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Offshore Substation Design Development of Standards

Presented to:

Bureau of Safety and Environmental Enforcement (BSEE) &

Bureau of Ocean Energy Management (BOEM)

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1. Introduction

The Bureau of Safety and Environmental Enforcement (BSEE) and the Bureau of Ocean Energy Management (BOEM) requested proposals to provide recommendations for offshore substation design development of standards. The purpose of this project is to provide recommendations to BSEE and BOEM as to what additional standards may be applicable to offshore substation design as the agencies update their regulations. These recommendations will take into account the critical nature of the substation to the operation of the wind farm, while also considering costs of the structures when recommending standards. This will allow for economical, yet safe and environmentally conscious structures to be constructed.

BSEE and BOEM are government agencies within the United States (US) Department of the Interior, and are tasked with the oversight of facilities on the Outer Continental Shelf (OCS). The laws governing these lands include the Outer Continental Shelf Lands Act (OCSLA) and the Code of Federal Regulations (CFR), with the 30 CFRs relating to Mineral Resources specifically created for BSEE and BOEM to provide oversight. The OCSLA defines BSEE and BOEM jurisdiction of the OCS as 3 nautical miles (nm) off the coast seaward to the end of international US waters, defined as 200 nm seaward from the coast. All structures within this area are under BSEE / BOEM jurisdiction. Structures within 3 nm of the coast fall within State waters, and must follow rules as decided upon by the individual states. Structures beyond 200 nm fall outside of United States regulations as they are in international waters.

Historically, offshore structures in the US have been related to the oil and gas industry. However, as offshore wind developments progress in the US, guidance for offshore wind farms is necessary for BSEE and BOEM to provide proper oversight. Wind farms consist of wind turbine generators (WTGs) and an offshore substation, sometimes referred to as an Electrical Service Platform (ESP). This project will focus on design standards for the ESPs only. Traditionally, offshore wind farms have used alternating current (AC) substations to transfer electricity from the wind turbines to the shore. However, European projects are also now using direct current (DC) substations for wind farms far off the coast. Design standards for both types of substations and their corresponding equipment are considered as part of this project.

As government oversight agencies, BSEE and BOEM have similar objectives in their oversight of OCS lands. BSEE's mission statement designates that it "promotes safety, protect the environment, and conserve resources offshore through vigorous regulatory oversight and enforcement." BOEM's focus is to promote "energy independence, environmental protection and economic development through responsible, science-based management of offshore conventional and renewable energy and marine mineral resources." To aid BSEE and BOEM in achieving these goals, Moffatt & Nichol (M&N) will focus on design aspects that relate to safety and environmental protection. It should be noted that this project is focused on the design and construction of facilities. Operations and maintenance requirements will not be considered.

M&N broke this project into three main tasks described below and detailed in Figure 1:

- Task 1 - Identification of Codes and Standards
- Task 2 - Identification of Gaps in Codes and Standards
- Task 3 - Develop Recommendation Practices for Applying the Codes and Standards

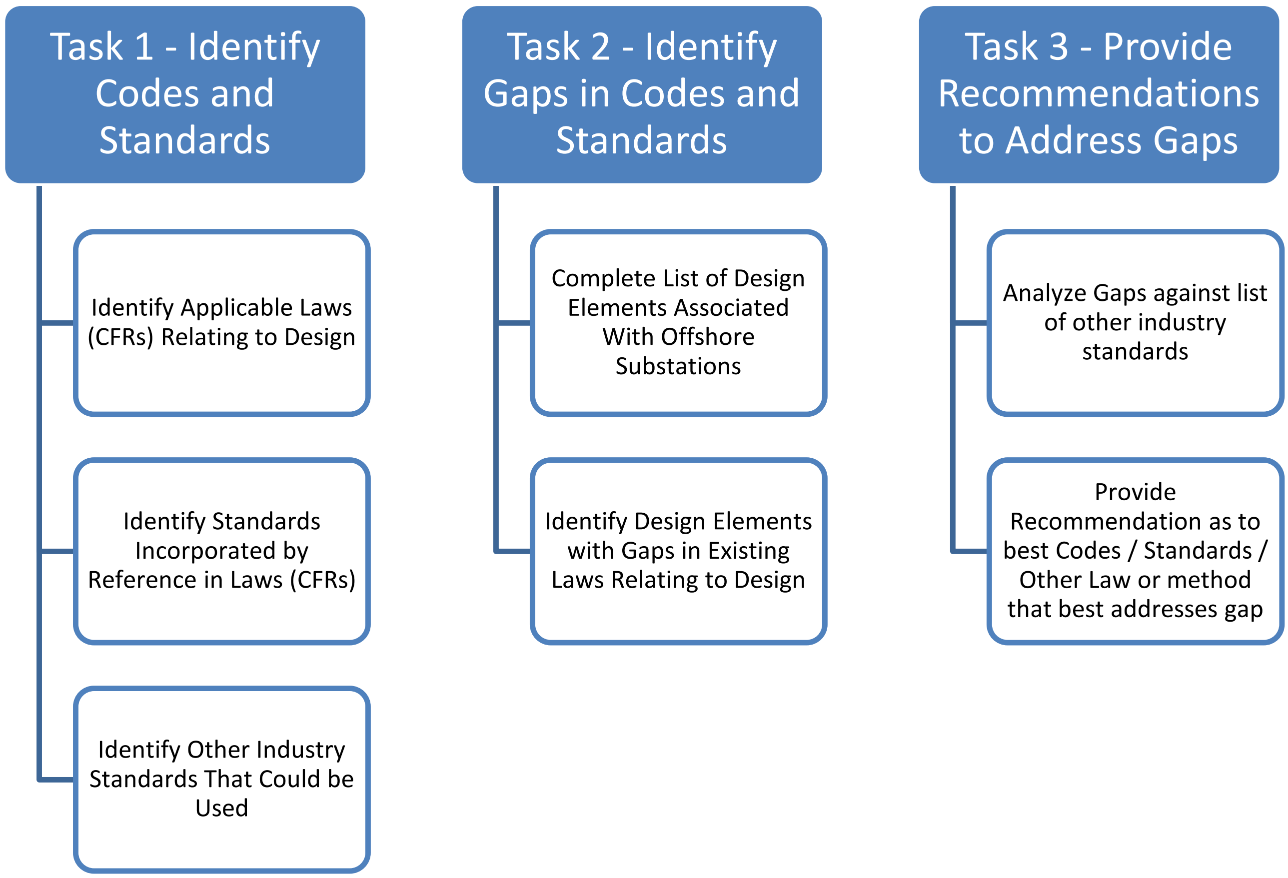

Figure 1: Project Plan

Each of these tasks was completed by M&N and submitted to BSEE / BOEM for intermediate reviews. Task 1 is now represented by Appendix A, while Tasks 2 & 3 are represented in Appendix B. This final report builds upon the three tasks and the comments received from the reviews completed by BSEE and BOEM to provide a final set of recommendations for the two respective agencies' use.

In this report, recommendations are provided for each design element associated with an offshore substation that was determined to lack sufficient guidance to design using current codes and standards. Recommendations are provided based upon industry standards currently available and assuming standards required for the oil and gas industry such as 30 CFR 250 do not apply unless it specifically references both structures relating to renewable energy and located on the Outer Continental Shelf. If no code or standard is deemed sufficient to address a particular design element, commentary on how BOEM / BSEE can provide oversight will be provided. These recommendations are summarized in tables included in the Appendices. This report provides the basis for each recommendation and explains the identification of the preferred standards to be used by designers and BOEM / BSEE.

2. Current Laws Governing Design

Gaps were identified in the second task of this project. The gaps were determined after consideration of standards that are clearly required by the Federal government only. If it is unclear whether a particular CFR or standard applied for an offshore substation, it was considered a gap in current guidance and a recommendation was provided on how to provide clarification. Analysis of codes and standards has determined that current offshore substation design is governed by the Code of Federal Regulations (CFR), with three specific CFRs clearly applicable to offshore substations, 29 CFR 1910, 29 CFR 1926, and 30 CFR 585. These are shown in Table 1 and described in detail below.

Table 1: Clearly Applicable CFRs to Offshore Substations

List of Applicable CFRs	Main Title	Subtitle
29 CFR 1910	Labor	Occupational Safety and Health Standards
29 CFR 1926	Labor	Safety and Health Regulations For Construction
30 CFR 585	Mineral Resources	Renewable Energy and Alternate Uses of Existing Facilities on the Outer Continental Shelf

2.1. 29 CFR 1910 – Occupational Safety and Health Standards

OSHA regulations found within 29 CFR 1910 specifically include Outer Continental Shelf lands within the areas that the OSHA rules apply, so these are considered mandatory for offshore substation design.

2.2. 29 CFR 1926 – Safety and Health Regulations for Construction

OSHA regulations relating to construction activities specifically include Outer Continental Shelf lands. Although developers tend to minimize construction at sea due to the expense, all construction related activities on the OCS of offshore substations fall under 29 CFR 1926.

2.3. 30 CFR 585 – Renewable Energy and Alternate Uses of Existing Facilities on the Outer Continental Shelf

30 CFR contains the Mineral Resources regulations that are used as the basis of oversight by BOEM and BSEE. Most of the 30 CFR regulations cover rules for mines and oil explorations, but one CFR has been created specifically for renewable energy, including offshore substations; 30 CFR 585 "Renewable Energy and Alternate Uses of Existing Facilities on the Outer Continental Shelf." Based on discussions with BOEM, 30 CFR 585 may be updated to provide clarification for future offshore substation design using the recommendations of the final report. Additional new CFRs within 30 CFR may also be created to expand upon 30 CFR 585 and provide further clarification for future wind farm projects.

2.4. Standards Incorporated by Reference

The CFRs have standards incorporated by reference. Standards incorporated by reference into CFRs are then required for design as if the standard was copied into the CFR directly. For 30 CFR 585, there is only one standard incorporated by reference, API RP 2A – WSD 21st edition, Section 17.2. 29 CFR 1910 and 29 CFR 1926 have many different standards incorporated by reference, including multiple ANSI, ASME, and NFPA standards. All standards that are incorporated by reference are designated with a "#" symbol in Appendix A of this report.

3. Gaps Identified in Design Elements

Over 200 codes, standards, and laws were considered for this project relating to offshore substation design. Using the existing codes and standards that are required that were identified in Section 2, gaps were identified in these codes and standards for the design elements relating to offshore substations. To accomplish this, a table of design elements has been included with a column identifying gaps in the required design standards.

Gaps were identified on the premise that the standard generally applies and covers the typical aspects of design or does not. All projects are different and an area that is defined as having no "gap" may in fact have a minor gap relating to a specific detail of a design element on that particular project. The purpose of this report is to address typical design situations and provide recommendations that will cover a significant amount of typical design aspects, but likely not 100% of all issues that may be considered during the design of an offshore platform.

It should be noted that gaps were identified for required standards only, as identified previously in Section 2. Although a standard such as API RP 2A may be applicable to steel design and provide clear guidance for designers, if it is not clearly required as a design standard as described in the previous section, it was not considered applicable to the particular design element and a gap was identified if necessary. A complete list of design elements and gaps can be found in Appendix B. Design elements and their corresponding gaps are broken down into the following categories:

1. Structural (including Geotechnical)
2. Pre-Service
3. Safety
4. Environmental
5. Electrical
6. Mechanical
7. Fire Protection
8. Helideck

The standards required for each category and how they impacted the gap research are described below. As recommendations were considered in Section 4, any additional gaps discovered were included in the design element list in Appendix B with gaps detailed. The complete design element list with gaps included in Appendix B is intended to be comprehensive of all design aspects under the jurisdiction of BSEE / BOEM that designers require guidance for.

3.1. Structural (Including Geotechnical) – In-Service

Structural design elements considered included standard steel pile-jacket structure platform design, gravity based structure (concrete) design, as well as design of floating and tension leg platform types that are used in the oil & gas industry. Other structural design related elements, including live and dead loads and corrosion protection, have also been included. The gap analysis of this section focuses on the text of 30 CFR 585 and the required standard of API RP 2A – WSD 21st edition (Section 17.2) referenced in 30 CFR 585. The structural gaps were then determined assuming only that section of API RP 2A 21st edition is required for structural design. API has also recently released a new edition of API RP 2A – WSD 22nd edition, as well as a few other structural related standards. These were reviewed to determine if the current CFR should be updated to reflect the newest edition of the CFRs, as the CFRs do not default to the newest edition of a standard and must refer to a specific edition of a standard to provide clear guidance to designers and reviewers. Geotechnical design and decommissioning are also included in this section.

3.2. Pre-Service

The pre-service section includes the transportation, fabrication, and installation conditions of the structure before it is completed at the site. As the CFRs only refer to the API RP 2A WSD 21st edition, Section 17.2 relating to existing structures, no standards apply for pre-service conditions at this time. Only the text of 30 CFR 585 provides guidance that is required. Design elements were compared with these requirements and gaps were identified assuming no standards are required regarding pre-service conditions. Design elements considered include forces during load out, transportation, lifting, impact loads, and tolerances during construction.

3.3. Safety

The safety section focuses on 29 CFR 1910 and 29 CFR 1926, commonly referred to as the OSHA codes, as well as the requirements within 30 CFR 585 for a Safety Management System. The OSHA codes reference many ANSI, NFPA, API, and ASTM standards for various human safety-related aspects of general building design and also includes text that can help guide design. The Safety Management System includes describing how the operator will ensure the safety of personnel and people near the facilities, as well as monitoring, emergency response, testing, training, and fire protection for the facility, but lacks specifics regarding how to design to achieve such measures. Design elements considered include design for handrails, ladders, stairways, aids to navigation, aviation aids, and emergency shelters. A complete list is included in Appendix B.

3.4. Environmental

Design elements relating to environmental issues include oil spills and an environmental management program. No CFR regarding environmental issues clearly states that it covers Outer Continental Shelf Lands for structures relating to renewable energy, which are commonly guided by permit requirements. 30 CFR 585 does require a Safety Management System for all facilities which must address equipment failure and environmental effects, but little specific guidance is provided in this text. All design elements are thus regarded as having gaps since no clear guidance is provided in the CFRs at this time. Recommendations are provided for both design elements.

3.5. Electrical

Design elements include design of various electrical components of electrical substations, including cables, cable trays, panelboards, switchgear, conduits, transformers, and transfer switches, as well as parts of an offshore platform including lighting, backup generators, backup batteries, communications systems, PAGA systems, surge arresters, and lightning protection. Guidance for the electrical sections focuses on the required 29 CFR 1910 and its corresponding safety-related aspects of the OSHA rules regarding electrical design. The text of 29 CFR 1910 itself also provides general guidance in some areas, so gaps in the text itself have been identified and are clarified with recommendations for some electrical design elements.

3.6. Mechanical

Design elements relating to mechanical design focused on cranes, HVAC, and drainage elements including pumps, pipes, and dump tanks. Mechanical codes reviewed focused on 29 CFR 1910 and the safety related aspects of the OSHA rules regarding mechanical standards. In a similar manner to the electrical section, the text of 29 CFR 1910 provides general statements that lack detail as to what codes and standards to follow to meet the requirements of the CFR. Gaps have been identified where a specific code may be added to provide designers with sufficient information to meet the CFR required design element.

3.7. Fire Protection

Design elements considered relating to fire protection include general fire protection philosophy, fire detection systems, fire suppression systems, and fire extinguishers. The fire protection rules required are from the OSHA codes in 29 CFR 1910. This includes multiple codes and standards from the National Fire Protection Association regarding safety. A complete list of design elements and their associated gaps are found in Appendix B.

3.8. Helideck

Design elements considered for the helideck include structural considerations, electrical connections to the platform and fire protection. The helideck codes and standards reviewed included API RP 2A 21st edition and the OSHA laws of 29 CFR 1910 and 29 CFR 1926. It should be noted that the FAA has recognized that helidecks on fixed offshore facilities are under the purview of the Department of the Interior. FAA standards are thus considered to not be required under law for offshore platforms at this time.

4. Commentary on Recommendations

Using the list of design elements and their associated gaps previously described in Section 3 and provided in Appendix B, recommendations for each design element and respective gap is provided. Commentary on the recommendations for each design element includes the section of the code or standard recommended, if applicable, and a description on why that code or standard addresses the gap. Special consideration is given to codes and standards that are readily available in the United States, with International codes and standards looked at as alternatives to US codes when required. It should be noted that recommendations are intended to cover typical design situations, but that 100% of all aspects of design will not be covered. Areas where no gap was identified may also have small gaps related to that particular design element.

4.1. Structural (Including Geotechnical) – In-Service

As previously identified in Section 3.1, the only design element with clear guidance regarding structural and geotechnical design is the inspections and assessment, as API RP 2A 21st edition, Section 17.2 is referenced in 30 CFR 585. However, Section 17.2 is applicable to existing structures, and does not address issues related to structural design. The text of 30 CFR 585 does require the designer to provide design related information such as loads used, design-life, fatigue, and material life, but does not provide any guidance as to what design methods or standards to follow to achieve these requirements. This lack of detail has led to gaps identified for every design element. Below is the commentary for each structural design element identified and its corresponding recommendation.

4.1.1. Platform Loads – Dead and Live Loads

Dead and live loads are a safety concern, in that assuming too little dead or live load could result in members that are under designed, potentially causing structural failure. API RP 2A-22nd edition provides general guidance for dead and live loads, but no specific information that can be utilized by the designer for expected live loads on an offshore substation. ASCE-07 may be utilized, along with any requirements specified by the owner to provide required design uniform distributed live loads. ASCE-07 can also be utilized to determine the load reduction factors that can be used for design along with the design loads. ASCE-07 is recommended to be required for offshore substation design.

4.1.2. Platform Loads – Environmental Loads: Wind, Current, Waves

API RP 2MET has recently been released to address metocean design and operating conditions for offshore structures. This document sufficiently addresses the methodologies required to develop comprehensive site specific metocean data that is needed to characterize the environmental loads associated with wind, waves, and currents for offshore substations, with detailed descriptions of the required data in Chapter 5. Additional guidance is provided in Annex C which includes indicative values for specific metocean parameters, such as wave height and wind speed, which is intended for initial planning and concept development. While there is some data provided along the East coast of the US (Georges Bank, Baltimore Canyon, Georgia Embayment), the metocean data provided in Annex C is intended for use for oil & gas developments and does not necessarily apply to areas where offshore wind developments may be planned. Areas not included in API RP 2MET will require additional analyses to develop data similar to that provided for the Gulf of Mexico included in Annex C, Section 4 of the API RP 2MET document.

It should also be noted that API RP 2MET considers 10 meter water depth as the minimum water depth. There are multiple offshore wind farms in water depth below 10 meters in Europe, so design conditions that fall outside of the limits of the data provided in API RP 2MET is possible even if a wind farm is located in a region contained within API RP 2MET. In this situation, a site specific study to determine the characteristics of the waves and current, including the breaking wave characteristics would be required in a similar manner to a site located in a region not included in API RP 2MET.

4.1.3. Platform Loads – Environmental Loads: Snow and Ice

API RP 2N section 4.5 provides ice loadings and calculation procedures for artic conditions. It includes typical ice thicknesses for areas off the coasts of Alaska, Canada, and Australia, but lacks information for many areas where offshore wind platforms may be constructed. It is therefore necessary that a site specific study be completed to provide the details required to complete the calculations contained within API RP 2N. This includes information on the ice including, but not limited to, its physical dimensions, velocity, density, and frequency of occurrence as described in API RP 2N section 4.1.1.

The National Oceanic and Atmospheric Administration (NOAA) US National Ice Center provides historic and forecasts for ice levels in the United States including the Chesapeake and Delaware Bays and the Great Lakes as well as information on ice levels in the Arctic and Antarctic. This allows the designer to best determine if an ice loading situation is possible and if a site specific ice study is required. Once these ice characteristics have been determined, calculations provided in API RP 2N Section 4.5 can then be used to determine the ice loadings on the structure.

4.1.4. Platform Loads – Environmental Loads: Earthquake

API RP 2EQ has recently been released to address seismic (earthquake) loads on offshore structures. API 2A-WSD, 22nd Edition references this document as the basis for seismic design. API RP 2EQ requires a two-level seismic design in which the structure is designed to the ultimate limit state (ULS) for strength and stiffness using extreme level earthquake (ELE) and then checked to the abnormal or accidental limit state (ALS) using abnormal level earthquake (ALE) to ensure that it meets reserve strength and energy dissipation requirements. The API RP-2EQ provides two alternative procedures for seismic design, a simplified and a detailed method. A simplified method may be used where seismic considerations are unlikely to govern the design of a structure, while the detailed method may be used where seismic considerations have a significant impact on the design. Selection of the appropriate design procedure shall follow API RP 2EQ. The selection of design procedure is based on exposure level of the structure and the expected intensity and characteristics of seismic events as described in API RP 2EQ. Determination of the structure exposure category shall be based on the requirements of API 2A – WSD, 22nd Edition, however, an exposure category of L-1 for offshore electric substations should be considered, as the failure of the platform has a significant economic impact on the entire wind farm. This standard (API RP 2EQ) has been deemed acceptable to address the gap of seismic design for an offshore substation platform. It should also be noted that API RP 2EQ was created with the intent that it would have a similar design process as ISO 19901-2, as API and ISO are in the process of a harmonization of their standards.

4.1.5. Platform Loads – Accidental Loads: Fire Loads

API RP 2A 22nd edition, Section C18.6.3 provides design methodologies relating to fire on a platform. These calculations include maximum allowable temperature of steel allowed for a given strain to maintain structural integrity of the platform (the zone method). This methodology is sufficient for offshore platforms, but an analysis by a fire protection engineer should be conducted to determine the maximum temperature and duration of a fire on an offshore substation given that only two common elements on an offshore substation can maintain a fire: a high voltage transformer and a diesel generator. API RP 2A 22nd edition is therefore acceptable as the design standard to use, but with additional guidance provided by a fire protection engineer.

DNV-RP-C204 Section 5 also details fire loads on offshore platforms. It references Eurocode codes for stress-strain relationships that US designers may be less familiar with. It is recommended that no required codes be provided by BSEE / BOEM and the designer should be allowed to provide documentation that analysis of fire loads on the platform has been completed, utilizing either of these codes.

4.1.6. Platform Loads – Accidental Loads: Blast Loads

API RP 2A 22nd edition Section C18.7 details calculations for blast loading on an offshore structure. Offshore substations have high voltage transformers and high voltage gas insulated switchgear equipment that can potentially create a blast situation. Information from the equipment supplier should be provided to determine the appropriate overpressure situation that a given equipment may create.

DNV-RP-C204 also provides information on designing for blast loads in Section 6. This section provides information on which types of resistance models are required for various failure modes. Similar to API RP 2A 22nd edition, information from the equipment supplier is required for this analysis.

Both API RP 2A 22nd edition and DNV-RP-C204 are sufficient for design. The recommendation is for BSEE/ BOEM to request documentation of analysis for blast loads and allow the designer to provide calculations. This is also practical, as equipment manufacturers of transformers and GIS gear may produce this analysis, and may be based in Europe and more familiar with DNV codes while the structural design may be performed by a US firm more familiar with API codes.

4.1.7. Platform Loads – Accidental Loads: Vessel Collision

API RP 2A 22nd edition has guidance in the commentary of section B17.9.2 regarding vessel collisions. These calculation procedures are appropriate for the structural design of an offshore substation. However, the default vessel mass and velocity should be determined from site conditions in lieu of the default values provided in section B17.9.2. This is reasonable as offshore wind farm supply vessels could potentially be smaller than oil and gas platform vessels. These smaller vessels may not produce the same force as the values provided in the commentary of API RP 2A 22nd edition. It is therefore recommended that the default velocity of the vessel equal the 1-year return period surface current in the area of the platform, while the largest vessel likely to transit the vicinity of the platform be used as the vessel mass. It should be noted that DNV-RP-C204 Section 3 has information on accidental loads. The default loads for vessels may be inconsistent with those utilized in API methods, with the site specific study of expected ships recommended for either the API or DNV calculations. The DNV document is an acceptable alternative to API RP 2A 22nd edition as both are quality documents. With two acceptable methods available for determining vessel collision design, it is recommended that the regulations are written in such a way that either standard is allowed to be used by the designer. This could be accomplished with no standard required for analysis and allow the designer to provide documentation of the analysis chosen, or stipulating both codes and clarifying that only one is to be utilized for design to prevent potential conflicts from using both.

4.1.8. Platform Loads – Accidental Loads: Dropped Objects

API RP 2A WSD 22nd edition Section 17.9.3 describes that dropped objects should be considered in design of offshore platforms, especially around crane loading areas. The platform is to survive initial impact from dropped objects and meet post-impact criteria similar to vessel collisions. The structural effect from dropped objects may either be determined by non-linear dynamic finite element analyses or by energy considerations combined with elastic-plastic methods. Impact forces and energy absorption design calculations for tubular members are provided in API RP 2A 22nd edition section B17.9.2 under "Damage Assessment." Further discussion and detail calculations on quantifying impact forces and energy dissipation should be more explicitly addressed as they relate to dropped objects.

DNV-RP-C204 also contains information on dropped objects in Section 4, but API RP 2A 22nd edition better describes the checks required for a structure given a design dropped object. The API RP 2A 22nd edition standard is therefore recommended for design of offshore substations for dropped objects.

4.1.9. Platform Loads - Load Combinations

API RP 2A – WSD 22nd edition Section 5.2.2 describes four loading conditions which combine environmental, dead, and live loadings to produce the most severe effects on the structure. These four loading conditions within API RP 2A 22nd edition sufficiently address an offshore ESP platform's design loadings. In cases where a particular loading is not addressed in API RP 2A 22nd edition, but is adequately addressed in a different standard (such as ASCE 7-05), then the requirements of that standard for that loading can be used to supplement API RP 2A 22nd edition.

In typical multi-piled structures (e.g., jackets, tripods) the overturning moments that are generated from environmental forces produce compressive reactions in the leeward piles and tensile reactions in the windward piles. There is potential for significant net tensile pile reaction in situations where pile axial reactions to gravity and buoyancy forces are small relative to those associated with environmental forces. The tensile capacity of a driven pile will typically be less than its compressive capacity due to the fact that the end bearing only contributes to compressive strength. It is therefore prudent to confirm that pile penetration is adequate to provide the necessary tensile capacity for cases where tensile reactions may control.

The load combinations provided in section 5.2.2 of API RP 2A WSD 22nd edition do not include provisions for conditions that would create greater potential for tensile pile reactions. A light deck load condition could include, for example, minimal live loads in combination with reduced dead loads. It is common practice to check for reduced deck load conditions as part of both structural design and determination of pile penetration requirements, however, this is not applied consistently. It is suggested that specific guidance be provided to address this issue. Such guidance could adopt either an explicit accounting for light deck load conditions used in the WSD design approach (e.g., determination of lighter live load conditions based on dry equipment weights, storage, etc.) or follow an LRFD methodology where the maximum gravity forces are reduced by 10% in situations where gravity loads are beneficial.

4.1.10. Steel Design – Materials

API RP 2A WSD 22nd edition Section 11 sufficiently defines the required material properties for structural steel, cement grout and concrete. Table 11.1 lists the yield and tensile strengths for a variety of ASTM graded steel plates, and Table 11.2 and Table 11.3 also list the material properties for structural steel shapes and pipes. Steel materials are grouped in Section 11.1.2 based on their strength level and welding characteristics. Considerations should be given for selection of steels per Section 11.1.3 based on steel classes with notch toughness characteristics suitable for the conditions of service. Steel specifications should conform to Section 11.1.4. The specifications, fabrication and selections for conditions of service for structural steel pipes should be per Section 11.2. Recommendations for steel tubular joints in Section 11.3 should be considered. Structural steel is often the principal framing material used in the offshore platforms and therefore more thoroughly addressed in API RP 2A 22nd edition. Cement grout and concrete materials are often applied as substructure materials. API RP 2A 22nd edition Section 11.4 provides minimal compressive strengths, ASTM specifications and concrete mixture limits.

4.1.11. Steel Design - Superstructure Design

API RP 2A WSD 22nd edition Section 6 has guidance for the design of tubular members. Equations for computing the allowable tensile, compressive, bending and shear stresses are provided within this section. Hydrostatic pressure considerations such as design hydrostatic head, hoop buckling stress and ring design are also applicable to offshore platform design. Section 6.3 of API RP 2A 22nd edition also addresses combined axial compression and bending of cylindrical members. Section 7 of API RP 2A 22nd edition includes strength of tubular joints. API RP 2A 22nd edition thoroughly discusses the design aspects of cylindrical steel members; however AISC Steel Construction Manual should be referenced for guidance on the design of other structural shapes (non-tubular) and their connections. For this purpose, use of Allowable Strength Design (ASD) approach in accordance to the latest edition of AISC 360 should be considered. Where permitted by API RP 2A 22nd edition, the non-tubular member and connection capacities calculated per ASD approach can be increased by one-third. API RP 2A 22nd edition recommendation for not using AISC 360 should be ignored for design of such members of offshore substations. Consistent with API's cylindrical design approach, working stress design (or allowable strength design per AISC 360) is the recommended design methodology to be implemented throughout the entirety of the platform's superstructure design.

4.1.12. Foundation Design - Substructure, Steel Pile / Jacket

API RP 2A WSD 22nd edition Section 9.2 provides guidance for the design of steel piles with references to API RP 2GEO for certain calculations. Dialogue on driven, drilled and belled piles is provided with descriptions on when and how to implement such procedures. Pile design is discussed in API RP 2A 22nd edition Section 9.3. Many vital aspects of pile design are thoroughly discussed within this section. Factors of safety, ultimate bearing capacities, skin friction and end bearing capacities for a variety of soils is also discussed. Soil strength parameters of the project site is vital to accurately portray the soil's bearing characteristics. Soil borings are recommended as part of the site geotechnical survey for all offshore substation projects. Other topics addressed in this section are the following: axial pile performance and corresponding soil reaction, lateral pile performance and corresponding soil reaction, load-deflection cures, pile group action and pile wall thickness.

The current design standards and recommended practices lack guidance regarding the assessment of pile fatigue that may occur during pile driving, particularly for projects at sites with potential for hard driving or early pile refusal. Fatigue damage that may occur during pile driving reduces the available in-service fatigue life and, in some instances, may require a modification to the pile design, welding procedures or installation methods if the combination of pre-service and in-service fatigue damage is excessive. API RP2A 22nd edition provides factors of safety for fatigue that range from 2 to 10 depending on the inspectability and criticality of each connection. Using the API RP 2A 22nd edition methodology, it is acceptable to apply a factor of safety of 2 for connections that are both accessible for inspection and do not contribute to the primary load carrying strength of the structure while a factor of safety of 10 is recommended for connections that are not easily accessible for inspections and contribute to the primary load carrying strength of the structure. A factor of safety of 5 is recommended for the other two conditions. As piles are both not accessible for inspection and contribute to both the vertical and lateral load carrying strength of the structure, a factor of safety of 10 would be indicated following API RP 2A 22nd edition recommendations.

The factors of safety recommended in API RP 2A 22nd edition have been developed for tubular joints that are subject to cyclic loading associated with wave loading. The conditions associated with pile driving are somewhat dissimilar to these presumed in the factors of safety that API RP 2A 22nd edition recommends in that; 1) the number of loading cycles that could occur during pile driving is limited, 2) pile driving stress amplitudes can be estimated with a greater level of confidence than those associated with a full wave spectrum and 3) the stress concentrations associated with typical girth welds are lower and include less uncertainty than those associated with most tubular joints.

Because of these three differences, the development of appropriate analytical methods and factors of safety for pile driving fatigue is an area that requires further investigation. It is recommended that the factors of safety provided in API RP 2A 22nd edition be generally applied for both pre and in-service fatigue conditions as this should constitute a conservative practice. However, a rational method should be acceptable to justify lower factors of safety for the pre-service portion of the fatigue analysis for situations with significant pile driving fatigue that may result in the estimate of total fatigue damage levels in the piles that is not acceptable.

4.1.13. Structural Design - Substructure, Concrete Gravity Foundation

ACI 357R-84 provides some general guidance on the design and construction of fixed offshore concrete structures. The design of mat\gravity foundations resting directly on the sea floor is mentioned within the document specifically addressing bearing, hydraulic stability, deformations\vibrations, and soil base reactions. No direct design parameters or formulas are given; however, a detailed list of items to include materials and durability, loads, design and analysis, foundations, construction-installation and relocation and inspection and repair are discussed in the document. It should be noted that API RP 2CON, when released, might also be a viable source of guidance for concrete gravity foundation design.

4.1.14. Structural Design - Substructure, Floating

Floating ESP substructures are likely to employ either conventional monohull/catamaran vessels, or semi-submersible vessels (SSV). The design of such vessels in the oil/gas industry is presently guided by API RP 2FPS Second Edition, October 2011 Planning, Designing, and Constructing Floating Production Systems. This was developed for the application of trading vessels to long-term use at a fixed location where repairs at a drydock are not possible.

These rules are written to be used in conjunction with normal class rules for the type of vessel under consideration. Many of the rules associated with the shipping industry have no application to an offshore substation, however the issues relating to rotationally fixed spread moorings versus turret moorings and the transfer of product from the seabed to the deck do have similarities. The spread mooring systems used for such vessels are designed to the guidance of API RP 2P Recommended Practice for the Analysis of Spread Mooring Systems for Floating Drilling Units, Second Edition, and May 1987.

It is recommended that API RP 2FPS and API RP 2P be utilized for floating offshore substation design.

4.1.15. Structural Design - Substructure, Tension Leg Platforms (TLP)s

The tension leg platform is an inverted pendulum that is kept on station by buoyancy forces. This type of platform is efficient and economically competitive in carrying significant payload only when the water is relatively deep. The current design of TLPs in the USA is guided by API RP 2T Third Edition, July 2010 Planning, Designing, and Constructing Tension Leg Platforms. This provides adequate guidance for the possible application of TLP technology for use as an offshore substation and is the recommended code to be utilized.

It should be noted that some parametric work would be beneficial to establish what ranges of applicability exist as the longer distances to deep water from shore in many locations suggest that the direct current (DC) electrical systems would be required to efficiently transmit the electricity to shore. These DC platforms are typically significantly heavier than alternating current (AC) platforms, a characteristic that makes DC platforms less likely to be appropriate for TLP use. The importance of the substation to the wind farm is paramount with a high consequence of failure, so particular attention should be paid to the rules defining the reliability of this type of substructure.

4.1.16. Structural Design - Jack-Ups

The jack-up barge platform offers a feasible concept for the installation, operating and removal phases of an ESP. The design of this type of substructure is sensitive to dynamic excitation.

The design process for jack-ups has evolved from a simple, highly empirical proprietary set of processes that assumed pin-supports at the spud cans. It passed to the present state of the code practice presented in SNAME's Guidelines for Site Specific Assessment of Mobile Jack-up Units [T&R Bulletin 5-5 and 5-5A, Panel OC-7 Site Assessment of Jack-Up Rigs, 2008] and more recently to ISO 19905-1 (2012) Petroleum and natural gas industries – Site-specific assessment of mobile offshore units – Part 1: Jack-ups.

The application of this type of structure is likely to be used in shallower waters than their Mobile Offshore Drilling Unit MODU counterparts, however, the application of the recent site-specific assessment codes may be simplified for the one-depth application for offshore substations, where the leg fixation and jacking systems may be modified after preload and setting to final elevation. A wind farm specific offshore substation code may benefit from such a study and simplification, but does not exist at this time. The use of ISO 19905-1 is thus recommended at this time.

4.1.17. Structural Design - Mobile Offshore Units

Mobile offshore drilling unit (MODU) is a general range of vessel classes covered historically under the classification rules of the American Bureau of Shipping (ABS). The vessel types covered are: surface-type (ship-shape), column-stabilized (semi-submersible) and self-elevating (jack-up) barges. An adaptation of these rules may be suitable for the design of the substructure types described under sections 1.1.9 thru 1.1.11, however, a large difference in some areas of structural reliability, such as metal fatigue, may exist between a permanent substructure application and a mobile structure. This is seen in the requirement for annual inspections for MODUs wherein repairs in a shipyard can be made. Offshore substations cannot practically be repaired in a shipyard since it must function and remain on station for the life of the unit. The development of, or the adaptation of MODU rules for wind industry offshore substations must reflect this difference in required reliability. This aspect of the offshore wind structures codes should reflect the implications of this difference. No code is recommended for Mobile Offshore Units at this time. Design must be approved on a case-by-case basis with a heavy consideration on fatigue of the structure.

4.1.18. Steel Design – Fatigue

API RP 2A WSD 22nd Edition Section 8 provides guidance for fatigue design of offshore structures. It includes descriptions on wave climate to be used for analyzes, requirements for modeling of space frames for analysis, as well as local stress, hot spot stresses, stress concentration factors (SCFs) and S-N curves for stiffened, non-stiffened, grouted tubular connections and cast nodes. The section also provides the fatigue life safety factors to be used. For S-N curves associated with fatigue of non-tubular connections and tubular connections where stress concentration factors are not known, API refers to AWS D1.1:2010. An S-N curve for tubular connections is included in Figure 8.1. This standard (API RP 2A WSD 22nd) has been deemed acceptable to address the gap of fatigue design for an offshore substation platform.

Although DNV-RP-C203 also describes fatigue design, providing design methodologies and procedures, including thorough discussions of fatigue analysis based on S-N data, simplified approaches and fracture mechanics, it is recommended that API be used, as it is a complete document and should be used to remain consistent, using American standards were possible.

4.1.19. Steel Design – Appurtenances

API RP 2A WSD 22nd Edition provides general guidance for the design of appurtenances such as J-tubes, mudmats, and boat landings. Although API RP 2A 22nd edition does not have a specific chapter related to these appurtenances, they should be designed according to the related topics described above such as dead and live loads, load combinations, materials, and fatigue. API RP 2A is the recommended standard for appurtenance design.

4.1.20. Corrosion Protection

NACE SP0176 provides guidance for the control of corrosion of submerged offshore steel structures. Protective coating systems and cathodic protection (CP) are used for corrosion control in the splash-atmospheric and submerged zones of the structure, respectively. Using tubular structural members and continuous welded joints are just some of the recommended design features that are noted within the document. Criteria for CP and methods of measuring its effectiveness are described along with procedures for the design of CP systems. Cathodic protection is extensively discussed within NACE SPO176; however, protective coating systems is more thoroughly addressed in NACE TG 313.

Submerged steel CP is most commonly provided using sacrificial CP anodes, however, the ample supply of power at an offshore substation suggests impressed current systems, especially for any floating options could be a viable option. NACE SP-0176 is thus recommended as the standard for corrosion protection.

4.1.21. Coatings

Coatings are a vital design element to maintain offshore substations in the corrosive marine environments. Coating failure can lead to structural failure due to loss of section if not properly maintained and inspected. To reduce these risks, requiring NACE SP-0108 in conjunction with NACE SP-0176 can provide sufficient design information to properly design the coating and corrosion protection systems for offshore substations.

4.1.22. Scour

The effects of seabed scour on the design and performance of offshore substation foundations include modified dynamic response, increased structural demands on piles, reduced capacity of gravity base foundations and problems due to movement at the points of contact of the electrical conductors with the seabed.

The evaluation of seabed scour is well developed for vertical cylinders in predictable soils, but when structures are supported by pile groups, or when oblique and horizontal framing members or mudmats are present, the problem becomes more complex. In these situations, some guidance is available but CFD numerical modeling or physical model testing may be the best method to obtain predictable characterization of the scour.

API RP 2A-22nd edition does address scour generally in Section 9.3.6, but provides no details to specifically determine scour. Evaluations should address general seabed scour, possible sand waves and local scour. USDOT FHWA HEC-18 – Evaluating Scour at Bridges, Fifth Edition is the recommended source for scour analysis, as it provides guidance for such issues as pile grouping that are common with offshore substations. Alternative methodologies directly referenced in HEC-18, such as that used by Florida DOT, are also appropriate for such analyses. Offshore Standard Det Norske Veritas AS, DNV-OS-J101 – Design of Offshore Wind Turbine Structures offers some guidance on the subject in chapter 4.E.900, but does not address pile grouping and is less applicable than HEC-18 for most substation foundation designs. Additionally, numerous other references and textbooks address the general mechanics of scour and sediment transport and should be consulted as needed. Because of the variation in site conditions and available methods commonly used, it is recommended that no standard is specified by BSEE / BOEM to be required at this time.

Site surficial soil characterization is important in this area, but offshore substation substructures are not specifically different from others for scour. The sensitivity of the structure to scour should be evaluated before large effort is made to develop results. Scour prevention systems should also be considered as an alternative to designing for predicted seabed scour.

4.1.23. Fabrication

API RP 2A WSD 22nd edition, Section 14 provides guidance for the fabrication of an offshore platform's primary structural members. Splicing of members, fabrication sequencing and slotted members are all discussed. Emphasis is placed on welding quality and particular techniques to ensure all weld profiles merge smoothly. Figure 14.1 provides some general guidance on what is considered a smooth weld transition for shielded metal arc welding. Fabrication tolerances for jacket and deck columns/bracing, deck beams, cap beams and other miscellaneous items are specified. API Specification 2B provides guidance specific to the fabrication of structural steel pile used as piling, main structural members and tubular truss connections. Welding techniques as well as pipe dimensions and tolerances are provided within the document.

4.1.24. Welding

API RP 2A WSD 22nd edition, Section 13 provides overall welding procedures, requirements, specifications, qualification, details and techniques to be used in offshore platforms which are equally applicable to offshore ESP. Section 14 of API RP 2A 22nd edition provides specific guidance on welded tubular connections. In few instances, API RP 2A 22nd edition specifically refers to AWS Structural Welding Code AWS D1.1:10 for a more detailed discussion on general welding techniques and procedures. The AISC Steel Construction Manual, Part 8 also provides guidance on design of welded connections, which may be considered as a supplement to API RP 2A 22nd edition. In cases of conflict, requirements of API RP 2A 22nd edition should be considered as governing requirements.

4.1.25. Connections

API RP 2A WSD 22nd edition, Section 7 provides guidance for design, details and construction of welded tubular and grouted joints. These guidance should apply to design and construction of ESP structures as well. Requirements of the AISC Steel Construction Manual may be considered for design and details of non-tubular connections (such as those for the offshore substation topside structure).

4.1.26. Inspections and Assessment

API RP 2A WSD 22nd edition, Section 16 provides guidance on quality control, inspection and testing required during each of the offshore platform's construction phases. Some of the topics covered within this section discuss inspector qualifications, inspection methods, inspection of welds, and inspection of corrosion protection systems. Section 16 also briefly discusses the inspection requirements during the load out, seafastening and transportation of all the offshore platform's structural components. Overall, each component and procedure performed during the offshore platform's construction is to be highly inspected and documented. In addition, a regulated inspection program is recommended to ensure the structure's continued serviceability throughout the many phases of the offshore platform's service life. API RP 2SIM also details the procedure for structural integrity management. These two documents are recommended for inspection and assessment of offshore platforms.

4.1.27. Decommissioning

The design for decommissioning of fixed offshore platforms has been implemented informally for some time. The application of code rules to this phase of platform life is relatively new. API Recommended Practice 2SIM Structural Integrity Management of Fixed Offshore Structures, First Edition, November 2014 does touch on this phase.

The objective of decommissioning a platform is to restore the site to essentially the same state as the surrounding area without the platform. Currently, 30 CFR 585 requires the removal of all facilities, projects, cables, pipelines, and obstructions within two years of the termination of a lease. This typically involves the piles being removed down to a depth safely below the ambient seabed, allowing for such transient changes as sand waves and general scour, but no clear guidance is available as to what is sufficient to be considered as fully removed. A code for this phase of an offshore substation would benefit from some standardization to permit developers to include an accepted level of practice in their project planning and implementation, but is typically detailed at the permit level and not in the design phase. As this is typically covered in permitting and not in design drawings, no standard is recommended at this time.

4.2. Pre-Service

No guidance is provided regarding design relating to pre-service conditions, as only a specific section of API RP 2A WSD 21st edition is referenced in 30 CFR 585 and it does not apply to pre-service conditions. In addition, the general design related information required in 30 CFR 585 described in the previous structural section applies in a similar manner to the pre-service analysis. A gap was thus identified for each design element. The commentary below details the recommendations for each design element associated with pre-service design and analysis. Refer to Appendix B for more information.

4.2.1. Platform Loads – Construction Loads, Load out and lifting

Loads on a platform during construction can cause added stress to a structure and reduce its design life. API RP 2A- 22nd edition provides general guidance on how to account for these stresses and design for them to occur. This guidance is sufficient for design of offshore substations.

4.2.2. Platform Loads – Construction Loads, Transportation and Installation

As offshore platforms are not constructed at sea, but rather constructed in land-based construction yards and shipped to their location, an additional loading is added to the structure during transportation to the site. Noble Denton Publication 0030 provides typical forces that can be experienced in open seas. However, not all offshore substations will be placed in open seas, for example, Cape Wind was in a protected sound that had reduced wave action. It is therefore recommended the Noble Denton not be required for all structures, but that it should be available as an acceptable resource if the engineer determines it is applicable. If the engineer determines that different conditions are expected, a study on the expected accelerations should be required to properly address the issue of platform loads during transportation. API RP 2A – 22nd edition has a general discussion on how to account for transportation and installation loads on the design lift of the structure once the loads have been determined. API RP 2A – 22nd edition is thus recommended as a required design guide, while Nobel Denton Publication 0030 be considered an industry standard that should be used as a starting point, but deviations from the requirements accepted if additional information is provided.

4.2.3. On-bottom Stability

The on-bottom stability of a pile-supported offshore substation substructure should be confirmed for the time of placement on bottom until the piles are driven and the pile-structure connections are completed. The provisions of API RP 2A – 22nd Edition, Section 15.4.5 address this topic in a manner that is adequate for most circumstances. The offshore installation contractor's approach may provide for non-standard methods of providing stability, or protecting the structure in conditions of marginal stability, so the acceptability of exceptions to the standard recommended factors of safety should be recognized.

Site conditions, structure type, foundation and installation method should be used to define a specific analysis method to confirm adequate pre-service performance of the structure. Given the potential for significant variation of these parameters for any project, it is neither possible nor prudent to define prescriptive analytical methods in a recommended practice. It is important that the designer and analyst develop an understanding of the installation method and, with this, describe each pre-service condition that requires an analysis to assure proper handling of the structure (e.g., hook-assist upending, pre-ballast stability on-bottom, etc.) and confirm conformance with the general requirements of API RP 2A – 22nd edition.

The specific pre-service conditions may require a-typical analysis to confirm adequate performance. Unusual aspects of pre-service conditions may include, for example;

- Potential sliding of a jacket in pre-piled conditions for sites with sloping seafloors
- Uncertain mudmat to seafloor contact for sites with hard sand and irregular bathymetry
- Varying support below mudmats due to cyclic motions under wave loading which may cause pumping of soils, local scour and degradation of soil strength

4.2.4. Impact Loads

Offshore substation equipment and deck systems experience vertical and lateral accelerations during fabrication, loadout, sea transportation and deck placement. In-service accelerations that can be defined as impact might only be expected during earthquake response.

The most critical impact loads are likely during placement of the deck system on the substructure either by crane or by repeated impact during lowering from a transportation barge. The method of placement, the metocean conditions, possible leg mating hardware and the deck framing stiffness all affect impact acceleration and loads. The various equipment manufacturers provide limits for their products' ability to tolerate vertical and lateral accelerations. The deck structure designers should also provide acceleration limits for their design. It is important to recognize that certain equipment in an offshore substation is far more sensitive to deformation during transportation and deck mating than the structure itself. This design must thus be guided by the owner supplied equipment. No structural code or standard is recommended to be required for guiding impact loads.

4.2.5. Tolerances

Tolerances for the plan location and orientation should be developed for a project based more on the legal and functional needs of the substation than by constraints established in a standard or code. In the absence of pre-existing devices which require mating, a radial tolerance of 6 ft. might be proposed and a plan orientation of 5 degrees for plan orientation. Other tolerances, such as verticality and dimensions of mating supports are often project specific, however API RP 2A – 22nd edition and associated specifications (API Spec 2B and AWS welding codes) has proven to be a satisfactory basis for achievable fabrication and site installation success. Interfaces between mating parts are always dependent on workable details. No specific tolerance standard is recommended to allow designers and marine contractors sufficient levels of flexibility with the design and installation.

4.3. Safety

Safety was one of the areas with more clear guidance, as 29 CFR 1910 provides guidance for egress, storage of flammable materials, stairways and enclosures through reference to NFPA and ANSI documents. Some gaps were identified, including a definition of manned vs. unmanned platforms for use in design relating to evacuation of the platform, aids to navigation lighting for ships and lighting with regards to aviation aids. Refer to Appendix B for more information.

4.3.1. Egress

29 CFR 1910.35 details egress for structures sufficiently for offshore substations under the exit-route provisions of NFPA 101. No additional guidance is recommended by BSEE / BOEM.

4.3.2. Handrails, Ladders, & stairways

29 CFR 1910 details guarding floor and wall openings and holes in structures in section 1910.23. This section sufficiently details safety related items regarding handrails and stairways. Fixed ladders are covered in section 1910.27. No additional guidance is recommended by BSEE / BOEM.

4.3.3. Noise

29 CFR 1910.95 provides guidance for design related to occupational noise exposure. This section is sufficient for design of offshore substations and no additional guidance is recommended by BSEE / BOEM.

4.3.4. Storage of Flammable Materials

NFPA 30 contained in 29 CFR 1910 addresses flammable and combustible materials. No gap was identified and no additional guidance is recommended by BSEE / BOEM.

4.3.5. Manned vs Unmanned

Both API and DNV have definitions on what should be considered a “manned” and “unmanned” platform when making decisions such as what safety factors should be considered for a structural analysis of the substations. However, using this same definition of “manned” vs. “unmanned” is less clear when determining what emergency evacuation parameters to use. The API definition is unclear for situations in which people are routinely accessing a platform for regular maintenance, but do not stay on the platform for weeks at a time like is common in the oil and gas industry. (API refers to unmanned as “no living accommodations or quarters” while DNV listed unmanned as “not routinely accommodated and which is only visited for inspection and maintenance tasks.”) It appears that with regards to designing the facilities for emergency evacuation, the DNV definition is more applicable. However, additional considerations for commissioning of the structure should also be analyzed when making this definition. BOEM providing further guidance within the CFR is recommended.

4.3.6. Platform Access

No guidance on restricting access is provided. This should be an owner decision and does not appear to fall under the BSEE / BOEM jurisdiction.

4.3.7. Slips, Trips, & Falls

The OSHA codes contained in 29 CFR 1910 address slips, trips, and falls and no gaps were identified. No additional guidance is recommended by BSEE / BOEM.

4.3.8. Maintenance and Rigging

29 CFR 1910 addresses maintenance and rigging by requiring ANSI A120.1. No gap was identified and no additional guidance is recommended by BSEE / BOEM.

4.3.9. Lifting

29 CFR 1910 addresses lifting procedures, requiring ANSI A17.1, ANSI A90.1, and ANSI B302. No was identified and no additional guidance is recommended by BSEE / BOEM.

4.3.10. Emergency Shelter

No guidance for how emergency shelters should be designed is available. This is typically an owner driven design element based upon expected operations of the facility. BSEE/ BOEM could provide further detail on the number of beds required based upon the definition of manned vs. unmanned and the expected number of people on the platform, but it is unclear if this falls under BSEE / BOEM jurisdiction.

4.3.11. Aids to Navigation

Aids to navigation is an important requirement to light up the offshore substations and allow ships to see the platform at night. 33 CFR 66 and 33 CFR 67 provide detailed information required for aids to navigation design on fixed structures and is recommended to be required. 33 CFR 66 provides the requirements for the luminaire on the platform while 33 CFR 67 provides the requirements for mounting of the luminaire. This is also consistent with AWEA OCRP 2012, which states 33 CFR 67 should be considered in design.

4.3.12. Aviation Aids

Aviation aids on tall structures over the water such as offshore substations are required to allow aircraft to see the structure at night. FAA Advisory Circular AC 70/7460-1K Obstruction Marking and Lighting details the proper lighting procedure for offshore substations and is recommended to be required.

4.3.13. Safety Shower and Eye Wash

Safety showers can prevent chemical accidents associated with acids exposure to skin. This is properly addressed in the text of 29 CFR 1910.151. No additional guidance is recommended by BSEE / BOEM.

4.4. Environmental

No guidance is provided with regards to design relating to the environment. Although a significant amount of these concerns are guided by permit constraints, the design elements provided were determined to have gaps in guidance. Refer to Appendix B for more information.

4.4.1. Oil Spills

Oil Spills on offshore substations is the subject of further investigation by the BSEE oil spill preparedness division (OSPD). As this report's focus is primarily on the electrical and structural aspects of offshore substation design, no recommendations regarding requirements are provided for oil spills. Further analysis focused on the limited hazards associated with offshore substations under the direction of the OSPD is recommended to provide modified requirements for offshore substations based upon the current requirements for the oil and gas industry, but altered to meet the reduced needs associated with offshore substations.

4.4.2. Environmental Management Program

API RP 75 details environmental management program development for offshore structures. Although this document contains extraneous text relating to drilling platforms, the philosophy of the management program is generally applicable, requiring hazards analysis, operating procedures detailed, safe work practices, training and emergency response plans. BSEE / BOEM can utilize API RP 75 as a guide for requiring a safety and environmental management plan similar to the requirements of the SEMS for the oil and gas industry, but with specifications more detailed to the offshore wind industry, specifically with regards to mechanical integrity, which is a much more significant issue for both safety and environmental responsibility in the oil and gas industry compared to offshore wind. This subject thus requires further study under the direction of BSEE to determine the most applicable requirements specific to offshore substations and the reduced risk to the environment they present compared to oil and gas platforms.

4.5. Electrical

Electrical design is largely not covered in required standards. The OSHA guidelines detailed in 29 CFR 1910 reference a few standards that provide minimal coverage in a few areas, including lighting, arc flash, and lightning protection, but most areas were identified as having a gap in clear guidance. 29 CFR 1910 provides generic guidance on the design of systems in the text of the CFR itself, such as equipment must be grounded, but lacks detail on what standards or codes to design to consider the equipment sufficiently grounded. Further detail is needed to provide designers with a clear understanding of the preferred standard or code to use and ensure BOEM / BSEE approves of this design method for an offshore platform. Other information commonly found in codes such as acceptable materials and spare capacity requirements for equipment or systems are not provided, which can be a safety issue for a platform. The following sections detail standards that can be used to address gaps and allow for clear design of offshore platforms. Many electrical codes will state that equipment must be "listed" or approved by standards per the jurisdictional authority. As BSEE / BOEM are the jurisdictional authority for Outer Continental Shelf Lands, many design elements will have two tables provided; one of codes that should be designed to, and a second table of recommended standards that should be utilized for equipment detailed within the codes. Refer to Appendix B for a complete list of required codes and Appendix C for a complete list of associated standards for each design element.

4.5.1. Arc Flash Analysis

Offshore substations can have high fault availability and possess high enough voltages that the electrical equipment such as the switchgear may have the capability to produce fatal arc flashes without proper precaution taken. NFPA 70 and NFPA 70E the National Electrical Code and the Standard for Electrical Safety in the Workplace should be required for safety reasons to reduce the chances of serious injuries and fatalities associated with these arc flash events. NFPA 70E provides steps that should be taken to create an electrically safe work condition and notify workers of the immediate danger while working on specific pieces of live equipment. These codes are summarized below in Table 2.

Table 2: Recommended Codes to be Required for Arc Flash Analysis

Standard	Description	Date	Errata
NFPA 70	National Electrical Code	2014	AMD 1 2013; Errata 1 2013; AMD 2 2013; Errata 2 2013; AMD 3 2014; Errata 3 2014
NFPA 70E	Standard for Electrical Safety in the Workplace	2013	-

4.5.2. Automatic Transfer Switches

Automatic transfer switches are an integral part of a standby power system. Proper design, specification, and installation of automatic transfer switches can help provide a seamless transition between primary power sources and backup sources upon interruption of electrical service. Requiring automatic transfer switches to follow NFPA 70, NFPA 110, & IEEE C2 for all offshore platforms will help standardize the requirements for backup systems. These codes are displayed below in Table 3.

Table 3: Recommended Codes to be Required for Automatic Transfer Switches

Standard	Description	Date	Errata
NFPA 70	National Electrical Code	2014	AMD 1 2013; Errata 1 2013; AMD 2 2013; Errata 2 2013; AMD 3 2014; Errata 3 2014
NFPA 110	Standard for Emergency and Standby Power Systems	2013	-
IEEE C2	National Electrical Safety Code	2012	Errata 2012; INT 1-4 2012; INT 5-7 2013

UL 489, 924, and 1066 should be listed as recommended standards, as these standards address equipment detailed in the recommended codes to be required. Refer to Table 4 for more information.

Table 4: Recommended Standards Relating to Automatic Transfer Switches

Standard	Description	Date	Errata
UL 489	Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures	2013; Reprint Mar 2014	-
UL 924	Standard for Emergency Lighting and Power Equipment	2006;	UL 924
UL 1066	Low-Voltage AC and DC Power Circuit Breakers Used in Enclosures	(2012; Reprint Jul 2013)	

4.5.3. Battery Systems

Two codes, NFPA 70 and IEEE C2, are recommended to be required relating to batteries. These codes address key safety issues relating to how the battery system is designed. Guidance for overcurrent protection selection, support racks and trays, and installation locations can be found in NFPA 70 and IEEE C2. Refer to Table 5 for more information on these two codes.

Table 5: Recommended Codes to be Required for Design of Battery Systems

Standard	Description	Date	Errata
NFPA 70	National Electrical Code	2014	AMD 1 2013; Errata 1 2013; AMD 2 2013; Errata 2 2013; AMD 3 2014; Errata 3 2014
IEEE C2	National Electrical Safety Code	2012	Errata 2012; INT 1-4 2012; INT 5-7 2013

Four IEEE standards are recommended relating to battery systems associated with the required codes. These are included below in Table 6.

Table 6: Recommended Standards Relating to Battery Systems

Standard	Description	Date
IEEE 450	Recommended Practice for Maintenance, Testing, and Replacement of Vented Lead-Acid Batteries for Stationary Applications	2010
IEEE 484	Recommended Practice for Installation Design and Implementation of Vented Lead-Acid Batteries for Stationary Applications	2002; R 2008
IEEE 485	485 Recommended Practice for Sizing Lead-Acid Batteries for Stationary Applications	2010
IEEE 1187	IEEE Recommended Practice for Installation Design and Installation of Valve-Regulated Lead-Acid Batteries for Stationary Applications	2013

4.5.4. Cable Trays

Cable tray design is addressed in NFPA 70 – The National Electric Code. Following NFPA 70 will provide design guidance in the sizing, filling, and installation of cable trays. Adherence to NFPA 70 guidelines can help prevent safety hazards such as (but not limited to) overheating of cables, overloading of cable trays, and risk of cable damage. NFPA 70 is included as the only recommended code to be required for tray design in Table 7 below.

Table 7: Recommended Code to be Required for Cable Tray Design

Standard	Description	Date	Errata
NFPA 70	National Electrical Code	2014	AMD 1 2013; Errata 1 2013; AMD 2 2013; Errata 2 2013; AMD 3 2014; Errata 3 2014

4.5.5. CCTV

NFPA 70 and IEEE C2 should be required to appropriately design and install a CCTV system within an offshore substation. These standards will ensure the equipment and cabling is properly designed to minimize the chances of component failure on the platform. See Table 8 for a details of these two codes.

Table 8: Recommended Codes to be Required for CCTV Design

Standard	Description	Date	Errata
NFPA 70	National Electrical Code	2014	AMD 1 2013; Errata 1 2013; AMD 2 2013; Errata 2 2013; AMD 3 2014; Errata 3 2014
IEEE C2	National Electrical Safety Code	2012	Errata 2012; INT 1-4 2012; INT 5-7 2013

One other recommended standard for the design of a CCTV system is from the Electronic Components Industry Associated guiding the design of the cabinets, rack, and panels while the NECA standard is commonly utilized for installation methods of telecommunications cabling. Both standards are included in Table 9 below.

Table 9: Recommended Standards Related to CCTV

Standard	Description	Date
ECIA EIA/ECA 310-E	Cabinets, Racks, Panels, and Associated Equipment	2005
NECA / BICSI 568	Standard for Installing Building Telecommunications Cabling	2006

4.5.6. Communications

Required codes regarding communications on offshore platforms should be the same as the CCTV standards, NFPA 70 and IEEE C2. These codes will allow for a safe design that can help minimize equipment failure and poor equipment performance relating to communications equipment. See Table 10 below for more information.

Table 10: Recommended Codes to by Required for Communications

Standard	Description	Date	Errata

NFPA 70	National Electrical Code	2014	AMD 1 2013; Errata 1 2013; AMD 2 2013; Errata 2 2013; AMD 3 2014; Errata 3 2014
IEEE C2	National Electrical Safety Code	2012	Errata 2012; INT 1-4 2012; INT 5-7 2013

There are many additional standards that pertain to specific elements relating to communications equipment, including standards for testing equipment and for quality of cable. Three key standards recommended are included below in Table 11. Refer to Appendix C for a complete list of industry standards related to communications.

Table 11: Recommended Standards Related to Communications

Standard	Description	Date
ECIA EIA/ECA 310-E	Cabinets, Racks, Panels, and Associated Equipment	2005
NECA / BICSI 568	Standard for Installing Building Telecommunications Cabling	2006
TIA-568-C.1	Commercial Building Telecommunications Cabling Standard	2009; Add 2 2011; Add 1 2012

4.5.7. Conductors – HV & MV

Key codes required to address safety and performance of medium voltage cables can be found below. Items such as permitted uses, ampacity limitations, cable construction, marking/identification requirements, etc. can be found in the codes found in Table 12.

Table 12: Recommended Codes to be Required for Conductors – HV & MV

Standard	Description	Date	Errata
NFPA 70	National Electrical Code	2014	AMD 1 2013; Errata 1 2013; AMD 2 2013; Errata 2 2013; AMD 3 2014; Errata 3 2014
IEEE C2	National Electrical Safety Code	2012	Errata 2012; INT 1-4 2012; INT 5-7 2013

Other key recommended standards that are commonly used for high and medium voltage conductor equipment include standards from the Underwriters Laboratories (UL). A full list of industry standards associated with conductors is included in Appendix C. The list of key UL standards recommended are included below in Table 13.

Table 13: Recommended Standards Relating to HV & MV Conductors

Standard	Description	Date
UL 44	Thermoset-Insulated Wires and Cables	2014; Reprint Jun 2014
UL 486A-486B	Wire Connectors	2013; Reprint Feb 2014
UL 1072	Medium-Voltage Power Cables	2006; Reprint Jun 2013

4.5.8. Low Voltage Conductors

Low voltage conductors pose hazards if not properly utilized. NFPA 70 and IEEE C2 provide guidance in cable type selection with respect to installation, potential hazards, location of use, etc. Adherence to the codes listed in Table 14 is recommended to minimize the risk of personal and property damage.

Table 14: Recommended Codes to be Required for Low Voltage Conductors

Standard	Description	Date	Errata
NFPA 70	National Electrical Code	2014	AMD 1 2013; Errata 1 2013; AMD 2 2013; Errata 2 2013; AMD 3 2014; Errata 3 2014
IEEE C2	National Electrical Safety Code	2012	Errata 2012; INT 1-4 2012; INT 5-7 2013

Other industry standards by ASTM, ANSI, and UL related to low voltage conductors that are commonly used by electrical engineers during design of substations are included in Table 15 below.

Table 15: Recommended Standards Relating to Low Voltage Conductors

Standard	Description	Date
ASTM B1	Standard Specification for Hard-Drawn Copper Wire	2013
ASTM B8	Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft	2011
ANSI C119.1	Electric Connectors - Sealed Insulated Underground Connector Systems Rated 600 Volts	2011
UL 1569	Standard for Metal-Clad Cables	1999; Reprint Jan 2012
UL 44	Thermoset-Insulated Wires and Cables	2014; Reprint Jun 2014
UL 486A-486B	Wire Connectors	2013; Reprint Feb 2014
UL 486C	Splicing Wire Connectors	2013; Reprint Feb 2014
UL 486E	Equipment Wiring Terminals for Use with Aluminum and/or Copper Conductors	2009; Reprint May 2013

4.5.9. Electric Field Testing and Communications

Electric field testing and communication testing provides verification that installed equipment is suitable for use. Testing according to the codes found in Table 16 help create a more safe and reliable installation.

Table 16: Recommended Codes to be Required for Electric Field Testing and Communications

Standard	Description	Date	Errata
NFPA 70	National Electrical Code	2014	AMD 1 2013; Errata 1 2013; AMD 2 2013; Errata 2 2013; AMD 3 2014; Errata 3 2014
IEEE C2	National Electrical Safety Code	2012	Errata 2012; INT 1-4 2012; INT 5-7 2013

One key standard relating to testing of electrical equipment in the NETA ATS standard. Refer to Table 17 below for more information on this standard.

Table 17: Recommended Standard Relating to Electric Field Testing and Communications

Standard	Description	Date	Errata
NETA ATS	Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems	2013	-

4.5.10. Equipment Enclosures & Hardware

Equipment enclosures are critical safety considerations when dealing with electrical equipment. The following three codes from NFPA and IEEE address issues such as enclosure type selection for indoor, outdoor, hazardous location, etc.to minimize hazards associated with personal safety around enclosures and equipment. Details of these codes are included below in Table 18.

Table 18: Recommended Codes to be Required for Equipment Enclosures & Hardware

Standard	Description	Date	Errata
NFPA 70	National Electrical Code	2014	AMD 1 2013; Errata 1 2013; AMD 2 2013; Errata 2 2013; AMD 3 2014; Errata 3 2014
NFPA 110	Standard for Emergency and Standby Power Systems	2013	-
IEEE C2	National Electrical Safety Code	2012	Errata 2012; INT 1-4 2012; INT 5-7 2013

There are multiple standards relating to enclosures that can be used in conjunction with the three required codes above. Standards from IEEE, ASTM, NEMA, and one from UL are listed in Table 19.

Table 19: Recommended Standards Relating to Enclosures & Hardware

Standard	Description	Date	Errata
IEEE C57.12.28	Standard for Pad-Mounted Equipment - Enclosure Integrity	2014	-
IEEE C57.12.29	Standard for Pad-Mounted Equipment - Enclosure Integrity for Coastal Environments	2014	-
ASTM A1008/A1008M	Standard Specification for Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy and High-Strength Low-Alloy with Improved Formability, Solution Hardened, and Bake Hardened	2013	-
ASTM A123/A123M	Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products	2013	-
ASTM A240/A240M	Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications	2014	-
ASTM A36/A36M	Standard Specification for Carbon Structural Steel	2012	-
ASTM A572/A572M	Standard Specification for High-Strength Low-Alloy Columbium-Vanadium Structural Steel	2013a	-
ASTM A633/A633M	Standard Specification for Normalized High-Strength Low-Alloy Structural Steel Plates	2013	-
ASTM A653/A653M	Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process	2013	-
ASTM B117	Standard Practice for Operating Salt Spray (Fog) Apparatus	2011	-
ASTM B633	Standard Specification for Electrodeposited Coatings of Zinc on Iron and Steel	2013	-
ASTM D1535	Specifying Color by the Munsell System	2013	-
ASTM D92	Standard Test Method for Flash and Fire Points by Cleveland Open Cup Tester	2012b	-
NEMA ICS 4	Terminal Blocks	(2010)	-
NEMA ICS 6	Enclosures	(1993; R 2011)	-
NEMA 250	Enclosures for Electrical Equipment (1000 Volts Maximum)	(2008)	-
UL 50	Enclosures for Electrical Equipment, Non-environmental Considerations	2007; Reprint Apr 2012	-

4.5.11. Diesel Generators

Diesel Generators have many safety hazards including shock, fire, explosions, and other mechanical issues such as pinching. To prevent such fire hazards and maintain a reliable backup power system, three National Fire Protection Association (NFPA) codes have been proposed, as well as the National Electrical Code and National Electrical Safety Code. These standards are summarized in Table 20.

Table 20: Recommended codes to be Required for Diesel Generators

Standard	Description	Date	Errata
NFPA 70	National Electrical Code	2014	AMD 1 2013; Errata 1 2013; AMD 2 2013; Errata 2 2013; AMD 3 2014; Errata 3 2014
IEEE C2	National Electrical Safety Code	2012	Errata 2012; INT 1-4 2012; INT 5-7 2013
NFPA 110	Standard for Emergency and Standby Power Systems	2013	-
NFPA 30	Flammable and Combustible Liquids Code	2015	-
NFPA 37	Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines	2015	-

There are many other standards relating to the piping and steel used in generators that engineers can use at their discretion. Key standards from ASTM, IEEE, NEMA, and UL are provided below in Table 21 that should be utilized in conjunction with the required codes listed above.

Table 21: Recommended Standards Related to Diesel Generators

Standard	Description	Date	Errata
ASTM D975	Standard Specification for Diesel Fuel Oils	2014a	-
IEEE 43	Recommended Practice for Testing Insulation Resistance of Rotating Machinery	2013	-
IEEE 519	Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems	2014	-
NEMA MG 1	Motors and Generators	2011	Errata 2012

Standard	Description	Date	Errata
UL 489	Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures	2013; Reprint Mar 2014	-

4.5.12. High Voltage & Medium Voltage Gas Insulated Switchgear (GIS)

Gas Insulated Switchgear reduces the potential of arc flashing, providing an attractive alternative to standard metal-clad switchgear. The dangers associated with HV and MV GIS equipment comes in the form of the insulating gas the gear uses to minimize an electric arc. The dangers can be mitigated by following the National Electrical Code as detailed in Table 22 address these hazards.

Table 22: Recommended Codes to be Required for HV & MV GIS

Standard	Description	Date	Errata
NFPA 70	National Electrical Code	2014	AMD 1 2013; Errata 1 2013; AMD 2 2013; Errata 2 2013; AMD 3 2014; Errata 3 2014

As this equipment is relatively new in the U.S. and more prominent in Europe, five International Electrotechnical Commission (IEC) standards relating to high voltage switchgear are recommended to be used in conjunction with the required National Electrical Code listed above. Refer to Table 23 below for more information on these five standards.

Table 23: Recommended Standards Relating to High Voltage & Medium Voltage Gas Insulated Switchgear (GIS)

Standard	Description	Date
IEC 62271-200	High-voltage Switchgear and controlgear	2011
IEC 60694	Common specifications for high-voltage switchgear and controlgear standards	1996
IEC 62271-102	Alternating current disconnectors and earthing switches	2001
IEC 62271-100	Alternating-current circuit-breakers	2008
ANSI/IEC 60529	Degrees of protection provided by enclosures	2004

4.5.13. Grounding

Grounding must be designed for to help mitigate safety and performance issues. Inadequate grounding can lead to personal injury, equipment damage, and poor equipment performance. Following the NFPA and IEEE codes listed in Table 24 will address those safety and performance issues.

Table 24: Recommended Codes to be Required for Grounding

Standard	Description	Date	Errata
NFPA 70	National Electrical Code	2014	AMD 1 2013; Errata 1 2013; AMD 2 2013; Errata 2 2013; AMD 3 2014; Errata 3 2014

IEEE C2	National Electrical Safety Code	2012	Errata 2012; INT 1-4 2012; INT 5-7 2013

Two other key standards specific to grounding are recommended from IEEE and UL. These standards are found in Table 25 belowTable 25: Recommended Standards Related to Grounding.

Table 25: Recommended Standards Related to Grounding

Standard	Description	Date	Errata
IEEE 81	Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System	2012	-
UL 467	Grounding and Bonding Equipment	2007	-

4.5.14. Interior Electrical

Various safety issues are associated with interior electrical elements in offshore substations including personal protection and building protection. Using NFPA 70, the National Electrical Code will minimize these safety hazards. NFPA is shown in Table 26.

Table 26: Recommended Codes to be Required for Interior Electrical

Standard	Description	Date	Errata
NFPA 70	National Electrical Code	2014	AMD 1 2013; Errata 1 2013; AMD 2 2013; Errata 2 2013; AMD 3 2014; Errata 3 2014

Other recommended standards relating to interior electrical items include ASHRAE standards that are mandated for government buildings by executive order, as well as three UL standards relating to switches and circuit-interrupters. These can be found below in Table 27.

Table 27: Recommended Standards Related to Interior Electrical

Standard	Description	Date	Errata
ASHRAE 189.1	Standard for the Design of High-Performance Green Buildings Except Low-Rise Residential Buildings	2011	Errata 1-2 2012; INT 1 2013; Errata 3-8 2013
ASHRAE 90.1-IP	Energy Standard for Buildings Except Low-Rise Residential Buildings	2010	ERTA 2011-2013
ASHRAE 90.1-SI	Energy Standard for Buildings Except Low-Rise Residential Buildings	2010	ERTA 2011-2013
UL 20	General-Use Snap Switches	2010; Reprint Feb 2012	-
UL 943	Ground-Fault Circuit-Interrupters	2006; Reprint Jun 2012	-
UL 1699	Arc-Fault Circuit-Interrupters	2006; Reprint Nov 2013	-

4.5.15. Lighting

Lighting is a vital design element for operations, as well as life safety. It is recommended to require NFPA 70, NFPA 101 and IEEE C2 to provide optimal lighting for individual tasks and egress lighting in an emergency event, as well as NFPA 900 for energy efficiency relating to BSEE and BOEM's goal of promoting the environment. In addition, two CFRs relating to illumination of the platform for aids to navigation to prevent ship collisions with the structure are also recommended. These codes are described in Table 28.

Table 28: Recommended Codes to be Required for Lighting

Standard	Description	Date	Errata
33 CFR 66	Private Aids to Navigation	2014	
33 CFR 67	Aids to Navigation on Artificial Islands and Fixed Structures	2014	
NFPA 70	National Electrical Code	2014	AMD 1 2013; Errata 1 2013; AMD 2 2013; Errata 2 2013; AMD 3 2014; Errata 3 2014
NFPA 101	Life Safety Code	2012; Amendment 1 2012	Errata 1-2 2012; INT 1 2013; Errata 3-8 2013
NFPA 900	Building Energy Code	2013	-
IEEE C2	National Electrical Safety Code	2012;INT 1-4 2012; INT 5-7 2013	Errata 2012

Other standards associated with lighting include ASHRAE, IES, Energy Star, and UL standards relating to energy efficiency and various lighting components. Key standards are included in Table 29 below. A full list of industry standards including FAA standards relating to helidecks is included in Appendix C.

Table 29: Recommended Standards Related to Lighting

Standard	Description	Date	Errata
ASHRAE 189.1	Standard for the Design of High-Performance Green Buildings Except Low-Rise Residential Buildings	2011	Errata 1-2 2012; INT 1 2013; Errata 3-8 2013
ASHRAE 90.1 - IP	Energy Standard for Buildings Except Low-Rise Residential Buildings	2010	ERTA 2011-2013
ASHRAE 90.1 - SI	Energy Standard for Buildings Except Low-Rise Residential Buildings	2010	ERTA 2011-2013
Energy Star	Energy Star Energy Efficiency Labeling System (FEMP)	1992; R 2006	-
IES HB-10	IES Lighting Handbook	2011	-
IES RP-16	Nomenclature and Definitions for Illuminating Engineering	2010; Addendum A 2008;	-

Standard	Description	Date	Errata
		Addenda B & C 2009	
UL 20	General-Use Snap Switches	2010; Reprint Feb 2012	-
UL 595	Marine - Type Electric Lighting Fixtures	1985	-
UL 924	Standard for Emergency Lighting and Power Equipment	2006; R Apr 2014	-
UL 935	Standard for Fluorescent-Lamp Ballasts	2001; Reprint Aug 2014	-
UL 1029	High-Intensity-Discharge Lamp Ballasts	1994; Reprint Dec 2013	-
UL 1598	Luminaires	2008; Reprint Oct 2012	-
UL 8750	UL Standard for Safety Light Emitting Diode (LED) Equipment for Use in Lighting Products	2009; Reprint May 2014	-

4.5.16. Lightning Protection

Lightning protection provides additional safety for employees as well as provide a line of protection against damaging voltage surges on equipment. NFPA 70 and NFPA 708 address these issues and should be required for design. These standards are included in below in Table 30.

Table 30: Recommended Codes to be Required for Lightning Protection

Standard	Description	Date	Errata
NFPA 70	National Electrical Code	2014	AMD 1 2013; Errata 1 2013; AMD 2 2013; Errata 2 2013; AMD 3 2014; Errata 3 2014
NFPA 780	Standard for the Installation of Lightning Protection Systems	2014	-

One additional standard relating to lighting protection of components is recommended from UL. It is included below in Table 31.

Table 31: Recommended Standards Relating to Lightning Protection

Standard	Description	Date
UL 96	Standard of Lightning Protection Components	2005

4.5.17. Motor Control Centers – Low Voltage (MCC-LV)

Motor control centers have safety hazards including arc flash and electrocution. Following NFPA 70 and IEEE C2 reduce these risks and are standard in US electrical design. These recommended codes are included in Table 32.

Table 32: Recommended Codes to be Required for MCC-LV

Standard	Description	Date	Errata
NFPA 70	National Electrical Code	2014	AMD 1 2013; Errata 1 2013; AMD 2 2013; Errata 2 2013; AMD 3 2014; Errata 3 2014
IEEE C2	National Electrical Safety Code	2012; INT 1-4 2012; INT 5-7 2013	Errata 2012

Other standards related to motor control centers include UL standards that are recommended to be followed. The full list is included in Table 33.

Table 33: Recommended Standards Related to MCC-LV

Standard	Description	Date	Errata
UL 489	Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures	2013; Reprint Mar 2014	-
UL 845	Motor Control Centers	2005; R Jul 2011	-

4.5.18. Metal Clad Switchgear (SG)

Metal clad switchgear provides a barrier against shock or electrocution for employees working on or near live equipment. Following the three recommended codes below, NFPA 70, 70B, and IEEE C2, and providing proper design and installation of metal clad switchgear can reduce personnel risk. See Table 34 for the recommended standards.

Table 34: Recommended Codes to be Required for Metal Clad SG

Standard	Description	Date	Errata
NFPA 70	National Electrical Code	2014	AMD 1 2013; Errata 1 2013; AMD 2 2013; Errata 2 2013; AMD 3 2014; Errata 3 2014
NFPA 70B	Recommended Practice for Electrical Equipment Maintenance	2013	
IEEE C2	National Electrical Safety Code	2012; INT 1-4 2012; INT 5-7 2013	Errata 2012

Other standards associated with metal clad switchgear include IEE standards regarding the components of the switchgear. Refer to the list of three key IEE standards below in Table 35.

Table 35: Recommended Standards Related to Metal Clad SG

Standard	Description	Date	Errata
IEEE C37.121	American National Standard for Switchgear - Unit Substations - Requirements	2012	-

Standard	Description	Date	Errata
IEEE C37.20.2	Standard for Metal-Clad Switchgear	1999; Corr 2000; R 2005	-
IEEE C37.46	Standard for High Voltage Expulsion and Current-Limiting Type Power Class Fuses and Fuse Disconnecting Switches	2010	-

4.5.19. Metering

Codes for metering are included to allow for greater accuracy and reliability. Further guidance on metering is provided in NFPA 70, 708, and IEEE C2. These are recommended as being required for design and are included below in Table 36.

Table 36: Recommended Codes to be Required for Metering

Standard	Description	Date	Errata
NFPA 70	National Electrical Code	2014	AMD 1 2013; Errata 1 2013; AMD 2 2013; Errata 2 2013; AMD 3 2014; Errata 3 2014
NFPA 780	Standard for the Installation of Lightning Protection Systems	2014	-
IEEE C2	National Electrical Safety Code	2012; INT 1-4 2012; INT 5-7 2013	Errata 2012

Recommended standards relating to metering include IEEE, ANSI, and UL standards for electrical components. Please refer to Table 37 for more information.

Table 37: Recommended Standards Related to Metering

Standard	Description	Date
IEEE C12.16	Solid-State Electricity Meters	1991
ANSI C12.1	Electric Meters Code for Electricity Metering	2008
ANSI C12.15	Solid-State Demand Registers for Electromechanical Watthour Meters	1990
ANSI C12.20	Electricity Meters - 0.2 and 0.5 Accuracy Classes	2010
UL 1437	Electrical Analog Instruments - Panel Board Types	2006

4.5.20. Metal Switchgear – Low Voltage (MSG-LV)

Metal switchgear can provide a level of personal protection if properly designed and installed. The use of NFPA 70 and IEEE C2 is recommended to be required to address the potential safety concerns associated with switchgear and are included in Table 38 below.

Table 38: Recommended Codes to be Required for MSG-LV

Standard	Description	Date	Errata
NFPA 70	National Electrical Code	2014	AMD 1 2013; Errata 1 2013; AMD 2 2013; Errata 2 2013; AMD 3 2014; Errata 3 2014
IEEE C2	National Electrical Safety Code	2012; INT 1-4 2012; INT 5-7 2013	Errata 2012

Standards relating to metal switchgear from NEMA and UL are used in conjunction with the required codes described above. These are included in Table 39 below.

Table 39: Recommended Standards Related to MSG-LV

Standard	Description	Date
NEMA C37.50	American National Standard for Switchgear--Low-Voltage AC Power Circuit Breakers Used in Enclosures - Test Procedures	2012
NEMA C37.51	American National Standard for Switchgear--Metal Enclosed Low-Voltage AC Power, Circuit-Breaker Switchgear Assemblies-Conformance Test Procedures	2003; R 2010; Add 2010
UL 489	Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures	2013; R Mar 2014
UL 891	Switchboards	2005; R Oct 2012
UL 1066	Low-Voltage AC and DC Power Circuit Breakers Used in Enclosures	1999; R Apr 2010

4.5.21. PAGA

Low voltage wiring associated with PAGA systems are governed by the National Electrical Code. It is recommended that NFPA 70 be required for PAGA system design on offshore substations. It is included in Table 40 below.

Table 40: Recommended Codes to be Required for PAGA

Standard	Description	Date	Errata
NFPA 70	National Electrical Code	2014	AMD 1 2013; Errata 1 2013; AMD 2 2013; Errata 2 2013; AMD 3 2014; Errata 3 2014

The NECA standard for installation of telecommunications cabling and the UL standard for communications cables are both recommended to be used in conjunction with the NEC code required. Details of these codes are included in Table 41 below.

Table 41: Recommended Standards Related to PAGA

Standard	Description	Date
NECA/BICSI 568	Standard for Installing Building Telecommunications Cabling	2006
UL 444	Communications Cables	2008

4.5.22. Panelboards

Panelboards can cause various safety issues including shocks and electrocution if not properly designed, installed, and maintained. M&N recommends using NFPA 70 and IEEE C2, to mitigate these risks. These are described below in Table 42.

Table 42: Recommended Codes to be Required for Panelboards

Standard	Description	Date	Errata
NFPA 70	National Electrical Code	2014	AMD 1 2013; Errata 1 2013; AMD 2 2013; Errata 2 2013; AMD 3 2014; Errata 3 2014
IEEE C2	National Electrical Safety Code	2012; INT 1-4 2012; INT 5-7 2013	Errata 2012

Four UL standards for components of panelboards are recommended to be used in conjunction with the National Electrical Code. Please refer to Table 43 for further information on the four UL standards.

Table 43: Recommended Standards Related to Panelboards

Standard	Description	Date
UL 489	Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures	2013; R Mar 2014
UL 67	Standard for Panelboards	2009; R Jan 2013
UL 870	Standard for Wireways, Auxiliary Gutters, and Associated Fittings	2008; Reprint Feb 2013
UL 943	Ground-Fault Circuit-Interrupters	2006; Reprint Jun 2012

4.5.23. Protective Relaying

Protective Relaying is a crucial item in designing a properly coordinated power system. Requirements can be addressed using the National Electrical Code and the National Electrical Safety

Code. It is recommended that both be required for offshore substation design. Details of these codes are included in Table 44.

Table 44: Recommended Codes to be Required for Protective Relaying

Standard	Description	Date	Errata
NFPA 70	National Electrical Code	2014	AMD 1 2013; Errata 1 2013; AMD 2 2013; Errata 2 2013; AMD 3 2014; Errata 3 2014
IEEE C2	National Electrical Safety Code	2012; INT 1-4 2012; INT 5-7 2013	Errata 2012

Three IEEE standards relating to protective relaying and a NEMA standard for control systems are recommended to be used with the required codes for design of protective relaying. Details of these standards are included below in Table 45.

Table 45: Recommended Standards Related to Protective Relaying

Standard	Description	Date	Errata
IEEE C37.2	Standard for Electrical Power System Device Function Numbers, Acronyms and Contact Designations	2008	
IEEE C37.90	Standard for Relays and Relay Systems Associated With Electric Power Apparatus	2005	-
IEEE C37.17	Standard for Trip Devices for AC and General-Purpose DC Low-Voltage Power Circuit Breakers	2012	-
NEMA ICS 1	Standard for Industrial Control and Systems: General Requirements	2000; R 2008	E 2010

4.5.24. Raceways

Raceways include wireways, conduits, and outlet boxes. Raceways provide a barrier against personnel danger, requirements are defined in NFPA 70 and IEEE C2. Both codes are recommended to be required, with details included in Table 46 below.

Table 46: Recommended Codes to be Required for Raceways

Standard	Description	Date	Errata
NFPA 70	National Electrical Code	2014	AMD 1 2013; Errata 1 2013; AMD 2 2013; Errata 2 2013; AMD 3 2014; Errata 3 2014
IEEE C2	National Electrical Safety Code	2012; INT 1-4 2012; INT 5-7 2013	Errata 2012

4.5.25. Selective Coordination

Selective coordination enhances the reliability of a power system. In an event such as a fault, selective coordination can help minimize the impact on the overall electrical system. It is recommended to address selective coordination by using the National Electrical Code and the National Electrical Safety Codes. Details of these codes are included in Table 47.

Table 47: Recommended Codes to be Required for Selective Coordination

Standard	Description	Date	Errata
NFPA 70	National Electrical Code	2014	AMD 1 2013; Errata 1 2013; AMD 2 2013; Errata 2 2013; AMD 3 2014; Errata 3 2014
IEEE C2	National Electrical Safety Code	2012; INT 1-4 2012; INT 5-7 2013	Errata 2012

Two additional standards by IEEE for power systems are also recommended to be used along with the required codes above. These are included below in Table 48.

Table 48: Recommended Standards Related to Selective Coordination

Standard	Description	Date	Errata
IEEE 242	Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems - Buff Book	2001	Errata 2003
IEEE 399	Brown Book IEEE Recommended Practice for Power Systems Analysis	1997	-

4.5.26. Seismic

Seismic safety concerns including equipment falling during an earthquake. Following the International Building Code or ASCE-08 can reduce these risks by allowing for proper design of equipment supports and foundations. It is recommended to require ASCE-07 for consistency purposes. Please refer to Table 49 below for details of ASCE-07.

Table 49: Recommended Codes to be Required for Seismic Design

Standard	Description	Date	Errata
ASCE-07	Minimum Design Loads for Buildings and Other Structures	2010	-

4.5.27. Surge Protection

Surge protection is both a safety hazard to employees performing maintenance on equipment and important for owners to prevent damage to their equipment. Following NFPA 70, 780 and IEEE C2 will minimize the hazards associated with surge protection on the offshore platform. Details of these three codes are included in Table 50.

Table 50: Recommended Codes to be Required for Surge Protection

Standard	Description	Date	Errata
NFPA 70	National Electrical Code	2014	AMD 1 2013; Errata 1 2013; AMD 2 2013; Errata

			2 2013; AMD 3 2014; Errata 3 2014
NFPA 780	Standard for the Installation of Lightning Protection Systems	2014	-
IEEE C2	National Electrical Safety Code	2012; INT 1-4 2012; INT 5-7 2013	Errata 2012

One UL standard regarding surge protection devices should also be utilized in conjunction with required codes above. Please refer to Table 51 below for details on this UL Standard.

Table 51: Industry Standards Related to Surge Protection

Standard	Description	Date	Errata
UL 1449	Surge Protective Devices	2014	-

4.5.28. Transformers – HV MV

Transformers carry inherent hazards to personnel, equipment, and the environment. Following NFPA 70 and IEEE C2 with respect to HV MV transformers can help reduce the level of hazard by requiring items such as vault/fire protection requirements and liquid containment. Both codes are recommended to be required for offshore substations and are included below in Table 52.

Table 52: Recommended Standards to be Required for Transformer – HV MV

Standard	Description	Date	Errata
NFPA 70	National Electrical Code	2014	AMD 1 2013; Errata 1 2013; AMD 2 2013; Errata 2 2013; AMD 3 2014; Errata 3 2014
IEEE C2	National Electrical Safety Code	2012; INT 1-4 2012; INT 5-7 2013	Errata 2012

Five additional standards for the oil and transformer design itself are recommended to be used along with the required codes. These are included below in Table 53.

Table 53: Recommended Standards Related to High & Medium Voltage Transformers

Standard	Description	Date
ASTM D3455	Compatibility of Construction Material with Electrical Insulating Oil of Petroleum Origin	2011
FM APP GUIDE	Approval Guide http://www.approvalguide.com/	Updated online
IEEE C57.12.25	Standard for Transformers - Pad-Mounted, Compartmental-Type, Self-Cooled, Single-Phase Distribution Transformers With Separable Insulated High-Voltage Connectors; High Voltage,	1990

Standard	Description	Date
	34,500 Grdy/ 19,920 Volts and Below; Low Voltage, 240/120 Volts; 167 kVa and Smaller Requirements	
IEEE C57.12.34	Standard for Requirements for Pad-Mounted, Compartmental-Type, Self-Cooled, Three-Phase Distribution Transformers, 5 MVA and Smaller; High Voltage, 34.5 kV Nominal System Voltage and Below; Low Voltage, 15 kV Nominal System Voltage and Below	2009
OECD Test 203	Fish Acute Toxicity Test	1992

4.5.29. Transformer – LV

Similar to the high & medium voltage transformer, low voltage transformers have personnel, equipment, and environmental hazards. Following NFPA 70 and IEEE C2 when designing the electrical systems for the transformers is critical for the safety of employees, structures, environment, etc. Both codes are recommended to be required for offshore substations and are included in Table 54 below.

Table 54: Recommended Codes to be Required for Transformer – HV MV

Standard	Description	Date	Errata
NFPA 70	National Electrical Code	2014	AMD 1 2013; Errata 1 2013; AMD 2 2013; Errata 2 2013; AMD 3 2014; Errata 3 2014
IEEE C2	National Electrical Safety Code	2012; INT 1-4 2012; INT 5-7 2013	Errata 2012

Four standards are recommended to be utilized for low voltage transformers, including a UL standard for the transformers themselves and an ASTM standard for the insulating oil. Refer to Table 55 for further information.

Table 55: Recommended Standards Related to Transformer – LV

Standard	Description	Date
ASTM D3455	Compatibility of Construction Material with Electrical Insulating Oil of Petroleum Origin	2011
FM APP GUIDE	Approval Guide http://www.approvalguide.com/	Updated online
OECD Test 203	Fish Acute Toxicity Test	1992
UL 1561	Dry-Type General Purpose and Power Transformers	2011; Reprint Sep 2012

4.5.30. Transformer Neutral Grounding Resistors

The National Electrical Code is recommended for the design on transformer neutral grounding resistors on offshore platforms. The use of transformer neutral grounding resistors (in appropriate applications) can help reduce fault current levels. Details of this code are provided below in Table 56.

Table 56: Recommended Codes to be Required for Transformer Neutral Grounding Resistors

Standard	Description	Date	Errata
NFPA 70	National Electrical Code	2014	AMD 1 2013; Errata 1 2013; AMD 2 2013; Errata 2 2013; AMD 3 2014; Errata 3 2014

Two standards recommended to be utilized along with the National Electrical Code are IEEE standards relating to grounding of power systems and test procedures. They are included below in Table 57.

Table 57: Recommended Standards Related to Transformer Neutral Grounding Resistors

Standard	Description	Date
IEEE Standard 32-1972	IEEE Standard Requirements, Terminology, and Test Procedures for Neutral Grounding Devices	1972
IEEE Standard 32-1972	IEEE Recommended Practice for Grounding of Industrial and Commercial Power Systems	2007

4.5.31. UPS Systems

UPS systems can pose safety hazards including shock if improperly designed or constructed. UPS systems may maintain hazardous items, such as batteries, and proper design and installation precautions should be acknowledged. Designing the systems using NFPA 70 and NFPA 110 can reduce the chances of these hazards. These are included below in Table 58.

Table 58: Recommended Codes to be Required for UPS Systems

Standard	Description	Date	Errata
NFPA 70	National Electrical Code	2014	AMD 1 2013; Errata 1 2013; AMD 2 2013; Errata 2 2013; AMD 3 2014; Errata 3 2014
NFPA 110	Standard for Emergency and Standby Power Systems	2013	-

One additional standard that can be utilized along with the codes required above is the NEMA PE 1 standard for power systems. Refer to Table 59 below for further information.

Table 59: Recommended Standards Related to UPS Systems

Standard	Description	Date
NEMA PE 1	Uninterruptible Power Systems (UPS) Specification and Performance Verification	2003

4.6. Mechanical

Mechanical design has some areas that are clearly covered by OSHA standards in 29 CFR 1910 including dump tanks, life rafts, drain systems, pipes, and HVAC equipment, but lack details in other areas including cranes (both pedestal and bridge cranes) and deck washing. Refer to Appendix B for more information.

4.6.1. Drain System

Proper design of a drainage system is important to avoid safety hazards on the platform such as slips and falls, and is also important to maintaining the environment by preventing accidental discharge of fluids from the platform. 40 CFR 112 contains general information for design to prevent spills, as well as spill control and countermeasures. NFPA 850 also provides information for curbed or "bunded" area sizing to properly contain spills. Both 40 CFR 112 and NFPA 850 should apply for offshore substations and are recommended to be required.

One industry standard that could be utilized in some situations is DNV-OS-D101. It provides requirements for offshore drainage systems that is more focused on applicability to offshore environments. This standard does not need to be a requirement given the information included in NFPA 850 and 40 CFR 112.

4.6.2. Pipes

No gap was identified regarding pipes.

4.6.3. Pumps / Sump Pumps

29 CFR 1910 does not contain a section regarding pumps, but pumps can pose safety hazards relating to shocks, as well as other safety hazards relating to moving parts. In addition, environmental risks are associated with pumps, as a leaking pump could discharge unwanted fluids to the environment. An improperly working sump pump could also cause hazards including flooded and slippery areas, especially in cold environments.

To address these issues, several different standards describing pump requirements are recommended. For maximum pump operating conditions of 300 psig pressure and 300 ^{O}F temperature, ANSI/HI 2.1-2.6 is recommended for vertical pumps and ANSI/HI 1.1-1.6 is recommended for centrifugal pumps. These standards outline the nomenclature, design, application, installation, operation, maintenance, and pump test requirements for rotodynamic vertical pumps and centrifugal pumps. For maximum pump operating conditions reaching up to 750 psig pressure and 500 ^{O}F temperature, API STD 610 is recommended for vertical and centrifugal pumps. Pumps produced to API STD 610 are cost effective when pumping liquids at conditions exceeding any one of the following: 275 psig discharge pressure, 75 psig suction pressure, 300 ^{O}F pumping temperature, 3,600 r/min rotative speed, 400 feet rated total head, or 13 inch impeller diameter for overhung pumps. API STD 682 is recommended for sealing systems for pumps complying to API STD 610. Pumps at this pressure and temperature are unexpected for typical offshore substations and should not be a requirement. However, if one of the conditions is met, the use of API would be appropriate. API RP 686 provides recommended procedures, practices, and checklists for the installation and pre-commissioning of new pumps on offshore substations. The choice between ANSI and API pumps will depend on operating conditions for pumps on the substation platform. API standard compliance is recommended for pumps in more severe operating environments, while ANSI/HI standard compliance is recommended for lighter duty pumps.

To summarize, ANSI/HI 2.1-2.6, ANSI/HI 1.1-1.6, and API RP 686 are recommended to be required for pumps on offshores substations.

4.6.4. Deck Washing

Deck washing can be an issue with regards to permitting of offshore structures due to the potential for discharge of fluids. However, if deck washing is allowed on an offshore substation by permit, UL 1776 provides guidance for portable and fixed high pressure cleaning machines to prevent any safety issues that could arise and is recommended to be utilized.

4.6.5. HVAC

No gap was identified regarding HVAC systems. 29 CFR 1910 properly addresses safety issues associated with HVAC systems. The owner may require more extensive design related specifications, including conditioned spaces for certain pieces of electrical equipment (such as GIS gear), but that is related to minimizing maintenance costs of equipment and increasing the reliability of the equipment. In the case that HVAC system is used, NFPA 90A is the standard for the installation of air conditioning and ventilating systems.

4.6.6. Pedestal Crane

Pedestal cranes can cause significant safety hazards, including not properly designing them for the weights that may be lifted and not maintaining them properly on offshore environments. Crane failure can easily lead to fatalities and is a serious concern for offshore facilities. These safety hazards can be addressed by using API Spec 2C for the design, construction, and testing of offshore pedestal mounted cranes. In addition, API RP 2D can be used for safe operation and maintenance of pedestal cranes.

4.6.7. Bridge Crane

Bridge cranes are commonly used on offshore platforms to move heavy electrical equipment including GIS and shunt reactors. These can lead to fatal accidents if a crane failure occurs. To prevent these hazards, ASME B30.2 applies to the construction, installation, operation, inspection, and maintenance of manual and power driven overhead and gantry cranes that have a top running girder bridge.

Other industry standards that could be referenced include UFGS 41 22 13.13 that covers requirements for bridge cranes with capacities between 10 and 30 tons, while UFGS 41 22 13.14 covers requirements for bridge cranes with capacities less than 10 tons.

4.6.8. Jib Crane

Jib cranes has similar safety hazards as pedestal cranes and can be addressed with the same standards, API Spec 2c and API RP 2D.

4.6.9. Dump Tanks

No gap was identified regarding dump tanks, as the existing codes required in the OSHA standards are adequate for dump tank selection on offshore substations. No additional guidance is recommended by BSEE / BOEM.

4.6.10. Life Rafts

No guidance is provided in 29 CFR 1910 regarding life rafts. 46 CFR 133 includes details for the number of ring life buoys required for ships, but this does not translate well to offshore platforms as there are limited places where a person could fall into the water from an offshore platform. There is also guidance in the International Convention for the Safety of Life at Sea (SOLAS), 1974; Chapter III, amended 2008. SOLAS also connects the life boat and life jacket requirement to type of ship, which does not directly apply, but does provide quality guidance for maintenance of life rafts and other lifesaving equipment, as well as accessibility requirements for the life boats and details for davit launched systems. It is recommended the BSEE / BOEM add text to the CFR based upon the SOLAS rules, but focus on the limited access to boats that are typically present in offshore platforms (typically only two access ladders to the water). Neither 46 CFR 133 nor SOLAS is recommended to be a requirement since they do not directly translate to offshore platforms.

4.7. Fire Protection

NFPA 101 identified in 29 CFR 1910 provides detail for life safety design, but lacks detail for fire protection related to specific electrical equipment commonly found on offshore substations including transformers, gas insulated switchgear, and shunt reactors. Gaps were identified with regards to these various design elements and recommendations have been provided below. Refer to Appendix B for more information.

4.7.1. Fire detection system

Fire detection is a key safety issue for an offshore platform. DNV-OS-J201 provides recommendations for fire and gas detection systems in offshore substations. NFPA 72 should also be included, as it provides detail on fire alarm systems and fire detectors in all structures. NFPA 1221 details the communications systems related to fire detection systems. As offshore substations can have no employees on them for periods of time, having an appropriately designed communication system between the platform and the shore-based operator is vital. DNV-OS-J201, NFPA 72, and NFPA 1221 are all recommended to be required. The UL 268 standard is recommended for the smoke detector component and the UL 864 standard is recommended for the fire alarm system components, but neither are recommended to be required at this time, as foreign made parts could be adequate, but not created to the UL standards.

However, API RP 14G should be an acceptable replacement for DNV-OS-J201. DNV is preferred in that it is designed specifically for offshores substations, but API RP 14G is acceptable in that the oil and gas industry has a larger risk of significant fires. API RP 14G should be considered a more conservative standard that should not be required with regards to fire protection systems, as it could lead to additional costs for the structures without providing a benefit in terms of safety. The use of DNV-OS-J201 also does not conflict with the use of API standards in other components of the structure.

4.7.2. Fire Suppression System

In the event that a fire does occur, suppressing the fire to ensure that evacuation routes are available and the structure maintains structural stability are key to avoid fatalities. DNV-OS-J201 addresses these issues, including detail of fire water pump systems, fire mains, deluge systems, sprinkler systems, pressure water-spraying systems, water mist and gaseous systems, and foam systems. For the design of the dry chemical systems, NFPA 17 should be included, while NFPA 11 should be included for foam systems and NFPA 15 should be used for water spray systems. To ensure reliability of the systems during emergency situations, NFPA 110 Standard for Emergency and Standby Power Systems should be utilized. NFPA 11, NFPA 15, NFPA 17, and NFPA 110 are all recommended to be required. No requirement is recommended between DNV-OS-J201 and API RP 14G, as both are sufficient for design.

4.7.3. Life Safety Design

Life safety design is largely addressed in 29 CFR 1910 through the use of NFPA 101 with additional information included in 33 CFR 140-147, but both API RP 14G and DNV-OS-J201 provide additional guidance specific for offshore structures relating to egress and personnel safety. Either is acceptable, and whichever document is utilized for the fire detection and fire suppression system design should be utilized for life safety design for consistency.

4.7.4. Passive Protection

Passive fire protection is a safety related issue relating to maintaining structural stability in the event of a fire. DNV-OS-J201 provides passive protection recommendations to prevent escalation of a fire from one area to an adjacent area, ensure the temporary safe area is intact for the time necessary, protect personnel from the fire and make escape or evacuation possible, protect systems and equipment of essential importance for safety, and maintain structural integrity for the required period of time. API RP 14G does provide some design details for fire protection, but lacks the details provided in J201. DNV-OS-J201 is thus recommended for the design of passive protection of the offshore substation.

4.7.5. Fire Extinguishers

Fire extinguishers are important to prevent small fires from becoming a hazard for the entire offshore platform. NFPA 10 provides information on fire extinguishers and API RP 14G provides information on locations fire extinguishers should be provided on offshore platforms. DNV-OS-J201 does not provide as much detail regarding fire extinguishers. Using API RP 14G for fire extinguisher placement does not lead to a conflict with regards to other areas of fire protection designed to DNV standards. Both NFPA 10 and API RP 14G are recommended to be required.

4.8. Helideck

No guidance is provided regarding design relating to helidecks, as only a specific section of API RP 2A WSD 21st edition is referenced in 30 CFR 585 and other documents like the BSEE Notice to Lessees No 2011 N-08 directly refer to oil and gas leases. The FAA circular identified previously in Task 1 is only a recommended design guide unless federal money is provided for the helideck, which is unexpected since offshore substations are privately owned structures. Recommendations are thus provided based on the gaps previously identified and the standards used in the oil and gas industry, as they are similar with regards to risks when compared to offshore substations. Refer to Appendix B for more information.

4.8.1. Structural

API RP 2L provides design loads for helicopters, as well as how the size of the helideck should be calculated. In addition, API RP 2L provides information for marking and placement of the helideck with regard to wind direction to minimize the risk of an accident while landing or during take-off. Design of structural steel for tubular members should be completed based on the requirements of API RP 2A WSD – 22nd Edition, whereas, design of non-tubular members is recommended to be completed based on the requirements of Allowable Strength Design (ASD) design approach in AISC 360. It should also be noted that API is updating their 2L recommended practice, with three separate documents likely being released in the next year or two. API RP 2L is the recommended document to be required at this time, but this should be reevaluated once API RP 2L-1 is released.

4.8.2. Electrical

Electrical issues on a helideck could cause a crash if the helideck is not properly lit. FAA AC 150-2C provides details including perimeter lighting, floodlights, and landing direction lights. NFPA 70 should also be used for wiring of the lighting and NFPA 418 Standards for Heliports should be included as well. All three documents are recommended to be required.

4.8.3. Fire Protection

API RP 2L includes minimal discussion on fire protection of helidecks. FAA AC 150-2C includes additional information on fire protection, referencing three NFPA documents, NFPA 403 Standard for Aircraft Rescue and Fire-Fighting Service, NFPA 407 Standard for Aircraft Fuel Servicing, and NFPA 418 Standard for Heliports. As it is not considered normal practice for fuel servicing to occur on an offshore substation, only NFPA 403 and NFPA 418 are recommended to be required for fire protection of heliports on offshore substations.

5. Summary

As the third and final step in providing recommendations to BSEE and BOEM on appropriate standards for offshore substation design, approximately 100 design elements and associated design gaps were analyzed. For each of these gaps, a commentary on appropriate codes was provided, and the recommended code / standard(s) to be required was listed. The recommended codes to be required by discipline is provided in the following tables, Table 60 –

Table 63. A full list of the recommended codes by design element with the description of the gap identified is included in Appendix B.

Table 60: Structural Codes Recommended to be Required

Standard	Description	Date
ACI 357	Marine and Offshore Concrete Structures, Guide for the Design and Construction of Fixed Offshore Concrete Structures	2011
AISC	Steel Construction Manual 14th Edition	2011
API RP 2A	Planning, Designing and Constructing Fixed Offshore Platforms – Working Stress Design 22nd edition	2014
API RP 2EQ	Seismic Design Procedures and Criteria for Offshore Structures	2014
API RP 2FPS	Recommended Practice for Planning, Designing, and Constructing Floating Production Systems	2001
API RP 2GEO	Geotechnical and Foundation Design Considerations	
API RP 2L	Planning, Designing, and Constructing Heliports for Fixed Offshore Platforms	1996; R 2012
API RP 2MET	Derivation of Metocean Design and Operating Conditions	2014
API RP 2N	Recommended Practice for Planning, Designing, and Constructing Structures and Pipelines for Arctic Conditions	1995
API RP 2P	Recommended Practice for the Analysis of Spread Mooring Systems for Floating Drilling Units	1987
API RP 2SIM	Structural Integrity Management of Fixed Offshore Structures	2014
API RP 2T	Recommended Practice for Planning, Designing and Constructing Tension Leg Platforms	2010

Standard	Description	Date
API Spec 2B	Specification for the Fabrication of Structural Steel Pipe	2012
ASCE-07	Minimum Design Loads for Buildings and Other Structures	2013
AWS D1.1	Structural Welding Code	2010
DNV-OS-J101	Design of Offshore Wind Turbine Structures	2011
ISO 19905-1	Petroleum and Natural Gas Industries - Site-Specific Assessment of Mobile Offshore Units - Part 1: Jack-Ups	2012
NACE SP-0108	Corrosion Control of Offshore Structures by Protective Coatings	2008
NACE SP-0176	Corrosion Control of Submerged Areas of Permanently Installed Steel Offshore Structures Associated with Petroleum Production	2007
USFHA HEC-18	Evaluating Scour at Bridges, 5^{th} ed	2012

Table 61: Electrical Codes Recommended to be Required

Standard	Description	Date	Errata
33 CFR 66	Navigation and Navigable Waters: Private Aids to Navigation	2014	
33 CFR 67	Aids to Navigation on Artificial Islands and Fixed Structures	2014	
FAA AC 70/7460-1K	Obstruction Marking and Lighting	2007	
IEEE C2	National Electrical Safety Code	2012	Errata 2012; INT 1-4 2012; INT 5-7 2013
NFPA 30	Flammable and Combustible Liquids Code	2015	
NFPA 37	Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines	2015	
NFPA 70	National Electrical Code	2014	AMD 1 2013; Errata 1 2013; AMD

			22013; Errata 2 2013; AMD 3 2014; Errata 3 2014
NFPA 70B	Recommended Practice for Electrical Equipment Maintenance	2013	
NFPA 70E	Standard for Electrical Safety in the Workplace		
NFPA 101	Life Safety Code		
NFPA 110	Standard for Emergency and Standby Power Systems	2013	
NFPA 780	Standard for the Installation of Lightning Protection Systems	2014	
NFPA 900	Building Energy Code	2013	

Table 62: Mechanical Codes to be Required

Standard	**Description**	**Date**	**Errata**
40 CFR 112: B	Protection of Environment: Oil Pollution prevention. Requirements for Petroleum Oils and Non-Petroleum Oils, Except Animals Fats and Oils and Greases, and Fish and Marine Mammal Oils; and Vegetable Oils (Including Oils from Seeds, Nuts, Fruits, and Kernals)	2013	
API Spec 2C	Specification for Offshore Pedestal Mounted Cranes	2004	
API RP 2D	Operation and Maintenance of Offshore Cranes	2003	
API RP 686	Recommended Practices for Machinery Installation and Installation Design	1996	
ANSI/HI 1.1-1.6	Centrifugal Pumps	2008	
ANSI/HI 2.1-2.6	Vertical Pumps	2013	

ASME B30.2	Overhead and Gantry Cranes (Top Running Bridge, Single or Multiple Girder, Top Running Trolley Hoist)	2011	
NFPA 850	Recommended Practice for Fire Protection for Electric Generating Plants and High Voltage Direct Current Converter Stations	2010	
UFGS 41 22 13.13	Bridge Cranes	2008	
UFGS 41 22 13.14	Bridge Cranes, Overhead Electric, Top Running	2008	
UL 1776	Pressure Washer Safety Standard		

Table 63: Fire Protection Codes to Be Required

Standard	**Description**	**Date**	**Errata**
API RP 14G	Recommended Practice for Fire Prevention and Control on Fixed Open-type Offshore Production Platforms	2007	
NFPA 10	Standard for Portable Fire Extinguishers		
NFPA 11	Standard for Low-, Medium-, and High-Expansion Foam		
NFPA 15	Standard for Water Spray Fixed Systems for Fire Protection		
NFPA 17	Standard for Dry Chemical Extinguishing Systems	2013	
NFPA 72	National Fire Alarm and Signaling Code	(2014; AMD 1 2013; AMD 3 2014)	Errata 1 2013; AMD 2 2013; Errata 2 2013; Errata 3 2014)
NFPA 403	Standard for Aircraft Rescue and Fire-Fighting Services	2014	
NFPA 418	Standard For Heliports	2011	
NFPA 1221	Standard for the Installation, Maintenance, and Use of Emergency Services Communications Systems	2013	

In addition to the recommendations for required codes and standards, for the electrical design elements codes were provided that should be required, as well as a table of recommended standards that are often used in conjunction with those codes, but may not need to be required by the federal government. These standards were included in the commentary in 4.5. A full list of all industry standards relating to electrical design elements has also been included in Appendix C, with required and recommended codes and standards designated with * and # respectively.

As previously described, Appendix B contains 95 design elements that have been identified as under the jurisdiction of BSEE / BOEM that relate to the design of an offshore substation. It should be noted that not all of the design elements apply to all offshore substations, a substation may not require a CCTV system, but if one is provided, the intention of this report is to identify the proper standard that should be applied to the design of the system. The first column of Appendix B contains the design elements while the second column contains the existing CFRs and associated standards that currently address that design element. The third column contains the gaps that were identified for that particular design element. Lastly, the fourth column contains the recommended code to be required for the design element. Figure 2 below includes a depiction of standards determined to be applicable to offshore wind at this time, with laws in the top row and standards incorporated by reference listed below the corresponding laws. For specific standards incorporated by reference in CFRs, refer to the items in Appendix A marked with a "#".

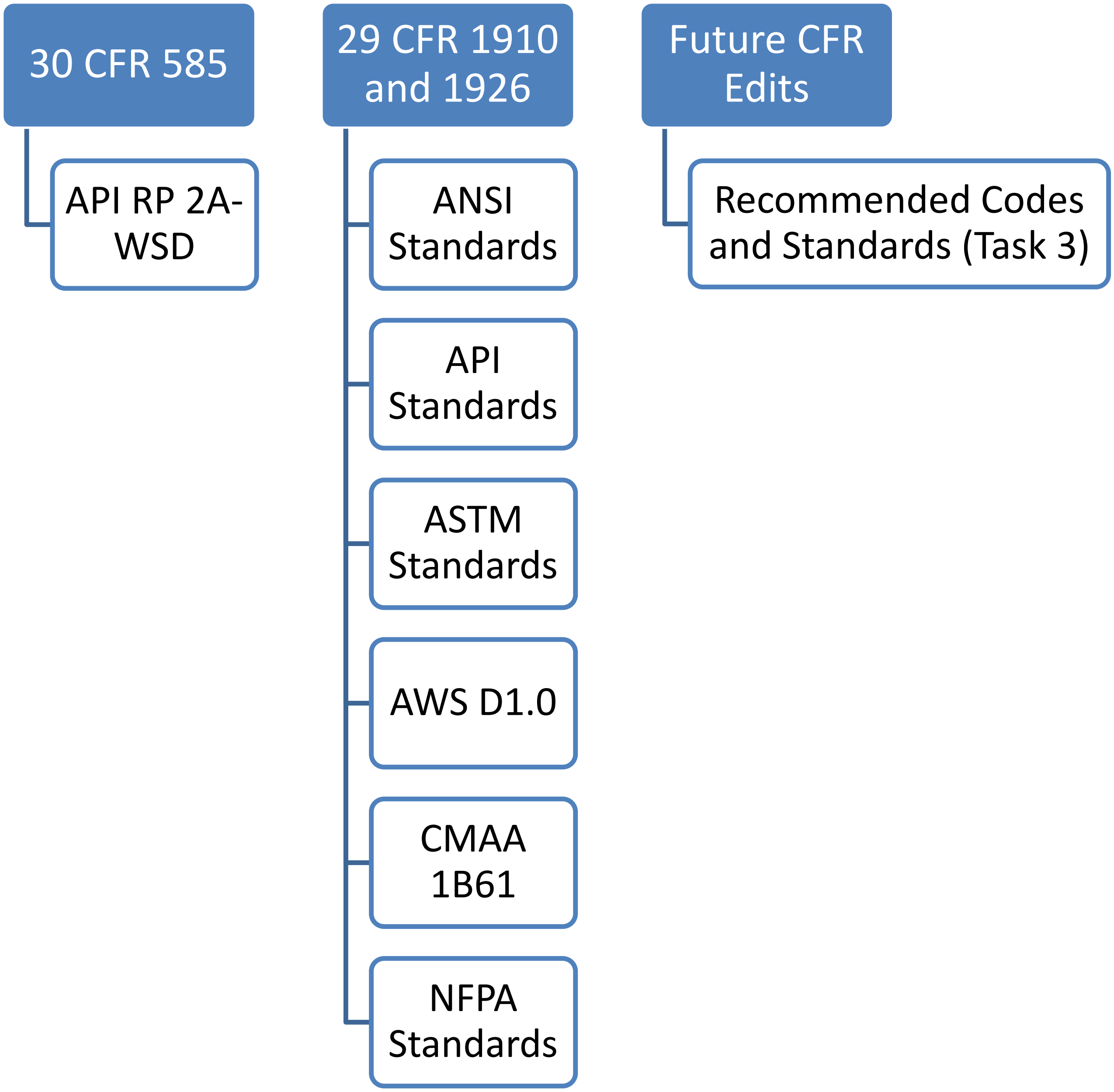

Figure 2: Laws and Standards Governing Offshore Substation Design

Each design element and gap has been provided with a recommended code for BSEE / BOEM to consider making a requirement of offshore substation design. For some instances, no recommendation was provided. Refer to the respective commentary sections on why no recommendation is considered applicable at this time. This list of recommended codes can be useful for BSEE / BOEM when updating the Code of Federal Regulations of required standards to use for offshore substation design. In addition, where applicable, other industry standards have been provided in situations where the industry standard may not be practical to be required, but may be acceptable for the designer to use in certain situations. The list of industry standards can be useful for BOEM / BSEE when reviewing offshore substation projects. Refer to Appendix B for the complete set of recommendations.

6. Next Steps

This report has provided recommended standards and methodologies that can be utilized for the design of offshore substations and as the basis of regulatory review. Additional work on this topic is required in the following areas:

- Operations and Maintenance
- Decommissioning
- Assessment for Life Extension, Change of Use and Modification
- Refined Hazards Assessment for Vessel Impact
- Design for Blast Loads
- Environmental Requirements

As the offshore wind industry is new in the United States, there is no prior experience and little guidance available to define the requirements for operations and maintenance. The operations of offshore wind is comparable to the design in that there is extensive experience in Europe and in the oil & gas industry in the United States, with the potential that a combination of existing standards could be used to address this need. The current CFRs reference a Safety Management System requirement for monitoring of the facility and definition of emergency response procedures, but lacks specific direction (such as what BSEE / BOEM determines is an acceptable level of monitoring and evacuation time). The oil & gas industry has a Safety and Environmental Management System (SEMS) requirement that references API RP 75. Some details required for the SEMS, including the Mechanical Integrity requirement and the extent of the Hazards Analysis may be obtrusive to the development of offshore substations without providing a measureable benefit to the safety of employees or the environment due to the different nature of the operations on an offshore substation. This topic should be researched in greater detail, with a focus on reducing oversight requirements for offshore wind when compared with the oil and gas industry for elements that have far lesser impact on the environment because of the nature of the work.

The requirements for decommissioning of offshore substations should be defined to provide developers and operators with a basis for their planning and assessment of potential financial impact. The information that is available within the oil and gas industry may be used as the basis for these requirements but modified to account for the different environmental impacts of offshore substations and typical oil and gas platforms.

The current requirements have been developed for new construction but have not addressed existing facilities. It is therefore recommended that BSEE / BOEM further research codes and standards for analysis of existing structures. API RP 2SIM is a key document to consider for this, but 2SIM is not a complete document with regards to an offshore substation and research into applicable codes for the significant amount of electrical equipment contained on offshore substations is needed. This is required to protect the employees on the platform and the environment as the unique equipment associated with offshore substations are impacted by the marine environment over time.

One area relating to offshore substations that could benefit from a more detailed study would be vessel collisions. It appears that many European codes are conservative with regards to design vessels (mass and velocity) that could impact the substations, potentially leading to unnecessary costs for the construction of the structures. A further study that could utilize a probabilistic approach for the design vessels, considering such factors as distance to main shipping channels, water depth (potentially limiting the draft of a vessel that could strike the structure), as well as the placement of the offshore substation within the wind farm. Many times, but not always, an offshore substation is located in the center of the wind farm. With regard to vessel collisions, vessels would likely strike the turbines before reaching the substation in the center of the wind farm, likely reducing the chances of a drifting ship impacting the substation.

Design with regards to blast loads is another area that could benefit from a detailed study. There is considerable debate in Europe as to the best way to design for an arcflash or explosion in switchgear or transformers located on an offshore substation. Blast panels are common, but the effectiveness of the panels is unknown. Determining an appropriate level of acceptable design, including allowing a wall to fail as long as the structural integrity of the whole platform is not threatened would be beneficial to designers of platforms in the future.

Environmental requirements pertaining to offshore substations is another area that would benefit from further study under the direction of BSEE and BOEM. BSEE OSPD sets oil spill response requirements for the oil and gas industry and has requested that no recommendation be provided in this study with regards to oil spill requirements, as regulations relating to oil spills require more detailed study with greater participation from the OSPD department of BOEM.

Another key focus for BSEE and BOEM as the CFRs are updated is the release of new API documents. As stated in this report, API is trying to harmonize their reference documents with ISO documents, resulting in significant changes to some of the API recommended practice documents. API RP 2L, "Planning, Designing, and Constructing Heliports for Fixed Offshore Platforms", one of the recommended documents in this report is currently in the process of a significant update, with an expected release date in 2015. It is anticipated that the new API RP 2L will be split into multiple documents, with API RP 2L-1 the document most likely to be referenced by BSEE and BOEM for offshore substation design.

Lastly, as wind farm technology advances there will be new technical requirements for offshore substations that will need to be addressed within the standards. These future needs may include, for example, floating substations, local storage of power (e.g., compressed air storage) and other means of power transmission. Regular updates of these standards is recommended to address the significance of these new requirements.

Appendix A – List of Codes and Standards Considered

Codes & Standards	Name	Edition	Year
American Bureau of Shipping			
ABS 24	Material Selection and Inspection of Inert Gas Systems		1980
ABS 29	Offshore Installations		2010
ABS 49	Inspection, Maintenance and Application of Marine Coating Systems		2007
ABS 63	Facilities on Offshore Installations		2014
ABS 115	Fatigue Assessment of Offshore Structures		2014
ABS 141	Fire-Fighting Systems		2014
ABS 197	Accidental Load Analysis and Design for Offshore Structures		2013
ABS 208	Implementation of Human Factors Engineering into the Design of Offshore installations		2014
American Concrete Institute			
ACI 318	Building Code Requirements for Structural Concrete		2011
ACI 357	Marine and Offshore Concrete Structures, Guide for the Design and Construction of Fixed Offshore Concrete Structures		1997
American Institute of Steel Construction			
AISC	Steel Construction Manual	14	
AISC 360	Specification for Structural Steel Buildings		2010
American National Standards Institute			
ANSI A10.32	Personal Fall Protection Used in Construction and Demolition Operations	12	2012
ANSI A11.1#	Practice for Industrial Lighting		2001
ANSI A13.1#*	Scheme for the Identification of Piping Systems		1956
ANSI A14.3#	Safety Code for Fixed Ladders		2008
ANSI A17.1#	Safety Code for Elevators, Dumbwaiters and Moving Walks		2007
ANSI A90.1#	Safety Standard for Manlifts		2009
ANSI A120.1#	Safety Code for Powered Platforms for Exterior Building Maintenance		2008
ANSI B15.1#*	Safety Code for Mechanical Power Transmission Apparatus		1999

Codes & Standards	Name	Edition	Year
ANSI B30.2.0#*	Overhead and Gantry Cranes	76	1976
ANSI B31.1#	Code for Pressure Piping		2014
ANSI S1.4#	Specification for Sound Level Meters		2014
ANSI Z4.1#	Requirements for Sanitation in Places of Employment		2005
ANSI Z9.2#	Fundamentals Governing the Design and Operation of Local Exhaust Systems		2012
ANSI Z35.1#	Specifications for Accident Prevention Signs		2011
ANSI Z41#*	American National Standard for Foot Protection		2009
ANSI Z87.1#	American National Standard for Occupational and Educational Personal Eye and Face Protection Devices	99	1999
ANSI Z88.2	American National Standard for Respiratory Protection	11	2011
ANSI Z89.1#	American National Standard for Industrial Head Protection	3	2003
ANSI Z358.1	American National Standard for Emergency Eyewash and Shower Equipment	92	1992
ANSI Z535.2#	Environmental and Facility Safety Signs		2011
ANSI Z535.4	American National Standard for Product Safety Signs and Labels	14	2014
ANSI/HI 1.1-1.6	Centrifugal Pumps		2008
ANSI/HI 2.1-2.6	Vertical Pumps		2013
American Petroleum Institute			
API 14 FZ	Recommended Practice For Design, Installation, And Maintenance Of Electrical Systems For Fixed And Floating Offshore Petroleum Facilities For Unclassified And Class 1, Zone 0, Zone 1, And Zone 2 Locations	2	2013
API 593	Ductile Iron Plug Valves, Flanged Ends	2	1981
API 594	Check Valves: Wafer, Wafer-Lug, and Double Flanged Type	5	1997
API 595	Cast-Iron Gate Valves Flanged Ends	2	1984
API 598	Valve Inspection and Test	7	1996
API 599	Metal Plug Valves—Flanged, Threaded, and Welding Ends	7	2013
API 600	Bolted Bonnet Steel Gate Valves for Petroleum and Natural Gas Industries	11	2011

Codes & Standards	Name	Edition	Year
API 602	Compact Design Carbon Steel Gate Valves for Refinery Use	7	1998
API 603	Corrosion-Resistant, Bolted Bonnet Gate Valves - Flanged and Butt-Welding Ends	6	2001
API 606	Compact Steel Gate Valves- Extended Body	3	1989
API 609	Butterfly Valves: Double Flanged, Lug- and Wafer-Type	6	2004
API 610	Centrifugal Pumps for Petroleum, Petrochemical and Natural Gas Industries	11	2010
API 620#	Design and Construction of Large, Welded, Low-pressure Storage Tanks	12	2013
API 682	Pumps-Shaft Sealing Systems for Centrifugal and Rotary Pumps	4	2012
API 686	Recommended Practices for Machinery Installation	1	1996
API RP 2MET	Derivation of Metocean Design and Operating Conditions	1	2014
API RP 12D#	Field Welded Tanks for Storage of Production Liquids	10	1994
API RP 12F#	Shop Welded Tanks for Storage of Production Liquids	11	1994
API RP 12P	Specifications for Fiberglass Reinforced Plastic Tanks	2	1995
API RP 14C	Recommended Practice for Analysis, Design, Installation, and Testing of Basic Surface Safety Systems for Offshore Production Platforms	7	2001
API RP 14E	Recommended Practice for Design and Installation of Offshore Products Platform Piping Systems		1993
API RP 14F	Design, Installation, and Maintenance of Electrical Systems for Fixed and Floating Offshore Petroleum Facilities for Unclassified and Class 1, Division 1 and Division 2 Locations	5	2008
API RP 14G	Recommended Practice for Fire Prevention and Control on Fixed Open-type Offshore Production Platforms	4	2007
API RP 14J	Recommended Practice for Design and Hazards Analysis for Offshore Production Facilities	2	2001

Codes & Standards	Name	Edition	Year
API RP 2A – WSD#	Recommended Practice for Planning, Designing and Constructing Fixed Offshore Platforms - Working Stress Design	22	2014
API RP 2C	Specification for Offshore Pedestal Mounted Cranes	6	2004
API RP 2CON (planned for development)			NA
API RP 2D	Operation and Maintenance of Offshore Cranes	5	2003
API RP 2EQ	Seismic Design Procedures and Criteria for Offshore Structures	1	2014
API RP 2FB	Recommended Practice for the Design of Offshore Facilities Against Fire and Black Loading	1	2006
API RP 2FPS	Recommended Practice for Planning, Designing, and Constructing Floating Production Systems	1	2001
API RP 2GEO	Geotechnical and Foundation Design Considerations	1	2014
API RP 2L	Planning, Designing, and Constructing Heliports for Fixed Offshore Platforms	4	1996
API RP 2N	Recommended Practice for Planning, Designing, and Constructing Structures and Pipelines for Arctic Conditions	2	1995
API RP 2P	Recommended Practice for the Analysis of Spread Mooring Systems for Floating Drilling Units	2	1987
API RP 2RD	Dynamic Risers for Floating Production Systems	2	2013
API RP 2SIM	Structural Integrity Management of Fixed Offshore Structures	1	2014
API RP 2T	Recommended Practice for Planning, Designing and Constructing Tension Leg Platforms	3	2010
API RP 2TOP (under development)			NA
API RP 500	Recommended Practice for Classification of Locations for Electrical Installations at Petroleum Facilities Classified as Class I, Division I and Division 2	3	2012
API Spec 2b	Specification for the Fabrication of Structural Steel Pipe	6	2012

Codes & Standards	Name	Edition	Year
American Society of Civil Engineers			
ASCE 7	Minimum Design Loads for Buildings and Other Structures		2013
American Society of Mechanical Engineers			
ASME A13.1	Scheme for the Identification of Piping Systems		2007
ASME B1.20.1	Pipe Threads, General Purpose (Inch)		2013
ASME B16.1	Gray Iron Pipe Flanges and Flanged Fittings Classes 25, 125, and 250		2010
ASME B16.5	Pipe Flanges & Flanged Fittings NPS 1/2 Through NPS 24 Metric / Inch Standard		2013
ASME B16.9	Factory-Made Wrought Butt-welding Fittings		2012
ASME B16.10	Face-to-Face and End-to-End Dimensions of Valves		2009
ASME B16.11	Forged Fittings, Socket-Welding and Threaded		2011
ASME B16.14	Ferrous Pipe Plugs, Bushings, and Locknuts with Pipe Threads		2013
ASME B16.20	Metallic Gaskets for Pipe Flanges - Ring-Joint, Spiral-Wound, and Jacketed		2012
ASME B16.21	Nonmetallic Flat Gaskets for Pipe Flanges		2011
ASME B16.25	Buttwelding Ends		2012
ASME B16.28	Wrought Steel Butt-welding Short Radius Elbows and Returns		1994
ASME B16.34	Valves - Flanged, Threaded, and Welding End		2013
ASME B16.47	Large Diameter Steel Flanges		2006
ASME B30.2	Overhead and Gantry Cranes (Top Running Bridge, Single or Multiple Girder, Top Running Trolley Hoist)		2011
ASME B30.7	Base-Mounted Drum Hoists		2001
ASME B30.10	Hooks		2014
ASME B30.11	Monorails and Underhung Cranes -Safety Standard for Cableways, Cranes, Derricks, Hoists, Hooks, Jacks, and Slings		2010
ASME B30.16	Overhead Hoists (Underhung)		2012
ASME B30.17	Overhead and Gantry Cranes (Top Running Bridge, Single Girder, Underhung Hoist)		2012
ASME B30.23	Personnel Lifting Systems		2011

Codes & Standards	Name	Edition	Year
ASME NUM-1	Rules for Construction of Cranes, Monorails, and Hoists (with Bridge or Trolley or Hoist of the Underhung Type)		2009
American Society for Testing and Materials			
ASTM A 47#	Malleable Iron Castings		2014
ASTM A 53#	Welded and Seamless Steel Pipe		2012
ASTM A 126#	Gray Iron Casting for Valves, Flanges, and Pipe Fitting		2014
ASTM A 391#	Alloy Steel Chain		2012
ASTM B 88#	Seamless Copper Water Tube		2009
ASTM B 117#	Salt Spray (Fog) Test		2011
ASTM B 210#	Aluminum-Alloy Drawn Seamless Tubes		2012
ASTM B 241#	Standard Specifications for Aluminum-Alloy Seamless Pipe and Seamless Extruded Tube		2012
ASTM D 1692#	Test for Flammability of Plastic Sheeting and Cellular Plastics		1976
ASTM F 2412#	Standard Test Methods for Foot Protection		2011
American Welding Society			
AWS D1.0	Code for Welding in Building Construction	9	2010
AWS D1.1	Structural Welding Code		2010
10.5.4 of AWS D1.2	Commentary on the Structural Welding Code		2008
AWS D3.6	Specification for Underwater Welding		2010
Civil Aviation Authority			
CAP 437	Standards for Offshore Helicopter Landing Areas	7	2013
Bureau of Safety and Environmental Enforcement			
Notice to Lessees No. 2011 N-08	Temporary Helideck Closures		2011
Code of Federal Regulations			
29 CFR 1910	Labor: Occupational Safety and Health Standards		2014
29 CFR 1910.132	Labor: Occupational Safety and Health Standards: Personal Protective Equipment: General Requirements		2014
29 CFR 1926.441	Labor: Safety and Health Regulations for Construction: Safety Requirements for Special Equipment: Batteries and Battery Charging		2014

Codes & Standards	Name	Edition	Year
30 CFR 254	Mineral Resources: Minerals Revenue Management: Offshore: Oil-Spill Response Requirements for Facilities Located Seaward of the Coast Line		2014
30 CFR 585	Mineral Resources: Minerals Revenue Management: Offshore: Renewable Energy and Alternate Uses of Existing Facilities on the Outer Continental Shelf		2014
33 CFR 125-199	Navigation and Navigable Waters: Waterfront Facilities		2014
33 CFR 140-147	Navigation and Navigable Waters: Waterfront Facilities: Outer Continental Shelf Activities		2014
33 CFR 66	Navigation and Navigable Waters: Private Aids to Navigation		2014
33 CFR 67	Aids to Navigation on Artificial Islands and Fixed Structures		2014
40 CFR 100-149	Protection of Environment: Water Programs		2014
46 CFR	Code of Federal Regulations: Shipping		2013
46 CFR 108	Shipping: Cargo and Miscellaneous Vessels: Design and Equipment		2013
46 CFR 111.15	Shipping: Cargo and Miscellaneous Vessels: Electric Systems: Storage Batteries and Battery Chargers: Construction and Installation		2013
46 CFR 112	Shipping: Cargo and Miscellaneous Vessels: Emergency Lighting and Power Systems		2013
Crane Manufacturer's Association			
CMAA 1B61#	Specification for Electric Overhead Traveling Cranes		
Det Norske Veritas			
DNV-CN-30.4	Foundations		1992
DNV-CN-30.6	Fatigue Assessment of Ship Structures		1992
DNV-OS-A101	Safety Principle and Arrangement		2013
DNV-OS-C101	Design of Offshore Steel Structures, General (LRFD Method)		2011
DNV-OS-C201	Structural Design of Offshore Units (WSD Method)		2011
DNV-OS-C401	Fabrication and Testing of Offshore Structures		2010

Codes & Standards	Name	Edition	Year
DNV-OS-C502	Offshore Concrete Structures		2010
DNV-OS-D101	Marine and Machinery Systems and Equipment		2013
DNV-OS-D301	Fire Protection		2014
DNV-OS-E401	Helicopter Decks		2012
DNV-OS-J103	Design of Floating Wind Turbine Structures		2013
DNV-OS-J201	Offshore Substations for Wind Farms		2009
DNV-RP-A205	Offshore Classification Projects- Testing and Commissioning		2013
DNV-RP-B401	Cathodic Protection Design		2010
DNV-RP-C203	Fatigue Strength Analysis of Offshore Steel Structures		2010
DNV-RP-C204	Design Against Accidental Loads		2010
DNV-RP-C205	Environmental Conditions and Environmental Loads		2010
DNV-RP-F205	Global Performance Analysis of Deepwater Floating Structures		2010
DNV-RP-J301	Subsea Power Cables in Shallow Water – Renewable Energy Applications		2014
Federal Aviation Administration			
FAA AC 70/7460-1K	Obstruction Marking and Lighting		2007
FAA AC 150 / 5390-2B*	Heliport Design		2004
FAA AC 150 / 5390-2C	Heliport Design		2012
FM Global			
FM Global Std. 3010	Approval Standard for Fire Alarm Signaling Systems		2010
Helicopter Safety Advisory Conference			
HSAC RP 2008-01	Gulf of Mexico Helideck Markings		2008
International Electrotechnical Commission			
IEC 60228	Conductors of Insulated Cables	3	2004
IEC 60229	Electric Cables - Tests on Extruded Oversheaths with a Special Protective Function	3	2007
IEC 60287	Electric Cables – Calculation of the Current Rating	1.1	1999
ANSI / IEC 60529	Degrees of Protection Provided by Enclosures		2004

Codes & Standards	Name	Edition	Year
IEC 60811	Common Test Methods for Insulating and Sheathing Materials of Electric Cables and Optical Cables	1.1	2001
IEC 60840	Power Cables with Extruded Insulation and Their Accessories for Rated Voltages Above 30 kV (Um = 36 kV) Up to 150 kV (Um = 170 kV) – Test Methods and Requirements	3	2004
Institute of Electrical and Electronics Engineers			
IEEE 112	Standard Test Procedure for Polyphase Induction Motors and Generators		2004
IEEE 1202	Standard for Flame Testing of Cables		1991
IEEE 1584	Guide for Performing Arc Flash Hazard Calculations		2002
IEEE 383	Qualifying Class 1E Electric Cables and Field Splices for Nuclear Power Generating Stations		2003
IEEE 450	Recommended Practice for Maintenance, Testing and Replacement of Vented Lead-Acid Batteries for Stationary Applications		2010
IEEE 484	Recommended Practice for Installation Design and Installation of Vented Lead-Acid Batteries for Stationary Applications		2002
IEEE 485	Recommended Practice for Sizing Lead-Acid Batteries for Stationary Applications		2010
IEEE 665	Guide for Generating Station Grounding		1995
IEEE 80	Guide for Safety in AC Substation Grounding		2000
IEEE SA 446	Recommended Practice for Emergency and Standby Power Systems for Industrial and Commercial Applications		1995
International Maritime Organization			
IMO A.414	Code for Construction and Equipment of Mobile Offshore Drilling Units		1979
International Safety Equipment Association			
ISEA Z87.1	American National Standard for Occupational and Educational Personal Eye and Face Protection Devices		2010
International Society of Automation			

Codes & Standards	Name	Edition	Year
ISA TR84	Safety Instrumented Functions - Safety Integrity Level Evaluation Techniques		2002
International Organization for Standardization			
ISO 19900	Petroleum and Natural Gas Industries - General Requirements for Offshore Structures		2013
ISO 19901-1	Petroleum and natural gas industries -- Specific requirements for offshore structures -- Part 1: Metocean design and operating considerations		2005
ISO 19901-2	Petroleum and Natural Gas Industries - Specific Requirements for Offshore Structures - Part 2: Seismic Design Procedures and Criteria		2004
ISO 19901-3	Petroleum and natural gas industries -- Specific requirements for offshore structures -- Part 3: Topsides structure		2010
ISO 19901-4	Petroleum and natural gas industries -- Specific requirements for offshore structures -- Part 4: Geotechnical and foundation design considerations		2003
ISO 19901-6	Petroleum and natural gas industries — Specific requirements for offshore structures — Part 6: Marine operations		2009
ISO 19903	Petroleum and Natural Gas Industries - Fixed Concrete Offshore Structures		2006
ISO 19904-1	Petroleum and Natural Gas Industries - Floating Offshore Structures - Part 1: Monohulls, Semi-Submersibles and Spars		2006
ISO 19905-1	Petroleum and Natural Gas Industries - Site-Specific Assessment of Mobile Offshore Units - Part 1: Jack-Ups		2012
ISO 19905-2	Petroleum and Natural Gas Industries - Site-Specific Assessment of Mobile Offshore Units - Part 2: Jack-Ups Commentary and Detailed Sample Calculations		2012
ISO 19906	Petroleum and natural gas industries -- Arctic offshore structures		2010
ISO 13702	Petroleum and natural gas industries -- Control and mitigation of fires and explosions on offshore production installations -- Requirements and guidelines		2010

Codes & Standards	Name	Edition	Year
Manufacturers Standardization Society			
MSS SP-25	Standard Marking System for Valves, Fittings, Flanges and Unions		2013
MSS SP-44	Steel Pipeline Flanges		1996
MSS SP-45	Bypass and Drain Connections		2008
MSS SP-6	Standard Finishes for Contact Faces of Pipe Flanges and Connecting-End Flanges of Valves and Fittings		2012
MSS SP-61	Pressure Testing of Valves		2009
National Association of Corrosion Engineers			
NACE RP 01 76	Corrosion Control Of Steel Fixed Offshore Structures Associated With Petroleum Production		2003
NACE SP0108	Corrosion Control of Offshore Structures by Protective Coatings		2008
NACE SP0169	Control of External Corrosion on Underground or Submerged Metallic Piping Systems		2013
NACE SP0176	Corrosion Control of Submerged Areas of Permanently Installed Steel Offshore Structures Associated with Petroleum Production		2007
NACE SP0178	Design, Fabrication, and Surface Finish Practices for. Tanks and Vessels to Be Lined for Immersion Service		2007
NACE SP0575	Internal Cathodic Protection Systems in Oil-Treating Vessels		2007
National Electric Code			
NEC 110.16	Flash Protection		2014
National Electrical Manufacturers Association			
NEMA 250	Enclosures for Electrical Equipment		2008
NEMA ICS-1	Industrial Control and Systems: General Requirements		2008
NEMA ICS-2			
ANSI / NEMA MG-1	Motors and Generators		2010
NEMA MG-2	Safety Standard for Construction and Guide for Selection, Installation and Use of Electric Motors and Generators		2014
NEMA PB 1	Panelboards		2011

Codes & Standards	Name	Edition	Year
NEMA PB 1.1	General Instructions for Proper Installation, Operation, and Maintenance of Panelboards Rated 600 Volts or Less		2013
NEMA PE 5	Utility-Type Battery Chargers		2003
NEMA VE-1	Metal Cable Tray Systems		2009
NEMA VE-2	Cable Tray Installation Guidelines		2013
National Fire Protection Association			
NFPA 10	Standard for Portable Fire Extinguishers		2013
NFPA 11	Standard for Low-, Medium-, and High-Expansion Foam		2010
NFPA 15	Standard for Water Spray Fixed Systems for Fire Protection		2012
NFPA 17	Dry Chemical Systems		2002
NFPA 30#	Flammable and Combustible Liquids Code		2012
NFPA 37#	Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines		2010
NFPA 68#	Guide for Explosion Venting		2013
NFPA 70	National Electrical Code		2014
NFPA 70E	Standard for Electrical Safety in the Workplace		2012
NFPA 72	National Fire Alarm and Signaling Code		2013
NFPA 77	Recommended Practice on Static Electricity		
NFPA 78#	Lightning Protection Code		2014
NFPA 80#	Standard for Fire Doors and Windows		2013
NFPA 90A	Standard for the Installation of Air-Conditioning and Ventilating Systems		2015
NFPA 91#	Standards for Blower and Exhaust Systems		2010
NFPA 101#	Life Safety Code		2012
NFPA 110	Standard for Emergency and Standby Power Systems		2013
NFPA 750	Standard on Water Mist Fire Protection Systems		2010
NFPA 780	Standard for the Installation of Lightning Protection Systems		2014
NFPA 850	Recommended Practice for Fire Protection for Electric Generating Plants and High Voltage Direct Current Converter Stations		2010
NFPA 900	Building Energy Code		2013
NFPA 5000	Building Construction and Safety Code		2012
Noble Denton Publication			
NOBLE:0030	Guidelines For Marine Transportations	5	2013

Codes & Standards	Name	Edition	Year
NORSOK			
NORSOK N-001	Integrity of Offshore Structures	8	2012
NORSOK N-003	Action and Action Effects	2	2007
NORSOK N-004	Design of Steel Structures	2	2004
NORSOK N-005	Condition Monitoring of Load Bearing Structures	1	1997
NORSOK N-006	Assessment of Structural Integrity for Existing Offshore Load-Bearing Structures	1	2009
Safety Of Life At Sea			
SOLAS	Safety of Life At Sea		2011
Underwriters Laboratories			
UL 67	Standard for Panelboards	12	2009
UL 96	Standard for Lightning Protection Components	5	2005
UL 96A	Standard for Installation Requirements for Lightning Protection Systems	12	2007
UL 142	Steel Above Ground Tanks for Flammable and Combustible Liquids	9	2006
UL 1008	Transfer Switch Equipment	7	2012
UL 1203	Standard for Explosion-Proof and Dust-Ignition-Proof Electrical Equipment for Use in Hazardous Locations		2013
UL 1564	Standard for Industrial Battery Chargers	3	2006
UL 1569	Standard for Metal-Clad Cables	4	2014
UL 1685	Standard for Vertical-Tray Fire-Propagation and Smoke-Release Test for Electrical and Optical-Fiber Cables	3	2007
UL 1776	Standard for High-Pressure Cleaning Machines		2013
ANSI / UL 1123#	Marine Buoyant Devices	7	
United Facilities Guide Specifications			
UFGS 41 22 13.13	Bridge Cranes		2008
UFGS 41 22 13.14	Bridge Cranes, Overhead Electric, Top Running		2008
United States Federal Highway Administration			
USFHA HEC-18	Evaluating Scour at Bridges	5	2012

Designates Codes & Standards Currently Required For Design.
* Code Superseded

Appendix B – Table of Design Elements with Gaps and Recommendations

Design Elements	Related CFRs & Standards Incorporated by Reference	Gap Identified	Recommendation of Code to be Required*
1. Structural (Including Geotechnical)			
Platform Loads - Dead and Live Loads	30 CFR 585	CFRs do not refer to any design code or standard for design, only that a description of loads must be provided. Gap identified.	ASCE-07
Platform Loads - Environmental Loads, Wind, Current, Waves	30 CFR 585	CFRs do not refer to any design code or standard for design, but do require all environmental data used for design be provided for review. Gap identified.	API RP 2MET
Platform Loads - Environmental Loads, Snow and Ice	30 CFR 585	CFRs do not refer to any design code or standard for design, but do require all environmental data used for design be provided for review. Gap identified.	API RP 2N
Platform Loads - Environmental Loads, Earthquake	30 CFR 585	CFRs do not refer to any design code or standard for design, but do require all loading information be provided. Gap identified.	API RP 2EQ; API RP 2A;
Platform Loads - Accidental Loads, Fire and Blast Loads	30 CFR 585	CFRs do not refer to any design code or standard for design, but do require all loading information be provided. Gap identified.	No Recommendation
Platform Loads - Accidental Loads, Vessel Impact	30 CFR 585	CFRs do not refer to any design code or standard for design, but do require all loading information be provided. Gap identified.	No Recommendation
Platform Loads - Accidental Loads, Dropped Objects	30 CFR 585	CFRs do not refer to any design code or standard for design, but do require all loading information be provided. Gap identified.	API RP 2A

Design Elements	Related CFRs & Standards Incorporated by Reference	Gap Identified	Recommendation of Code to be Required*
Platform Loads - Load Combinations		CFRs do not refer to any design code or standard for design. Gap identified.	API RP 2A; ASCE-07
Steel Design - Materials	30 CFR 585	CFRs do not refer to any design code or standard for design, but do require material types to be provided. Gap identified.	API RP 2A
Steel Design - Superstructure Design		CFRs do not refer to any design code or standard for design. Gap identified.	API RP 2A; AISC Steel Construction Manual
Foundation Design - Substructure, Steel Pile / Jacket	30 CFR 585	CFRs do not refer to any design code or standard for design, only that a list of all borings and design parameters must be provided. Gap identified.	API RP 2A; API RP 2GEO
Structural Design - Substructure, Concrete Gravity Foundation		CFRs do not refer to any design code or standard for design. Gap identified.	ACI 357
Structural Design - Substructure, Floating		CFRs do not refer to any design code or standard for design. Gap identified.	API RP 2P; API RP 2FPS
Structural Design - Substructure, Tension Leg Platforms		CFRs do not refer to any design code or standard for design. Gap identified.	API RP 2T
Structural Design - Jack-Ups		CFRs do not refer to any design code or standard for design. Gap identified.	ISO 19905-1
Structural Design - Mobile Offshore Units		CFRs do not refer to any design code or standard for design. Gap identified.	No Recommendation
Steel Design - Fatigue	30 CFR 585	CFRs do not refer to any design code or standard for design, but do require fatigue life to be provided. Gap identified.	API RP 2A
Steel Design – Appurtenances	30 CFR 585	CFRs do not refer to any design code or standard for design. Gap identified.	API RP 2A

Design Elements	Related CFRs & Standards Incorporated by Reference	Gap Identified	Recommendation of Code to be Required*
Corrosion Protection	30 CFR 585	CFRs do not refer to any design code or standard for design, but do require cathodic protection system information be provided. Gap identified.	NACE SP0176
Coatings		CFRs do not refer to any design code or standard for design. Gap identified.	NACE SP-0176; NACE SP-0108
Scour		CFRs do not refer to any design code or standard for design. Gap identified.	No Recommendation
Fabrication		CFRs do not refer to any design code or standard for design. Gap identified.	API RP 2A; API Spec 2B
Welding		CFRs do not refer to any design code or standard for design. Gap identified.	API RP 2A; AWS D1.1; AISC Steel Construction Manual
Connections		CFRs do not refer to any design code or standard for design. Gap identified.	API RP 2A; AISC Steel Construction Manual
Inspections	30 CFR 585; API RP 2A – WSD, Section 17.2	Section 17.2 is applicable to existing structures. Gap identified relating to inspections of new structures.	API RP 2A; API RP 2SIM
Decommissioning		CFRs do not refer to any design code or standard for design. Gap identified.	No Recommendation
2. Pre-Service			
Impact Loads		CFRs do not refer to any design code or standard for design. Gap identified.	No Recommendation
Platform Loads - Construction Loads, Load out and Lifting		CFRs do not refer to any design code or standard for design. Gap identified.	API RP 2A
Platform Loads - Construction Loads, Transportation and Installation		CFRs do not refer to any design code or standard for design. Gap identified.	API RP 2A

Design Elements	Related CFRs & Standards Incorporated by Reference	Gap Identified	Recommendation of Code to be Required*
On-bottom Stability		CRFs do not refer to any design code or standard for design. Gap identified	API RP 2A
Impact Loads		CRFs do not refer to any design code or standard for design. Gap identified	No Recommendation
Tolerances		CRFs do not refer to any design code or standard for design. Gap identified.	No Recommendation
3. Safety			
Egress	29 CFR 1910; NFPA 101, ANSI A14.3, ANSI A17.1	NFPA 101 addresses egress sufficiently. No gap identified.	No additional guidance recommended
Handrails, Ladders, Stairways	29 CFR 1910; ANSI A 14.3	No gap identified	No additional guidance recommended
Noise	29 CFR 1910; ANSI S1.4	No guidance for sound protection equipment. Gap identified	No additional guidance recommended
Storage of Flammable Materials	29 CFR 1910; NFPA 30	No gap identified	No additional guidance recommended
Manned Vs. Unmanned		No guidance on definition of manned vs unmanned. Gap identified	Further guidance required for evacuation / emergency shelter considerations
Platform Access		No guidance on security or restrictions to platform access. Gap identified.	No Recommendation
Slips, Trips, & Falls	29 CFR 1910; ANSI Z35.1, ANSI A14.3	No gap identified	No additional guidance recommended
Maintenance and Rigging	29 CFR 1910; ANSI A120.1	No gap identified	No additional guidance recommended

Design Elements	Related CFRs & Standards Incorporated by Reference	Gap Identified	Recommendation of Code to be Required*
Lifting	29 CFR 1910; ANSI A17.1, ANSI A90.1, ANSI B30.2	No gap identified	No additional guidance recommended
Emergency Shelter	29 CFR 1910; NFPA 101	More guidance needed on details depending on manned vs unmanned definition, gap identified.	No Recommendation
Aids to Navigation		No guidance on aids to navigation provided, gap identified.	33 CFR 66; 33 CFR 67
Aviation Aids		No guidance on aviation aids provided, gap identified.	FAA AC 70/7460-1K
Safety Shower and Eye Wash	29 CFR 1910	Addressed in 29 CFR 1910.151. No gap identified.	No additional guidance recommended
4. Environmental			
Oil Spills	29 CFR 1910; ANSI Z535.2	Guidance needed regarding if a spill response plan is required, limits of financial responsibility, worst case discharge calculation. Gap identified.	No Recommendation
Environmental Management Program	30 CFR 585.810	Guidance needed regarding details and extent of environmental management program required. Gap identified.	No Recommendation
5. Electrical			
Arc Flash	29 CFR 1910	Lack of clear direction on the treatment of Gas Insulated Switchgear when performing an arc flash study (working distance, gap between conductors, etc.) Gap identified.	NFPA 70, NFPA 70E
Automatic Transfer Switches	29 CFR 1910	29 CFR 1910 provides generic requirements for switches, but no direction related to design of platform utilizing transfer switches versus	NFPA 70, NFPA 110, IEEE C2

Design Elements	Related CFRs & Standards Incorporated by Reference	Gap Identified	Recommendation of Code to be Required*
		electrical interlocking/breaker switching, gap identified.	
Battery Systems	29 CFR 1910	29 CFR 1910 provides generic requirements for batteries. Battery system selection is not covered. Gap identified.	NFPA 70, IEEE C2
Cable Trays		Details for cable trays not defined in 29 CFR 1910, gap identified.	NFPA 70
CCTV System		No details regarding design of CCTV system. Gap identified.	NFPA 70, IEEE C2
Communications System		No details regarding design of communications system in CFRs. Gap identified.	NFPA 70, IEEE C2
Conductors - HV & MV	29 CFR 1910	29 CFR 1910 provides generic requirements for conductors, but lacks information sufficient for design. Gap identified.	NFPA 70, IEEE C2
Conductors - LV	29 CFR 1910	29 CFR 1910 provides generic requirements for conductors, but lacks information sufficient for design. Gap identified.	NFPA 70, IEEE C2
Electric Field Testing and Commissioning		Testing standards not located in 29 CFR 1910, gap identified.	NFPA 70, IEEE C2
Equipment Enclosures and Hardware	29 CFR 1910	29 CFR 1910 provides generic requirements for enclosures, but lacks information sufficient for design. Gap identified.	NFPA 70, NFPA 110, IEEE C2
Diesel Generator	29 CFR 1910	29 CFR 1910 provides generic requirements for generators, but lacks information to properly size generator for platform, gap identified.	NFPA 70, IEEE C2, NFPA 30, NFPA 37, NFPA 110
HV & MV Gas Insulated Switchgear	29 CFR 1910	29 CFR 1910 provides generic requirements for switchgear, but lack sufficient information to properly size switchgear. Gap identified.	NFPA 70

Design Elements	Related CFRs & Standards Incorporated by Reference	Gap Identified	Recommendation of Code to be Required*
Grounding	29 CFR 1910	29 CFR 1910 provides generic requirements for grounding, but does not describe overall platform grounding design basis, gap identified.	NFPA 70, IEEE C2
Interior Electrical	29 CFR 1910	29 CFR 1910 provides generic requirements for interior electrical items, but lacks information sufficient for design. Gap identified.	NFPA 70
Lighting	29 CFR 1910	29 CFR 1910 provides generic requirements for lighting, but does not provide lighting level design standards for all areas of an offshore platform, gap identified.	NFPA 70, IEEE C2, NFPA 101, NFPA 900
Lightning Protection	29 CFR 1910	NFPA 78 describes installation requirements but does not identify whether an ESP needs lightning protection. Gap identified.	NFPA 70, NFPA 780, IEEE C2
Low Voltage Motor Control Centers		The use of MCCs may or may not be needed depending on auxiliary system designs, but no guidance provided in 29 CFR 1910. Gap identified.	NFPA 70, IEEE C2
Metal-Clad Switchgear	29 CFR 1910	29 CFR 1910 provides generic requirements for switchgear, but lack sufficient information to properly size switchgear. Gap identified.	NFPA 70, NFPA 70B, IEEE C2
Metering	29 CFR 1910	29 CFR 1910 provides generic requirements for metering, but lacks information sufficient for design. Gap identified.	NFPA 70, NFPA 780, IEEE C2
Metal Clad Switchgear - Low Voltage	29 CFR 1910	29 CFR 1910 provides generic requirements for switchgear, but lack sufficient information to properly size switchgear. Gap identified.	NFPA 70, IEEE C2
PAGA System		No details regarding design of PAGA system in CFRs. Gap identified.	NFPA 70

Design Elements	Related CFRs & Standards Incorporated by Reference	Gap Identified	Recommendation of Code to be Required*
Power Panelboards	29 CFR 1910	29 CFR 1910 provides generic requirements for panelboards, but no requirements for future spare capacity in panelboards, gap identified.	NFPA 70, IEEE C2
Protective Relaying		Guidance on relay protection scheme not provided in CFRs. Gap identified.	NFPA 70, IEEE C2
Raceways	29 CFR 1910	29 CFR 1910 provides generic requirements for conduit or wires. No guidance in selecting type of conduit or wires provided, gap identified.	NFPA 70, IEEE C2
Selective Coordination		No information provided in 29 CFR 1910 on Selective Coordination	NFPA 70, IEEE C2
Seismic		No information provided in 29 CFR 1910 related to seismic aspects of securing equipment	ASCE-07
Surge Protection		Guidance on surge arresters not provided in CFRs. Gap identified.	NFPA 70, NFPA 780, IEEE C2
MV/HV Transformers	29 CFR 1910	29 CFR 1910 provides generic requirements for transformers, but requirements for fluid used in transformer on ESP not provided. Gap identified.	NFPA 70, IEEE C2
LV Transformers		No guidance provided in 29 CFR 1910 regarding LV transformers. Gap identified.	NFPA 70, IEEE C2
Transformer Neutral Grounding Resistors	29 CFR 1910	29 CFR 1910 provides generic requirements for TNGR, but acceptable levels of low voltage available fault current on ESP are not provided. Gap identified.	NFPA 70
UPS System	29 CFR 1910	UPS required backup time not defined in CFRs. Gap identified.	NFPA 70, NFPA 110

Design Elements	Related CFRs & Standards Incorporated by Reference	Gap Identified	Recommendation of Code to be Required*
6. Mechanical			
Drain System	29 CFR 1910; ANSI A13.1	No gap identified	40 CFR 112, NFPA 850
Pipes	29 CFR 1910; ANSI A13.1, ASTM A 53, ASTM A 126, ASTM B 241	No gap identified	No additional guidance recommended
Pumps / Sump Pumps	No section in 29 CFR 1910 on pumps		ANSI/HI 1.1-1.6; ANSI/HI 2.1-2.6; API RP 686
Deck Washing		No guidance provided, gap identified.	UL 1776
HVAC	29 CFR 1910; ANSI Z9.2	No gap identified	No additional guidance recommended
Pedestal Crane	29 CFR 1910; ANSI B30.2	No guidance for design of cranes. 29 CFR 1910 section covers general use of cranes, but nothing related to foundation design on offshore structures, gap identified.	API Spec 2C, API RP 2D
Bridge Crane	29 CFR 1910; ANSI B30.2.0, CMAA 1B61	No guidance for design of cranes. 29 CFR 1910 section covers general use of cranes, but nothing related to foundation design on offshore structures, gap identified.	ASME B30.2, UFGS 41 22 13.13; UFGS 41 22 13.14
Jib Crane	29 CFR 1910; ANSI B30.2.0, CMAA 1B61	No guidance for design of cranes. 29 CFR 1910 section covers general use of cranes, but nothing related to foundation design on offshore structures, gap identified.	API Spec 2C, API RP 2D
Dump Tanks	29 CFR 1910; API RP 12D, API RP 12F, API 620	No gap identified	No additional guidance recommended

Design Elements	Related CFRs & Standards Incorporated by Reference	Gap Identified	Recommendation of Code to be Required*
Life Rafts	29 CFR 1910; NFPA 101	No gap identified	No additional guidance recommended
7. Fire Protection			
Fire Detection System	29 CFR 1910	No standards for detection or suppression equipment exist in NFPA 101, gap identified.	NFPA 72, NFPA 1221, DNV-OS-J201
Fire Suppression System	29 CFR 1910, 30 CFR 585	No standards for suppression equipment exist in NFPA 101, gap identified	NFPA 11, NFPA 15, NFPA 17, NFPA 110
Life Safety Design	29 CFR 1910; NFPA 101	No details for offshore substation specific equipment such as high voltage transformers, GIS gear, and shunt reactors. Gap identified.	No Recommendation
Active Vs. Passive Protection		No guidance for active vs passive protection as ABS, SOLAS, and 46 CFR do not apply at this time, gap identified.	DNV-OS-J201
Fire Extinguishers		No guidance on number or placement of fire extinguishers, gap identified.	NFPA 10 and API RP 14G
8. Helideck			
Structural	30 CFR 585	CFRs do not refer to any design code or standard for design, but do require design data used be provided. Gap identified.	API RP 2L; API RP 2A
Electrical		CFRs do not refer to any design code or standard for design. Gap identified.	FAA AC 150/5390-2C, NFPA 70, NFPA 418
Fire Protection	29 CFR 1910; NFPA 101	CFRs do not refer to any design code or standard for design. Gap identified.	FAA AC 150/5390-2C, NFPA 403, NFPA 418

*Please refer to Appendix A for a complete description of codes recommended.

Appendix C – Industry Standards for Electrical Design Elements

Code or Standard	Description	Date of Current Publication	Errata
1. ARC FLASH ANALYSIS			
NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)			
NFPA 70*	National Electrical Code	2014	AMD 1 2013; Errata 1 2013; AMD 22013; Errata 2 2013; AMD 3 2014; Errata 3 2014
NFPA 70E*	Standard for Electrical Safety in the Workplace	2015	-
2. AUTOMATIC TRANSFER SWITCHES			
NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)			
NFPA 70*	National Electrical Code	2014	AMD 1 2013; Errata 1 2013; AMD 22013; Errata 2 2013; AMD 3 2014; Errata 3 2014
NFPA 110*	Standard for Emergency and Standby Power Systems	2013	-
INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)			
IEEE C2*	National Electrical Safety Code	2012	Errata 2012; INT 1-4 2012; INT 5-7 2013
IEEE C37.13	Standard for Low-Voltage AC Power Circuit Breakers Used in Enclosures	2008; INT 1 2009; AMD 1 2012	-
IEEE C37.90.1	Standard for Surge Withstand Capability (SWC) Tests for Relays and Relay Systems Associated with Electric Power Apparatus	2012	-
NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)			
NEMA ICS 1	Standard for Industrial Control and Systems: General Requirements	2000; R 2008; E 2010	-

Code or Standard	Description	Date of Current Publication	Errata
NEMA ICS 10 Part 2	AC Transfer Equipment, Part 2: Static AC Transfer Equipment	2005	-
NEMA ICS 2	Standard for Controllers, Contactors, and Overload Relays Rated 600 V	2000; R 2005	Errata 2008
UNDERWRITERS LABORATORIES (UL)			
UL 489#	Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures	2013; Reprint Mar 2014	-
UL 508	Industrial Control Equipment	1999; Reprint Oct 2013	-
UL 924#	Standard for Emergency Lighting and Power Equipment	2006; Reprint Apr 2014	-
UL 1008	Transfer Switch Equipment	2012; Reprint Apr 2013	-
UL 1066#	Low-Voltage AC and DC Power Circuit Breakers Used in Enclosures	2012; Reprint Jul 2013	-
3. BATTERY SYSTEMS			
NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)			
NFPA 70*	National Electrical Code	2014	AMD 1 2013; Errata 1 2013; AMD 22013; Errata 2 2013; AMD 3 2014; Errata 3 2014
INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)			
IEEE C2*	National Electrical Safety Code	2012	Errata 2012; INT 1-4 2012; INT 5-7 2013
IEEE 484#	Recommended Practice for Installation Design and Implementation of Vented Lead-Acid Batteries for Stationary Applications	2002; R 2008	-
IEEE 485#	Recommended Practice for Sizing Lead-Acid Batteries for Stationary Applications	2010	-

Code or Standard	Description	Date of Current Publication	Errata
IEEE 450#	Recommended Practice for Maintenance, Testing, and Replacement of Vented Lead-Acid Batteries for Stationary Applications	2010	-
IEEE 1187#	IEEE Recommended Practice for Installation Design and Installation of Valve-Regulated Lead-Acid Batteries for Stationary Applications	2013	-
4. CABLE TRAYS			
NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)			
NFPA 70*	National Electrical Code	2014	AMD 1 2013; Errata 1 2013; AMD 22013; Errata 2 2013; AMD 3 2014; Errata 3 2014
NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)			
NEMA VE 1	Standard for Metal Cable Tray Systems	2009	-
NEMA VE 2	Cable Tray Installation Guidelines	2013	-
5. CCTV			
NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)			
NFPA 70*	National Electrical Code	2014	AMD 1 2013; Errata 1 2013; AMD 22013; Errata 2 2013; AMD 3 2014; Errata 3 2014
INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)			
IEEE C2*	National Electrical Safety Code	2012	Errata 2012; INT 1-4 2012; INT 5-7 2013
ELECTRONIC COMPONENTS INDUSTRY ASSOCIATION (ECIA)			

Code or Standard	Description	Date of Current Publication	Errata
ECIA EIA/ECA 310-E	Cabinets, Racks, Panels, and Associated Equipment	2005	-
NATIONAL ELECTRICAL CONTRACTORS ASSOCIATION (NECA)			
NECA/BICSI 568	Standard for Installing Building Telecommunications Cabling	2006	-
UNDERWRITERS LABORATORIES (UL)			
UL 1492	Audio-Video Products and Accessories	1996; Reprint Jul 2013	-
6. COMMUNICATIONS			
NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)			
NFPA 70*	National Electrical Code	2014	AMD 1 2013; Errata 1 2013; AMD 22013; Errata 2 2013; AMD 3 2014; Errata 3 2014
INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)			
IEEE C2*	National Electrical Safety Code	2012	Errata 2012; INT 1-4 2012; INT 5-7 2013
ELECTRONIC COMPONENTS INDUSTRY ASSOCIATION (ECIA)			
ECIA EIA/ECA 310-E	Cabinets, Racks, Panels, and Associated Equipment	2005	-
NATIONAL ELECTRICAL CONTRACTORS ASSOCIATION (NECA)			
NECA/BICSI 568#	Standard for Installing Building Telecommunications Cabling	2006	-
NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)			
ANSI/NEMA WC 66	Performance Standard for Category 6 and Category 7 100 Ohm Shielded and Unshielded Twisted Pairs	2013	-
TELECOMMUNICATIONS INDUSTRY ASSOCIATION (TIA)			

Code or Standard	Description	Date of Current Publication	Errata
TIA-1152	Requirements for Field Test Instruments and Measurements for Balanced Twisted-Pair Cabling	2009	-
TIA-455-21	FOTP-21 - Mating Durability of Fiber Optic Interconnecting Devices	1988a; R 2012	-
EIA/TIA 455-165A	Standard for Mode-Field Diameter Measurement by Near-Field Scanning Technique	1993	-
TIA-455-104	Standard for FOTP-104 Fiber Optic Cable Cyclic Flexing Test	1993a; R 2013	-
TIA-455-175	FOTP-175 IEC-60793-1-42: Measurement Methods and Test Procedures – Chromatic Dispersion	2003b	-
TIA-455-177	FOTP-177 IEC-60793-1-43: Measurement Methods and Test Procedures - Numerical Aperture	2003b	-
TIA-455-33	Optical Cable Tensile Loading and Bending Test	2005b; R 2013	-
TIA-455-78-B	FOTP-78 Optical Fibres - Part 1-40: Measurement Methods and Test Procedures - Attenuation	2002	-
TIA-455-82	FOTP-82 Fluid Penetration Test for Fluid-Blocked Fiber Optic Cable	1992b	-
TIA-472D000	Fiber Optic Communications Cable for Outside Plant Use	2007b	-
TIA-526-14	OFSTP-14A Optical Power Loss Measurements of Installed Multimode Fiber Cable Plant	2010b	-
TIA-526-7	OFSTP-7 Measurement of Optical Power Loss of Installed Single-Mode Fiber Cable Plant	2002; R 2008	-
TIA-568-C.0	Generic Telecommunications Cabling for Customer Premises	2009; Add 1 2010; Add 2 2012	-

Code or Standard	Description	Date of Current Publication	Errata
TIA-568-C.1#	Commercial Building Telecommunications Cabling Standard	2009; Add 2 2011; Add 1 2012	-
TIA-568-C.2	Balanced Twisted-Pair Telecommunications Cabling and Components Standards	2009	Errata 2010
TIA-568-C.3	Optical Fiber Cabling Components Standard	2008; Add 1 2011	-
TIA-569	Commercial Building Standard for Telecommunications Pathways and Spaces	2012c; Addendum 1 2013	Errata 2013
TIA-606	Administration Standard for the Telecommunications Infrastructure	2012b	-
TIA-607	Generic Telecommunications Bonding and Grounding (Earthing) for Customer Premises	2011b	-
TIA/EIA-455	Standard Test Procedure for Fiber Optic Fibers, Cables, Transducers, Sensors, Connecting and Terminating Devices, and Other Fiber Optic Components	1998b	-
TIA/EIA-455-25	FOTP-25 Impact Testing of Optical Fiber Cables	2002c; R 2013	-
TIA/EIA-455-81	FOTP-81 Compound Flow (Drip) Test for Filled Fiber Optic Cable	2000b	-
TIA/EIA-472DAAA	Detail Specification for All Dielectric Fiber Optic Communications Cable for Outside Plant Use Containing Class 1a 62.5 Um Core Diameter/125 um Cladding Diameter/250 um Coating Diameter Fiber(s).	1993	-
TIA/EIA-4750000-C	Generic Specifications for Fiber Optic Connectors (ANSI)	1996	-
TIA/EIA-598	Optical Fiber Cable Color Coding	2014d	-
TIA/EIA-604-3	Fiber Optic Connector Intermateability Standard (FOCIS), Type SC and SC-APC, FOCIS-3	2004b; R 2014	-

Code or Standard	Description	Date of Current Publication	Errata
TIA/EIA-604-10	FOCIS 10 Fiber Optic Connector Intermateability Standard - Type LC	2002a	-
TIA/EIA-604-12	FOCIS 12 Fiber Optic Connector Intermateability Standard Type MT-RJ	2000	-
TIA/EIA-604-2	FOCIS 2 Fiber Optic Connector Intermateability Standard	2004b; R 2014	-
TIA/EIA-604-3	Fiber Optic Connector Intermateability Standard (FOCIS), Type SC and SC-APC, FOCIS-3	2004b; R 2014	-
TIA-758	Customer-Owned Outside Plant Telecommunications Infrastructure Standard	2012b	-
UNDERWRITERS LABORATORIES (UL)			
UL 1863	Communication Circuit Accessories	2004; Reprint Nov 2012	-
UL 444	Communications Cables	2008; Reprint Apr 2010	-
UL 969	Standard for Marking and Labeling Systems	1995; Reprint Jun 2014	-
7. CONDUCTORS – HV & MV			
NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)			
NFPA 70*	National Electrical Code	2014	AMD 1 2013; Errata 1 2013; AMD 22013; Errata 2 2013; AMD 3 2014; Errata 3 2014
INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)			
IEEE C2*	National Electrical Safety Code	2012	Errata 2012; INT 1-4 2012; INT 5-7 2013
ASSOCIATION OF EDISON ILLUMINATING COMPANIES (AEIC)			
AEIC CS8	Specification for Extruded Dielectric Shielded Power Cables Rated 5 Through 46 kV	2007	-
ASTM INTERNATIONAL (ASTM)			

Code or Standard	Description	Date of Current Publication	Errata
ASTM B1	Standard Specification for Hard-Drawn Copper Wire	2013	-
ASTM B231/B231M	Standard Specification for Concentric-Lay-Stranded Aluminum 1350 Conductors	2012	-
ASTM B3	Standard Specification for Soft or Annealed Copper Wire	2013	-
ASTM B400/B400M	Standard Specification for Compact Round Concentric-Lay-Stranded Aluminum 1350 Conductor	2008	E 2013
ASTM B496	Standard Specification for Compact Round Concentric-Lay-Stranded Copper Conductors	2014	-
ASTM B609/B609M	Standard Specification for Aluminum 1350 Round Wire, Annealed and Intermediate Tempers, for Electrical purposes	2012	-
ASTM B8	Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft	2011	-
ASTM B800	Standard Specification for 8000 Series Aluminum Alloy Wire for Electrical Purposes-Annealed and Intermediate Tempers	2005; R 2011	-
INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)			
IEEE 386	Standard for Separable Insulated Connector Systems for Power Distribution Systems Above 600V	2006; INT 1 2011	-
IEEE 400.2	Guide for Field Testing of Shielded Power Cable Systems Using Very Low Frequency (VLF)	2013	-
IEEE 404	Standard for Extruded and Laminated Dielectric Shielded Cable Joints Rated 2500 V to 500,000 V	2012	-

Code or Standard	Description	Date of Current Publication	Errata
IEEE 48	Standard for Test Procedures and Requirements for Alternating-Current Cable Terminations Used on Shielded Cables Having Laminated Insulation Rated 2.5 kV through 765 kV or Extruded Insulation Rated 2.5 kV through 500 kV	2009	-
INSULATED CABLE ENGINEERS ASSOCIATION (ICEA)			
ICEA S-94-649	Standard for Concentric Neutral Cables Rated 5 Through 46 KV	2013	-
NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)			
ANSI/NEMA WC 71/ICEA S-96-659	Standard for Nonshielded Cables Rated 2001-5000 Volts for use in the Distribution of Electric Energy	1999	-
NEMA C119.4	Electric Connectors - Connectors for Use Between Aluminum-to-Aluminum or Aluminum-to-Copper Conductors Designed for Normal Operation at or Below 93 Degrees C and Copper-to-Copper Conductors Designed for Normal Operation at or Below 100 Degrees C	2011	-
NEMA WC 70	Power Cable Rated 2000 V or Less for the Distribution of Electrical Energy--S95-658	2009	-
NEMA WC 74/ICEA S-93-639	5-46 kV Shielded Power Cable for Use in the Transmission and Distribution of Electric Energy	2012	-
UNDERWRITERS LABORATORIES (UL)			
UL 1072#	Medium-Voltage Power Cables	2006; Reprint Jun 2013	-
UL 44#	Thermoset-Insulated Wires and Cables	2014; Reprint Jun 2014	-
UL 486A-486B#	Wire Connectors	2013; Reprint Feb 2014	-
8. CONDUCTORS - LV			

Code or Standard	Description	Date of Current Publication	Errata
NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)			
NFPA 70*	National Electrical Code	2014	AMD 1 2013; Errata 1 2013; AMD 22013; Errata 2 2013; AMD 3 2014; Errata 3 2014
INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)			
IEEE C2*	National Electrical Safety Code	2012	Errata 2012; INT 1-4 2012; INT 5-7 2013
ASTM INTERNATIONAL (ASTM)			
ASTM B1#	Standard Specification for Hard-Drawn Copper Wire	2013	-
ASTM B8#	Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft	2011	-
ASTM B173	Standard Specification for Rope-Lay-Stranded Copper Conductors Having Concentric-Stranded Members, for Electrical Conductors	2010	-
NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)			
ANSI C119.1#	Electric Connectors - Sealed Insulated Underground Connector Systems Rated 600 Volts	2011	-
NEMA BU 1.1	General Instructions for Proper Handling, Installation, Operation and Maintenance of Busway Rated 600 V or Less	2010	-
NEMA ICS 4	Terminal Blocks	2010	-
NEMA WD 1	Standard for General Color Requirements for Wiring Devices	1999; R 2005; R 2010	-
UNDERWRITERS LABORATORIES (UL)			
UL 1569#	Standard for Metal-Clad Cables	1999; Reprint Jan 2012	-

Code or Standard	Description	Date of Current Publication	Errata
UL 44#	Thermoset-Insulated Wires and Cables	2014; Reprint Jun 2014	-
UL 486A-486B#	Wire Connectors	2013; Reprint Feb 2014	-
UL 486C#	Splicing Wire Connectors	2013; Reprint Feb 2014	-
UL 486E#	Equipment Wiring Terminals for Use with Aluminum and/or Copper Conductors	2009; Reprint May 2013	-
UL 719	Nonmetallic-Sheathed Cables	2006; Reprint Apr 2013	-
UL 817	Standard for Cord Sets and Power-Supply Cords	2001; Reprint Jul 2014	-
UL 83	Thermoplastic-Insulated Wires and Cables	2014	-
UL 854	Standard for Service-Entrance Cables	2004; Reprint Sep 2011	-
UL 857	Busways	2009; Reprint Dec 2011	-
9. ELECTRIC FIELD TESTING AND COMMISSIONING			
NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)			
NFPA 70*	National Electrical Code	2014	AMD 1 2013; Errata 1 2013; AMD 22013; Errata 2 2013; AMD 3 2014; Errata 3 2014
INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)			
IEEE C2*	National Electrical Safety Code	2012	Errata 2012; INT 1-4 2012; INT 5-7 2013
IEEE C57.19.00	Standard General Requirements and Test Procedures for Outdoor Power Apparatus Bushings	2009; INT 1 2009	Errata 2010
INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)			
NETA ATS#	Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems	2013	-
10. EQUIPMENT ENCLOSURES & HARDWARE			
NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)			

Code or Standard	Description	Date of Current Publication	Errata
NFPA 70*	National Electrical Code	2014	AMD 1 2013; Errata 1 2013; AMD 22013; Errata 2 2013; AMD 3 2014; Errata 3 2014
NFPA 110*	Standard for Emergency and Standby Power Systems	2013	-
INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)			
IEEE C2*	National Electrical Safety Code	2012	Errata 2012; INT 1-4 2012; INT 5-7 2013
IEEE C57.12.28#	Standard for Pad-Mounted Equipment - Enclosure Integrity	2014	-
IEEE C57.12.29#	Standard for Pad-Mounted Equipment - Enclosure Integrity for Coastal Environments	2014	-
ASTM INTERNATIONAL (ASTM)			
ASTM A1008/A1008M	Standard Specification for Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy and High-Strength Low-Alloy with Improved Formability, Solution Hardened, and Bake Hardened	2013	-
ASTM A123/A123M	Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products	2013	-
ASTM A240/A240M	Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications	2014	-
ASTM A36/A36M	Standard Specification for Carbon Structural Steel	2012	-
ASTM A572/A572M	Standard Specification for High-Strength Low-Alloy Columbium-Vanadium Structural Steel	2013a	-

Code or Standard	Description	Date of Current Publication	Errata
ASTM A633/A633M	Standard Specification for Normalized High-Strength Low-Alloy Structural Steel Plates	2013	-
ASTM A653/A653M	Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process	2013	-
ASTM B117	Standard Practice for Operating Salt Spray (Fog) Apparatus	2011	-
ASTM B633	Standard Specification for Electrodeposited Coatings of Zinc on Iron and Steel	2013	-
ASTM D1535	Specifying Color by the Munsell System	2013	-
ASTM D92	Standard Test Method for Flash and Fire Points by Cleveland Open Cup Tester	2012b	-
NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)			
NEMA ICS 4#	Terminal Blocks	2010	-
NEMA ICS 6#	Enclosures	1993; R 2011	-
NEMA 250#	Enclosures for Electrical Equipment (1000 Volts Maximum)	2008	-
UNDERWRITERS LABORATORIES (UL)			
UL 50#	Enclosures for Electrical Equipment, Non-environmental Considerations	2007; Reprint Apr 2012	-
11. GENERATOR - DIESEL			
NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)			
NFPA 70*	National Electrical Code	2014	AMD 1 2013; Errata 1 2013; AMD 22013; Errata 2 2013; AMD 3 2014; Errata 3 2014
NFPA 110*	Standard for Emergency and Standby Power Systems	2013	-
NFPA 30*	Flammable and Combustible Liquids Code	2015	-

Code or Standard	Description	Date of Current Publication	Errata
NFPA 37*	Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines	2015	-
INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)			
IEEE C2*	National Electrical Safety Code	2012	Errata 2012; INT 1-4 2012; INT 5-7 2013
ASTM INTERNATIONAL (ASTM)			
ASTM D975	Standard Specification for Diesel Fuel Oils	2014	-
ELECTRICAL GENERATING SYSTEMS ASSOCIATION (EGSA)			
EGSA 101P	Performance Standard for Engine Driven Generator Sets	1995	-
INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)			
IEEE 115	Guide for Test Procedures for Synchronous Machines: Part I Acceptance and Performance Testing; Part II Test Procedures and Parameter Determination for Dynamic Analysis	2009	-
IEEE 404	Standard for Extruded and Laminated Dielectric Shielded Cable Joints Rated 2500 V to 500,000 V	2012	-
IEEE 43#	Recommended Practice for Testing Insulation Resistance of Rotating Machinery	2013	-
IEEE 48	Standard for Test Procedures and Requirements for Alternating-Current Cable Terminations Used on Shielded Cables Having Laminated Insulation Rated 2.5 kV through 765 kV or Extruded Insulation Rated 2.5 kV through 500 kV	2009	-
IEEE 519#	Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems	2014	-

Code or Standard	Description	Date of Current Publication	Errata
INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO)			
ISO 3046	Reciprocating Internal Combustion Engines - Performance	1986; Am. 1	-
ISO 8528	Reciprocating Internal Combustion Engine Driven Alternating Current Generator Sets	1993; R 2005	-
NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)			
NEMA MG 1#	Motors and Generators	2011	Errata 2012
NEMA WC 74/ICEA S-93-639	5-46 kV Shielded Power Cable for Use in the Transmission and Distribution of Electric Energy	2012	-
NEMA C50.10	Rotating Electrical Machinery - Synchronous Machines	1990	-
SOCIETY OF AUTOMOTIVE ENGINEERS INTERNATIONAL (SAE)			
SAE ARP892	DC Starter-Generator, Engine	1965; R 1994	-
UNDERWRITERS LABORATORIES (UL)			
UL 142	Steel Aboveground Tanks for Flammable and Combustible Liquids	2006; Reprint Jul 2013	-
UL 429	Electrically Operated Valves	2013	-
UL 489#	Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures	2013; Reprint Mar 2014	-
12. GIS – HV & MV			
NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)			
NFPA 70*	National Electrical Code	2014	AMD 1 2013; Errata 1 2013; AMD 22013; Errata 2 2013; AMD 3 2014; Errata 3 2014
INTERNATIONAL ELECTROTECHNICAL COMMISSION (IEC)			
IEC 62271-200#	High-voltage Switchgear and controlgear	2011	-

Code or Standard	Description	Date of Current Publication	Errata
IEC 60694#	Common specifications for high-voltage switchgear and controlgear standards	1996	-
IEC 62271-102#	Alternating current disconnectors and earthing switches	2001	-
IEC 62271-100#	Alternating-current circuit-breakers	2008	-
ANSI/IEC 60529#	Degrees of protection provided by enclosures	2004	-
13. GROUNDING			
NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)			
NFPA 70*	National Electrical Code	2014	AMD 1 2013; Errata 1 2013; AMD 22013; Errata 2 2013; AMD 3 2014; Errata 3 2014
INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)			
IEEE 80	Guide for Safety in AC Substation Grounding	2000; INT 1 2002	Errata 2007
IEEE 81#	Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System	2012	-
IEEE C2*	National Electrical Safety Code	2012	Errata 2012; INT 1-4 2012; INT 5-7 2013
UNDERWRITERS LABORATORIES (UL)			
UL 467#	Grounding and Bonding Equipment	2007	-
14. INTERIOR ELECTRICAL			
NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)			
NFPA 70*	National Electrical Code	2014	AMD 1 2013; Errata 1 2013; AMD 22013; Errata 2 2013; AMD 3 2014; Errata 3 2014
AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS (ASHRAE)			

Code or Standard	Description	Date of Current Publication	Errata
ASHRAE 189.1	Standard for the Design of High-Performance Green Buildings Except Low-Rise Residential Buildings	2011	Errata 1-2 2012; INT 1 2013; Errata 3-8 2013
ASHRAE 90.1 - IP	Energy Standard for Buildings Except Low-Rise Residential Buildings	2010	ERTA 2011-2013
ASHRAE 90.1 - SI	Energy Standard for Buildings Except Low-Rise Residential Buildings	2010	ERTA 2011-2013
NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)			
NEMA ICS 1	Standard for Industrial Control and Systems: General Requirements	2000; R 2008	E 2010
NEMA ICS 2	Standard for Controllers, Contactors, and Overload Relays Rated 600 V	2000; R 2005	Errata 2008
NEMA ICS 3	Medium-Voltage Controllers Rated 2001 to 7200 V AC	2005; R 2010	
NEMA ICS 3.1	Guide for the Application, Handling, Storage, Installation and Maintenance of Medium-Voltage AC Contactors, Controllers and Control Centers	2009	-
NEMA WD 1	Standard for General Color Requirements for Wiring Devices	1999; R 2005; R 2010	-
NEMA WD 6	Wiring Devices Dimensions Specifications	2012	-
NEMA Z535.4	American National Standard for Product Safety Signs and Labels	2011	-
UNDERWRITERS LABORATORIES (UL)			
UL 1283	Electromagnetic Interference Filters	2005; Reprint Feb 2013	-
UL 1699#	Arc-Fault Circuit-Interrupters	2006; Reprint Nov 2013	-
UL 198M	Standard for Mine-Duty Fuses	2003; Reprint Feb 2013	-
UL 20#	General-Use Snap Switches	2010; Reprint Feb 2012	-

Code or Standard	Description	Date of Current Publication	Errata
UL 4248-1	UL Standard for Safety Fuseholders - Part 1: General Requirements	2007; Reprint Oct 2013	-
UL 4248-12	UL Standard for Safety Fuseholders - Part 12: Class R	2007; Reprint Dec 2012	-
UL 498	Attachment Plugs and Receptacles	2012; Reprint Feb 2014	-
UL 674	Electric Motors and Generators for Use in Division 1 Hazardous (Classified) Locations	2011; Reprint Jul 2013	-
UL 773	Standard for Plug-In, Locking Type Photocontrols for Use with Area Lighting	1995; Reprint Mar 2002	-
UL 773A	Standard for Nonindustrial Photoelectric Switches for Lighting Control	2006; Reprint Nov 2013	-
UL 817	Standard for Cord Sets and Power-Supply Cords	2001; Reprint Jul 2014	-
UL 943#	Ground-Fault Circuit-Interrupters	2006; Reprint Jun 2012	-
UL 98	Enclosed and Dead-Front Switches	2004; Reprint May 2012	-
15. LIGHTING			
NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)			
NFPA 70*	National Electrical Code	2014	AMD 1 2013; Errata 1 2013; AMD 22013; Errata 2 2013; AMD 3 2014; Errata 3 2014
NFPA 101*	Life Safety Code	2012; Amendment 1 2012	-
NFPA 900*	Building Energy Code	2013	-
AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS (ASHRAE)			
ASHRAE 189.1	Standard for the Design of High-Performance Green Buildings Except Low-Rise Residential Buildings	2011	Errata 1-2 2012; INT 1 2013; Errata 3-8 2013

Code or Standard	Description	Date of Current Publication	Errata
ASHRAE 90.1 - IP	Energy Standard for Buildings Except Low-Rise Residential Buildings	2010	ERTA 2011-2013
ASHRAE 90.1 - SI	Energy Standard for Buildings Except Low-Rise Residential Buildings	2010	ERTA 2011-2013
U.S. ENVIRONMENTAL PROTECTION AGENCY (EPA)			
Energy Star#	Energy Star Energy Efficiency Labeling System (FEMP)	1992; R 2006	-
U.S. FEDERAL AVIATION ADMINISTRATION (FAA)			
FAA AC 150/5345-12	Specification for Airport and Heliport Beacon	2005; Rev E	-
FAA AC 150/5345-13	Specification for L-841 Auxiliary Relay Cabinet Assembly for Pilot Control of Airport Lighting Circuits	2007; Rev B	-
FAA AC 150/5345-26	FAA Specification for L-823 Plug and Receptacle, Cable Connectors	2008; Rev D	-
FAA AC 150/5345-28	Precision Approach Path Indicator (PAPI) Systems	2005; Rev F	-
FAA AC 150/5345-43	Specification for Obstruction Lighting Equipment	2006; Rev F	-
FAA AC 70/7460-1	Obstruction Marking and Lighting	2007; Rev K	-
ILLUMINATING ENGINEERING SOCIETY (IES)			
IES HB-10#	IES Lighting Handbook	2011	-
IES LM-48	Guide for Testing the Calibration of Locking - Type Photoelectric Control Devices Used in Outdoor Applications	2001	-
IES LM-79	Electrical and Photometric Measurements of Solid-State Lighting Products	2008	-
IES LM-80	Measuring Lumen Maintenance of LED Light Sources	2008	-

Code or Standard	Description	Date of Current Publication	Errata
IES RP-16#	Nomenclature and Definitions for Illuminating Engineering	2010; Addendum A 2008; Addenda B & C 2009	-
IES TM-15	Luminaire Classification System for Outdoor Luminaires	2011	-
IES TM-21	Projecting Long Term Lumen Maintenance of LED Light Sources	2011	-
INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)			
IEEE 100	The Authoritative Dictionary of IEEE Standards Terms	2000; Archived	-
IEEE C2*	National Electrical Safety Code	2012; INT 1-4 2012; INT 5-7 2013	Errata 2012
NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)			
ANSI ANSLG C78.41	For Electric Lamps--Guidelines for Low-Pressure Sodium Lamps	2006	-
ANSI ANSLG C78.42	For Electric Lamps: High-Pressure Sodium Lamps	2009	-
ANSI ANSLG C78.43	American National Standard for Electric Lamps - Single-Ended Metal-Halide Lamps	2013	-
NEMA ANSLG C78.44	For Electric Lamps - Double-Ended Metal Halide Lamps	2008	-
NEMA ANSLG C78.81	American National Standard for Electric Lamps--Double-Capped Fluorescent Lamps--Dimensional and Electrical Characteristics	2013	-
NEMA ANSLG C78.377	American National Standard for Electric Lamps— Specifications for the Chromaticity of Solid State Lighting Products	2011	-
ANSI C78.379	American National Standard for Electric Lamps--Classification of the Beam Patterns of Reflector Lamps	2006	-

Code or Standard	Description	Date of Current Publication	Errata
NEMA ANSLG C78.380	Electric Lamps - High Intensity Discharge Lamps, Method of Designation	2007	-
ANSI C78.389	American National Standard for Electric Lamps - High Intensity Discharge (HID) - Methods of Measuring Characteristics	2004; R 2009	-
ANSI NEMA ANSLG C78.390	Method of Designation for Electric Lamps, - Miniature and Sealed-Beam Incandescent Lamps	2006	-
ANSI C78.901	American National Standard for Electric Lamps - Single Base Fluorescent Lamps--Dimensional and Electrical Characteristics	2005	-
ANSI C78.1381	American National Standard for Electric Lamps - 250-Watt, 70 Watt, M85 Metal-Halide Lamps	1998	-
ANSI C82.1	American National Standard for Electric Lamp Ballasts - Line Frequency Fluorescent Lamp Ballasts	2004	-
ANSI C82.2	American National Standard for Lamp Ballasts--Methods of Measurement of Fluorescent Lamp Ballasts	2002	-
ANSI C82.4	American National Standard for Ballasts for High-Intensity-Discharge and Low-Pressure Sodium (LPS) Lamps (Multiple-Supply Type)	2002	-
NEMA ANSLG C82.9	American National Standard for Lamp Ballasts— High-Intensity Discharge and Low-Pressure Sodium Lamps— Definitions	2010	-
NEMA ANSLG C82.11	Lamp Ballasts - High-Frequency Fluorescent Lamp Ballasts	2011	-
NEMA ANSLG C82.14	Lamp Ballasts Low-Frequency Square Wave Electronic Ballasts -- for Metal Halide Lamps	2006	-
NEMA C82.77	Harmonic Emission Limits - Related Power Quality Requirements for Lighting Equipment	2002	-

Code or Standard	Description	Date of Current Publication	Errata
NEMA WD 7	Occupancy Motion Sensors Standard	2011	-
UNDERWRITERS LABORATORIES (UL)			
UL 1029#	High-Intensity-Discharge Lamp Ballasts	1994; Reprint Dec 2013	-
UL 1310	UL Standard for Safety Class 2 Power Units	2011; Reprint Oct 2013	-
UL 1598#	Luminaires	2008; Reprint Oct 2012	-
UL 20#	General-Use Snap Switches	2010; Reprint Feb 2012	-
UL 595#	Marine - Type Electric Lighting Fixtures	1985	-
UL 773	Standard for Plug-In, Locking Type Photocontrols for Use with Area Lighting	1995; Reprint Mar 2002	-
UL 773A	Standard for Nonindustrial Photoelectric Switches for Lighting Control	2006; Reprint Nov 2013	-
UL 8750#	UL Standard for Safety Light Emitting Diode (LED) Equipment for Use in Lighting Products	2009; Reprint May 2014	-
UL 916	Standard for Energy Management Equipment	2007; Reprint Aug 2014	-
UL 924#	Standard for Emergency Lighting and Power Equipment	2006; Reprint Apr 2014	-
UL 935#	Standard for Fluorescent-Lamp Ballasts	2001; Reprint Aug 2014	-
16. LIGHTING PROTECTION			
NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)			
NFPA 70*	National Electrical Code	2014	AMD 1 2013; Errata 1 2013; AMD 22013; Errata 2 2013; AMD 3 2014; Errata 3 2014
NFPA 780*	Standard for the Installation of Lightning Protection Systems	2014	-
UNDERWRITERS LABORATORIES (UL)			
UL 96#	Standard for Lightning Protection Components	2005; Reprint Sep 2013	-
17. MCC - LV			

Code or Standard	Description	Date of Current Publication	Errata
NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)			
NFPA 70*	National Electrical Code	2014	AMD 1 2013; Errata 1 2013; AMD 22013; Errata 2 2013; AMD 3 2014; Errata 3 2014
INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)			
IEEE C2*	National Electrical Safety Code	2012; INT 1-4 2012; INT 5-7 2013	Errata 2012
AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)			
ANSI C39.1	Requirements for Electrical Analog Indicating Instruments	1981; R 1992	-
INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)			
IEEE C37.17	Standard for Trip Devices for AC and General-Purpose DC Low-Voltage Power Circuit Breakers	2012	-
IEEE C37.90	Standard for Relays and Relay Systems Associated With Electric Power Apparatus	2005	-
IEEE C57.12.01	General Requirements for Dry-Type Distribution and Power Transformers Including Those with Solid-Cast and/or Resin-Encapsulated Windings	2005	-
IEEE C57.13	Standard Requirements for Instrument Transformers	2008; INT 2009	-
IEEE C63.2	Standard for Electromagnetic Noise and Field Strength Instrumentation, 10 Hz to 40 GHz - Specifications	2009	-
IEEE C63.4	American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic	2014	-
NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)			

Code or Standard	Description	Date of Current Publication	Errata
NEMA AB 3	Molded Case Circuit Breakers and Their Application	2013	-
NEMA ICS 1	Standard for Industrial Control and Systems: General Requirements	2000; R 2008	E 2010
NEMA ICS 2	Standard for Controllers, Contactors, and Overload Relays Rated 600 V	2000; R 2005	Errata 2008
NEMA ST 1	Specialty Transformers (Except General Purpose Type)	1988; R 1994; R 1997	-
UNDERWRITERS LABORATORIES (UL)			
UL 489#	Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures	2013; Reprint Mar 2014	-
UL 508	Industrial Control Equipment	1999; Reprint Oct 2013	-
UL 845#	Motor Control Centers	2005; Reprint Jul 2011	-
18. METAL CLAD SWITCHGEAR			
NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)			
NFPA 70*	National Electrical Code	2014	AMD 1 2013; Errata 1 2013; AMD 22013; Errata 2 2013; AMD 3 2014; Errata 3 2014
NFPA 70B	Recommended Practice for Electrical Equipment Maintenance	2013	
INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)			
IEEE C2*	National Electrical Safety Code	2012; INT 1-4 2012; INT 5-7 2013	Errata 2012
IEEE 386	Standard for Separable Insulated Connector Systems for Power Distribution Systems Above 600V	2006; INT 1 2011	-

Code or Standard	Description	Date of Current Publication	Errata
IEEE C37.04	Standard for Rating Structure for AC High-Voltage Circuit Breakers	1999; R 2006; AMD 1 2003; R 2006; R 2006; AMD 2 2008; CORR 2009; INT 2010	ERTA 2005
IEEE C37.06	Standard for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis - Preferred Ratings and Related Required Capabilities for Voltage Above 1000 V	2009	-
IEEE C37.081	Guide for Synthetic Fault Testing of AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis	1981; Supp 1997; R 2007	-
IEEE C37.09	Standard Test Procedure for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis	1999; AMD 1 2005; Corr 1 2007; R 2007; Amendment B 2011	Errata 2007
IEEE C37.121#	American National Standard for Switchgear - Unit Substations - Requirements	2012	-
IEEE C37.20.2#	Standard for Metal-Clad Switchgear	1999; Corr 2000; R 2005	-
IEEE C37.20.3	Standard for Metal-Enclosed Interrupter Switchgear	2013	-
IEEE C37.23	Standard for Metal-Enclosed Bus	(2003; R 2008	-
IEEE C37.30	Standard Requirements for High-Voltage Switches	1997; INT 1 2011	-
IEEE C37.32	Standard for High-Voltage Switches, Bus Supports, and Accessories - Schedules of Preferred Ratings, Construction Guidelines and Specifications	2002	-
IEEE C37.34	Standard Test Code for High-Voltage Air Switches	1994	-
IEEE C37.41	Standard Design Tests for High-Voltage (>1000 V) Fuses, Fuse and Disconnecting Cutouts,	2008	Errata 2009

Code or Standard	Description	Date of Current Publication	Errata
	Distribution Enclosed Single-Pole Air Switches, Fuse Disconnecting Switches, and Accessories Used with These Devices		
IEEE C37.46#	Standard for High Voltage Expulsion and Current-Limiting Type Power Class Fuses and Fuse Disconnecting Switches	2010	-
IEEE C37.71 S	Standard Three-Phase, Manually Operated Subsurface or Vault Load-Interrupting Switches for Alternating-Current Systems	2001	-
IEEE C37.74	Standard Requirements for Subsurface, Vault, and Pad-Mounted Load-Interrupter Switchgear and Fused Load-Interrupter Switchgear for Alternating Current Systems Up to 38 kV	2003; Int 1 2004	-
ASTM INTERNATIONAL (ASTM)			
ASTM B188	Standard Specification for Seamless Copper Bus Pipe and Tube	2010	-
ASTM B317/B317M	Standard Specification for Aluminum-Alloy Extruded Bar, Rod, Tube, Pipe, and Structural Profiles for Electrical Purposes (Bus Conductor)	2007	-
NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)			
NEMA C37.72	Manually-Operated, Dead-Front Padmounted Switchgear with Load Interrupting Switches and Separable Connectors for Alternating-Current Systems	1987	-
19. METERING			
NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)			
NFPA 70*	National Electrical Code	2014	AMD 1 2013; Errata 1 2013; AMD 22013;

Code or Standard	Description	Date of Current Publication	Errata
			Errata 2 2013; AMD 3 2014; Errata 3 2014
NFPA 780*	Standard for the Installation of Lightning Protection Systems	2014	-
INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)			
IEEE C2*	National Electrical Safety Code	2012; INT 1-4 2012; INT 5-7 2013	Errata 2012
IEEE C12.16#	Solid-State Electricity Meters	1991	-
IEEE C37.90.1	Standard for Surge Withstand Capability (SWC) Tests for Relays and Relay Systems Associated with Electric Power Apparatus	2012	-
IEEE C57.13	Standard Requirements for Instrument Transformers	2008; INT 2009	-
INTERNATIONAL ELECTROTECHNICAL COMMISSION (IEC)			
IEC 61000-4-5	Electromagnetic Compatibility (EMC) - Part 4-5: Testing and Measurement Techniques - Surge Immunity Test	2014	-
IEC 62053-22	Electricity Metering Equipment (a.c.) - Particular Requirements - Part 22: Static Meters for Active Energy (Classes 0,2 S and 0,5 S)	2003; ED 1.0	-
AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)			
ANSI C12.1#	Electric Meters Code for Electricity Metering	2008	-
ANSI C12.15#	Solid-State Demand Registers for Electromechanical Watthour Meters	1990	-
ANSI C12.20#	Electricity Meters - 0.2 and 0.5 Accuracy Classes	2010	-
UNDERWRITERS LABORATORIES (UL)			
UL 1437#	Electrical Analog Instruments - Panel Board Types	2006	-

Code or Standard	Description	Date of Current Publication	Errata
20. METAL CLAD SWITCHGEAR - LV			
NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)			
NFPA 70*	National Electrical Code	2014	AMD 1 2013; Errata 1 2013; AMD 22013; Errata 2 2013; AMD 3 2014; Errata 3 2014
INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)			
IEEE C2*	National Electrical Safety Code	2012; INT 1-4 2012; INT 5-7 2013	Errata 2012
IEEE C37.13	Standard for Low-Voltage AC Power Circuit Breakers Used in Enclosures	2008; INT 1 2009; AMD 1 201	-
IEEE C37.16	Standard for Preferred Ratings, Related Requirements, and Application Recommendations for Low-Voltage AC (635 V and below) and DC 3200 V and below) Power Circuit Breakers	2009	-
IEEE C37.17	Standard for Trip Devices for AC and General-Purpose DC Low-Voltage Power Circuit Breakers	2012	-
IEEE C37.2 S	Standard for Electrical Power System Device Function Numbers, Acronyms and Contact Designations	2008	-
IEEE C37.20.1	Standard for Metal-Enclosed Low-Voltage	2002; INT 1 2005; AMD A 2005; AMD B 2006; R 2007	-
ASTM INTERNATIONAL (ASTM)			
ASTM B187/B187M	Standard Specification for Copper, Bus Bar, Rod and Shapes and General Purpose Rod, Bar and Shapes	2011	-

Code or Standard	Description	Date of Current Publication	Errata
ASTM B188	Standard Specification for Seamless Copper Bus Pipe and Tube	2010	-
ASTM B236	Standard Specification for Aluminum Bars for Electrical Purposes (Bus Bars)	2007	-
ASTM B236M	Standard Specification for Aluminum Bars for Electrical Purposes (Bus Bars) (Metric)	2007	-
ASTM B317/B317M	Standard Specification for Aluminum-Alloy Extruded Bar, Rod, Tube, Pipe, and Structural Profiles for Electrical Purposes (Bus Conductor)	2007	-
ASTM D149	Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies	2009; R 2013	-
NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)			
NEMA AB 3	Molded Case Circuit Breakers and Their Application	2013	-
NEMA C37.50#	American National Standard for Switchgear--Low-Voltage AC Power Circuit Breakers Used in Enclosures - Test Procedures	2012	-
NEMA C37.51#	American National Standard for Switchgear--Metal Enclosed Low-Voltage AC Power, Circuit-Breaker Switchgear Assemblies-Conformance Test Procedures	2003; R 2010; Addenda 2010	-
ANSI/NEMA PB 2.1	General Instructions for Proper Handling, Installation, Operation and Maintenance of Deadfront Distribution Switchboards Rated 600 V or Less	2013	-
NEMA LI 1	Industrial Laminating Thermosetting Products	1998; R 2011	-
NEMA PB 2	Deadfront Distribution Switchboards	2011	-
UNDERWRITERS LABORATORIES (UL)			

Code or Standard	Description	Date of Current Publication	Errata
UL 1066#	Low-Voltage AC and DC Power Circuit Breakers Used in Enclosures		-
UL 1558	Metal-Enclosed Low-Voltage Power Circuit Breaker Switchgear	1999; Reprint Apr 2010	-
UL 198M	Standard for Mine-Duty Fuses	2003; Reprint Feb 2013	-
UL 4248-12	UL Standard for Safety Fuseholders - Part 12: Class R	2007; Reprint Dec 2012	-
UL 489#	Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures	2013; Reprint Mar 2014	-
UL 891#	Switchboards	2005; Reprint Oct 2012	-
21. PAGA			
NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)			
NFPA 70*	National Electrical Code	2014	AMD 1 2013; Errata 1 2013; AMD 22013; Errata 2 2013; AMD 3 2014; Errata 3 2014
ELECTRONIC COMPONENTS INDUSTRY ASSOCIATION (ECIA)			
ECIA EIA/ECA 310-E	Cabinets, Racks, Panels, and Associated Equipment	2005	-
INSULATED CABLE ENGINEERS ASSOCIATION (ICEA)			
ICEA S-83-596	Indoor Optical Fiber Cables	2011	-
ICEA S-90-661	Category 3, 5, & 5e Individually Unshielded Twisted Pair Indoor Cables for Use in General Purpose and LAN Communications Wiring Systems Technical Requirements	2012	-
NATIONAL ELECTRICAL CONTRACTORS ASSOCIATION (NECA)			
NECA/BICSI 568#	Standard for Installing Building Telecommunications Cabling	2006	-
NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)			

Code or Standard	Description	Date of Current Publication	Errata
ANSI/NEMA WC 66	Performance Standard for Category 6 and Category 7 100 Ohm Shielded and Unshielded Twisted Pairs	2013	-
TELECOMMUNICATIONS INDUSTRY ASSOCIATION (TIA)			
TIA-1152	Requirements for Field Test Instruments and Measurements for Balanced Twisted-Pair Cabling	2009	-
TIA-568-C.3	Optical Fiber Cabling Components Standard	2008	Add 1 (2011)
UNDERWRITERS LABORATORIES (UL)			
UL 444#	Communications Cables	2008	
22. PANELBOARDS			
NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)			
NFPA 70*	National Electrical Code	2014	AMD 1 2013; Errata 1 2013; AMD 22013; Errata 2 2013; AMD 3 2014; Errata 3 2014
INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)			
IEEE C2*	National Electrical Safety Code	2012; INT 1-4 2012; INT 5-7 2013	Errata 2012
ASTM INTERNATIONAL (ASTM)			
ASTM B187/B187M	Standard Specification for Copper, Bus Bar, Rod and Shapes and General Purpose Rod, Bar and Shapes	2011	-
ASTM B317/B317M	Standard Specification for Aluminum-Alloy Extruded Bar, Rod, Tube, Pipe, and Structural Profiles for Electrical Purposes (Bus Conductor)	2007	-
NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)			

Code or Standard	Description	Date of Current Publication	Errata
NEMA BU 1.1	General Instructions for Proper Handling, Installation, Operation and Maintenance of Busway Rated 600 V or Less	2010	-
NEMA FU 1	Low Voltage Cartridge Fuses	2012	-
NEMA KS 1	Enclosed and Miscellaneous Distribution Equipment Switches (600 V Maximum) NEMA PB 1 (2011) Panelboards	2013	-
UNDERWRITERS LABORATORIES (UL)			
UL 489#	Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures	2013; Reprint Mar 2014	-
UL 869A	Reference Standard for Service Equipment	2006	-
UL 870#	Standard for Wireways, Auxiliary Gutters, and Associated Fittings	2008; Reprint Feb 2013	-
UL 943#	Ground-Fault Circuit-Interrupters	2006; Reprint Jun 2012	-
UL 67#	Standard for Panelboards	2009; Reprint Jan 2013	-
23. PROTECTIVE RELAYING			
NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)			
NFPA 70*	National Electrical Code	2014	AMD 1 2013; Errata 1 2013; AMD 22013; Errata 2 2013; AMD 3 2014; Errata 3 2014
INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)			
IEEE C2*	National Electrical Safety Code	2012; INT 1-4 2012; INT 5-7 2013	Errata 2012
IEEE C37.09	Standard Test Procedure for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis	1999; AMD 1 2005; Corr 1 2007; R 2007; Amendment B 2011	Errata 2007

Code or Standard	Description	Date of Current Publication	Errata
IEEE C37.2#	Standard for Electrical Power System Device Function Numbers, Acronyms and Contact Designations	2008	-
IEEE C37.90#	Standard for Relays and Relay Systems Associated With Electric Power Apparatus	2005	-
IEEE C37.90.1	Standard for Surge Withstand Capability (SWC) Tests for Relays and Relay Systems Associated with Electric Power Apparatus	2012	-
IEEE C37.121	American National Standard for Switchgear-Unit Substations - Requirements	2012	-
IEEE C37.13	Standard for Low-Voltage AC Power Circuit Breakers Used in Enclosures	2008; INT 1 2009; AMD 1 2012	-
IEEE C37.16	Standard for Preferred Ratings, Related Requirements, and Application Recommendations for Low-Voltage AC (635 V and below) and DC 3200 V and below) Power Circuit Breakers	2009	-
IEEE C37.17#	Standard for Trip Devices for AC and General-Purpose DC Low-Voltage Power Circuit Breakers	2012	-
IEEE C37.90	Standard for Relays and Relay Systems Associated With Electric Power Apparatus	2005	-
IEEE C57.13	Standard Requirements for Instrument Transformers	2008; INT 2009	-
IEEE C57.13.1	Guide for Field Testing of Relaying Current Transformers	2006	-
IEEE C63.2	Standard for Electromagnetic Noise and Field Strength Instrumentation, 10 Hz to 40 GHz - Specifications	2009	-

Code or Standard	Description	Date of Current Publication	Errata
IEEE C63.4	American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz	2014	-
AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)			
ANSI C39.1	Requirements for Electrical Analog Indicating Instruments	1981; R 1992	-
ASSOCIATION CONNECTING ELECTRONICS INDUSTRIES (IPC)			
D330	Design Guide Manual	1992	-
ELECTRONIC INDUSTRIES ALLIANCE (EIA)			
EIA 443	NARM Standard for Solid State Relays Service	1979	-
INTERNATIONAL ELECTROTECHNICAL COMMISSION (IEC)			
IEC 60255-21-3	Electrical Relays - Part 21: Vibration, Shock, Bump And Seismic Tests On Measuring Relays And Protection Equipment - Section 3: Seismic Tests	1993; ED 1.0	-
NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)			
ANSI C78.23	American National Standard for Incandescent Lamps - Miscellaneous Types	1995; R 2003	-
NEMA 107	Methods of Measurement of Radio Influence Voltage (RIV) of High-Voltage Apparatus (inactive)	1987; R 1993	-
NEMA 250	Enclosures for Electrical Equipment (1000 Volts Maximum)	2008	-
NEMA ICS 1#	Standard for Industrial Control and Systems: General Requirements	2000; R 2008	E 2010
NEMA ICS 2	Standard for Controllers, Contactors, and Overload Relays Rated 600 V	2000; R 2005	Errata 2008
NEMA ICS 3	Medium-Voltage Controllers	2005; R 2010	-

Code or Standard	Description	Date of Current Publication	Errata
NEMA SG 2	Standard for High-Voltage Fuses	1993	-
UNDERWRITERS LABORATORIES (UL)			
UL 20	General-Use Snap Switches	2010; Reprint Feb 2012	-
UL 508	Industrial Control Equipment	1999; Reprint Oct 2013	-
24. RACEWAYS			
NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)			
NFPA 70*	National Electrical Code	2014	AMD 1 2013; Errata 1 2013; AMD 22013; Errata 2 2013; AMD 3 2014; Errata 3 2014
INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)			
IEEE C2*	National Electrical Safety Code	2012; INT 1-4 2012; INT 5-7 2013	Errata 2012
NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)			
ANSI C80.1	American National Standard for Electrical Rigid Steel Conduit (ERSC)	2005	-
ANSI C80.3	American National Standard for Electrical Metallic Tubing (EMT)	2005	-
ANSI C80.5	American National Standard for Electrical Rigid Aluminum Conduit	2005	-
NEMA FB 1	Standard for Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit, Electrical Metallic Tubing, and Cable	2012	-
NEMA RN 1	Polyvinyl-Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit	2005; R 2013	-
NEMA TC 2	Standard for Electrical Polyvinyl Chloride (PVC) Conduit	2013	-

Code or Standard	Description	Date of Current Publication	Errata
NEMA TC 3	Standard for Polyvinyl Chloride (PVC) Fittings for Use With Rigid PVC Conduit and Tubing	2013	-
UNDERWRITERS LABORATORIES (UL)			
UL 1	Standard for Flexible Metal Conduit	2005; Reprint Jul 2012	-
UL 1242	Standard for Electrical Intermediate Metal Conduit -- Steel	2006; Reprint Mar 2014	-
UL 360	Liquid-Tight Flexible Steel Conduit	2013; Reprint Aug 2014	-
UL 514B	Conduit, Tubing and Cable Fittings	2012; Reprint Jun 2014	-
UL 6	Electrical Rigid Metal Conduit-Steel	2007; reprint Nov 2010	-
UL 797	Electrical Metallic Tubing - Steel	2007; Reprint Dec 2012	-
UL 1242	Standard for Electrical Intermediate Metal Conduit -- Steel	2006; Reprint Mar 2014	-
25. SELECTIVE COORDINATION			
NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)			
NFPA 70*	National Electrical Code	2014	AMD 1 2013; Errata 1 2013; AMD 22013; Errata 2 2013; AMD 3 2014; Errata 3 2014
INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)			
IEEE C2*	National Electrical Safety Code	2012; INT 1-4 2012; INT 5-7 2013	Errata 2012
IEEE 242#	Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems - Buff Book	2001	Errata 2003
IEEE 399#	Brown Book IEEE Recommended Practice for Power Systems Analysis	1997	-
IEEE C37.04	Standard for Rating Structure for AC High-Voltage Circuit Breakers	1999; R 2006; AMD 1 2003; R 2006; R 2006; AMD 2	ERTA 2005

Code or Standard	Description	Date of Current Publication	Errata
		2008; CORR 2009; INT 2010	
IEEE C37.06	Standard for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis - Preferred Ratings and Related Required Capabilities for Voltage Above 1000 V	2009	-
IEEE C37.13	Standard for Low-Voltage AC Power Circuit Breakers Used in Enclosures	2008; INT 1 2009; AMD 1 2012	-
IEEE C37.16	Standard for Preferred Ratings, Related Requirements, and Application Recommendations for Low-Voltage AC (635 V and below) and DC 3200 V and below) Power Circuit Breakers	2009	-
IEEE C37.2	Standard for Electrical Power System Device Function Numbers, Acronyms and Contact Designations	2008	-
IEEE C37.20.1	Standard for Metal-Enclosed Low-Voltage Power Circuit-Breaker Switchgear	2002; INT 1 2005; AMD A 2005; AMD B 2006; R 2007	-
IEEE C37.46	Standard for High Voltage Expulsion and Current-Limiting Type Power Class Fuses and Fuse Disconnecting Switches	2010	-
NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)			
NEMA C37.50	American National Standard for Switchgear--Low-Voltage AC Power Circuit Breakers Used in Enclosures - Test Procedures	2012	-
NEMA FU 1	Low Voltage Cartridge Fuses	2012	-
NEMA ICS 1	Standard for Industrial Control and Systems: General Requirements	2000; R 2008	E 2010
NEMA ICS 2	Standard for Controllers, Contactors, and Overload Relays Rated 600 V	2000; R 2005	Errata 2008

Code or Standard	Description	Date of Current Publication	Errata
NEMA ICS 3	Medium-Voltage Controllers Rated 2001 to 7200 V AC	2005; R 2010	-
NEMA SG 4	AC High-Voltage Circuit Breakers	2009; R 2013	-
NEMA SG 6	Standard for Power Switching Equipment	2000	-
UNDERWRITERS LABORATORIES (UL)			
UL 198M	Standard for Mine-Duty Fuses	2003; Reprint Feb 2013	-
UL 489	Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures	2013; Reprint Mar 2014	-
UL 508	Industrial Control Equipment	1999; Reprint Oct 2013	-
26. SIESMIC			
AMERICAN SOCIETY OF CIVIL EGINEERS			
ASCE-07	Minimum Design Loads for Buildings and Other Structures	2013	-
ASTM INTERNATIONAL (ASTM)			
ASTM E580/E580M	Application of Ceiling Suspension Systems for Acoustical Tile and Lay-In Panels in Areas Requiring Moderate Seismic Restraint	2014	-
UNDERWRITERS LABORATORIES (UL)			
UL 1598	Luminaires	2008; Reprint Oct 2012	-
27. SURGE PROTECTION			
NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)			
NFPA 70*	National Electrical Code	2014	AMD 1 2013; Errata 1 2013; AMD 22013; Errata 2 2013; AMD 3 2014; Errata 3 2014
NFPA 780	Standard for the Installation of Lightning Protection Systems	2014	-
INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)			

Code or Standard	Description	Date of Current Publication	Errata
IEEE C2*	National Electrical Safety Code	2012; INT 1-4 2012; INT 5-7 2013	Errata 2012
IEEE 32	Standard Requirements, Terminology, and Test Procedures for Neutral Grounding Devices	1972; R 1997	-
IEEE C37.41	Standard Design Tests for High-Voltage (>1000 V) Fuses, Fuse and Disconnecting Cutouts, Distribution Enclosed Single-Pole Air Switches, Fuse Disconnecting Switches, and Accessories Used with These Devices	2008	Errata 2009
IEEE C62.11	Standard for Metal-Oxide Surge Arresters for Alternating Current Power Circuits (>1kV)	2012	-
IEEE C62.41.1	Guide on the Surges Environment in Low-Voltage (1000 V and Less) AC Power Circuits	2002; R 2008	-
IEEE C62.41.2	Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and Less) AC Power Circuits	2002	-
NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)			
NEMA LA 1	Standard for Surge Arresters	2009	-
UNDERWRITERS LABORATORIES (UL)			
UL 1283	Electromagnetic Interference Filters	2005; Reprint Feb 2013	-
UL 1449#	Surge Protective Devices	2014	-
28. TRANSFORMERS – HV & MV			
NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)			
NFPA 70*	National Electrical Code	2014	AMD 1 2013; Errata 1 2013; AMD 22013; Errata 2 2013; AMD 3 2014; Errata 3 2014
INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)			

Code or Standard	Description	Date of Current Publication	Errata
IEEE C2*	National Electrical Safety Code	2012; INT 1-4 2012; INT 5-7 2013	Errata 2012
IEEE 386	Standard for Separable Insulated Connector Systems for Power Distribution Systems Above 600V	2006; INT 1 2011	-
IEEE C37.121	American National Standard for Switchgear-Unit Substations - Requirements	2012	-
IEEE C37.46	Standard for High Voltage Expulsion and Current-Limiting Type Power Class Fuses and Fuse Disconnecting Switches	2010	-
IEEE C37.47	Standard for High Voltage Current-Limiting Type Distribution Class Fuses and Fuse Disconnecting Switches	2011	-
IEEE C37.121	American National Standard for Switchgear-Unit Substations - Requirements	2012	-
IEEE C57.12.00	Standard General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers	2010	-
IEEE C57.12.10	Liquid-Immersed Power Transformers Corrigendum 2: Correction of A.3.2.13 Autotransformer LTC Application Considerations	2013	-
IEEE C57.12.25#	Standard for Transformers - Pad-Mounted, Compartmental-Type, Self-Cooled, Single-Phase Distribution Transformers With Separable Insulated High-Voltage Connectors; High Voltage, 34,500 Grdy/ 19,920 Volts and Below; Low Voltage, 240/120 Volts; 167 kVa and Smaller Requirements	1990	-

Code or Standard	Description	Date of Current Publication	Errata
IEEE C57.12.34#	Standard for Requirements for Pad-Mounted, Compartmental-Type, Self-Cooled, Three-Phase Distribution Transformers, 5 MVA and Smaller; High Voltage, 34.5 kV Nominal System Voltage and Below; Low Voltage, 15 kV Nominal System Voltage and Below	2009	-
IEEE C57.12.80	Standard Terminology for Power and Distribution Transformers	2010	-
IEEE C57.12.90	Standard Test Code for Liquid-Immersed Distribution, Power, and Regulating Transformers	2010	-
IEEE C57.19.00	Standard General Requirements and Test Procedures for Outdoor Power Apparatus Bushings	2009; INT 1 2009	Errata 2010
IEEE C57.19.01	Standard Performance Characteristics and Dimensions for Outdoor Apparatus Bushings	2000; R 2005; INT 1 2010	-
IEEE C57.93	Guide for Installation and Maintenance of Liquid-Immersed Power Transformers	2007	-
IEEE C57.96	Guide for Loading Dry-Type Distribution and Power Transformers	2013	-
IEEE C57.98	Guide for Transformer Impulse Tests	2011	-
ASTM INTERNATIONAL (ASTM)			
ASTM B188	Standard Specification for Seamless Copper Bus Pipe and Tube	2010	-
ASTM B317/B317M	Standard Specification for Aluminum-Alloy Extruded Bar, Rod, Tube, Pipe, and Structural Profiles for Electrical Purposes (Bus Conductor)	2007	-
ASTM D117	Standard Guide for Sampling, Test Methods, Specifications and Guide for Electrical Insulating Oils of Petroleum Origin	2010	-

Code or Standard	Description	Date of Current Publication	Errata
ASTM D3455#	Compatibility of Construction Material with Electrical Insulating Oil of Petroleum Origin	2011	-
ASTM D3487	Standard Specification for Mineral Insulating Oil Used in Electrical Apparatus	2009	-
ASTM D4059	Analysis of Polychlorinated Biphenyls in Insulating Liquids by Gas Chromatography	2000; R 2010	-
ASTM D877/D877M	Standard Test Method for Dielectric Breakdown Voltage of Insulating Liquids Using Disk Electrodes	2013	-
ASTM D923	Standard Practice for Sampling Electrical Insulating Liquids	2007	-
FM GLOBAL (FM)			
FM APP GUIDE#	Approval Guide http://www.approvalguide.com/	updated on-line	-
NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)			
ANSI C29.1	American National Standard for Electrical Power Insulators--Test Methods	1988; R 2012	-
ANSI C29.2	American National Standard for Insulators - Wet-Process Porcelain and Toughened Glass - Suspension Type	2012	-
ANSI C29.9	American National Standard for Wet-Process Porcelain Insulators - Apparatus, Post-Type	1983; R 2012	-
NEMA C37.72	Manually-Operated, Dead-Front Padmounted Switchgear with Load Interrupting Switches and Separable Connectors for Alternating-Current Systems	1987	-
NEMA ST 20	Standard for Dry-Type Transformers for General Applications	1992; R 1997	-
NEMA TP 1	Guide for Determining Energy Efficiency for Distribution Transformers	2002	-

Code or Standard	Description	Date of Current Publication	Errata
ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT (OECD)			
OECD Test 203	Fish Acute Toxicity Test	1992	-
U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)			
10 CFR 431	Energy Efficiency Program for Certain Commercial and Industrial Equipment	2014	-
29. TRANSFORMERS - LV			
NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)			
NFPA 70*	National Electrical Code	2014	AMD 1 2013; Errata 1 2013; AMD 22013; Errata 2 2013; AMD 3 2014; Errata 3 2014
ASTM INTERNATIONAL (ASTM)			
ASTM D3455#	Compatibility of Construction Material with Electrical Insulating Oil of Petroleum Origin	2011	-
FM GLOBAL (FM)			
FM APP GUIDE#	Approval Guide http://www.approvalguide.com/	updated on-line	-
NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)			
NEMA ST 20	Standard for Dry-Type Transformers for General Applications	1992; R 1997	-
NEMA TP 1	Guide for Determining Energy Efficiency for Distribution Transformers	2002	-
INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)			
IEEE C57.110	Recommended Practice for Establishing Liquid-Filled and Dry-Type Power and Distribution Transformer Capability When Supplying Nonsinusoidal Load Currents	2008	-
ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT (OECD)			
OECD Test 203#	Fish Acute Toxicity Test	1992	-

Code or Standard	Description	Date of Current Publication	Errata
UNDERWRITERS LABORATORIES (UL)			
UL 1561#	Dry-Type General Purpose and Power Transformers	2011; Reprint Sep 2012	-
UL 869A	Reference Standard for Service Equipment	2006	-
30. TRANSFORMER NEUTRAL GROUNDING RESISTORS			
NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)			
NFPA 70*	National Electrical Code	2014	AMD 1 2013; Errata 1 2013; AMD 22013; Errata 2 2013; AMD 3 2014; Errata 3 2014
INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)			
IEEE Standard 32-1972#	IEEE Standard Requirements, Terminology, and Test Procedures for Neutral Grounding Devices	1972	-
IEEE Standard 32-1972#	IEEE Recommended Practice for Grounding of Industrial and Commercial Power Systems	2007	-
31. UPS SYSTEMS			
NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)			
NFPA 70*	National Electrical Code	2014	AMD 1 2013; Errata 1 2013; AMD 22013; Errata 2 2013; AMD 3 2014; Errata 3 2014
NFPA 110*	Standard for Emergency and Standby Power Systems	2013	
INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)			
IEEE C2*	National Electrical Safety Code	2012; INT 1-4 2012; INT 5-7 2013	Errata 2012

Code or Standard	Description	Date of Current Publication	Errata
IEEE 450	Recommended Practice for Maintenance, Testing, and Replacement of Vented Lead-Acid Batteries for Stationary Applications	2010	-
ACOUSTICAL SOCIETY OF AMERICA (ASA)			
ASA S1.4	Specification for Sound Level Meters (ASA 47)	1983; Amendment 1985; R 2006	-
NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)			
NEMA PE 1#	Uninterruptible Power Systems (UPS) Specification and Performance Verification	2003	-

* Required Code
# Recommended Standards