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

API RECOMMENDED PRACTICE 14F
FOURTH EDITION, JUNE 1999

Strategies for Today's Environmental Partnership

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Strategies for Today's Environmental Partnership

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

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API RECOMMENDED PRACTICE 14F
FOURTH EDITION, JUNE 1999

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FOREWORD

This Recommended Practice contains information for use primarily by engineers with a working knowledge of electrical systems and production operations. Some of the information may be useful to experienced electrical maintenance and operating personnel. The intent of the document is to identify important features of offshore electrical systems and to present generally accepted practices for electrical design and installation that experience in the offshore petroleum industry has shown results in safe, reliable, efficient, and maintainable operations. Nothing in this Recommended Practice is to be construed as a fixed rule without regard to sound engineering judgment, nor is it intended to supersede or override any federal, state, or local regulation where applicable.

The First Edition of RP 14F was published in July 1978 as RP 14F, *Design and Installation of Electrical Systems for Offshore Production Platforms,* under the jurisdiction of the API Production Department. The Second Edition was published on July 1, 1985. The Third Edition was published September 1, 1991. The Fourth Edition was published June 1999, with a new title, *Recommended Practice for Design and Installation of Electrical Systems for Fixed and Floating Offshore Petroleum Facilities for Unclassified and Class I, Division 1 and Division 2 Locations.*

This document includes usage of the verbs *shall* and *should,* whichever is the more applicable to the function. For the purpose of this document:

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

1 General

1.1 SCOPE

1.1.1 This document recommends minimum requirements and guidelines for the design and installation of electrical systems on fixed and floating petroleum facilities located offshore. 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. The inherent electrical shock possibility presented by the marine environment and steel decks.

b. Space limitations that require that equipment be installed in or near classified locations.

c. The 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 classified locations on offshore petroleum facilities but does not include guidelines for classification of areas; for guidance on classification of areas, refer to API RP 500 and RP 505, as applicable.

1.2 APPLICABILITY OF NATIONAL ELECTRICAL CODE

1.2.1 Electrical systems for offshore petroleum facilities should be designed and installed in accordance with the National Electrical Code, 1999 edition, except where specific departures are noted.

2 References

2.1 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 recommended practice except for those specific sections of documents referenced elsewhere in this recommended practice.

API

RP 2L	*Planning, Designing, and Constructing Heliports for Fixed Offshore Platforms*
RP 14C	*Analysis, Design, Installation and Testing of Basic Surface Safety Systems on Offshore Production Platforms*
RP 14G	*Fire Prevention and Control on Open Type Offshore Production Platforms*
RP 14J	*Design and Hazards Analysis for Offshore Production Facilities*
RP 55	*Conducting Oil and Gas Producing and Gas Processing Plant Operations Involving Hydrogen Sulfide*
RP 68	*Oil and Gas Well Servicing and Workover Operations Involving Hydrogen Sulfide*
RP 75	*Development of a Safety and Environmental Management Program for Outer Continental Shelf Operations and Facilities*
RP 500	*Classification of Locations for Electrical Installations at Petroleum Facilities Classified as Class I, Division 1 and Division 2*
RP 505	*Classification of Locations for Electrical Installations at Petroleum Facilities Classified as Class I, Zone 0, Zone 1, and Zone 2*
RP 540	*Electrical Installations in Petroleum Processing Plants*
RP 2003	*Protection Against Ignitions Arising Out of Static, Lightning, and Stray Currents*
Publ 2216	*Ignition Risk of Hydrocarbon Vapors by Hot Surfaces in the Open Air*

ABS[1]

Rules for Building and Classing Steel Vessels

Rules for Building and Classing Mobile Offshore Drilling Units

[1]American Bureau of Shipping, Two World Trade Center, 106th Floor, New York, New York 10048.

ANSI[2]

C37.12	*For AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis—Specification Guide*
C37.20.1	*Standard for Metal-Enclosed Low-Voltage Power Circuit Breaker Switchgear*
C37.20.2	*Standard for Metal-Clad and Station-Type Cubicle Switchgear*
C57.12.70	*Terminal Markings and Connections for Distribution and Power Transformers*
C84.1	*Voltage Ratings for Electric Power Systems and Equipment (60 Hz)*
Y32.9	*Graphic Symbols for Electrical Wiring and Layout Diagrams used in Architecture and Building Construction*

ASME[3]

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

ASTM[4]

B 117	*Standard Practice for Operating Salt Spray (Fog) Apparatus*
D 4066	*Standard Specification for Nylon Injection and Extrusion Materials (PA)*
SI	*Standard for Use of the International System of Units (SI): The Modern Metric System*

CSA[5]

C22.1	*Canadian Electrical Code, Part I*
Std C22.2, No. 30	*Explosionproof Enclosures for Use in Class I, Hazardous Locations*
Std C22.2, No. 157	*Intrinsically Safe and Nonincendive Equipment for Use in Hazardous Locations*
Std C22.2, No. 245	*Marine Shipboard Cable*
Plus 2203	*Hazardous Locations—Guide for the Design, Testing, Construction, and Installation of Equipment in Explosive Atmospheres*

FM[6]

3600	*Electrical Equipment for Use in Hazardous (Classified) Locations, General Requirements*
3610	*Intrinsically Safe Apparatus and Associated Apparatus for Use in Class I, II and III, Division 1, Hazardous (Classified) Locations*
3611	*Electrical Equipment for Use of Class I, Division 2, Class II, Division 2, and Class III, Divisions 1 and 2, Hazardous (Classified) Locations*
3615	*Explosionproof Electrical Equipment General Requirements*
3620	*See NFPA No. 496*
3810	*Electrical and Electronic Test, Measuring, and Process Control Equipment*

IADC[7]

IADC-DCCS-1/1991	*Guidelines for Industrial System DC Cable for Mobile Offshore Drilling Units*

ICEA[8]

P-32-382	*Short Circuit Characteristics of Insulated Cables*
P-45-482	*Short Circuit Characteristics of Metallic Shields and Sheaths of Insulated Cable*

IEC[9]

50 (426)	*International Electrotechnical Vocabulary (IEV)—Chapter 426—Electrical Apparatus for Explosive Atmospheres, 1990*
56	*High-Voltage Alternating-Current Circuit Breakers, 1987, (Including Amendment 1, 1992, Amendment 2, 1995, and Amendment 3, 1996)*
68-2-52	*Basic Environmental Testing Procedures, Part 2: Tests. Test KB: Salt Mist, Cyclic (Sodium Chloride Solution), 1984*
298	*(CENE EN 60298) A.C. Metal-Enclosed Switchgear and Controlgear for Rated Voltages Above 1 kV and Up to and Including 52 kV (IEC 298 : 1990 + Corrigendum 1995 + A1 : 1994) (Supersedes HD 187 S5 : 1992)*
331	*Fire-Resisting Characteristics of Electric Cables, 1970*
363	*Short-Circuit Current Evaluation with Special Regard to Rated Short-Circuit Capacity of Circuit Breakers in Installations in Ships, 1972*
529	*Degrees of Protection Provided by Enclosures (IP Code), 1989*

[2]American National Standards Institute, 11 West 42nd Street, New York, New York.
[3]American Society of Mechanical Engineers, 345 East 47th Street, New York, New York 10017.
[4]American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, Pennsylvania 19428-2959.
[5]Canadian Standards Association, 178 Rexdale Boulevard, Etobicoke (Toronto) Canada, M9W 1R3.
[6]Factory Mutual Research Corporation, 1151 Boston-Providence Turnpike, Norwood, Massachusetts 02062.
[7]International Association of Drilling Contractors, P.O. Box 4287, Houston, Texas 77210.
[8]Insulated Cable Engineers Association, P.O. Box P, South Yamouth, Massachusetts 02664.
[9]International Electrochemical Commission, 1 rue de Varembe, Geneva, Switzerland.

533	*Electromagnetic Compatibility of Electrical and Electronic Installations in Ships, 1977*
947-2	*Low-Voltage Switchgear and Controlgear, Part 2: Circuit Breakers, 1989 (Including Amendment 1, 1992, and Amendment 2, 1993)*

IEEE[10]

C37.04	*Rating Structure for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis*
Std C37.13	*IEEE Standard for Low-Voltage AC Power Circuit Breakers Used in Enclosures*
Std C37.14	*IEEE Standard for Low-Voltage DC Power Circuit Breakers Used in Enclosures*
Std. 100	*Standard Dictionary of Electrical and Electronics Terms*
Std 141	*Electric Power Distribution for Industrial Plants*
Std 142	*Grounding of Industrial and Commercial Power Systems*
Std 242	*Protection and Coordination of Industrial and Commercial Power Systems*
Std 303	*Auxiliary Devices for Motors in Class I, Groups A, B, C, and D, Division 2 Locations*
Std 315	*Graphic Symbols for Electrical and Electronics Diagrams*
Std 320	*Application Guide for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis (ANSI/IEEE C37.010-79)*
Std 331	*Application Guide for Low-Voltage AC Nonintegrally Fused Power Circuit Breakers (Using Separately Mounted Current-Limiting Fuses) (ANSI/ IEEE C37.27)*
Std 383	*Standard for Type Test of Class 1E Electric Cables, Field Splices, and Connections for Nuclear Power Generating Stations*
RP 446	*Emergency and Standby Power Systems for Industrial and Commercial Applications*
Std 450	*Maintenance, Testing, and Replacement of Large Lead Storage Batteries for Generating Stations and Substations*
Std 484	*Installation Design and Installation of Large Lead Storage Batteries for Generating Stations and Substations*
Std 485	*Sizing Large Lead Storage Batteries for Generating Stations and Substations*
Std 515	*Testing, Design, Installation, and Maintenance of Electrical Resistance Heat Tracing for Industrial Applications*
Std 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*
Std 835-1994	*Standard Power Cable Ampacity Tables*
Std 1202	*Standard for Flame Testing of Cables for Use in Cable Tray in Industrial and Commercial Occupancies*

IES[11]

RP-1	*American National Standard Practice for Office Lighting*
RP-7	*American National Standard Practices for Industrial Lighting*
	Lighting Handbook

IMO[12]

	International Convention for the Safety of Life at Sea, SOLAS 1974, as amended

IP[13]

IP 15	*Model Code of Safe Practice in the Petroleum Industry, Part 15: Area Classification Code for Petroleum Installations*

ISA[14]

S 5.1	*Instrumentation Symbols and Identification*
S 5.1.1	*Process Instrumentation Technology*
S 12.0.01 (IEC 79-0 MOD)	*Electrical Apparatus for Use in Class I, Zone 0 and 1 Hazardous (Classified) Locations: General Requirements*
RP 12.1	*Recommended Practice for Electrical Instruments in Hazardous Atmospheres*
S 12.2.01 (IEC 79-11 MOD)	*Electrical Apparatus for Use in Class I, Zones, 0, 1 and 2 Hazardous (Classified) Locations: Type of Protection "i"*
RP 12.6	*Recommended Practice for Installation of Intrinsically Safe Systems for Hazardous (Classified) Locations*
S 12.12	*Electrical Equipment for Use in Class I, Division 2 Hazardous (Classified) Locations*
S 12.12.01 (IEC 79-15 MOD)	*Electrical Apparatus for Use in Class I, Zone 2 Hazardous (Classified) Locations: Type of Protection "n"*
S 12.13	*Part I, Performance Requirements. Combustible Gas Detectors*

[10]Institute of Electrical and Electronics Engineers, 445 Hoes Lane, Piscataway, New Jersey 08855-1331.

[11]Illuminating Engineering Society, 120 Wall Street, 17th Floor, New York, New York 10005-40001.

[12]IMO Publications, 4 Albert Embankment, London, England, SE1 7BP.

[13]Institute of Petroleum, 61 New Cavendish Street, London W1M 8AR, United Kingdom.

[14]Instrument Society of America, 67 Alexander Drive, P.O. Box 12277, Research Triangle Park, North Carolina 27709.

RP 12.13	*Part II, Installation Operation and Maintenance of Combustible Gas Detection Instruments*
S 12.16.01 (IEC 79-7 MOD)	*Electrical Apparatus for Use in Class I, and Zones 1 and 2 Hazardous (Classified) Locations: Type of Protection–Increased Safety "e"*
S 12.22.01 (IEC 79-1 MOD)	*Electrical Apparatus for Use in Class I, Zone 1 Hazardous (Classified) Locations: Type of Protection–Flameproof "d"*
S 12.23.01 (IEC 79-18 MOD)	*Electrical Apparatus for Use in Class I, Zone 1 Hazardous (Classified) Locations: Type of Protection–Encapsulation "m"*
S 12.24.01 (IEC 79-10 MOD)	*Recommended Practice for Classification of Locations for Electrical Installations Classified as Class I, Zone 0, Zone 1, or Zone 2*
S 12.25.01 (IEC 79-5 MOD)	*Electrical Apparatus for Use in Class I, Zone 1 Hazardous (Classified) Locations: Type of Protection–Powder Filling "q"*
S 12.26.01 (IEC 79-6 MOD)	*Electrical Apparatus for Use in Class I, Zone 1 Hazardous (Classified) Locations: Type of Protection–Oil Immersion "o"*
	Electrical Instruments in Hazardous Locations
	Electrical Systems for Oil and Gas Production Facilities, ISBN 1-55617-127-7
S 92.0.01	*Part I, Performance Requirements for Toxic Gas Detection Instruments: Hydrogen Sulfide (formerly ISA S12.15, Part I)*
RP 92.0.02	*Part II, Installation, Operation, and Maintenance of Toxic Gas Detection Instruments: Hydrogen Sulfide (formerly ISA RP 12.15, Part II)*

NACE[15]

RP-01-76	*Corrosion Control of Steel, Fixed Offshore Platforms Associated with Petroleum Production*

NEMA[16]

MG 1	*Motors and Generators*
MG 2	*Safety Standard for Construction and Guide for Selection, Installation, and Use of Electric Motors and Generators*
MG 10	*Energy Guide for Selection and Use of Polyphase Motors*
VE 1	*Cable Tray Systems*
ICS 1	*Standards for Industrial Control Devices, Controllers and Assemblies*
ICS 2.1	*Seismic Testing of Motor Control Centers*
Std Publ No. 2.3	*Instructions for the Handling, Installation, Operation, and Maintenance of Motor Control Centers*
Std Publ No. 2.4	*NEMA and IEC Devices for Motor Service—A Guide for Understanding the Differences*
ICS 6	*Enclosures for Industrial Controls and Systems*
Std Publ No. 250	*Enclosures for Electrical Equipment (1,000 Volts Maximum)*
Std Publ No. WC-3	*Rubber Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy*
Std Publ No. WC-7	*Cross-Linked-Thermosetting Polyethylene Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy*
Std Publ No. WC-8	*Ethylene-Propylene-Rubber-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy*

NFPA[17]

30	*Flammable and Combustible Liquids Code*
37	*Standard for the Installation and Use of Stationary Combustion Engines and Turbines*
54	*Fuel Gas Code*
69	*Explosion Prevention Systems*
70	*National Electrical Code*
70B	*Recommended Practice for Electrical Equipment Maintenance*
70E	*Electrical Safety Requirements for Employee Workplaces*
77	*Recommended Practice on Static Electricity*
78	*Lightning Protection Code*
90A	*Standard for the Installation of Air Conditioning and Ventilating Systems*
91	*Standard for Exhaust Systems for Air Conveying of Vapors, Gases, Mists, and Nonparticulate Solids*
99	*Standard for Health Care Facilities*
101	*Life Safety Code—Code for Safety to Life from Fire in Buildings and Structures*
325	*Guide to Fire Hazard Properties of Flammable Liquids, Gases, and Volatile Solids*
496	*Standard for Purged and Pressurized Enclosures for Electrical Equipment in Hazardous (Classified) Locations*
497	*Recommended Practice for the Classification of Flammable Liquids, Gases, or*

[15]NACE International, (formerly the National Association of Corrosion Engineers), 1440 South Creek Drive, P.O. Box 218240, Houston, Texas 77218-8340.

[16]National Electrical Manufacturers Association, 1300 North 17th Street, Suite 1847, Rosslyn, Virginia 22209.

[17]National Fire Protection Association, 1 Batterymarch Park, Quincy, Massachusetts 02269.

	Vapors and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas
	Electrical Installations in Hazardous Locations
UL[18]	
13	*Power Limited Circuit Cables*
44	*Rubber-Insulated Wire and Cable*
50	*Enclosures for Electrical Equipment*
62	*Flexible Cord and Fixture Wire*
83	*Thermoplastic-Insulated Wires and Cables*
489	*Molded Case Circuit Breakers, Molded Case Switches, and Circuit Breaker Enclosures*
514A	*Metallic Outlet Boxes*
514B	*Fittings for Conduit and Outlet Boxes*
514C	*Nonmetallic Outlet Boxes, Flush-Device Boxes, and Covers*
595	*Marine-Type Electric Lighting Fixtures*
674B	*Safety Standard for Electric Motors and Generators for Use in Division 1 Hazardous (Classified) Locations, Class I, Groups C and D*
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*
783	*Electrical Flashlights and Lanterns for Use in Hazardous (Classified) Locations, Class I, Groups C and D*
844	*Electric Lighting Fixtures for Use in Hazardous (Classified) Locations*
886	*Outlet Boxes and Fittings for Use in Hazardous (Classified) Locations*
891	*Safety—Dead Front Switchboards*
913	*Intrinsically Safe Apparatus and Associated Apparatus for Use in Class I, II, and III Division 1 Hazardous (Classified) Locations*
1042	*Electric Baseboard Heating Equipment*
1072	*Medium-Voltage Power Cables*
1096	*Electric Central Air Heating Equipment*
1104	*Marine Navigation Lights*
1203	*Explosionproof and Dust-Ignition-Proof Electrical Equipment for Use in Hazardous (Classified) Locations*
1277	*Power and Control Tray Cable With Optional Optical-Fiber Members*
1309	*Marine Shipboard Cable*
1558	*Switchgear Assemblies, Metal Enclosed Low Voltage Power Circuit Breaker Type*
1569	*Metal-Clad Cables*
1570	*Fluorescent Lighting Fixtures*
1571	*Incandescent Lighting Fixtures*
1572	*High Intensity Discharge Lighting Fixtures*
1574	*Track Lighting Systems*
1581	*Reference Standard for Electrical Wires, Cables, and Flexible Cords*
1604	*Electrical Equipment for Use in Hazardous Locations, Class I and II, Division 2, and Class III, Divisions 1 and 2 Hazardous (Classified) Locations*
2225	*Metal-Clad Cables and Cable-Sealing Fittings For Use in Hazardous (Classified) Locations*
2250	*Instrumentation Tray Cable*

[18]Underwriters Laboratories, 333 Pfingsten Road, Northbrook, Illinois 60062-2096.

2.2 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:

2.2.1 Code of Federal Regulations (CFR)

DOI[19]

30 *CFR* Part 250, Oil and Gas and Sulphur Operation in the Outer Continental Shelf

DOT[20]

49 *CFR* Parts 190, 191, 192, 193, and 195, Pipeline Safety Regulations.

OSHA[21]

29 *CFR* Part 1910, Subpart H. Process Safety Management of Highly Hazardous Chemicals

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

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

[19]U.S. Department of the Interior, Minerals Management Service. *The Code of Federal Regulations* is available from the U.S. Government Printing Office, Washington, D.C. 20402.
[20]U.S. Department of Transportation. *The Code of Federal Regulations* is available from the U.S. Government Printing Office, Washington, D.C. 20402.
[21]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.

USCG[22]

33 *CFR* Parts 140–147, Subchapter N. Outer Continental Shelf Activities

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

46 *CFR* Parts 107–108, Shipping Subchapter I-A. Mobile Offshore Drilling Units

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

2.2.2 United States Department of the Interior, Bureau of Mines

Bull 627 *Flammability Characteristics of Combustible Gases and Vapors*

Note: No longer available from Bureau of Mines, but included as an Appendix in ISA RP 12.13, Part II.

3 Acronyms and Abbreviated Definitions

3.1 ACRONYMS

ABS	American Bureau of Shipping
AHJ	Authority Having Jurisdiction
ANSI	American National Standards Institute
API	American Petroleum Institute
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
CSA	Canadian Standards Association
EP	Explosionproof
EPR	Ethylene Propylene Rubber
FA	Forced Air
FM	Factory Mutual Research Corporation
FPS	Floating Production System
FPSO	Floating Production Storage Offloading
FPU	Floating Production Unit
GFI	Ground Fault Interrupter
HMWPE	High Molecular Weight Polyethylene
hp	Horsepower
Hz	Hertz (cycles per second)
IADC	International Association of Drilling Contractors
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
IES	Illuminating Engineering Society of North America
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
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
P.A.	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, GENERAL

3.2.1 approved: Acceptable to the authority enforcing the rules. (Electrical devices that are listed or approved by UL, FM or CSA normally are acceptable.)

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

3.2.3 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 Article 504-2 for additional details.)

3.2.4 busway: A grounded metal enclosure containing bare or insulated conductors that usually are copper or aluminum bars, rods or tubes. (See NEC Article 364.)

3.2.5 cable:

3.2.5.1 impervious sheathed cable: 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.

3.2.5.2 ITC cable: 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.

3.2.5.3 jacketed cable: Cable with a nonmetallic protective covering.

3.2.5.4 marine cable: Same as shipboard cable, marine.

[22]United States Coast Guard, U.S. Department of Defense. *The Code of Federal Regulations* is available from the U.S. Government Printing Office, Washington, D.C. 20402.

3.2.5.5 MC cable: Metal-clad cable as defined by NEC Article 334.

3.2.5.6 MC-HL cable: Metal-clad cable for hazardous locations as defined in UL 2225.

3.2.5.7 MI cable: Mineral-insulated metal-sheathed cable as defined by NEC Article 330.

3.2.5.8 MV cable: Medium voltage single or multiphase solid dielectric insulated conductor or cable rated 2001 volts or higher as defined by NEC Article 326.

3.2.5.9 PLTC cable: 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.

3.2.5.10 shipboard cable, marine: Impervious sheathed armored or nonarmored cable constructed in accordance with UL 1309/CSA C22.2 No. 245, 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).

3.2.5.11 TC cable: Power and control tray cable as defined by NEC Article 340.

3.2.6 cable bus: An approved assembly of insulated conductors with fittings and conductor terminations in a totally enclosed protective metal housing.

3.2.7 classification:

3.2.7.1 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 Articles 500 and 505 and API RP 500 and 505.)

3.2.7.2 Class I, Division 1 location: A Class I, Division 1 location is a location: (a) in which ignitable concentrations of flammable gases or vapors exist continuously, intermittently, or periodically under normal operating conditions; or (b) in which ignitable concentration of such gases or vapors may exist frequently because of repair or maintenance operations or because of leakage; or (c) 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 RP 500).

3.2.7.3 Class I, Division 2 location: A Class I, Division 2 location is a location: (a) 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 (b) 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 (c) 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 RP 500.)

3.2.7.4 Gas Groups (Division classification method): For purposes of testing, approval, and area classification, various air mixtures (not oxygen enriched) are grouped as shown below.

3.2.7.4.1 Group C: Atmospheres that do or may contain hydrogen sulfide (H_2S), or other substances specified by NFPA 497.

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

3.2.7.5 Gas Groups (Zone classification method):

a. **Group I:** A term used by ISA S12.24.01 (IEC 79-10 MOD) to describe atmospheres containing firedamp (a mixture of gases, composed mostly of methane, found underground, usually in mines). Since this recommended practice does not apply to installations underground in mines, this term is not used further.

b. **Group II:** The group used to describe gases found aboveground and is subdivided into IIC, IIB, and IIA, as noted below, according to the nature of the gas or vapor, for protection techniques "d", "ia", "ib" "[ia]", and "[ib]", and, where applicable, "n" and "o".

c. **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. (NFPA 497)

d. **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 maximum experimental safe gap (MESG) value greater than 0.50 mm and less than or equal to 0.90 mm, or a minimum igniting current ratio (MIC ratio) greater than 0.45 and less than or equal to 0.80. (NFPA 497)

e. **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 maximum experimental safe gap (MESG) value less than or equal to 0.50 mm or a minimum igniting current ratio (MIC ratio) less than 0.45. (NFPA 497)

3.2.7.6 unclassified location: An unclassified location is a location not classified as Division 1 or Division 2.

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

3.2.8 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.

3.2.9 copper-free or low copper content aluminum: Aluminum alloys containing 0.4% or less copper.

3.2.10 electrical enclosure: 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.

3.2.11 enclosed and gasketed lighting fixtures: 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.

3.2.12 enclosed area (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. (RP 500)

3.2.13 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 ISA RP12.13, Part II for U.S. Bureau of Mines Bulletin 627, *Flammability Characteristics of Combustible Gases and Vapors*.)

3.2.14 explosionproof enclosure: 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. (See 4.3.1.)

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

3.2.16 hermetically sealed device: A device that prevents a hazardous or corrosive gas or vapor from coming in physical contact with an arcing or high temperature component. (See 4.3.2.)

3.2.17 high temperature device: A device whose maximum operating temperature exceeds 80% of the ignition temperature in degrees Celsius (°C) of all the gas or vapor involved. (See 4.2.)

3.2.18 ignitable mixture (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*.

3.2.19 ignition temperature (autoignition): The ignition temperature is the minimum temperature required to ignite an ignitable mixture.

3.2.20 intrinsically safe apparatus: Apparatus in which all the circuits are intrinsically safe.

3.2.21 intrinsically safe circuit: 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.

3.2.22 intrinsically safe system: 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.

3.2.23 machinery space: An enclosed area that contains rotating equipment exceeding 10 hp.

3.2.24 manned platform: A platform on which people are routinely accommodated for more than 12 hours per day.

3.2.25 NEMA enclosure: An electrical enclosure manufactured to NEMA standards. (See Table 10.)

3.2.26 nonincendive equipment: Electrical equipment that in its normal operating condition would not ignite a specific hazardous atmosphere in its most easily ignited concentration. (See 4.3.4.)

3.2.27 oil-immersed equipment: 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.

3.2.28 oil-resistant: Ability to withstand exposure to oil as defined by ANSI C-33.80. (see UL Std 83.)

3.2.29 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.

3.2.30 purged and pressurized enclosure: 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.)

3.2.31 sealing:

3.2.31.1 cable seal: A cable terminator filled with compound and designed to contain an explosion in the enclosure to which it is attached. A conduit seal may also be used as a cable seal.

3.2.31.2 conduit seal: A sealing fitting poured with cement-like potting compound designed to contain an explosion in the enclosure to which it is attached. (See 6.8.)

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

3.2.31.4 factory seal: A factory seal is a seal provided in an explosionproof device during manufacture for the purpose of eliminating external, field-installed "conduit seals" for that device.

3.2.31.5 hermetic seal: See *hermetically sealed device*.

3.2.31.6 oil sealed: See *oil-immersed equipment*.

3.2.32 sun-resistant: Ability to withstand exposure to direct sunlight as defined by UL Std 1581.

3.2.33 unclassified location: See 3.2.7.6.

3.2.34 vaportight lighting fixture: See 3.2.11.

3.2.35 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). Reference 6.3.2 of API RP 500 or 6.6.2 of API RP 505, as applicable.

3.2.36 ventilation, inadequate: Ventilation that is less than adequate. Reference 6.3.3 of API RP 500 or 6.6.3 of API RP 505, as applicable.

3.3 DEFINITIONS SPECIFIC TO FLOATING FACILITIES

3.3.1 cargo: a flammable gas or vapor or flammable or combustible liquid with a 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 B-117 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 dripproof: 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 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.

3.3.9 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.

3.3.10 watertight: 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 Division 1 or Division 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 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. For electrical equipment installed in buildings in unclassified locations, see 12.6.

4.1.3 The "Definitions" section of this recommended practice includes brief definitions of classified locations and various types of equipment used in 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 RP 500 or 505, as applicable.

4.2 HIGH TEMPERATURE DEVICES

4.2.1 High temperature devices are defined as those devices whose maximum operating temperature exceed 80% of the ignition 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 ignition 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 ignition 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_2S 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 ignition temperatures.

4.2.2 High temperature devices shall be installed in explosionproof enclosures unless they have been determined to be suitable for the specific area by a nationally recognized testing laboratory.

4.2.3 Certain equipment is tested by nationally recognized testing laboratories (NRTL) and given one of 14 Temperature Identification Numbers ("T" ratings). This equipment may exceed the temperature determined by the 80% rule, but the T rating shall be below the ignition temperature of the specific gas or vapor involved. As an example, equipment rated T1 has been verified not to exceed 842°F (450°C), and therefore is suitable for most natural gas applications. Reference NEC Table 500-3(b).

4.3 PROTECTION TECHNIQUES RELATED TO EQUIPMENT INSTALLED IN LOCATIONS CLASSIFIED AS DIVISION 1 OR DIVISION 2

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 hazardous gases within. If an explosion occurs within, the enclosure must withstand a very rapid buildup of pressure. The gases escaping will relieve the pressure buildup. These gases must be cooled before they reach the surrounding atmosphere. 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.

c. Precision serrated joints.

4.3.1.3 In addition, the surface temperature of the enclosure shall not be higher than 80% of the ignition temperature in °C of the gas or vapor involved or the assembly must be determined to be suitable for the specific area by a recognized testing laboratory.

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 must 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 must be permanent, mechanically strong, and capable of withstanding the surrounding environment. Hermetically sealed enclosures must be 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 an 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 is apparatus in which the circuits are not necessarily intrinsically safe themselves, but 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 must 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. Standards UL 913, ISA RP12.6, and NEC Article 504 should be followed closely when designing and installing an intrinsically safe system. Also, control drawings must 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 classified locations without de-energizing the equipment or shutting down process equipment.

4.3.4 Nonincendive Equipment

4.3.4.1 Nonincendive equipment must 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 must 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 classified location without using explosionproof enclosures. NFPA No. 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 No. 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 RESERVED FOR FUTURE USE

4.5 GENERAL PURPOSE EQUIPMENT

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

4.5.2 For special cases the NEC permits the installation of fuses, circuit breakers, or disconnect switches in general purpose enclosures in Division 2. It is recommended, however, that circuit breakers and disconnect switches in general purpose enclosures not be used offshore in classified locations.

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.

5.2 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):

$$HP_{MIN} = \frac{100 \times Design\ kw\ Load}{0.746 \times Generator\ Efficiency} \quad (1)$$

The efficiency of 25 kW and larger generators typically ranges from 88% to 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. 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.

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.

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, 900, 1,200 or 1,800 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 1,200 rpm or less. Reciprocating-type engines for standby (noncontinuous) applications often are operated at speeds up to 1,800 rpm. Gas turbines normally operate at higher speeds and drive generators through gearbox assemblies.

5.2.5 Reciprocating Engine Controls

5.2.5.1 It is recommended that automatic controls be provided to shut down all reciprocating engines that are driving generators when any of the following conditions occur:

a. Low lube oil pressure.
b. High jacket water temperature.
c. Overspeed.

Overspeed shutdowns should operate independently of governor controllers and should be set at no more than 115% of rated speed.

5.2.5.2 Overvoltage, for generators 500 kW and larger: it is recommended that either overvoltage shutdown controls be provided or that breakers be tripped and voltage regulators be de-energized.

5.2.5.3 Optional shutdown controls include:

a. Low lube oil level.
b. Low jacket water level.
c. Underspeed.
d. Vibration.

Note: Vibration shutdown controls normally are not used for generators under 250 kW.

e. High lube oil temperature.
f. Undervoltage, for generators 500 kW and larger.

Note: Undervoltage shutdown controls normally are not used for generators under 500 kW.

g. Underfrequency, for generators 500 kW and larger.

Note: Underfrequency shutdown controls normally are not used for generators under 500 kW.

h. Loss of excitation, for generators 950 kW or larger or units that are to be paralleled.

Note: Loss of excitation shutdown controls normally are not used for generators under 950 kW or units that are not to be paralleled.

i. Generator differential, for generators 950 kW or larger.

Note: Generator differential shutdown controls normally are not used for generators under 950 kW.

j. Overfrequency, for generators 500 kW or larger.

Note: Overfrequency shutdown controls normally are used for generators over 500 kW.

5.2.6 Gas Turbine Controls

5.2.6.1 It is recommended that automatic controls be provided to shut down gas turbines that are driving generators when any of the following conditions occur:

a. Fail-to-start.
b. High running exhaust temperature.
c. High lube oil temperature.
d. Low lube oil pressure.
e. Underspeed.
f. Overspeed.
g. Vibration.
h. Overvoltage for generators 500 kW and larger, it is recommended that either overvoltage shutdown controls be provided or that breakers be tripped and voltage regulators be de-energized.

5.2.6.2 Optional shut-down controls include:

a. Overfrequency.

Note: Overfrequency shutdown controls should be considered for generators larger than 500 kW.

b. Loss of excitation.

Note: Loss of excitation shutdown controls should be considered for paralleled generators larger than 950 kW.

c. Generator differential.

Note: Generator differential shutdown controls should be considered for generators larger than 950 kW.

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-type 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 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, paralleled units are operated in the isochronous mode (that is, all generators sharing the load equally) if all units are of the same size. Units of different sizes in continuous parallel operation require detailed engineering analysis.

5.2.8 Accessories

5.2.8.1 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 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 significant voltage drop during cranking.

5.2.8.2 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 RP 14C.

5.2.9 Ignition Systems

For prime movers installed in classified locations, ignition systems should be designed and installed to minimize the possibility of the systems being a source of ignition in a hazardous (classified) location.

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. Breaker point distributor-type ignition systems should not be used in areas classified as Class I, Division 1 or 2, by API RP 500. 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 specifically recommended.

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.

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 and 40°C ambient conditions. Generators operated in ambient temperatures in excess of 40°C, such as in unit enclosures, should be properly derated. The generator size should be at least equal to the highest expected system operating load. 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 variable frequency drives) may be utilized to reduce the required capacity of generators when motor starting is of concern.

5.3.2.2 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 in the United States normally are 60-Hertz design.

5.3.2.4 Voltage

Generator design voltage normally matches the majority of the load requirements. The following are recommended system design voltages: 120/240 volt single-phase, and 208Y/120, 480, 480Y/277, 600, 2400, 4160 and 13,800 volt three-phase.

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, 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 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 must be considered if dissimilar machines are to be paralleled. Equipment manufacturers should be consulted for equipment compatibility.

5.3.3 Voltage Regulators

Solid state voltage regulators are recommended for high reliability, long life, fast response and stable regulation. Regulator systems should be protected from under-frequency conditions. It is recommended that voltage regulators for machines rated in excess of 150 kW be provided with under-frequency and overvoltage sensors for protection of the voltage regulators. If necessary for operation of protective devices under short circuit conditions, the regulator should be equipped with series boost support equipment, or should be provided with a separate source of power such as a permanent magnet generator. Similar measures may be desirable for coordinating protective devices or starting large motors. It is recommended that regulators on generators to be operated in parallel be provided with crosscurrent compensation to provide stable operation. Relays of the hermetically sealed type are recommended in classified and exposed areas. Where power electronic devices (such as VFDs, soft starters, and switching power supplies) create measurable waveform distortions, voltage regulator sensing inputs should be protected by means of passive filters or isolation transformers. Power supplies and voltage sensing leads for voltage regulators should be taken from the generator side of the generator circuit breaker. Normally, voltage-sensing leads should not be protected by an overcurrent protection device. If short circuit protection is provided for the sensing leads, this 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 Overload and Short Circuit

5.3.4.1.1 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. 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 molded case breaker) will allow full utilization of the generator nameplate capacity. The use of series boost equipment or a permanent magnet generator (PMG) should be considered if a molded case circuit breaker is used to provide adequate short circuit current for proper operation of the breaker during fault conditions.

5.3.4.1.2 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.

5.3.4.1.3 It is recommended that instantaneous breaker trips not be used on single generators or two generators operated in parallel or generators that have differential protection. It is recommended that instantaneous breaker trips be used on generators that normally operate in parallel with two or more other generators that are not equipped with differential protection.

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

5.3.4.2 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.

5.3.4.3 Undervoltage and Overvoltage Sensing Devices

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

5.3.4.4 Underfrequency and Overfrequency Sensing Devices

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

5.3.4.5 Synchronizing Controls

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

5.3.4.5.1 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.

5.3.4.5.2 A synchronizing 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.

5.3.4.5.3 Interlocking controls to assure that all other generator circuit breakers for nonoperating generators and incoming feeders are open when an oncoming generator breaker is closed on a dead bus.

5.3.4.6 Ground-Fault Detection

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

5.3.4.6.2 When the electrical system is high resistance grounded, a ground-fault alarm is recommended.

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

5.3.4.6.4 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: Reference IEEE Std 142 for additional information on generator grounding.

5.3.4.7 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 voltage and capacitor trip units is recommended for the circuit breaker trip coils on power breakers to ensure trip voltage availability.

5.3.4.8 Special Considerations

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.

5.3.4.8.1 Induction disc or solid state relays are recommended to operate generator circuit breakers. These relays provide greater flexibility in setting and are more easily tested than circuit breakers with direct acting, mechanical, integral trips.

5.3.4.8.2 Voltage restraint or voltage control overcurrent relays.

5.3.4.8.3 Instantaneous differential current relays to detect internal generator faults.

5.3.4.8.4 Reverse VARs or loss of excitation (loss of field) relays on paralleled units.

5.3.4.8.5 Ground-fault time-overcurrent relay.

5.3.4.8.6 Negative phase sequence overcurrent relay for protection against unbalanced conditions, for units over 600 volts.

5.3.4.8.7 Stator winding temperature relay for units over 600 volts.

5.3.4.8.8 Voltage balance relay on machines greater than 3,000 kW and over 600 volts, where a separately derived power source is feeding the voltage regulator.

Note: Several of these functions may be combined in a multifunction relay.

Reference IEEE Std 242 for additional information on generator protection.

5.3.4.9 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 shut-down 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 watt meter are optional.

5.3.5.2 Parallel Operation

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

5.4 GENERATOR PACKAGING CONSIDERATIONS

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

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 General

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

5.5.1.2 The sides, rear, and—where necessary—front of switchboards shall be suitably guarded and metal enclosed. Dead-front-type construction without exposed live parts on the front is recommended. Drip covers or drip shields should be provided over switchboards subject to damage by leaks or falling objects.

5.5.1.3 Electric grade nonconducting deck coverings meeting MIL-M-15562 (e.g., nonconducting mats) or nonconducting gratings should be provided in each working area in front of and behind switchboards.

5.5.2 Bus Bars

5.5.2.1 Generator 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.

5.5.2.2 Bus bars should be sized for a maximum temperature rise of 65°C over a 40°C ambient.

5.5.2.3 Copper bar is recommended for all buses.

5.5.2.4 All circuits that supply switchboard devices 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.

5.5.2.5 It is recommended that instrument and control wiring be Type TA, TBS, or SIS stranded copper, Class C or better, minimum wire size No. 14 AWG (2.1 mm^2). All wiring should meet the flame-retardant requirements of UL 83 and, if used on a hinged panel, should be extra flexible.

5.5.2.6 Each device should have a nameplate showing the device's function. Each power circuit breaker should have a nameplate showing the electrical load served and the continuous rating of the circuit breaker.

5.5.2.7 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.

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

5.5.3 Arrangement of Equipment

5.5.3.1 Low voltage (600 volt and less) air circuit breakers should be metal enclosed and meet ANSI C37.20.1 with proper insulation barriers. NRTL-approved equipment should comply with UL 1558. 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. All low voltage motor control centers should meet the requirements of UL 345.

5.5.3.2 Medium voltage (601 volts to 34.5kV) vacuum circuit breakers should be metal clad and comply with ANSI C37.20.2. All medium voltage motor starters should meet the requirements of UL 347.

5.5.3.3 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.

5.6 SPECIAL REQUIREMENTS FOR FLOATING FACILITIES

5.6.1 Prime Movers

Prime movers shall meet 46 *CFR* Subpart 58.10. Additionally, turbines should meet applicable ABS Steel Vessel Rules, Part 4, Section 4/5 reproduced as Annex B for the convenience of the reader. Prime movers may be self-certified by their manufacturers.

5.6.2 Generators

Generators should meet the construction and test requirements of ABS Steel Vessel Rules, Part 4, Section 4/5C2, reproduced as Annex B for the convenience of the reader. Generators may be self-certified by their manufacturers.

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 provided an independent battery source of power, the following loads shall 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 watertight 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 watertight 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 feed back, 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 shall be supplied to the emergency loads by an automatic transfer device located remotely from the main switchboard.

5.6.4.3 Upon interruption of normal power, the prime mover driving the emergency power source shall start automatically.

5.6.4.4 When the voltage of the emergency source reaches 85% to 95% of nominal value, the emergency loads shall 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.

5.6.4.5 All nonemergency 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.

5.6.4.6 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 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 45°C.

5.6.5.3 Any liquid fuels used shall have a flash point of 43°C 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. Except for a thermostatically controlled electric water-jacket heater connected to the emergency bus, generator prime movers shall 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° 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 engine prime movers should be provided with an audible alarm that sounds on low oil pressure and high cooling water temperature.

5.6.5.9 Gas turbine prime movers 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. 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 shall 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 shall be a hand-cranked, diesel-powered air compressor for recharging the air receiver.

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

5.6.6 Switchboards

5.6.6.1 Switchboards subject to dripping liquids from above should have a drip shield. It is recommended that switchboards on floating facilities be provided a door at each entrance to a working space and front nonconducting handrails (and rear nonconducting guardrails if the switchboard has a rear working space). It is recommended that piping not be installed above switchboards, but if piping is necessary, that welded or brazed joints only 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. Buses should be designed for a maximum 50°C rise in a 50°C ambient.

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 classified and unclassified locations. Recommendations are presented for circuit protection, grounding, and enclosure selection; 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 volts, 4160 volts, 13,800 volts, and 34,500 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(a). The tables in 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(b), which is based on IEEE/ICEA Std S-135/P-46-426, Power Cables Ampacities.

c. For NRTL-listed marine shipboard cables, ampacities for low voltage cables shown in Tables 1 and 2 should be used.

6.3.2.3 For medium voltage cables, ampacities at various conductor temperatures are given in Tables 3, 4, and 5.

6.3.2.4 Termination considerations are also a limiting factor in the ampacity selection of conductors. See 6.3.5.

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 310-6 requires shielding on insulated conductors operated above 2000 volts to ground. Reference NEC 310-6 for exceptions for single conductor cables for use up to 8000 volts and three conductor cables up to 5000 volts where specified conditions are met.

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 nonmagnetic conductor over a semiconducting layer applied over the insulation. The metallic components of the shield are designed to carry cable-charging current. Shields can be designed to carry ground-fault 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 shall be solidly grounded at least at 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.

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.

Table 1—Ampacities for Marine Shipboard Distribution, Control and Signal Cables, 2000 Volts or Less, AC or DC, Copper Conductors, Single-Banked (Single-Layered), Maximum Current-Carrying Capacity Based on 45°C Ambient

			Single-Conductor Cable				Two-Conductor Cable				Three-Conductor Cable			
			Maximum Conductor Insulation Temperature Ratings											
AWG or kcmil	mm^2	Circular Mils	75°C	90°C	100°C	110°C	75°C	90°C	100°C	110°C	75°C	90°C	100°C	110°C
20	0.52	1,020	9	11	12	13	8	9	10	10	6	8	9	9
18	0.82	1,620	13	15	16	17	11	13	14	15	9	11	12	13
16	1.31	2,580	18	21	23	24	15	18	19	21	13	15	16	17
14	2.08	4,110	28	34	37	39	24	29	31	33	20	24	25	27
12	3.31	6,530	35	43	45	49	31	36	40	41	24	29	31	33
10	5.26	10,380	45	54	58	61	38	46	49	52	32	38	41	43
8	8.37	16,510	56	68	72	77	49	60	64	68	41	48	52	55
7	10.55	20,820	65	77	84	88	59	72	78	82	48	59	63	67
6	13.30	26,240	73	88	96	100	66	79	85	90	54	65	70	74
5	16.77	33,090	84	100	109	114	78	92	101	105	64	75	82	85
4	21.15	41,740	97	118	128	134	84	101	110	115	70	83	92	95
3	26.66	52,620	112	134	146	153	102	121	132	138	83	99	108	113
2	33.62	66,360	129	156	169	178	115	137	149	156	93	111	122	126
1	44.21	83,690	150	180	194	205	134	161	174	183	110	131	143	149
1/0	53.50	105,600	174	207	227	236	153	183	199	208	126	150	164	171
2/0	67.44	137,100	202	240	262	274	187	233	242	265	145	173	188	197
3/0	85.02	167,800	231	278	300	317	205	245	265	279	168	201	218	229
4/0	107.20	211,600	271	324	351	369	237	284	307	323	194	232	252	264
250	126.70	250,000	300	359	389	409	264	316	344	360	217	259	282	295
263	133.10	262,600	314	378	407	431	278	333	358	380	228	273	294	311
313	158.60	313,100	351	423	455	482	303	363	391	414	249	298	321	340
350	177.30	350,000	372	446	485	508	324	387	421	441	265	317	344	361
373	189.30	373,700	393	474	516	540	339	406	442	463	277	332	361	378
444	225.20	444,400	453	546	588	622	391	468	504	534	319	382	411	435
500	253.30	500,000	469	560	609	638	401	479	520	546	329	393	428	448
535	271.20	535,300	485	579	630	660	415	496	538	565	340	407	443	464
646	327.50	646,400	557	671	731	765	485	581	632	662	396	474	516	540
750	380.00	750,000	605	723	786	824	503	602	656	686	413	494	537	563
777	394.00	777,700	627	755	822	861	525	629	684	717	431	516	562	588
1,000	506.70	1,000,000	723	867	939	988	—	—	—	—	—	—	—	—
1,111	563.10	1,111,000	767	942	1,025	1,074	—	—	—	—	—	—	—	—
1,250	633.30	1,250,000	824	990	1,072	1,128	—	—	—	—	—	—	—	—
1,500	760.00	1,500,000	917	1,100	1,195	1,254	—	—	—	—	—	—	—	—
2,000	1,013.30	2,000,000	1,076	1,292	1,400	1,473	—	—	—	—	—	—	—	—

Table 2—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 Ambient

		Single-Conductor Cable			
kcmil	mm^2	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	1013.3	1195	1435	1557	1636

Notes to Tables 1 and 2
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

Notes:

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, 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. The current capacities shown in the tables are calculated based on the free air ratings, derated by 15% to account for unspaced single banking. 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. See IEEE Std S-135-1, Volume 1.

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 1. If more than one circuit of 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.

Table 3—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 Ambient

			Three-Conductor Cable						
			Up to 5kV Nonshielded	Up to 8kV Shielded		8,001–15,000V Shielded		15,001–35,000V Shielded	
AWG or kcmil	mm^2	Circular Mils	90°C	90°C	105°C	90°C	105°C	90°C	105°C
8	8.37	16,510	48	—	—	—	—	—	—
6	13.30	26,240	64	75	85	—	—	—	—
4	21.15	41,740	84	99	112	—	—	—	—
2	33.62	66,360	112	129	146	133	150	—	—
1	42.40	83,690	130	149	168	151	170	149	172
1/0	53.50	105,600	151	171	193	174	196	174	196
2/0	67.44	133,100	174	197	222	199	225	198	225
3/0	85.02	167,800	202	226	255	229	259	230	257
4/0	107.20	211,600	232	260	294	263	297	262	294
250	126.70	250,000	258	287	324	291	329	291	327
263	133.10	262,600	266	296	334	299	338	299	336
313	158.60	313,100	296	328	370	331	374	329	373
350	177.30	350,000	319	352	397	355	401	351	400
373	189.30	373,700	330	365	412	367	414	363	414
444	225.20	444,400	365	387	437	388	438	402	470
500	253.30	500,000	393	434	490	434	490	432	490
535	271.20	535,300	407	449	507	449	507	447	507
646	327.50	646,400	453	496	560	497	561	496	559
750	380.00	750,000	496	541	611	542	612	541	609
777	394.00	777,700	504	550	621	550	621	550	619
1,000	506.70	1,000,000	571	622	702	623	703	622	703

Table 4—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 Ambient

			Single-Conductor Cable (in triplexed or triangular configuration)					
			Up to 8kV Shielded		8,001–15,000V Shielded		15,001–35,000V Shielded	
AWG or kcmil	mm^2	Circular Mils	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

Table 5—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 Ambient, Shields Grounded on One End (Open-Circuited Shields)

			Single-Conductor Cable					
			Up to 8kV Shielded		8,001–15,000V Shielded		15,001–35,000V Shielded	
AWG or kcmil	mm^2	Circular Mils	90°C	105°C	90°C	105°C	90°C	105°C
6	13.30	26,240	91	103	—	—	—	—
4	21.15	41,740	120	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

Notes to Tables 3, 4, and 5

Notes:

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, cable ampacities should be multiplied by the following factors:

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

4. Double banking of medium voltage cables is not recommended.

5. The current capacities shown in the tables are calculated based on the free air ratings, derated by 15% to account for unspaced single banking. 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. See IEEE Std S-135-1, Volume 1.

6. Minimum conductor size for 35 kV cable is 1/0.

7. Specific notes for Table 4:

a. Each triplexed or triangular configuration of single-conductor cable must consist of phases A, B and C.

b. If more than one circuit of parallel runs of the same circuit are installed, there should be a maintained spacing of 2.15 times one conductor diameter between each triplexed or triangular configuration group.

Notes to Tables 3, 4 and 5 (Continued)

8. Specific notes for Table 5:
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.
c. More than three conductors without maintained spacing require additional 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.

6.3.4 Voltage Drop

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.

6.3.5 Termination

Conductors should be sized to limit conductor operating temperatures to those designated for the termination devices involved. For 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, and devices rated in excess of 100A typically are limited to 75°C. In selecting circuit conductors, the designer shall 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 International Association of Drilling Contractors "Interim Guidelines for Industrial System DC Cable for Mobile Offshore Drilling Units (IADC-DCCS-1)." This is a departure from the NEC.

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

6.3.6.1.3 The duty factors to be used follow:

a. Mud pumps and cement pumps—0.80.
b. Drawworks, rotary tables, and power swivels—0.65.

6.3.6.1.4 The cables need only be sized for a maximum ambient temperature of 45°C.

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

6.4 WIRING METHODS FOR CLASSIFIED LOCATIONS

6.4.1 General

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 as Class I, Division 1 and Division 2 and associated departures from the NEC are summarized in Table 6 for electrical systems typically installed on offshore facilities. This section should be used in conjunction with API RP 500 that provides guidance for classification of areas. In addition, the following special conditions should be considered when selecting wiring methods for Division 1 locations.

6.4.1.1 Most Division 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.

6.4.1.2 Areas that are continuously exposed to a hazardous concentration of gases or vapors (such as the vapor space within atmospheric tanks and vessels containing hydrocarbons) should not contain electrical equipment or wiring of any kind unless the system is specifically approved as being intrinsically safe (see 4.3.3 and 4.4.3).

6.4.1.3 Oil treaters with electric grids, electric motor-driven skim pile or oil sump submersible pumps, 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 submersible pumps, see API RP 11S3.

6.4.2 Power, Lighting, Instrumentation, and Control Systems

6.4.2.1 The wiring methods recommended for Division 1 locations are:

a. Type MC-HL cable. Reference 3.2.5.6.
b. Threaded rigid copper-free aluminum conduit.
c. Threaded rigid steel, hot dipped galvanized conduit, coated with 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. Reference 3.2.5.10.
e. Type ITC cable that is NRTL-listed for use in Class I, Division 1 locations, with a gas/vaportight continuous corrugated aluminum sheath and with an overall PVC (or other suitable polymeric material) jacket.

6.4.2.2 Additional wiring methods acceptable for Division 1 follow:

6.4.2.2.1 *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 explosionproof enclosures (if approved 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 (referred to as type SSMI Cable), one of the conductors shall be used as an equipment-grounding conductor in accordance with NEC Article 250.

6.4.2.2.2 *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 6.4.2.1c 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 (for example, a compressor building) or where humidity control is provided.

6.4.2.2.3 *Intermediate Metal Conduit*. IMC is not recommended for outdoor use offshore in a Division 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.

6.4.2.3 Wiring methods recommended for Division 2 locations are:

6.4.2.3.1 The wiring methods recommended for use in Division 1 locations as listed in 6.4.2.1.

6.4.2.3.2 Type MC 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.

6.4.2.3.3 Nonarmored marine shipboard cable, with an overall impervious sheath. Reference 3.2.5.10.

6.4.2.4 Additional wiring methods acceptable for Division 2 locations are:

a. The wiring methods acceptable for use in Division 1 locations as listed in 6.4.2.2.
b. Type MC cable (Type MC-HL preferred).
c. Type PLTC cable.
d. Type ITC cable.
e. Type TC cable.
f. Type MV cable.
g. Enclosed and gasketed busways and busducts if designed and installed in accordance with 6.7.3.
h. Enclosed and gasketed wireways.

Note 1: It is recommended that an overall PVC (or other suitable polymeric material) jacket be included for Type MC, PLTC, MV and ITC 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 preferred 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 Division 1 and Division 2 locations.

6.4.3.2 In Division 2 locations, other 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 Division 1 or Division 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, IEEE Std 383 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.

6.4.4 Sheath Grounding

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 Division 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 Division 1 or Division 2 locations in accordance with NEC Article 501-11, but are recommended only for temporary service in Division 1 locations.

6.4.6 Heat Trace Cables

For Heat Trace Systems, refer to 11.6.

6.4.7 Special Considerations for Cables in 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.

6.4.7.2 In Division 1 locations, all electrical equipment (except intrinsically safe systems and equipment inside purged enclosures in accordance with 4.3.5) including fittings, junction boxes, pull boxes, unions, enclosures and flexible conduit should be explosionproof. Conduit or cable seals, as appropriate, should be installed on all cable terminations.

6.4.7.3 In Division 2 locations, conduit fittings, unions, nonarcing devices and junction boxes (with or without splices or terminations) need not be explosionproof, except when necessary to maintain the integrity of an explosionproof installation as described in 6.8. Equipment containing high temperature devices should be 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 explosionproof if one of the following conditions is satisfied:

6.4.7.3.1 The contacts of instrumentation and control devices are immersed in oil;

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

6.4.7.3.3 The contacts are hermetically sealed;

6.4.7.3.4 The devices are in nonincendive circuits;

6.4.7.3.5 The devices are part of an intrinsically safe system; or

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

6.4.7.3.7 Fuses are of the nonindicating, silver-sand, current limiting type and used for the protection of motors, appliances and lamps.

6.4.7.3.8 Fuses are of the nonindicating, silver-sand, current limiting type and used in instrumentation and control circuits not subject to overloading under normal operating conditions.

6.4.7.4 Where flexibility is required, the following systems are recommended:

6.4.7.4.1 In Division 1 locations, explosionproof, flexible metal conduit, 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 501-11.

6.4.7.4.2 For fixed equipment in Division 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. Where practical, the length of flexible connections should not exceed three feet. For portable equipment, flexible cord approved for extra-hard usage and containing an equipment grounding conductor; reference NEC 501-11.

6.4.7.5 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, IEEE Std 383 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.

6.5 WIRING METHODS FOR UNCLASSIFIED LOCATIONS

6.5.1 It is recommended that, in general, the wiring methods employed for unclassified outdoor locations be similar to those recommended for Division 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.

6.6 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 is acceptable in Division 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, 6.4.7.4.1, and 6.7.1. Fixed wiring, including that on movable and portable modules, should meet applicable portions of this recommended practice.

Table 6—Wiring Methods for Classified Locations
(See 6.4, 6.6, 6.7, and 6.8 for Explanations and Qualifications)

	Div. 1	Div. 2
Power & Lighting Systems		
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[a]	X[a]
Nonarmored		X[a]
ITC Cable NRTL-listed for Class I, Division 1 locations with a gas/vapor-tight continuous corrugated aluminum sheath and an overall PVC (or other suitable polymeric material) jacket	X	X
ITC		X
TC or PLTC 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[a]
Electrical Equipment		
Conduit Fittings, Unions, Junction Boxes, etc.	EP	Non EP
Nonarcing Devices	EP	Non EP
High Temperature Devices	EP	EP
Arcing Devices	EP	EP
Arcing Contacts of Instrumentation & Control Devices Immersed in Oil	EP	Non EP
Arcing Contacts of Power Devices Immersed in Oil and Specifically Approved for the Purpose	EP	Non EP
Hermetically Sealed Arcing Contacts	EP	Non EP
Nonincendive Circuits	EP	Non EP
Intrinsically Safe Systems	Non EP	Non EP

[a]Departure from the National Electrical Code (NEC).
Legend: EP: Explosionproof; Non EP: Nonexplosionproof; X: Acceptable

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

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. It is recommended that all cables have stranded conductors in preference to solid conductors to provide superior flexibility and resistance to fatigue, and copper in lieu of aluminum conductors to provide more reliable terminations. 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.

6.7.2 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- (or other suitable material) coated 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 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 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.

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 UL 1309 (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, 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 polyvinyl chloride (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 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; or

c. Rigid metal conduit with Type MV insulated conductors or Type MV cable.

6.7.8 Critical Circuit Cable

Reserved for future use.

6.7.9 Splices

6.7.9.1 Inline splices in electrical cables 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 either should 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.

6.7.9.2 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.

6.7.9.3 For additional information concerning splicing, refer to NEC Articles 110-14 and 400-9.

6.7.10 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 Tables 7 and 8. 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.

Table 7—Common Power and Control Cables Sizes and Configurations

Size	600V Marine Shipboard	600V Type TC, MC, MC-HL	5kV Non-Shielded Type MV, MC, MC-HL	5-35kV 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 (15kv)
1/0	3	3+G		3+G (35kV)
2/0	3	3+G,4+G	3+G	
4/0	3	3+G,4+G	3+G	3+G
250		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 8—Common Instrumentation Cable Sizes and Configurations

Size	600V Marine Shipboard		300V/600V Types PLTC, ITC, TC, MC	
	No. Pairs	No. Triads	No. Pairs	No. Triads
18	1,2,3,4,5,8,12,18	1	1,2,4,8,12,24	1,4,8,12
16	1,2,3,4,810,12,24	1	1,2,4,8,12,24	1,4,8,12
14	1,2			

6.7.11 Ambient Temperature Considerations

Unless demonstrated otherwise by engineering calculation or empirical data, the following design ambient temperatures for conductor sizing should be utilized.

6.7.11.1 An ambient temperature of 40°C unless otherwise stated below:

a. A 45°C ambient temperature in boiler rooms, engine rooms and machinery spaces.
b. A 30°C ambient temperature in air conditioned spaces.

6.8 CONDUIT AND CABLE SEALS AND SEALING METHODS

6.8.1 General

In this section all references to seal(s) and sealing refer to an approved conduit or cable seal that is filled with a suitable compound, is designed to contain an explosion in the enclosure to which it is attached, and is approved for use in Class I 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 501.) Refer to Figures 1 through 7 for typical installations.

6.8.1.1 Seals are installed in conduit and cable systems for the following reasons:

a. To confine an explosion occurring in an enclosure or a conduit system to only that enclosure or that portion of the conduit system.
b. To minimize the passage of gases, vapors, or liquids through the conduit or cable system from a classified location to an unclassified location, or from one enclosure to another.
c. To minimize the entrance of process gases, vapors, or liquids from process piping to the conduit or cable system.
d. To prevent pressure piling—the build-up of pressure inside conduit systems (ahead of an explosion's flame-front) caused by precompression as the explosion travels through the system. Exploding precompressed gases can introduce excessively high pressures that may exceed the design pressure of the enclosures.

6.8.2 Seal Requirements

6.8.2.1 Enclosure Entries

6.8.2.1.1 In Division 1 and Division 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 explosionproof.

6.8.2.1.2 Cables installed in Division 1 locations require a seal at all terminations.

6.8.2.1.3 Multiconductor Type MC-HL 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 NRTL-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 explosionproof, even in Division 2 locations, as the conduit system must be able to withstand the same internal explosive pressure as the enclosure to which it is attached. In Division 1 and Division 2 locations, approved 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.

In Division 1 locations only, 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. from the enclosures to which they are attached.

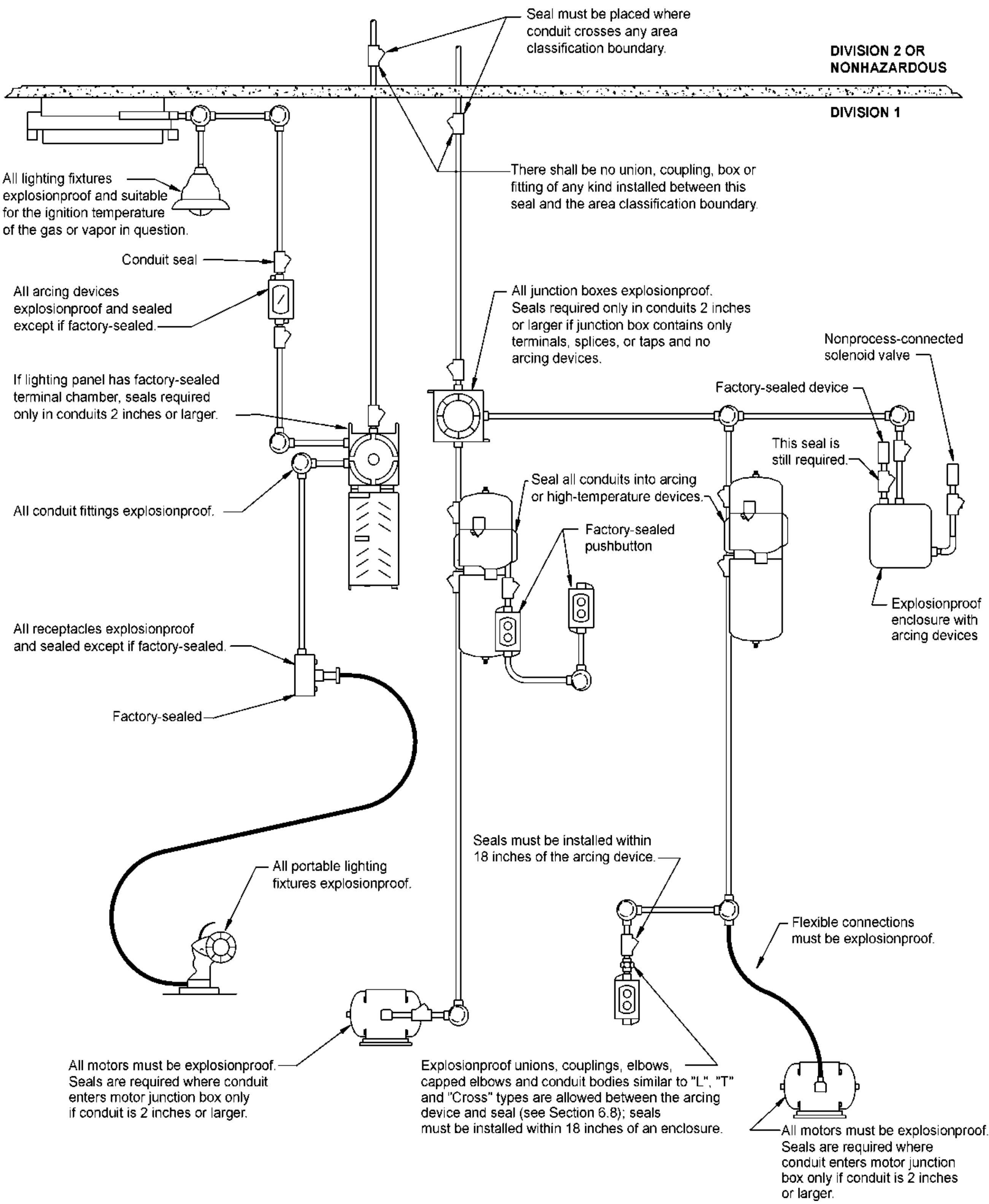

Figure 1—Typical Class 1, Division 1 Electrical Installation Conduit System

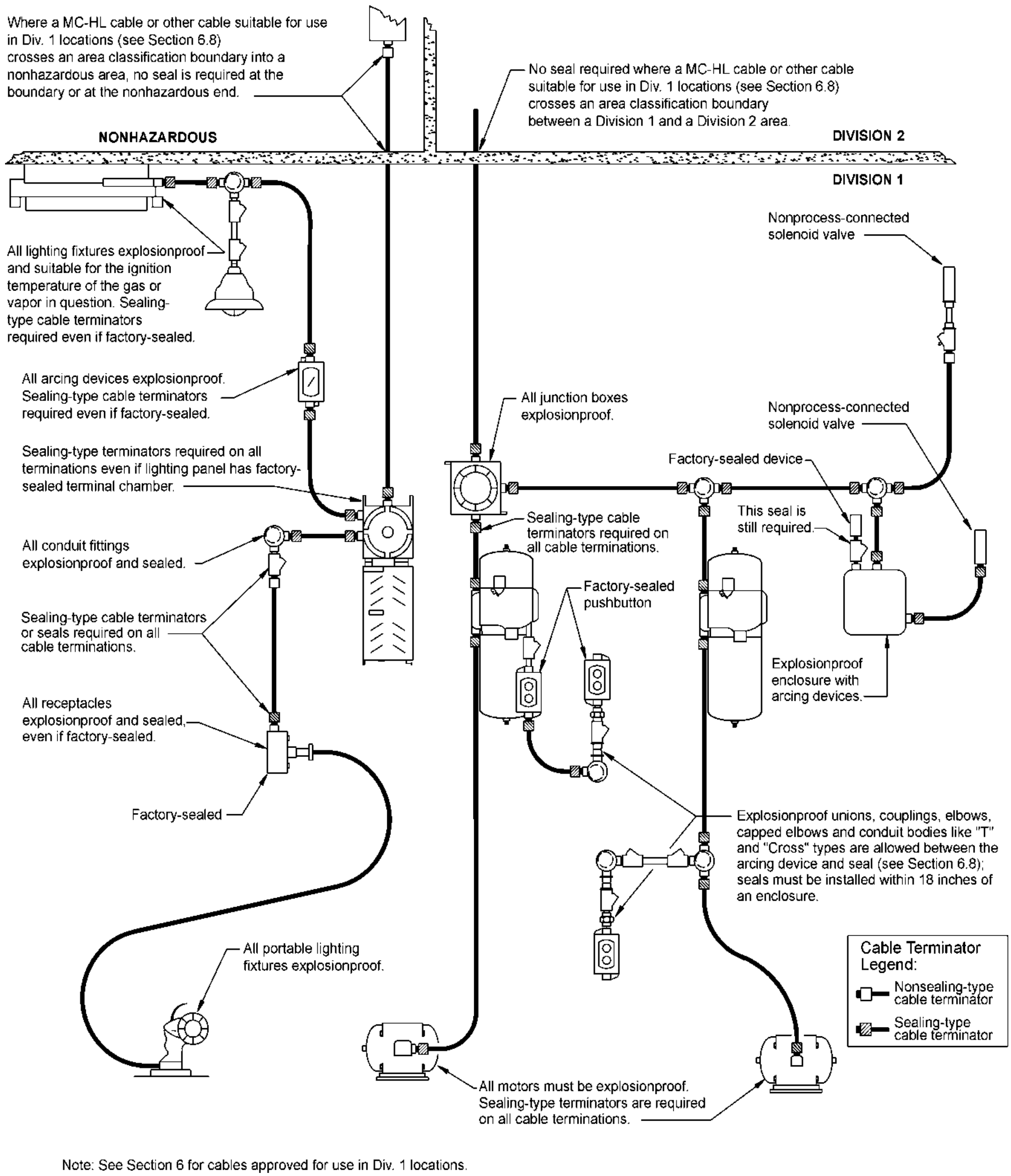

Figure 2—Typical Class 1, Division 1 Electrical Installation Cable System

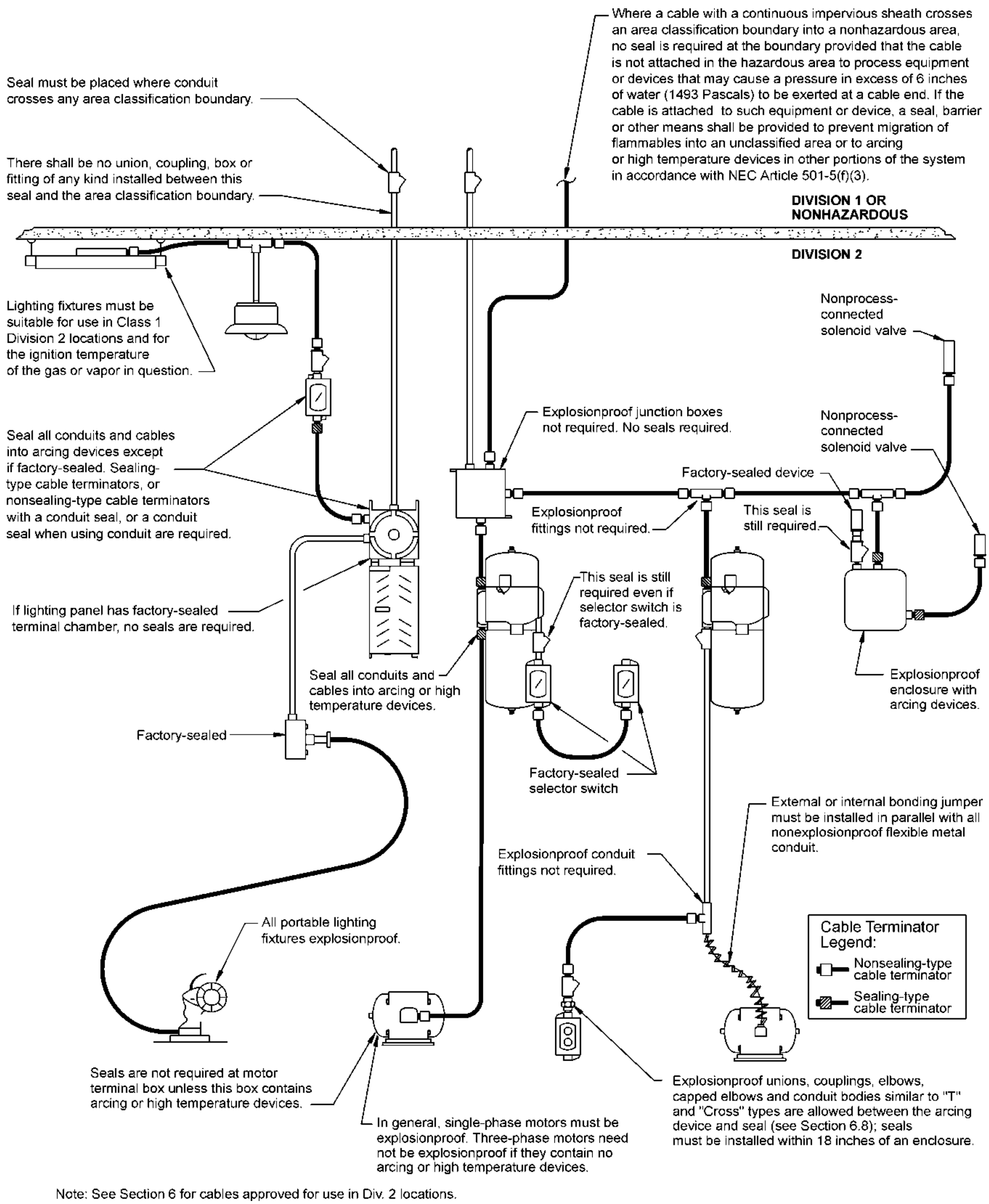

Figure 3—Typical Class 1, Division 2 Electrical Installation Conduit or Cable System

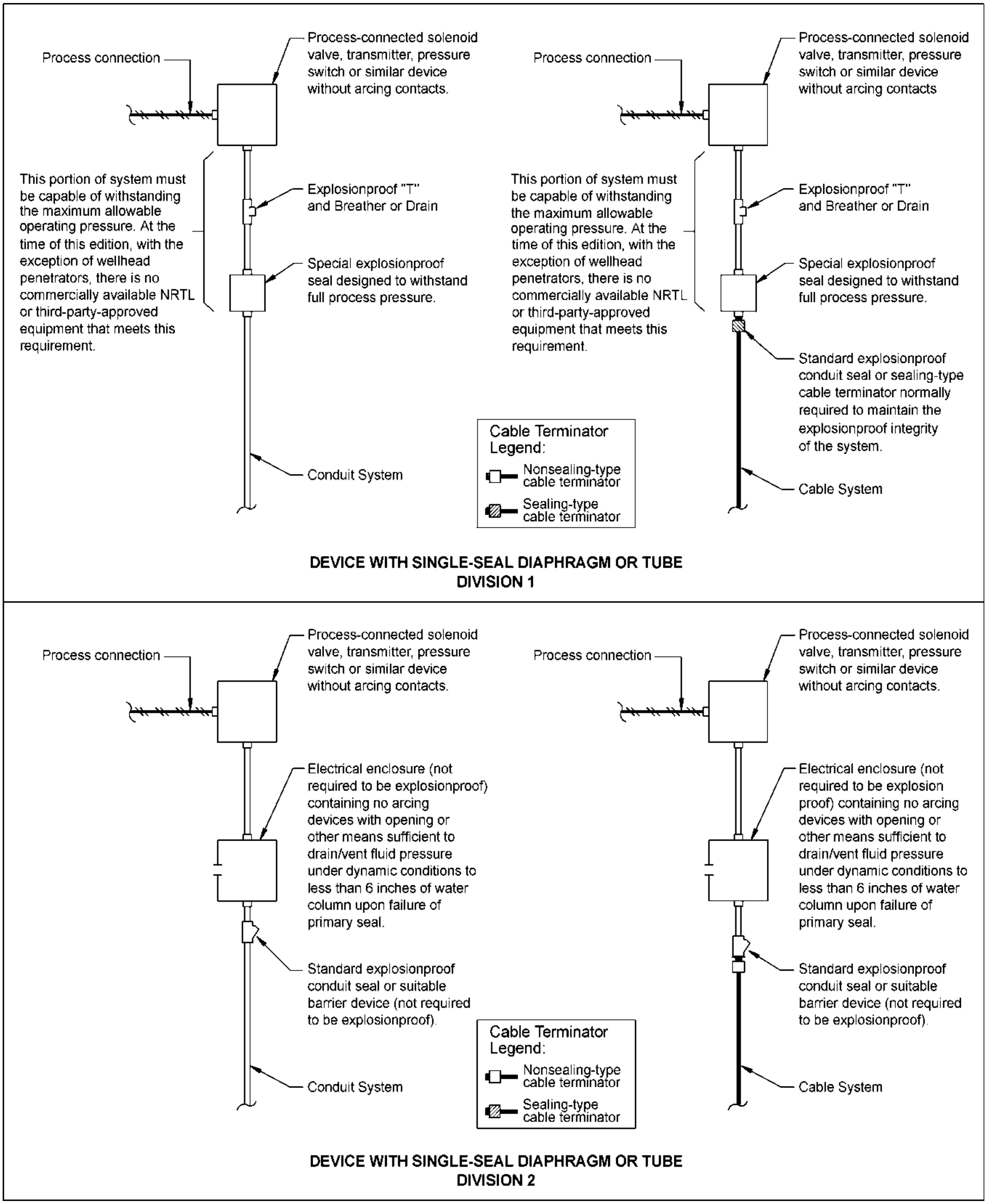

Figure 4—Typical Class 1, Division 1 or Division 2 Electrical Installation Conduit and Cable Connections to Process-Connected Nonarcing Devices with Single-seal Diaphragm or Tube

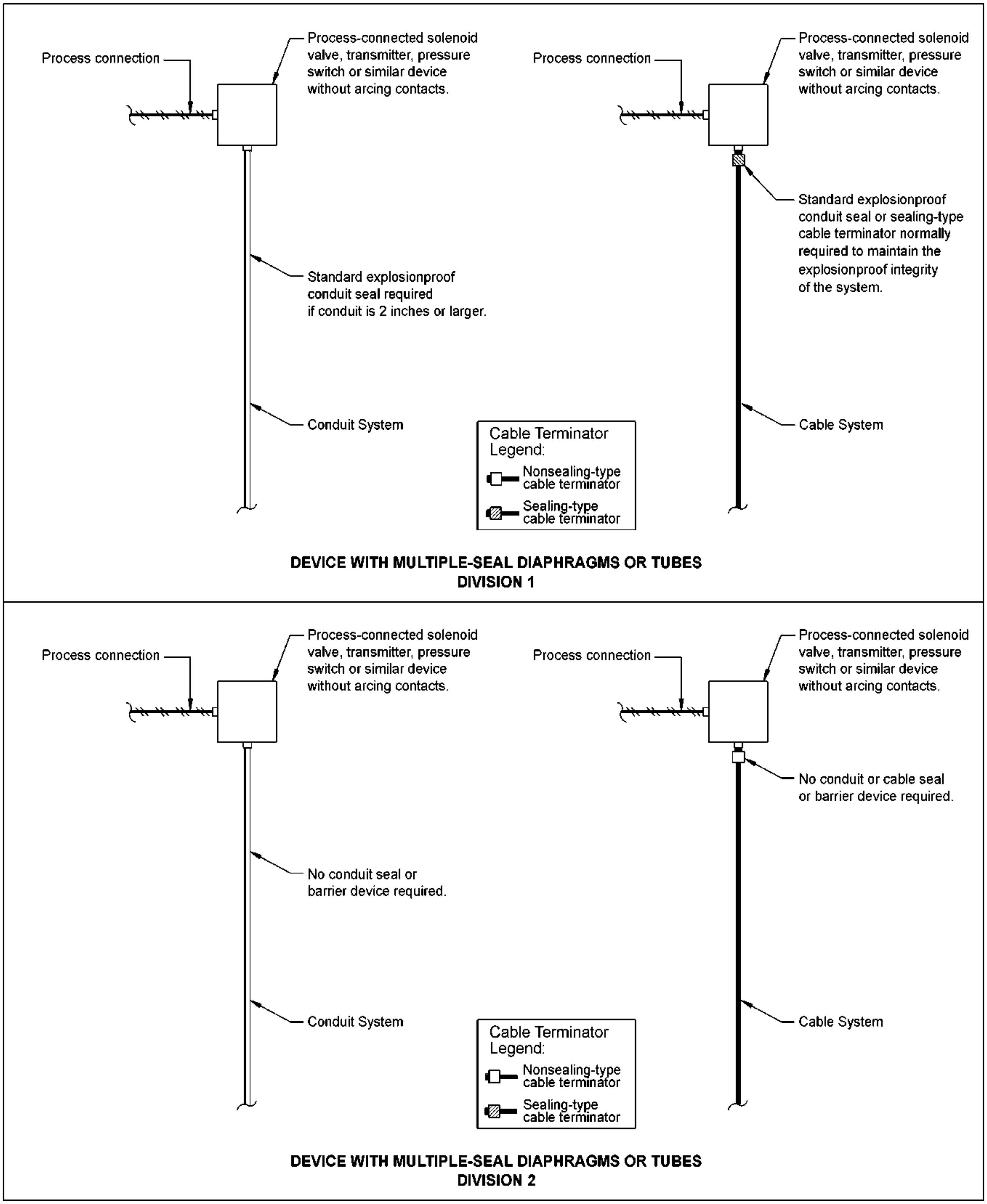

Figure 5—Typical Class 1, Division 1 or Division 2 Electrical Installation Conduit and Cable Connections to Process-Connected Nonarcing Devices with Multiple Seal Diaphragms or Tubes

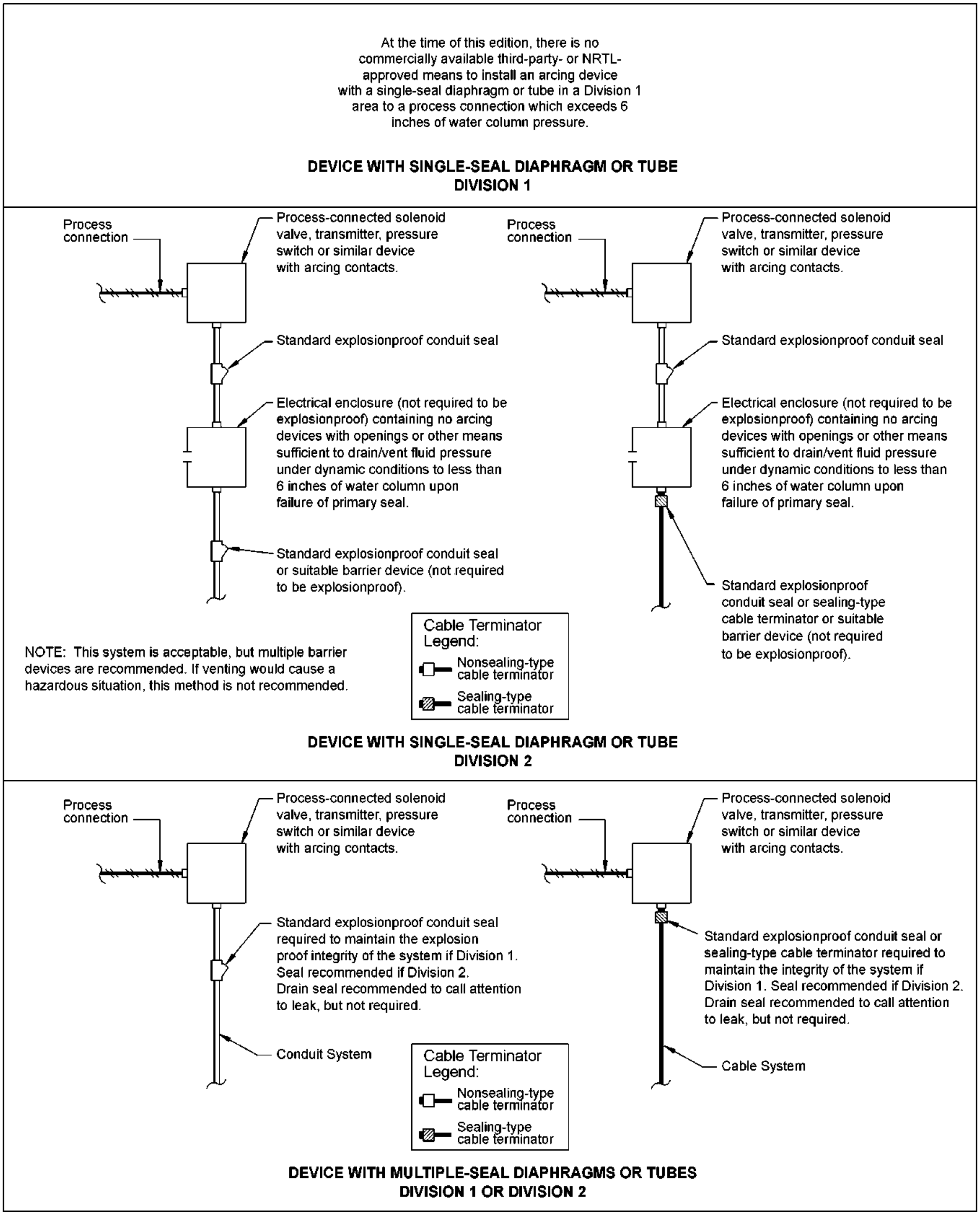

Figure 6—Typical Class 1, Division 1 or Division 2 Electrical Installation Conduit or Cable Connections to Process-Connected Arcing Devices

6.8.2.2 Process Instruments

Conduit seals or barriers and drains shall be installed in each conduit or cable connection to devices installed on process lines or process vessels containing flammable fluids and that depend on a single-seal diaphragm or tube (such as a Bourdon tube or a thermowell) as a barrier between the process fluid and the conduit or cable. This is 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. The additional seal or barrier and the interconnecting enclosure or conduit system shall meet the temperature and pressure conditions to which they will be subjected upon failure of the primary seal. Ordinary conduit seals typically cannot meet these criteria because of their permissible leakage rate. Typical examples of such devices are solenoid valves and pressure, temperature and flow switches or transmitters. This requirement applies even in unclassified locations. Draining provisions should be such that process fluid leaks past the primary seal will be obvious. Conduit drains and drain seals may not be capable of relieving typical process leaks at a rate sufficient to adequately relieve the pressure generated by primary seal failure to 6 in. of water column (1493 Pascals).

6.8.2.3 Classified Area Boundaries

6.8.2.3.1 Wherever a conduit run passes from a Division 1 location to a Division 2 location, from a Division 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 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 Division 1 or Division 2 location. An exception to the above is that unbroken rigid metal conduit that passes completely through a Division 1 or a Division 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. 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 7 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 Pascals) 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 501). 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 Division 2 and unclassified location.

6.8.2.3.4 For additional information on seals for classified area boundaries, refer to NEC 501-5.

6.8.3 Installation

In addition to being placed in proper locations, 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 7 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 Division 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.

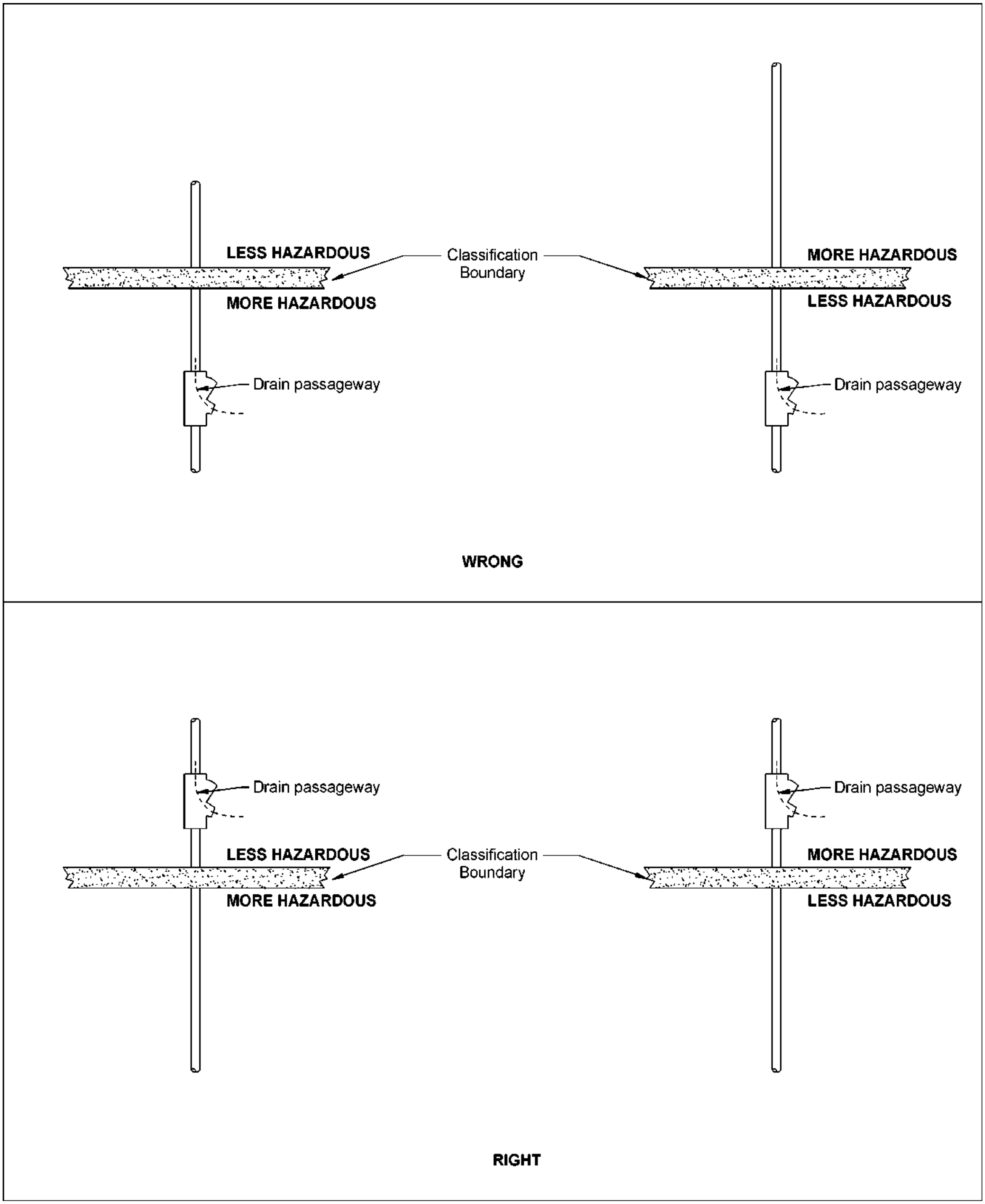

Figure 7—Typical Class 1, Division 1 or Division 2 Electrical Installation Placement of Drain Seals

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 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 9.

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 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) 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 It is recommended that circuit-protection devices 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 classified locations due to their availability in approved explosion-proof 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.

6.9.2.2 Power circuit breaker usage normally is limited to generator breaker or large-sized feeder breaker applications. Power circuit breakers (commonly referred to as open-frame or air-frame breakers) should meet the requirements of ANSI C37.04. Some of the significant features of power circuit breakers follow:

a. Remote operation capability.

b. Spring-operated (stored energy) closing and opening.

c. Fixed mount or drawout-type.

d. Availability of 1) instantaneous and long time, 2) short time and long time, and 3) instantaneous, short time and long time trip units.

e. Availability of multiple auxiliary contacts.

f. Adaptability to protective relaying.

Table 9—Circuit Protection Devices—
Advantages and Disadvantages

Circuit Breakers
Advantages
1. Prevent single phasing.
2. More suitable for remote operation.
3. Resettable operation without replacement.
4. Discourage improper replacement.
5. More suitable for EP enclosures.
6. More suitable for GFI installations.
7. Available with shunt trip or low voltage release options.
Disadvantages
1. Moderate operating speed.
2. Limited interrupting capacities for larger frame sizes.
3. Mechanically complex and not necessarily fail-safe.
Fuses
Advantages
1. Mechanically simple and fail-safe.
2. Fast operating speed.
3. High interrupting capacities.
4. More easily coordinated.
5. Greater size selection available.
Disadvantages
1. Nonrepetitive operations.
2. Require proper procedures for safe replacement.
3. Spare inventory required.
4. Possible single phasing.
5. Subject to replacement with an improperly rated fuse.

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.

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 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.

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 accomplish 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.

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 10 for a listing and description of various NEMA enclosures available. For additional information, see NEMA ICS6 and NEMA 250. Refer to Table 11 for a listing and description of various IEC enclosures available. For additional information, see IEC 529. 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 IEC IP 32 degree of protection, as appropriate for the service intended.

6.11.1.5 Electrical equipment in locations requiring watertight protection should be manufactured to meet at least a NEMA Type 4 or 4X or IEC IP 56 rating, as appropriate for the service intended.

6.11.1.6 Electrical equipment subject to submersion should be manufactured to meet at least a NEMA Type 6 or 6P or IEC IP 67 degree of protection, as appropriate for the service intended.

6.11.1.7 Each enclosure should be selected such that the total rated temperature of the equipment inside the enclosure is not exceeded.

6.11.1.8 Equipment enclosures for interior locations not subject to dripping liquids or falling solid particles should be manufactured to at least NEMA Type 1 or IEC 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.

Table 10—NEMA Enclosures

NEMA Type No.	Type of Enclosure	Characteristics	Intended Use	Typical Offshore Applications
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 dusttight or watertight.	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-Dusttight	A semi-dusttight 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 dusttight.	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.

Table 10—NEMA Enclosures (Continued)

NEMA Type No.	Type of Enclosure	Characteristics	Intended Use	Typical Offshore Applications
2	Driptight	A driptight enclosure (NEMA Type 2), also referred to as "Dripproof", 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: Driptight 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	Weathertight	A weathertight 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	Watertight	A watertight 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.
4X	Watertight	A watertight 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	Dusttight	A dusttight (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	Explosionproof, Class I	An explosionproof enclosure (NEMA Type 7) is designed to meet the application requirements in NEC 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 classified locations when arcing or high temperature devices are utilized.
8		Explosionproof, oil-filled, Class I. An explosionproof, oil-filled enclosure (NEMA Type 8) is designed to meet the application requirements in NEC 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.

Table 10—NEMA Enclosures (Continued)

NEMA Type No.	Type of Enclosure	Characteristics	Intended Use	Typical Offshore Applications
9	Dust-ignition Proof, Class II	A dust-ignition-proof enclosure (NEMA Type 9) is designed to meet the application requirements in NEC 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		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.
12	Dusttight and Driptight	A dusttight and driptight (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 area 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	Oiltight and Dusttight	An oiltight and dusttight (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 oiltight conduit entry.	Indoor locations where spraying oil or coolant might enter the enclosure.	Indoors in areas protected from the environment for control panels.

Table 11—Degree of Protection of Enclosures in Accordance With IEC 529

	First Number Degree of Protection Against Solid Objects		Second Number Degree of Protection Against Water
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°.
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°.
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	Dusttight. No dust ingress.	6	Protected against heavy seas of powerful jets of water. Prevents ingress sufficient to cause harm.
		7	Protected against harmful ingress of water when immersed between a depth of 150mm to 1 meter.
		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.

Table 12—Approximate US Enclosure Types Equivalent to IP Codes (Ingress Protection)

NEMA Type	Definition	IEC IP	Definition
1	General Purpose, indoor.	11	Protection from solid object larger than 55 mm.
2	Suitable where severe condensation present.	32	Protection against dripping water, spillage, (not rain).
3	Weathertight against rain and sleet.	54	Dustproof and resistant to constant splashing water.
3R	Less severe than NEMA 3.	14	Protection from splashing water.
4	Watertight. Resistant to direct water jet spray.	56	Dust and water jet spray.
4X	Same as NEMA 4, although corrosion resistant; stainless, nonmetallic.		
5	Dusttight.	52	Dustproof and resistant to dripping 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	Dusttight and Dripproof.	52	Dustproof and resistant to dripping water (not rain).
13	Oiltight and Dusttight. Constructed with special gasketing to resist oil and liquid chemical penetration.	54	Dustproof and resistant to constant splashing water.

6.12 ADDITIONAL REQUIREMENTS FOR FLOATING FACILITIES

6.12.1 Inclination of a Facility

6.12.1.1 All electrical equipment should be designed and installed to operate under the following two conditions: (a) 15° static list at 7.5° static trim, and (b) 22.5° dynamic roll at 7.5° static trim.

6.12.1.2 All emergency installations should be designed and installed to operate when the facility is at 22.5° list and 10° trim. In addition, emergency generators should also comply with 5.6.5.

6.12.1.3 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. For motors 10 to 500 hp, it is recommended that motors comply with IEEE 841. For motors larger than 500 hp, it is recommended that motors comply with API RP 541.

7.1.2 Variable speed AC motors, in addition to the requirements of this section, should be carefully matched to the drive motor controller for optimum performance. 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, 230 or 575 volts are recommended for supply systems voltages of 208, 240 or 600 volts, respectively. Where motors larger than 200 hp are used, 2300 or 4000V volt motors are usually preferable. In view of the problems of 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 optimum protection from the environment and also to satisfy the area classification requirements. In Class I, Division 1 locations, motors shall be either explosionproof or approved to meet one of three specific methods of construction: a special ventilation system complying with NFPA 496, inert gas-filled, or a special submerged unit—as described by NEC Article 501-8(a).

7.2.4.2 Totally enclosed, open dripproof, or NEMA weather protected Type I or Type II motors that have no arcing or high-temperature devices may be used in Class I, Division 2 locations. Note that most single-phase motors have a centrifugal switch, which is an arcing device. In Class I, Division 2 locations, motors containing arcing or high-temperature devices (while either starting or running) shall comply with one of the following: (a) the motors shall be explosionproof; (b) all arcing and high-temperature devices shall be provided with enclosures approved for Class I, Division 2 locations; or (c) the motors shall be supplied with positive-pressure ventilation from a source of clean air and shall comply with the requirements of NFPA 496, with air-discharge from the enclosure to an area classified as nonhazardous (unclassified) or Division 2. For ventilation purposes, clean air is defined as air that is free of hazardous concentrations of flammable gases and vapors. Totally enclosed motors 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), totally enclosed water-air-cooled (TEWAC), or totally enclosed air-to-air-cooled (TEAAC) motors with sealed insulation systems are recommended.

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 antifriction 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. 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 6.7.11.

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 nonhygroscopic 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 5-6 times the horsepower rating. This starting kVA corresponds to NEMA locked rotor Codes F and 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 high efficiency 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

7.3.1 For increased reliability, a motor can be equipped with space heaters or a low-voltage (usually 24 to 32 volts AC) circuit to keep the motor windings dry while not in operation. For motors located in 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 system.

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. Nonautomatically started fractional horsepower motors may be protected by an internal temperature switch.

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 (a) part winding starting, (b) Wye-Delta starting, (c) resistance reduced voltage starting, (d) solid state reduced voltage starting, and (e) autotransformer reduced voltage starting. Of these methods, the latter three do not require special motors. The autotransformer reduced voltage type starter provides the highest starting torque per ampere of line current, and the greatest reduction of inrush line current.

7.4.3 Starter Sizing

Full voltage motor starters for AC induction motors should be sized according to NEMA recommendations listed in Table 13.

Table 13—NEMA Motor Starter Sizing

NEMA Size	Maximum Motor Size—HP				
	Single-Phase		Three-Phase		
	115V	230V	200V	230V	460/575V
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.

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, Section 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.

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.

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

Motor starters installed in Class I, Division 1 and 2 locations shall be installed in approved explosionproof enclosures. For additional recommendations, refer to 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.

7.4.9 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

8.1.1 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 C-57 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.

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 must be replaced if any one of the windings fail. Advantages of three-phase transformers are higher efficiency, less weight, and small physical size.

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 harmonic frequency and magnitude. As K-factor ratings increase, transformers become larger and heavier. Typical nonlinear loads include lighting ballasts, AFCs, DC drives, computers, and UPS systems.

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

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.

8.2.3.1 For dry transformers:

a. Nonventilated enclosures (TENV) are recommended for outdoor locations, but 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.
e. Vacuum pressure impregnated (VPI) core and coil.

8.2.3.1.1 Copper coil material. (If aluminum coils are utilized, special precautions should be taken at terminations.)

8.2.3.1.2 Permanently attached nameplates of corrosion resistant material. It is recommended that the nameplates 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.

8.2.3.1.3 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 liquid-filled transformers:

a. It is recommended that permanently attached nameplates 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.
c. Full load temperature rise not to exceed 55°C OA.
d. Low oil-level indication.
e. High oil-temperature indication.
f. Field replaceable cooling fin assemblies, if provided with cooling fins.

8.3 INSTALLATION

8.3.1 General

It is recommended that transformers be installed in accordance with the NEC, particularly Article 450. ANSI C-57.12.70 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.

8.3.2.2 Transformers installed in Division 1 locations shall be installed in NEMA 7 enclosures. Standard transformers are permitted in Division 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: 1) Wye-Wye (also referred to as Star-Star), 2) Wye-Delta, 3) Delta-Delta, and 4) 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

a. 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.

b. 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.

c. 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 above in 8.4.2.1b. 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 4000 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 indication system is recommended.

8.5.2.5 When the electrical system is high-resistance grounded, a ground-fault alarm is recommended.

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.

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: Reference IEEE Std 142 for additional information on transformer grounding.

9 Lighting

9.1 GENERAL

9.1.1 Lighting is provided for offshore installations for two distinct, but different, 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 14 are typical examples of recommended minimum maintained lighting levels for the designated areas for efficiency of visual operations (adapted from the IES Lighting Handbook).

9.2.3 Minimum Recommended Levels of Illumination for Safety

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. In general, these recommended levels are given by the following:

Hazard Requiring Visual Detection	Slight		High	
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, NFPA 101 requires a minimum of 0.1 foot-candles for means of egress.

Table 15 gives typical examples of recommended minimum levels of illumination for safety.

Table 14—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, & Counter Areas	100

Table 14—Minimum Recommended Levels of Illumination for Efficient Visual Tasks (Continued)

Area	Minimum Lighting Level (Foot-candles)
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 15—Minimum Recommended Levels of Illumination for Safety

Area	Minimum Lighting Level (Foot-candles)
Stairways	2.0
Offices	1.0
Exterior Entrance	1.0
Compressor and Generator Rooms	5.0
Electrical Control Rooms	5.0
Open Deck Areas	0.5
Lower Catwalks	2.0

9.3 FIXTURE SELECTION AND INSTALLATION

9.3.1 General

Fixture selection for offshore use involves choosing which type of lamp (incandescent, mercury vapor, etc.) should be used, whether the fixture should be of the explosionproof, Division 2, or general usage type, and whether the fixture will withstand the environment.

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 Mercury Vapor

Mercury vapor fixtures are often used for lighting general outside areas and inside large buildings. Such fixtures are available in essentially all styles, are readily available, and have high efficacy (lumens/watt). Mercury vapor lamps are available that provide color correction; however, the noncolor-corrected type usually is adequate for general area lighting.

9.3.2.2 Fluorescent

Fluorescent fixtures often are a good selection for lighting building interiors and areas with low headroom because of high lamp efficacy, long lamp life, and low profile.

9.3.2.3 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 is recommended.

9.3.2.4 Sodium and Metal Halide

High-pressure sodium and metal halide lamps should be considered because of their higher efficacy, particularly where fixtures must be located a considerable distance from the area to be illuminated (such as boat landing). Metal halide lamps are especially well suited for areas where superior color rendition is required. Low-pressure sodium fixtures are not desirable because of poor color rendition and difficulty of safe disposal of lamps. High-pressure sodium fixtures are being widely utilized offshore due to their improved, longer lamp life and greater fixture availability. Reference, however, 9.3.3.7.2.

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 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 type should be considered.

9.3.3.3 Lighting fixtures installed in classified locations shall be suitable for the particular area, Division 1 or Division 2. When installed in Division 1 locations, lighting fixtures (including ballasts) shall be explosionproof.

9.3.3.4 Wiring with high temperature insulation should be utilized inside fixtures for interconnections. This is particularly important when installing 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). (See also NEC Articles 501-9(a)(3) and 501-9(b)(3).)

9.3.3.6 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.

9.3.3.7 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 (ceilings of compressor buildings, for example) for extended life.

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.

9.3.3.8 Mercury vapor and metal halide lamps will not relight 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 re-light 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 will give rapid return to full brilliance after power dips.

9.3.3.9 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.

9.3.3.10 Consideration should be given when berth lights are selected to minimum horizontal projections so that the lights may not be covered by 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, standby 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 standby system may be separate from or part of the regular lighting system. Where loss of lighting presents a danger to personnel, light 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, restrooms, and power generating spaces.

9.4.4 Lighting Circuits Requiring Dual Feeders

9.4.4.1 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 for the following exception:

9.4.4.2.2.1 Lighting branch circuits rated at 25 and 30 amperes may be used to supply fixed nonswitched lighting fixtures.

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 for stairways in Table 15. A minimum of 0.5 FC 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.

9.4.4.3.1 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.

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. Reference 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 electrolyte solution 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 16.

Table 16—Comparison of Batteries by Cell Type

Type	Projected Useful Life (Years)	Projected Cycle Life[a] (Number of Cycles)	Wet Shelf Life[b] (Months)	Comments[c]
Primary	1–3	1	12	Least maintenance. Periodic replacement. Cannot be recharged.
SLI (Starting, Lighting & Ignition) (Automotive Type)	1/2–2	400–500	2–3	High hydrogen emission. High maintenance. Not recommended for float service or deep discharge. Low shock tolerance. Susceptible to damage from high temperature.
Lead Antimony	8–15	600–800	4	High hydrogen emission. Periodic equalizing is required for float service and full recharging. Low shock tolerance. Susceptible to damage from high temperature.
Lead Calcium	8–15	40–60	6	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 high temperature. Low shock tolerance.
Lead Selenium	20+	600–800	6	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. Low shock tolerance. Susceptible to damage from high temperature.
Lead Plante (Pure Lead)	20+	600–700	4	Moderate hydrogen emission. Periodic equalizing is required for float service and full recharging. Low shock tolerance. Susceptible to damage from high temperature.
Nickel Cadmium (Ni-Cad)	25+	1000+	120+	Low hydrogen emission. Periodic equalizing charge is not required for float service, but is required for recharging to full capacity. High shock tolerance. Can be deep cycled. Least susceptible to temperature. Can remain discharged without damage.

[a]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 15% of the rated battery ampere-hour capacity.
[b]Wet shelf life is defined as the time that an initially fully charged battery can be stored at 77°F until permanent cell damage occurs.
[c]Float voltages listed are for 77°F.

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 RP 500 be maintained to ensure that the interiors of battery enclosures remain unclassified.

10.3.4.3 Rooms and Enclosures

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:

10.3.4.3.1 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 1, Division 1, Group B 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.

10.3.4.3.2 Installation of electrical equipment in the vicinity of battery room power ventilation discharge openings should be avoided. Any electrical equipment installed within 18 inches of such openings should be suitable for use in a Class 1, Division 1, Group B hazardous area.

10.3.4.3.3 All battery boxes installed on open decks should be weathertight 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

10.3.4.3.4 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.

10.3.4.3.5 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 Division 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.

10.4 BATTERY CHARGERS

10.4.1 When specifying battery chargers for offshore use, the following features should be considered:

10.4.1.1 *Frequency and Voltage Tolerance*. It is recommended that chargers installed offshore be capable of tolerating voltage variations of ± 10% and frequency variations of ± 5%.

10.4.1.2 *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.

10.4.1.3 *Size*. The minimum charger output current rating can be calculated according to Equation (2) following:

$$C = \frac{L + (AH \times 1.4)}{T} \qquad (2)$$

where

C = charger size (amperes),

L = connected load (amperes),

AH = capacity of batteries (ampere-hours),

T = desired recharge time (hours).

10.4.1.4 *Enclosure*. The enclosure should be suitable for both the area classification and the environment. If explosion-proof or nonventilated enclosures are used, care should be taken to ensure proper heat dissipation.

10.4.1.5 *Area Classification*. If chargers are to be installed in classified locations, they shall be suitable for such areas.

10.4.1.6 *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 (a) counter-EMF cells, (b) dropping diode circuit, (c) DC-DC converters, (d) a reduction in the number of cells when the connected equipment will operate at the reduced voltage, or (e) other effective means of protecting the load. If equalizing is desired, timers are available to automatically provide the proper frequency and duration of equalization.

10.4.1.7 *Regulation*. It is recommended that battery chargers be capable of maintaining their output voltage within ± 1% from no load to full load current.

10.4.1.8 *Current limiter.* It is recommended that chargers be provided with output current limiters.

10.4.1.9 *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.

10.4.1.10 *Meters*. It is recommended that both an output ammeter and an output voltmeter be provided. For certain applications, AC input meters may be desirable.

10.4.1.11 *Alarms*. Alarm outputs may be useful for the following conditions:

a. Low DC voltage.
b. High DC voltage.
c. AC power failure.
d. Ground indication.
e. Charger failure.

10.4.1.12 *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.

10.4.1.13 *Transient suppression*. It is recommended that transient suppressers be provided on the AC input and the DC output.

10.4.1.14 *Environmental considerations*. The following options are recommended when available:

a. Hermetically sealed relays.
b. Conformally coated printed circuit cards.
c. Environmentally sealed or hermetically sealed switches and circuit breakers.
d. Corrosion-resistant enclosures and hardware.

10.4.1.15 *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 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:

10.5.2.1 The UPS should be capable of tolerating frequency variations of ± 5% and voltage variations of ± 10%.

10.5.2.2 The output voltage should be within ± 5% of rated voltage and output frequency should be within ± 1% of rated frequency from no load to full load.

10.5.2.3 The UPS should be capable of supplying the rated load kVA at power factors ranging from 0.75 lagging to 0.8 leading.

10.5.2.4 It is recommended that UPS systems operate at rated output without any adverse affect in an ambient temperature of 0°C to 40°C.

10.5.2.5 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 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 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 $^1/_4$ 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 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 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 RP 14C covers in detail the basic safety systems on offshore platforms.

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). 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.

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 (a) monitored by the safety system, with visual or audible alarms (as most appropriate for the particular location) actuated upon power source failure), or (b) 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 RP 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 of this recommended practice.

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 ± 10% and frequency variations of ± 5%. Special filtering of noise/transients should be considered when electronics equipment is operated directly from AC supplies.

11.1.4.3 RFI

11.1.4.3.1 Most electronics equipment is susceptible to electromagnetic interference (EMI), especially radio frequency interference (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 (Division 1, Division 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 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.

11.2.1.2 Hydrogen sulfide (H_2S) 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.

11.2.1.3 Sensor placement is outside the scope of this document. Recommended practices for sensor location and operation of combustible gas detectors are presented in API RP 14C. The following discusses some electrical considerations for the selection and installation of gas detection equipment.

11.2.2 Equipment Selection

11.2.2.1 It is recommended that units have a minimum of two adjustable set points, preferably with the set points selected being visually indicated.

11.2.2.2 Separate function lights 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 It is recommended that combustible gas detection instruments be approved by a nationally recognized testing laboratory (NRTL) as meeting the minimum performance requirements of ISA S12.13, Part I.

11.2.2.7 It is recommended that hydrogen sulfide detection instruments be approved by a nationally recognized testing laboratory (NRTL) as meeting the minimum performance requirements of ISA S92.0.01, Part I (formerly ISA S12.15, Part I).

11.2.2.8 To better ensure proper application, it is recommended that an environmental and application checklist (similar to the examples shown in Appendix 1, ISA RP12.13, Part II and RP12.15, 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 RP 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 ISA RP12.13, Part II.

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 (formerly ISA RP12.15, Part II). Reference also API RP 55 and 68.

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 RP 14C and 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.

11.4 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 contain aids-to-navigation equipment (obstruction lights and fog signals).

11.4.1.2 The USCG specifies three classes of aids to navigation equipment—A, B, and C—based, in general, on water depth and the distance from the coast. Class C equipment is required at locations closest to the coast, Class B at locations within approximately 12 miles of the coast but beyond locations requiring Class C equipment, and Class A at locations approximately beyond 12 miles of the coast. The appropriate USCG district (e.g., District 8 in New Orleans) should be consulted for the class of aids-to-navigation equipment required at specific locations. The number of obstruction lights required is based primarily on the dimensions of the facility, and specific minimum heights of equipment above mean high water are also specified by the USCG.

11.4.1.3 Class C locations require obstruction lights only. Class B and Class A locations require both obstruction lights and fog signals. Class B fog signals are required to be audible for approximately one-half mile and Class A fog signals are required to be audible for approximately 2 miles, but all fog signals shall be specifically approved by the USCG for the specific class. Obstruction lights have varying flash characteristics, lens diameters, and lamps. The combination of these factors determines the minimum allowable voltage at the lamp, specified by the USCG. Class C, B, and A obstruction lights are required to be visible for approximately 1, 3 and 5 miles, respectively, but shall be approved by the USCG for the specific class.

11.4.1.4 The USCG specifies minimum degrees of level from horizontal required for obstruction lights. This imposes specific restrictions on lights on floating facilities since their levelness may vary with sea conditions.

11.4.2 Equipment Selection

11.4.2.1 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 Wiring Methods

Circuits supplying power to aids-to-navigation equipment should be in accordance with this recommended practice. To properly consider voltage drop and to minimize wire size, the following recommendations are offered.

11.4.3.1 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.

11.4.3.2 Looped or radial systems provide less voltage drop and higher reliability, compared to a branched network.

11.4.3.3 If wiring splices are required, they should be watertight and low resistance, preferably soldered, to prevent excessive voltage drops.

11.4.4 Due to varying requirements between USCG districts, it is recommended that advice be obtained from an individual familiar with the requirements of the particular district in question before actually designing an aids-to-navigation system.

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 Classified Locations

The placement of communications equipment in classified locations should be avoided. Most communications equipment is not designed to meet the requirements of Division 1 or Division 2 locations. Communications equipment located in classified locations must 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). Either system 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 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. 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 also API RP 14G.

11.7.2 Electric Pumps

11.7.2.1 All electric fire pumps should be installed with a wiring system that will withstand direct flame impingement for a minimum of 30 minutes. 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 secured with hardware of stainless steel or other flame-resistant material.

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. Special purpose fire pump controllers are available.

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 above.

11.8 ADJUSTABLE FREQUENCY CONTROLLERS (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, and other electrical equipment. In addition, the harmonics may adversely effect electronic devices that are frequency sensitive.

11.8.1.2 Effective application of adjustable frequency controllers (AFCs) can present unique challenges to the application engineer. A detailed understanding of AFC 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 AFC 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 AFC 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 AFC 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. Load torque is given by the following equation:

$$T = \frac{HP \times 5250}{S} \qquad (3)$$

where

HP = horsepower of the load,

T = torque in foot-pounds at the load,

S = speed in RPM.

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 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%.

11.8.2.3 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 AFC 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 8). 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 9.)

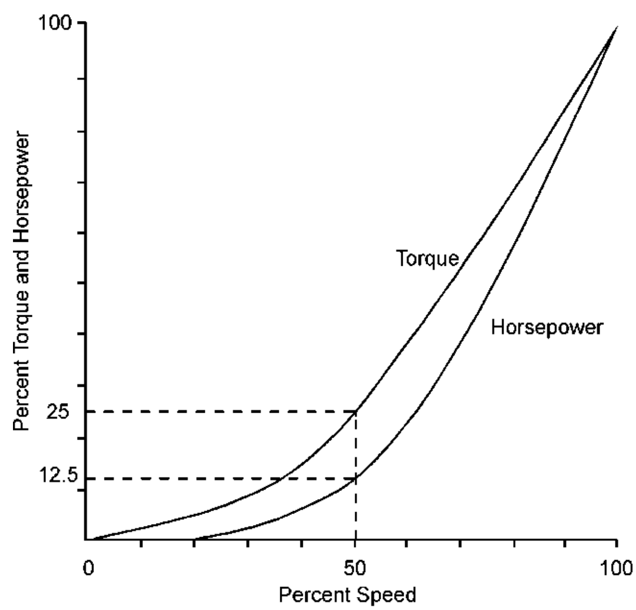

Figure 8—Typical Speed Torque Curve for Variable Torque Load

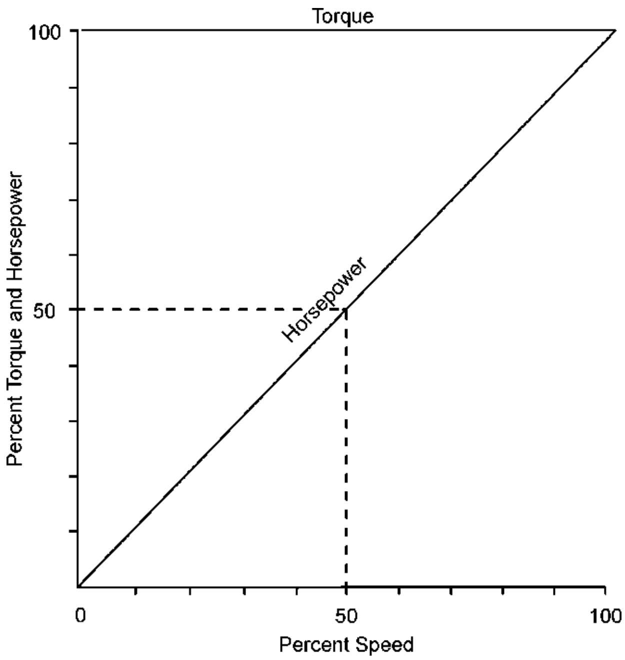

Figure 9—Typical Speed Torque Curve for Constant Torque Load

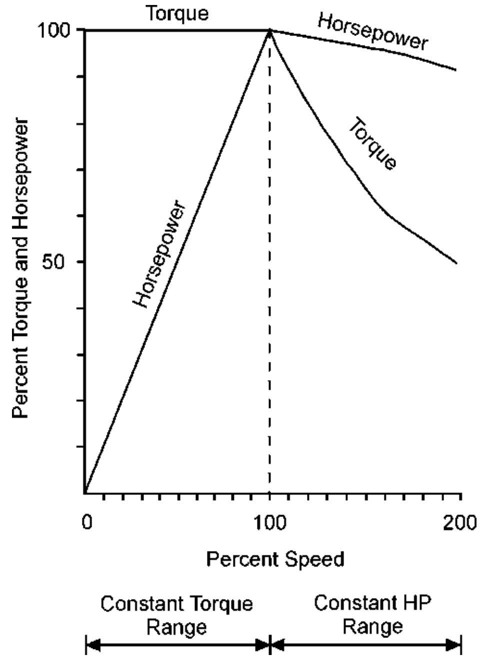

Figure 10—Typical Speed Torque Curve for Constant Horsepower Load

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 10).

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 11).

11.8.4.5 Application Considerations

11.8.4.5.1 Applications of AFCs 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.

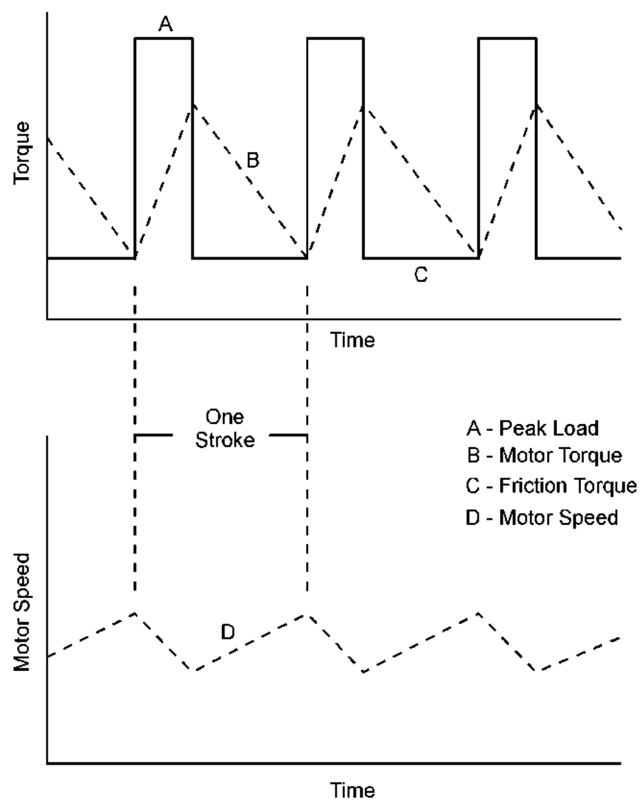

Figure 11—Typical Speed Torque Characteristics for Impact-Type Loads

11.8.5 Inverted Duty Versus IGBT Inverter Duty

Inverted 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 inverted duty to mean different things. Inverted 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 480 volt motor is the NEMA MG1 Part 31 motor, which has a 1600V corona-inception voltage 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 limitation of cable length, application of filters, output reactors at motor or drive, or the application of matching terminators.

11.8.6 Cable Considerations for AFCs

11.8.6.1 For applications of 600 volts and below, motor load conductors with less than a 30 mil insulation require additional application considerations. Conductors with PVC insulation thickness less than 30 mils are not recommended for IGBT drive installations where moisture is present.

11.8.6.2 Motor lead cables for adjustable frequency controllers require special consideration because of harmonics, reflective wave voltages, and induced voltages in adjacent cables. The most effective wiring method for this application is MC cable with continuous corrugated metal sheath and three segmented grounding conductors, one in each interstice. Depending on nominal voltage rating and the reflected voltage, over insulated conductor ratings should be considered.

11.8.6.3 Voltage drop on load cables between the AFC and the motor requires special considerations when loads with high starting torques are involved.

11.8.6.4 Cable length between the AFC and the motor requires special consideration because of the potential for reflective wave voltages. It is recommended that the AFC manufacturer be consulted for technical guidance.

11.8.7 AC Power Source Considerations

AFCs 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 AFC should be based on the input current rating of the AFC as opposed to the motor full load current value. The AFC manufacturer's user manual should be consulted as well as the NEC. [See NEC 430-1, NEC 430-6(c), 430-22, and 430-22(b).]

11.8.9 Line Voltage Ratings

The AC line voltage supply to the AFC 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 affect on AFCs, depending on the magnitude of the transient and the type of AFC design. In most cases, isolation transformers are not necessary for PWM-type AFCs.

11.8.11 Transient Line Notching

Depending on the installation, voltage notching created by AFCs normally is not significant in PWM-type designs using diode front ends. AFCs 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 AFCs 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 AFC manufacturer's manual for proper application. Deviations greater than the specified tolerance may cause AFC malfunctions.

11.8.15 Environmental Considerations

Environmental considerations are important for successful AFC installations. The following conditions should be reviewed.

11.8.15.1 Ambient Temperature

AFCs normally can be operated in ambient temperatures of 0°C to 40°C without derating. Manufacturers can furnish supply derating curves for higher rating temperatures. Large AFCs, isolation transformers, and line reactors may contribute significant heat load to air-conditioned spaces.

11.8.15.2 Humidity Considerations

AFCs 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 AFCs should be suitable for the environmental conditions in which they are applied. NEMA has established standards for electrical enclosure construction. A wide range of AFCs in enclosures for hazardous locations is normally not available. The use of an explosionproof motor with an AFC may be required for certain hazardous locations. Normally, AFCs should be located in unclassified locations.

11.8.16.2 An 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 AFC, additional heat may be produced in the motor and raise its surface temperature. To apply an explosionproof motor to a specific AFC with a NRTL listing, the motor should be tested with the specific type of AFC to ensure that the motor operates within the allowable surface temperature range for the specifically defined hazardous (classified) location.

11.8.17 AFC Grounding

11.8.17.1 In addition to the NEC requirements, it is important to follow the manufacturer's recommendations for grounding. See also 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 AFC manufacturer.

11.9 SUBMARINE CABLES

Submarine cables are used to supply electrical power from central offshore generating stations and land-based (utility and self-generated) generation/distribution systems to offshore platforms. Distribution is normally at 2400 volts, 4160 volts, 13,800 volts, and 34,500 volts, although higher voltages are occasionally used. In general, submarine cables are custom designed 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 and control conductors are provided in the interstices of the power conductors.

11.10 ELECTRIC OIL-IMMERSION HEATERS

11.10.1 Excluding lube oil service, each oil-immersion heater should have 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:

   1. 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.
   2. 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 WATERTIGHT DOORS

Electrical power and control systems for watertight 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 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:

a. The authority having jurisdiction.
b. API RP 500 to establish or maintain area classification.

11.14 CARGO TANKS ON FLOATING FACILITIES

A cargo tank is defined by API RP 500 as a Class I, special Division 1 (Class I, Zone 0) location. Cargo tanks shall not contain any electrical equipment except the following: (a) 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, Division 1 or occasionally special Division 1 in accordance with API RP 500, depending on the conditions. Explosionproof lighting fixtures and their associated wiring may be used in those rooms classified as Class I, Special Division 1, where:

a. A minimum of 6 air changes per hour is provided.
b. Loss of ventilation is alarmed in accordance with 11.13.3.
c. Combustible gas detection systems are installed and maintained in accordance with API RP 500, 6.5.2.

11.15.2 In cargo handling rooms classified Class I, Special Division 1 and not meeting the requirements of 11.15.1 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 3.2.24) are required by the USCG (Title 33, *CFR* Part 146.105) to have general alarm systems. 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. 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 (1) 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 central paging and alarm system is recommended. A general alarm supplemented by verbal instructions over the Public Address (P.A.) system will enhance safety. These instructions may be automatically generated by an electronic voice synthesizer or vocalized by operations personnel.

11.16.1.10 One possible combination of tones for five-tone general alarm systems follows:

Priority	Condition	Tone
1	Abandon	Siren
2	Emergency	Yelp
3	Safety System Alarms	Warble
4	Process Alarms	Steady
5	Special Alarms	Pulse

11.16.2 Floating Facilities

11.16.2.1 Floating offshore platforms that are manned (see 3.2.24) are required by the USCG (Title 46, *CFR* Part 113.25) to have general alarm systems 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. 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.

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. 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. 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 central 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) 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 P.A. 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 battery banks 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 Battery systems powering general alarm systems should be designed for a minimum of 4 hours of continuous operation of the system at maximum system load without recharge.

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 zone. On facilities not divided into fire zones by vertical fire bulkheads, the facility should be divided into areas not exceeding 120 ft 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. It is recommended that the number of general alarm devices supplied by each branch circuit be limited to 5.

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

One possible combination of tones for five-tone general alarm systems follows:

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 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 incendive energy levels. However, some larger cathodic protection systems can operate at incendive 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, the system depending on 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, incendive levels of voltage and current can be produced. The anodes usually are attached to the structures at levels 10 feet 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. It may be desirable to furnish an alarm indicating loss of power.

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:

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, Division 1 locations, unless the wiring method meets the requirements for such location, as specified by this recommended practice. DC conductors in Division 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.

12 Special Considerations

12.1 CONSTRUCTION PRACTICES

12.1.1 Corrosion Prevention

Corrosion is not only undesirable in terms of repair and replacement of equipment, but also can present a safety hazard if it is allowed to negate the effect of special enclosures that are required in 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 follows:

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 explosionproof equipment should be suitable for the purpose.

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.

12.1.1.4.3 If stainless steel is used, Type 316 is more resistant to corrosion than Types 303 and 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.[23]

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 noncombustible 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. Cable tray supports made of hot-dipped galvanized steel or properly painted pipe or structural steel are recommended.

[23]Aluminum Association, Inc., 900 19th Street, NW, Washington, DC, 20006.

12.1.2.3 Design

Cable tray systems should be designed in accordance with Article 318 "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 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 following a procedure described by an authorized hot work permit.

12.3.2 A power cord permanently attached to an electrical tool that can be an ignition source should not be equipped with an explosionproof type plug. To allow for use of these portable electrical tools in areas where only explosionproof receptacles are installed, adapter cords should be provided that incorporate an explosionproof plug on one end and a three-wire, grounded, nonexplosionproof receptacle on the other end.

12.3.3 The nonexplosionproof 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.

12.3.3.1 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 an explosionproof receptacle on one end and an 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, Group D 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 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 Division 1 or Division 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 explosion-proof or nonexplosionproof, 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 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.

12.8 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 the authority having jurisdiction.

12.9 PORTABLE ELECTRONIC DEVICES

Where portable electronic devices (e.g., pagers, cell phones, cameras, video equipment, and radios) are used in classified locations they should be either suitable for the location or used in conjunction with a hot work permit.

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 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 across the insulation. The suggested minimum insulation resistance is 2.0 megohms; new or rebuilt machines should provide 10 megohms, minimum, insulation resistance readings.

13.2.3 If generators are to be operated in parallel, check their phase rotation and the synchronizing circuits for proper operation.

13.2.4 Check motor starter overload relay heater elements for proper sizing.

13.2.5 Check circuit breaker trip settings and fuse sizes.

13.2.6 Jog motors to check for proper direction of rotation after first uncoupling any loads that might be damaged by reverse rotation.

13.2.7 Check motor-to-load and generator-to-prime mover alignments.

13.2.8 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.

ANNEX A—(INFORMATIVE) INSPECTION INTERVALS

The following inspection intervals 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, "Electrical Safety Requirements for Employee Workplaces," provides guidelines for proper selection and use of personal protective equipment, which may be required for certain inspections.

Equipment	Inspection Intervals	
	Routine	Detailed
Motors		
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
Motor Controllers (Outdoors/Indoors)		
Oil immersed (MV)	6 mos	4–6 yrs
Vacuum (MV)	6 mos	4–6 yrs
Air (MV)	6 mos	4–6 yrs
AFCs (MV/LV)	6 mos	1–4 yrs
Air (LV)	6 mos	4–6 yrs
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
Transformers		
Oil-filled	6 mos	2 yrs
Oil analysis	2 yrs	2 yrs
Dry	1 yr	6 yrs
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 recommended practice 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 D.C. and the insulation resistance in megohms of the circuits while at their operating temperatures is to be normally at least equal to:

$$\frac{\text{Rated Voltage of the Machine}}{(\text{Rating in kVA}/100) + 1000}$$

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 A.C. Generators

A.C. 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 A.C. 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 (D.C.) 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 (3.6°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 he within 5°C (8°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 (18°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 he 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, 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.

b. ***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.

c. ***Emergency Generator Prime Movers*** (*1998*) Prime movers driving emergency generators are to be able to maintain the speed within the limits in 4/5C2.15.1a and .lb 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 .lb 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 (A.C.) 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.

4/5C2.19.2 Voltage Regulation

a. ***Voltage Regulators*** A separate regulator is to be supplied for each A.C. 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 A.C. 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.

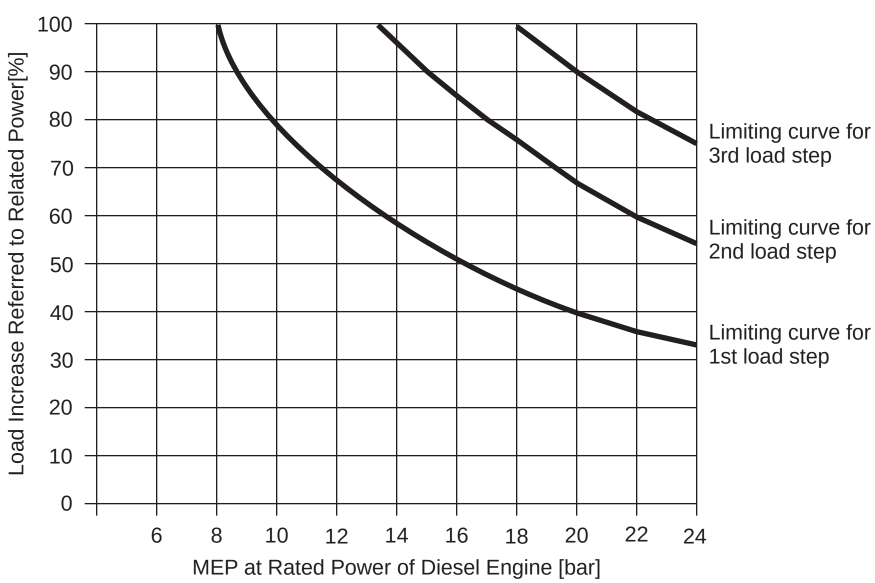

Figure 4/5C.1—Limiting Curves for Loading 4-Stroke Diesel Engines Step By Step From No-Load to Rated Power as Function of the Brake Mean Effective Pressure

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 A.C. generating sets operating in parallel, the following requirements are to be complied with. See also 4/5A.5.5.2 for protection of A.C. 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 (D.C.) 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 D.C. 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 D.C. 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 D.C. generating sets operating in parallel, the following requirements are to be complied with. See also 4/5A.5.7.2 for protection of D.C. 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*** D.C.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

The following information was extracted from USCG Regulations and is included only for the convenience of the reader. It may reference other portions of USCG Regulations that are not included. Users of this recommended practice are cautioned that the latest revision of the subject document should be referred to for actual design criteria.

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, April 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

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46 CFR Ch. I (10-1-97 Edition) § 111.97-3

§ 111.97-3 General requirements. Each watertight door operating system must meet Subpart § 163.001 of this chapter.

§ 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 § 163.001-5(b) 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 upper-most 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, April 8, 1982, as amended by CGD 94-108, 61 *FR* 28283, June 4, 1996]

§ 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 water-tight 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

The following information was extracted from USCG Regulations and is included only for the convenience of the reader. It may reference other portions of USCG Regulations that are not included. Users of this recommended practice are cautioned that the latest revision of the subject document should be referred to for actual design criteria.

46 CFR Ch. I (10-1-97 Edition) § 111.105-1, Subpart 111.105—Hazardous Locations

§ 111.105-1 Applicability. This subpart applies to installations in hazardous locations as defined in the NEC and in IEC 79-0.

Note to § 111.105-1: Chemicals and materials in addition to those listed in Table 500-2 of the NEC and IEC 79-12 are listed in subchapter O of this chapter.
[CGD 94-108, 61 *FR* 28284, June 4, 1996]

§ 111.105-3 General requirements. All electrical installations in hazardous locations must comply with the general requirements of section 43 of IEEE Std 45 and either the NEC articles 500-505 or IEC series 79 publications. When installations are made in accordance with the NEC articles, marine shipboard cable that complies with subpart 111.60 of this chapter may be used instead of rigid metal conduit, if installed fittings are approved for the specific hazardous location and the cable type.
[CGD 94-108, 61 *FR* 28284, June 4, 1996]

§ 111.105-5 System integrity. In order to maintain system integrity, each individual electrical installation in a hazardous location must comply specifically with NEC articles 500–505, as modified by § 111.105-3, or IEC series 79 publications, but not in combination in a manner that would 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 non-approved equipment is prohibited.
[CGD 94-108, 61 *FR* 28284, June 4, 1996]

§ 111.105-7 Approved equipment. When this subpart or the NEC states that an item of electrical equipment must be approved or when IEC 79-0 states that an item of electrical equipment must be tested or approved in order to comply with IEC 79 series publications, 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 No. 496 or IEC 79-2.
[CGD 94-108, 61 *FR* 28284, June 4, 1996]

§ 111.105-9 Explosionproof and flame-proof equipment. Each item of electrical equipment that is required in this subpart to be explosionproof under the NEC classification system must be approved as meeting UL 1203. Each item of electrical equipment that is required in this subpart to be flameproof must be approved as meeting IEC 79-1.
[CGD 94-108, 61 *FR* 28284, June 4, 1996]

§ 111.105-11 Intrinsically safe systems. (a) Each system required under this subpart to be intrinsically safe must use approved components meeting UL 913 or IEC 79-11(Ia). (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 (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 RP 12.6, except Appendix A.1.
[CGD 94-108, 61 *FR* 28284, June 4, 1996, as amended at 62 *FR* 23909, May 1, 1997]

§ 111.105-15 Additional methods of protection. Each item of electrical equipment that is- (a) A sand-filled apparatus must meet IEC 79-5; (b) An oil-immersed apparatus must meet either IEC 79-6 or NEC article 500-2; (c) Type of protection ‘’e’’ must meet IEC 79-7; (d) Type of protection “n” must meet IEC 79-15; and (e) Type of protection “m” must meet IEC 79-18.
[CGD 94-108, 61 *FR* 28284, June 4, 1996]

§ 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 § 111.60-23. (b) Where conduit is installed, the applicable requirements of either the NEC or IEC 79 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 § 111.105-9. (d) Each cable entrance into Class II and Class III (Zones 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]

§ 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 No. 77.

§ 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, April 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°C (140°F), liquid sulphur carriers and inorganic acid carriers. (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 § 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 center-line 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 shut down 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 which has additional electrical equipment restrictions outlined in IEEE Std 45 and IEC 92-502. Cargo tanks must not contain any electrical equipment except the following: (1) Intrinsically safe equipment. (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 (3m) forward and aft of the cargo area on the open deck and up to 8 ft (2.4 m) above the deck. (3) Within 16 ft (5 m) of cargo pressure/vacuum valves with an unlimited height; or (4) Within 33 ft (10 m) 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, double bottom, or duct keel must meet ABS Rules for Building and Classing Steel Vessels, Section 4/5E1.15. (2) If a fixed gas detection system is installed, it must meet the requirements of SOLAS 74 and ABS Rules for Building and Classing Steel Vessels, section 4/5.

[CGD 74-125A, 47 *FR* 15236, April 8, 1982, as amended by CGD 82-096, 49 *FR* 4947, February 9, 1984; CGD 94-108, 61 *FR* 28285, June 4, 1996; 61 *FR* 33045, June 26, 1996; 62 *FR* 23909, May 1, 1997]

§ 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 § 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 (G-MSE) 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 § 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 § 154.459 of this chapter, except: (1) Through runs of marine shipboard cable; (2) Explosionproof lighting fixtures; (3) Depth sounding devices in gas-tight 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 § 154.459 of this chapter, except: (1) Through runs of marine shipboard cable; (2) Explosionproof lighting fixtures; (3) Depth sounding devices in gas-tight 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, April 8, 1982, as amended by CGD 77-069, 52 *FR* 31626, August 21, 1987; CGD 94-108, 61 *FR* 28285, June 4, 1996; 62 *FR* 23909, May 1, 1997]

§ 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 re-lease 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 d2 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 down-stream of the final degassing discharge. (5) A location in the weather or a semi-enclosed location, except as provided in paragraph d2 of this section, that is within 5 ft (1.5 m) of the boundary of any: (i) Equipment or opening specified in paragraph d1 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 ft (3m) above the drill floor; (ii) Below the drill floor and within a radius of 10 ft (3m) of a possible source of release, such as the top of a drilling nipple; or (iii) Within 5 ft (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 ft (1.5m) of a semi-enclosed Class I, Division 1 location indicated in paragraph d2 of this section; or (ii) Within 5 ft (1.5m) of a Class I, Division 1 space indicated in paragraph d5. (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 nonhazardous by the methods indicated in paragraph f of this section must be limited to essential equipment.

§ 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 10 ft (3 m) 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 No. 99.
[CGD 74-125A, 47 *FR* 15236, April 8, 1982, as amended by CGD 94-108, 61 *FR* 28285, June 4, 1996]

§ 111.105-39 Additional requirements for vessels carrying vehicles with fuel in their tanks. Each vessel that carries vehicles with fuel in their tanks must meet the requirements of ABS Rules for Building and Classing Steel Vessels, Section 4/5E3, except as follows: (a) If the ventilation requirement of ABS Rules for Building and Classing Steel Vessels, Section 4/5E3 is 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]

§ 111.105-40 Additional requirements for RO/RO vessels. (a) Each RO/RO vessel must meet ABS Rules for Building and Classing Steel Vessels, section 4/5E4. (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 18 in. (460 mm) or more above the deck of closed cargo spaces. Electrical equipment installed within 18 in. (460 mm) 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 Rules for Building and Classing Steel Vessels, section 4/5E4 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]

§ 111.105-41 Battery rooms. Each electrical installation in a battery room must meet Subpart 111.15 of this part and IEEE Std 45.
[CGD 94-108, 61 *FR* 28285, June 4, 1996]

§ 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, April 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 3 ft (1 m) 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 6.5 ft (2 m) of a Division 1 (Zone 10 or Z) location in all directions except when there is an intervening barrier, such as a bulk-head 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.’’
[CGD 94-108, 61 *FR* 28285, June 4, 1996]

§ 111.107-1 Industrial systems. (a) For the purpose of this subpart, an industrial system is a system that (1) Is not a ship’s service load, as defined in § 111.10-1; (2) Is used only for the industrial function of the vessel; (3) Is not connected to the emergency power source; and (4) Does not have specific requirements addressed elsewhere in this subchapter. (b) An industrial system that meets the applicable requirements of the NEC must meet only the following: (1) The switchgear standards in Part 110, Subpart 110.10, of this chapter. (2) Part 110, Subpart 110.25, of this chapter, Plan Submittal. (3) Subpart 111.01 of this part General. (4) Subpart 111.05 of this part, Equipment Ground, Ground Detection, and Grounded Systems. (5) Sections 111.12-1(b) and 111.12-1(c), Prime Movers. (6) Subpart 111.105 of this part, Hazardous Locations. (c) Cables that penetrate a watertight or fire boundary deck or bulkhead must (1) Be installed in accordance with § 111.60-5 and meet the flammability test requirements of IEEE Std 1202, Section 18.13.5 of IEEE Std 45, or IEC 332-3, Category A; or (2) Be specialty cable installed in accordance with § 111.60-2. [CGD 94-108, 61 *FR* 28286, June 4, 1996, as amended at 62 *FR* 23910, May 1, 1997] Visible indicators.

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