see 46 *CFR* 110.10-1).

[USCG-2003-16630, 73 FR 65199, Oct. 31, 2008]

#### **§ 111.105-3 General requirements.**

All electrical installations in hazardous locations must comply with the general requirements of section 33 of IEEE 45-1998 (incorporated by reference; see 46 *CFR* 110.10-1), and with either Articles 500 through 505 of NFPA NEC 2002 (incorporated by reference; see 46 *CFR* 110.10-1) or with the IEC 60079 series (as defined in 46 *CFR* 111.105-1 and incorporated by reference; see 46 *CFR* 110.10-1). When installations are made in accordance with NFPA NEC 2002 articles, and when installed fittings are approved for the specific hazardous location and the cable type, marine shipboard cable that complies with 46 *CFR* subpart 111.60 may be used instead of rigid metal conduit.

[USCG-2003-16630, 73 FR 65199, Oct. 31, 2008]

#### **§ 111.105-5 System integrity.**

In order to maintain system integrity, each individual electrical installation in a hazardous location must comply specifically with Articles 500-505 of NFPA NEC 2002 (incorporated by reference; see 46 *CFR* 110.10-1), as modified by 46 *CFR* 111.105-3, or with the IEC 60079 series (as defined in 46 *CFR* 111.105-1 and incorporated by reference; see 46 *CFR* 110.10-1), but not in combination in a manner that will compromise system integrity or safety. Hazardous location equipment must be approved as suitable for use in the specific hazardous atmosphere in which it is installed. The use of nonapproved equipment is prohibited.

[USCG-2003-16630, 73 FR 65200, Oct. 31, 2008]

#### **§ 111.105-7 Approved equipment.**

When this subpart or NFPA NEC 2002 (incorporated by reference; see 46 *CFR* 110.10-1) states that an item of electrical equipment must be approved, or when IEC 60079-0 (incorporated by reference; see 46 *CFR* 110.10-1) states that an item of electrical equipment must be tested or approved in order to comply with the IEC 60079 series (as defined in Sec. 111.105-1 and incorporated by reference; see 46 *CFR* 110.10-1), that item must be:

(a) Listed or certified by an independent laboratory as approved for use in the hazardous locations in which it is installed; or

(b) Purged and pressurized equipment that meets NFPA 496 (incorporated by reference; see 46 *CFR* 110.10-1) or IEC 60079-2.

[CGD 94-108, 61 FR 28284, June 4, 1996, as amended by USCG-2003-16630, 73 FR 65200, Oct. 31, 2008]

### **§ 111.105-9 Explosionproof and flameproof equipment.**

Each item of electrical equipment required by this subpart to be explosionproof under the classification system of NFPA NEC 2002 (incorporated by reference; see 46 *CFR* 110.10-1) must be approved as meeting UL 1203 (incorporated by reference; see 46 *CFR* 110.10-1). Each item of electrical equipment required by this subpart to be flameproof must be approved as meeting IEC 60079-1 (incorporated by reference; see 46 *CFR* 110.10-1).

[USCG-2003-16630, 73 FR 65200, Oct. 31, 2008]

### **§ 111.105-11 Intrinsically safe systems.**

(a) Each system required by this subpart to be intrinsically safe must use approved components meeting UL 913 or IEC 60079-11 (both incorporated by reference; see 46 *CFR* 110.10-1).

(b) Each electric cable of an intrinsically safe system must--

(1) Be 50 mm (2 in.) or more from cable of non-intrinsically safe circuits, partitioned by a grounded metal barrier from other non-intrinsically safe electric cables, or a shielded or metallic armored cable; and

(2) Not contain conductors for non-intrinsically safe systems.

(c) As part of plan approval, the manufacturer must provide appropriate installation instructions and restrictions on approved system components. Typical instructions and restrictions include information addressing the following:

(1) Voltage limitations;

(2) Allowable cable parameters;

(3) Maximum length of cable permitted;

(4) Ability of system to accept passive devices;

(5) Acceptability of interconnections with conductors or other equipment for other intrinsically safe circuits; and

(6) Information regarding any instructions or restrictions which were a condition of approval of the system or its components.

(d) Each intrinsically safe system must meet ISA-RP12.6 (incorporated by reference, see 46 *CFR* 110.10-1), except Appendix A.1.

[CGD 94-108, 61 FR 28284, June 4, 1996, as amended at 62 FR 23909, May 1, 1997; USCG-2003-16630, 73 FR 65200, Oct. 31, 2008]

### **§ 111.105-15 Additional methods of protection.**

Each item of electrical equipment that is--

(a) A powder-filled apparatus must meet IEC 60079-5 (incorporated by reference; see 46 *CFR* 110.10-1);

(b) An oil-immersed apparatus must meet either IEC 79-6 (incorporated by reference; see 46 *CFR* 110.10-1) or Article 500.7(I) of NFPA NEC 2002 (incorporated by reference; see 46 *CFR* 110.10-1);

- (c) Type of protection ``e" must meet IEC 60079-7 (incorporated by reference; see 46 *CFR* 110.10-1);
- (d) Type of protection ``n" must meet IEC 60079-15 (incorporated by reference; see 46 *CFR* 110.10-1); and
- (e) Type of protection ``m" must meet IEC 79-18 (incorporated by reference; see 46 *CFR* 110.10-1).

[USCG-2003-16630, 73 FR 65200, Oct. 31, 2008]

#### **§ 111.105-17 Wiring methods for hazardous locations.**

(a) Through runs of marine shipboard cable meeting subpart 111.60 of this part are required for all hazardous locations. Armored cable may be used to enhance ground detection capabilities. Additionally, Type MC cable may be used subject to the restrictions in Sec. 111.60-23.

(b) Where conduit is installed, the applicable requirements of either NFPA NEC 2002 (incorporated by reference; see 46 *CFR* 110.10-1) or the IEC 60079 series (as defined in Sec. 111.105-1 and incorporated by reference; see 46 *CFR* 110.10-1) must be followed.

(c) Each cable entrance into explosionproof or flameproof equipment must be made with approved seal fittings, termination fittings, or glands that meet the requirements of Sec. 111.105-9.

(d) Each cable entrance into Class II and Class III (Zone 10, 11, Z, or Y) equipment must be made with dust-tight cable entrance seals approved for the installation.

[CGD 94-108, 61 FR 28284, June 4, 1996, as amended at 62 FR 23909, May 1, 1997; USCG-2003-16630, 73 FR 65200, Oct. 31, 2008]

#### **§ 111.105-19 Switches.**

A switch that is explosionproof or flameproof, or that controls any explosionproof or flameproof equipment, under §111.105-19 must have a pole for each ungrounded conductor.

[CGD 94-108, 61 FR 28284, June 4, 1996]

#### **§ 111.105-21 Ventilation.**

A ventilation duct which ventilates a hazardous location has the classification of that location. Each fan for ventilation of a hazardous location must be nonsparking.

[CGD 94-108, 61 FR 28285, June 4, 1996]

#### **§ 111.105-27 Belt drives.**

Each belt drive in a hazardous location must have:

- (a) A conductive belt; and
- (b) Pulleys, shafts, and driving equipment grounded to meet NFPA 77 (incorporated by reference, see 46 *CFR* 110.10-1).

[CGD 74-125A, 47 FR 15236, Apr. 8, 1982, as amended by USCG-2003-16630, 73 FR 65200, Oct. 31, 2008]

**§ 111.105-29 Combustible liquid cargo carriers.**

(a) Each vessel that carries combustible liquid cargo with a closed-cup flashpoint of 60° C (140° F) or higher must have:

- (1) Only intrinsically safe electric systems in cargo tanks; and
- (2) No storage battery in any cargo handling room.

(b) If a submerged cargo pump motor is in a cargo tank, it must meet the requirements of §111.105–31(d).

(c) Where the cargo is heated to within 15° C of its flashpoint, the cargo pumproom must meet the requirements of §111.105–31(f) and the weather locations must meet §111.105–31(l).

[CGD 74–125A, 47 FR 15236, Apr. 8, 1982, as amended by CGD 94–108, 61 FR 28285, June 4, 1996; 61 FR 36787, July 12, 1996; 61 FR 39695, July 30, 1996]

**§ 111.105-31 Flammable or combustible cargo with a flashpoint below 60 [deg]C (140 [deg]F), carriers of liquid-sulphur or inorganic acid.**

(a) Applicability. Each vessel that carries combustible or flammable cargo with a closed-cup flashpoint lower than 60° C (140° F) or liquid sulphur cargo, or inorganic acid cargo must meet the requirements of this section, except--

- (1) A vessel carrying bulk liquefied flammable gases as a cargo, cargo residue, or vapor which must meet the requirements of Sec. 111.105-32; and
- (2) A vessel carrying carbon disulfide must have only intrinsically safe electric equipment in the locations listed in paragraphs (e) through (l) of this section.

(b) Cable location. Electric cable must be as close as practicable to the centerline and must be away from cargo tank openings.

(c) Lighting circuits. An enclosed hazardous space that has explosionproof lighting fixtures must:

- (1) Have at least two lighting branch circuits;
- (2) Be arranged so that there is light for relamping any deenergized lighting circuit; and
- (3) Not have the switch within the space for those spaces containing explosionproof lighting fixtures under paragraphs (g), (i) and (j) of this section.

(d) Submerged cargo pump motors. If a submerged cargo pump motor is in a cargo tank:

- (1) Low liquid level, motor current, or pump discharge pressure must automatically shutdown power to the motor if the pump loses suction;
- (2) An audible and visual alarm must be actuated by the shutdown of the motor; and
- (3) There must be a lockable circuit breaker or lockable switch that disconnects power to the motor.

(e) Cargo Tanks. A cargo tank is a Class I, Division 1 (IEC Zone 0) location that has additional electrical equipment restrictions outlined in section 33 of IEEE 45-1998 and IEC 60092-502 (both incorporated by reference; see 46 CFR 110.10-1). Cargo tanks must not contain any electrical equipment except the following:

(1) Intrinsically safe equipment; and

(2) Submerged cargo pump motors and their associated cable.

(f) Cargo handling rooms. A cargo handling room must not have any electric cable or other electric equipment, except:

(1) Intrinsically safe equipment;

(2) Explosionproof lighting fixtures;

(3) Cables supplying intrinsically safe equipment in the cargo handling room; and

(4) Marine shipboard cables that supply explosionproof lighting fixtures that are in the cargo handling room.

(g) Lighting of cargo handling rooms. Lighting for a cargo handling room except a cargo handling room under paragraph (h) of this section, must be lighted through fixed glass lenses in the bulkhead or overhead. Each fixed glass lens must be wire-inserted glass that is at least .025 in. (6.35 mm) thick and arranged to maintain the watertight and gastight integrity of the structure. The fixed glass lens may form a part of a listing fixture if the following are met:

(1) There is no access to the interior of the fixture from the cargo handling room.

(2) The fixture is vented to the engineroom or a similar nonhazardous area.

(3) The fixture is wired from outside the cargo handling room.

(4) The temperature on the cargo handling room surface of the glass lens, based on an ambient temperature of 40° C, is not higher than 180° C.

(h) A cargo handling room which precludes the lighting arrangement of paragraph (g) of this section, or where the lighting arrangement of paragraph (g) of the section does not give the required light, must have explosionproof lighting fixtures.

(i) Enclosed spaces. An enclosed space that is immediately above, below, or next to a cargo tank must not contain any electric equipment except equipment allowed for cargo handling rooms in paragraphs (f) and (g), and:

(1) Through runs of marine shipboard cable; and

(2) Watertight enclosures with bolted and gasketed covers containing only:

(i) Depth sounding devices;

(ii) Log devices; and

(iii) Impressed-current cathodic protection system electrodes.

(j) Cargo hose stowage space. A cargo hose stowage space must not have any electrical equipment except explosionproof lighting fixtures and through runs of marine shipboard cable.

(k) Cargo piping in a space. A space that has cargo piping must not have any electrical equipment except explosionproof lighting fixtures and through runs of marine shipboard cable.

(l) Weather locations. The following locations in the weather are Class I, Division 1 (Zone 1) locations (except the open deck area on an inorganic acid carrier which is considered a non-hazardous location) and may have only



approved intrinsically safe, explosionproof, or purged and pressurized electrical equipment, and through runs of marine shipboard cable if the location is--

(1) Within 10 ft (3 m) of:

- (i) A cargo tank vent outlet;
- (ii) A cargo tank ullage opening;
- (iii) A cargo pipe flange;
- (iv) A cargo valve;
- (v) A cargo handling room entrance; or
- (vi) A cargo handling room ventilation opening; or

(2) On a tankship and on the open deck over the cargo area and 10 ft (3 m) forward and aft of the cargo area on the open deck and up to 8 ft (2.4 m) above the deck.

(3) Within 5 m (16 ft) of cargo pressure/vacuum valves with an unlimited height; or

(4) Within 10 m (33 ft) of vent outlets for free flow of vapor mixtures and high velocity vent outlets for the passage of large amounts of vapor, air or inert gas mixtures during cargo loading and ballasting or during discharging.

(m) Other spaces. Except for those spaces listed in paragraphs (e) through (k), a space that has a direct opening to any space listed in paragraphs (e) through (l) must have only the electric installations that are allowed for the space to which it opens.

(n) Duct keel ventilation or lighting.

(1) The lighting and ventilation system for each pipe tunnel must meet ABS Steel Vessel Rules (incorporated by reference; see 46 *CFR* 110.10-1), section 5-1-7/31.17.

(2) If a fixed gas detection system is installed, it must meet the requirements of IMO SOLAS 74 (incorporated by reference; see 46 *CFR* 110.10-1) and Part 4, Chapter 3 of ABS Steel Vessel Rules.

[CGD 74-125A, 47 FR 15236, Apr. 8, 1982, as amended by CGD 82-096, 49 FR 4947, Feb. 9, 1984; CGD 94-108, 61 FR 28285, June 4, 1996; 61 FR 33045, June 26, 1996; 62 FR 23909, May 1, 1997; USCG-2003-16630, 73 FR 65200, Oct. 31, 2008]

#### **§ 111.105-32 Bulk liquefied flammable gas and ammonia carriers.**

(a) Each vessel that carries bulk liquefied flammable gases or ammonia as a cargo, cargo residue, or vapor must meet the requirements of this section.

(b) As used in this section:

- (1) The terms "gas-safe" and "gas-dangerous" spaces are used as defined in Sec. 154.7 of this chapter.
- (2) The term "gas-dangerous" does not include the weather deck of an ammonia carrier.

(c) Each submerged cargo pump motor design must receive concept approval by the Commandant (CG-521) and its installation must receive plan approval by the Commanding Officer, Marine Safety Center.

(d) Electrical equipment must not be installed in a gas-dangerous space or zone, except:

- (1) Intrinsically safe electrical equipment and wiring, and
- (2) Other equipment as allowed in this section.

(e) A submerged cargo pump motor, if installed in a cargo tank, must meet Sec. 111.105-31(d).

(f) Electrical equipment must not be installed in a hold space that has a tank that is not required to have a secondary barrier under Sec. 154.459 of this chapter, except:

- (1) Through runs of marine shipboard cable;
- (2) Explosionproof lighting fixtures;
- (3) Depth sounding devices in gastight enclosures;
- (4) Log devices in gastight enclosures;
- (5) Impressed current cathodic protection system electrodes in gastight enclosures; and
- (6) Armored or MI type cable for a submerged cargo pump motor.

(g) Electrical equipment must not be installed in a space that is separated by a gastight steel boundary from a hold space that has a tank that must have a secondary barrier under the requirements of Sec. 154.459 of this chapter, except:

- (1) Through runs of marine shipboard cable;
- (2) Explosionproof lighting fixtures;
- (3) Depth sounding devices in gastight enclosures;
- (4) Log devices in gastight enclosures;
- (5) Impressed current cathodic protection system electrodes in gastight enclosures;
- (6) Explosionproof motors that operate cargo system valves or ballast system valves;
- (7) Explosionproof bells for general alarm systems; and
- (8) Armored or MI type cable for a submerged cargo pump motor.

(h) A cargo-handling room must not have any installed electrical equipment, except explosionproof lighting fixtures.

(i) A space for cargo hose storage or a space that has cargo piping must not have any installed electrical equipment, except:

- (1) Explosionproof lighting fixtures; and
- (2) Through runs of marine shipboard cable.

(j) A gas dangerous zone on the open deck must not have any installed electrical equipment, except:

- (1) Explosionproof equipment that is necessary for the operation of the vessel; and
- (2) Through runs of marine shipboard cable.

(k) A space, except those named in paragraphs (f) through (i) of this section, that has a direct opening to gas-dangerous spaces or zones must have no electrical equipment except as allowed in the gas-dangerous space or zone.

(l) Each gas-dangerous space that has lighting fixtures must have at least two branch circuits for lighting.

(m) Each switch and each overcurrent protective device for any lighting circuit that is in a gas-dangerous space must open all conductors of the circuit simultaneously.

(n) Each switch and each overcurrent protective device for lighting in a gas-dangerous space must be in a gas-safe space.

[CGD 74-125A, 47 FR 15236, Apr. 8, 1982, as amended by CGD 77-069, 52 FR 31626, Aug. 21, 1987; CGD 94-108, 61 FR 28285, June 4, 1996; 62 FR 23909, May 1, 1997; USCG-2009-0702, 74 FR 49234, Sept. 25, 2009]

#### **§ 111.105-33 Mobile offshore drilling units.**

(a) Applicability. This section applies to each mobile offshore drilling unit.

(b) Definitions. As used in this section:

- (1) "Enclosed spaces" are locations delineated by floors, bulkheads, or decks which may have doors or windows.
- (2) "Semi-enclosed spaces" are locations where natural conditions of ventilation are notably different from those on open deck due to the presence of structures such as roofs, windbreaks, and bulkheads which are so arranged that dispersion of gas may not occur.

(c) The internal space of each pressure vessel, tank, and pipe for drilling mud and for gas venting must have only intrinsically safe electric equipment.

(d) The following are Class I, Division 1 locations:

- (1) An enclosed space that contains any part of the mud circulating system that has an opening into the space and is between the well and final degassing discharge.
- (2) An enclosed or semi-enclosed location that is below the drill floor and contains a possible source of gas release such as the top of a drilling nipple.
- (3) An enclosed space that is on the drill floor and is not separated by a solid, gas-tight floor from the spaces specified in paragraph (d)(2) of this section.
- (4) A space that would normally be considered a Division 2 location under paragraph (e) of this section but where combustible or flammable gases might accumulate. This could include pits, ducts, and similar structures downstream of the final degassing discharge.
- (5) A location in the weather or a semi-enclosed location, except as provided in paragraph (d)(2) of this section, that is within 5 feet (1.5 m) of the boundary of any:

- (i) Equipment or opening specified in paragraph (d)(1) of this section;
  - (ii) Ventilation outlet, access, or other opening to a Class I, Division 1 space; or
  - (iii) Gas vent outlet.
- (6) Except as provided in paragraph (f) of this section, an enclosed space that has an opening into a Class I, Division 1 location.
- (e) The following are Class I, Division 2 locations:
- (1) An enclosed space that has any open portion of the mud circulating system from the final degassing discharge to the mud suction connection at the mud pit.
  - (2) A location in the weather that is:
    - (i) Within the boundaries of the drilling derrick up to a height of 10 feet (3m) above the drill floor;
    - (ii) Below the drill floor and within a radius of 10 feet (3m) of a possible source of release, such as the top of a drilling nipple; or
    - (iii) Within 5 feet (1.5m) of the boundaries of any ventilation outlet, access, or other opening to a Class I, Division 2 space.
  - (3) A location that is:
    - (i) Within 5 feet (1.5m) of a semi-enclosed Class I, Division 1 location indicated in paragraph (d)(2) of this section; or
    - (ii) Within 5 feet (1.5m) of a Class I, Division 1 space indicated in paragraph (d)(5).
  - (4) A semi-enclosed area that is below and contiguous with the drill floor to the boundaries of the derrick or to the extent of any enclosure which is liable to trap gases.
  - (5) A semi-enclosed derrick to the extent of its enclosure above the drill floor, or to a height of 10 ft (3m) above the drill floor, whichever is greater.
  - (6) Except as provided in paragraph (f) of this section, an enclosed space that has an opening into a Class I, Division 2 location.
- (f) An enclosed space that has direct access to a Division 1 or Division 2 location is the same division as that location, except:
- (1) An enclosed space that has direct access to a Division 1 location is not a hazardous location if:
    - (i) The access has self-closing gas-tight doors that form an air lock;
    - (ii) The ventilation causes greater pressure in the space than in the Division 1 location; and
    - (iii) Loss of ventilation overpressure is alarmed at a manned station;
  - (2) An enclosed space that has direct access to a Division 1 location can be considered as a Division 2 location if:
    - (i) The access has a self-closing, gas-tight door that opens into the space and that has no hold-back device;

(ii) Ventilation causes the air to flow with the door open from the space into the Division 1 location; and

(iii) Loss of ventilation is alarmed at a manned control station; and

(3) An enclosed space that has direct access to a Division 2 location is not a hazardous location if:

(i) The access has a self-closing, gas-tight door that opens into the space and that has no hold-back device;

(ii) Ventilation causes the air to flow with the door open from the space into the Division 2 location; and

(iii) Loss of ventilation actuates an alarm at a manned control station.

(g) Electrical equipment and devices installed in spaces made non-hazardous by the methods indicated in paragraph (f) of this section must be limited to essential equipment.

Sec. 111.105-35 Vessels carrying coal.

(a) The following are Class II, Division 1, (Zone 10 or Z) locations on a vessel that carries coal:

(1) The interior of each coal bin and hold.

(2) Each compartment that has a coal transfer point where coal is transferred, dropped, or dumped.

(3) Each open area within 3 m (10 ft) of a coal transfer point where coal is dropped or dumped.

(b) Each space that has a coal conveyer on a vessel that carries coal is a Class II, Division 2, (Zone 11 or Y) space.

(c) A space that has a coal conveyer on a vessel that carries coal must have electrical equipment approved for Class II, Division 2, (Zone 11 or Y) hazardous locations, except watertight general emergency alarm signals.

[CGD 94-108, 61 FR 28285, June 4, 1996]

#### **§ 111.105-37 Flammable anesthetics.**

Each electric installation where a flammable anesthetic is used or stored must meet NFPA 99 (incorporated by reference, see 46 *CFR* 110.10-1).

[USCG-2003-16630, 73 FR 65200, Oct. 31, 2008]

#### **§ 111.105-39 Additional requirements for vessels carrying vehicles with fuel in their tanks.**

Each vessel that carries a vehicle with fuel in its tank must meet the requirements of ABS Steel Vessel Rules (incorporated by reference; see 46 *CFR* 110.10-1), section 5-10-4/3, except as follows:

(a) If the ventilation requirements of ABS Steel Vessel Rules section 5-10-4/3 are not met, all installed electrical equipment must be suitable for a Class I, Division 1; Zone 0; or Zone 1 hazardous location.

(b) If the vessel is fitted with an approved fixed gas detection system set at 25 percent the LEL, each item of the installed electrical equipment must meet the requirements for a Class I, Division 1; Class I, Division 2; Zone 0; Zone 1; or Zone 2 hazardous location.

[CGD 94-108, 61 FR 28285, June 4, 1996, as amended at 62 FR 23909, May 1, 1997; USCG-2003-16630, 73 FR 65200, Oct. 31, 2008]

**§ 111.105-40 Additional requirements for RO/RO vessels.**

(a) Each RO/RO vessel must meet ABS Steel Vessel Rules (incorporated by reference; see 46 *CFR* 110.10-1), section 4-8-4/27.3.2.

(b) Each item of installed electrical equipment must meet the requirements for a Class I, Division 1; Class I, Division 2; Zone 0; Zone 1; or Zone 2 hazardous location when installed 460 mm (18 inches) or more above the deck of closed cargo spaces. Electrical equipment installed within 460 mm (18 inches) of the deck must be suitable for either a Class I, Division 1; Zone 0; or Zone 1 hazardous location.

(c) Where the ventilation requirement of ABS Steel Vessel Rules section 4-8-4/27.3.2 is not met--

(1) All installed electrical equipment must be suitable for a Class I, Division 1; Zone 0; or Zone 1 hazardous location; or

(2) If fitted with an approved fixed gas detection system (set at 25 percent of the LEL), each item of installed electrical equipment must meet the requirements for either a Class I, Division 1; Class I, Division 2; Zone 0; Zone 1; or Zone 2 hazardous location.

[CGD 94-108, 61 FR 28285, June 4, 1996; 61 FR 33045, June 26, 1996, as amended at 62 FR 23909, May 1, 1997; USCG-2003-16630, 73 FR 65200, Oct. 31, 2008]

**§ 111.105-41 Battery rooms.**

Each electrical installation in a battery room must meet 46 *CFR* subpart 111.15 and IEEE 45-1998 (incorporated by reference; see 46 *CFR* 110.10-1).

[USCG-2003-16630, 73 FR 65201, Oct. 31, 2008]

**§ 111.105-43 Paint stowage or mixing spaces.**

A space for the stowage or mixing of paint must not have any electric equipment, except:

(a) Intrinsically safe electric equipment approved for a Class I, Division 1, Group D (Zone 0 or Zone 1) location;

(b) Explosionproof electric equipment approved for a Class I, Division 1, Group D (Zone 0 or Zone 1) location; or

(c) Through runs of marine shipboard cable.

[CGD 74-125A, 47 FR 15236, Apr. 8, 1982, as amended by CGD 94-108, 61 FR 28285, June 4, 1996; 62 FR 23909, May 1, 1997]

**§ 111.105-45 Vessels carrying agricultural products.**

(a) The following areas are Class II, Division 1, (Zone 10 or Z) locations on vessels carrying bulk agricultural products that may produce dust explosion hazards:

(1) The interior of each cargo hold or bin.

(2) Areas where cargo is transferred, dropped, or dumped and locations within 1 meter (3 feet) of the outer edge of these areas in all directions.

(b) The following areas are Class II, Division 2, (Zone 11 or Y) locations on vessels carrying bulk agricultural products that may produce dust explosion hazards:

(1) All areas within 2 meters (6.5 feet) of a Division 1 (Zone 10 or Z) location in all directions except when there is an intervening barrier, such as a bulkhead or deck.

Note to §111.105–45: Information on the dust explosion hazards associated with the carriage of agricultural products is contained in Coast Guard Navigation and Vessel Inspection Circular 9–84 (NVIC 9–84) “Electrical Installations in Agricultural Dust Locations.”

## **Annex F** **(informative)**

### **Electrical Inspection Checklist**

This annex provides a basic electrical checklist that can be utilized by facility operators, inspection authorities and electrical personnel. The use of this checklist is optional, but facility operators may find it useful in preparing for electrical inspections. Some topics shown will not be applicable to all facilities, and this checklist should not be considered all-inclusive.

- Are electrical one-line drawings available? Are they current? Do they properly reflect changes made to the facility? Are all major electrical items included on the drawings? (30 *CFR* 250.122(e) 4)
- Are area classification drawings available? Are they current? Do they cover all parts and levels of the facility? (30 *CFR* 250.122(e) 4)
- Are provisions made for sufficient ventilation of hydrogen to prevent the accumulation of explosive mixtures from rechargeable batteries? (API 505, section 8.2.6)
- Are all conductive (metal) enclosures containing live parts properly grounded? (API 14FZ, section 6.10.3.1)
- Does the facility have a documented lock out/tag out (LOTO) procedure? (API 14FZ, section 12.8)
- Does the facility have a documented hot work permit procedure? (30 *CFR* 250.52)
- Unless their purpose is obvious, are all disconnect switches properly labeled to show their service? (NFPA 70E Section 1-7.)
- Do the electrical equipment buildings and spaces have adequate means of egress? (API 14FZ, section 6.12.3)
- Are adequate workspace clearances provided around electrical equipment? (API 14FZ, section 6.12)
- Are all live parts adequately enclosed or insulated against accidental contact? (API 14FZ, section 6.11)
- Are tools and voltage detection equipment tested and rated for the voltages involved? (NFPA 70E2-3.1.2(e))
- Is all electrical equipment operating at over 600 Volts adequately identified? (API 14FZ, section 12.7)
- Are buildings (e.g. electrical equipment buildings and communications buildings) located within hazardous (classified) locations provided with gas detector systems in accordance with API 505, or otherwise properly handled, to assure that enclosed electrical equipment not suitable for hazardous (classified) locations will not be a source of ignition? (API 505, sections, 6.3, 6.4, 6.5)
- Are all hand held radios, portable gas detectors, or other Personal Electronic Devices (PED) approved for use in hazardous (classified) locations and labeled by a NRTL as suitable for the location? (API 14FZ, section 12.4)
- Are electrical tools provided with adequate warning signs in accordance with 12.3.4? (API 14FZ, section 12.3)
- Are all explosionproof or flameproof enclosures provided with conduit or cable seals and properly installed? (API 14FZ, section 6.8)
- Are all openings in explosionproof or flameproof enclosures provided with plugs?



- Are all enclosures provided with covers and are all bolts in place and securely tightened? (API 14FZ, section 4.3)
- Is the nameplate data on transformers, generators and motors legible? (API 14FZ, section 8.2.3.1.2)
- Are all electrical equipment and raceways clear of combustible materials (for example no rags stored on top)? (29 *CFR* 1910.38(b)3)
- Are hazardous locations lighting fixtures properly protected from physical damage by guards or by location? (API 14FZ, section 9.3)
- Are fixtures, cables, raceways and other electrical equipment adequately supported? (API 14FZ, section 12.1.2)
- Are all splices in cables and extension cords suitable for the application and installation? (API 14FZ, section 6.7.10)
- Are abandoned cables and raceways properly handled? (API 14FZ, section 12.10)
- Are grounding pins on extension cord plugs intact? (API 14FZ, section 12.5)
- Are extension cords used for temporary wiring only (i.e. not used in lieu of permanent wiring)? (API 14FZ, section 12.5)
- Is the area surrounding liquid-filled transformers adequately curbed for spill containment? (API 14FZ, section 8.3.2.1)







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