
# FEDERAL ENERGY REGULATORY COMMISSION

**Office of Energy Projects**

# GUIDANCE MANUAL FOR ENVIRONMENTAL REPORT PREPARATION

**For Applications Filed Under the Natural Gas Act**

## Volume II

**Liquefied Natural Gas Project Resource Reports 11 & 13**
**Supplemental Guidance**

## February 2017

# BACKGROUND

In 1999, the Federal Energy Regulatory Commission (FERC or Commission) referenced in its regulations the document *National Bureau of Standards Information Report (NBSIR) 84-2833 Data Requirements for Seismic Review of LNG Facilities* for seismic hazard evaluations and seismic design criteria for LNG facilities. However, this document was published in 1984 and its seismic requirements were based on the version of Title 49 of the Code of Federal Regulations (CFR), Part 193 (49 CFR Part 193) that existed and the edition of National Fire Protection Association (NFPA) Standard 59A that was referenced by 49 CFR Part 193 at that time.

DOT regulations under 49 CFR 193 largely went unchanged from 1980 until 1999. After 1999, DOT changed substantial portions of their regulations. When the Commission received applications for liquefied natural gas (LNG) import terminals in the early- and middle-2000s, we therefore developed a series of guidance documents to assist project sponsors preparing applications to satisfy our regulations and needs to evaluate the safety of the proposed projects. On December 15, 2005, we issued *Draft Guidance on Resource Report 11 and 13* to assist project sponsors in interpreting regulations under 18 CFR §380.12(m) and 18 CFR §380.12(o) for LNG applications. On April 12, 2006, we issued the *Draft Preferred Format Submittal Guidance* to recommend the format of submitted material to make our review more efficient. Finally, on January 23, 2007, we issued the *Draft FERC Seismic Design Guidelines and Data Submittal Requirements for LNG Facilities* in recognition that new U.S. Department of Transportation (DOT requirements in 2003 adopted the 2001 edition of National Fire Protection Association (NFPA) Standard 59A.

The *Draft Guidance on Resource Report 11 and 13* and *Draft Preferred Format Submittal Guidance* were based upon what was understood to be the requirements of Title 49 CFR Part 193, incorporated references (e.g., NFPA 59A), and practices of LNG facilities at the time. However, since then, a number of LNG project proposals have necessitated our evaluation of distinct hazards and potential safety impacts. In addition, we participated in a number of studies with the Fire Protection Research Foundation, Department of Energy, Coast Guard, and Department of Transportation to better address these hazards and potential safety impacts. In 2010, we assisted DOT in issuing additional interpretations on the requirements to meet the exclusion zones and siting requirements in 49 CFR Part 193 and in 2011 assisted DOT in evaluating and approving additional hazard modeling programs to demonstrate compliance with the 49 CFR Part 193 siting regulations. Accordingly, we have refined and clarifed the level of information needed for our evaluation of the hazards associated with proposed LNG facilities per 18 CFR §380.12(m) and 18 CFR §380.12(o).

Similarly, *Draft FERC Seismic Design Guidelines and Data Submittal Requirements for LNG Facilities* has benefited from years of application and were based on DOT requirements for seismic evaluations, which have since changed. The current seismic requirements for LNG facilities in DOT regulations under 49 CFR Part 193 incorporate by reference NFPA 59A-2006 and NFPA 59A-2001. NFPA 59A-2006 is only applicable to stationary LNG storage tanks to be seismically designed for the safe shutdown earthquake (SSE) and operating basis earthquake (OBE) design earthquake ground motions. NFPA 59A-2001 requires piping with cold contents (−20 °F or lower) to be designed dynamically for the OBE or statically 0.60 $S_{DS}$ (maximum spectral acceleration of the design earthquake which equals 2/3 of the maximum considered earthquake [MCE]) as specified in the National Earthquake Hazards Reduction Program (NEHRP) Recommended Provisions. NFPA 59A-2001, Appendix B.5.2, refers seismic design for the remainder of the LNG facilities to NEHRP Recommended Provisions, but these are in non-mandatory Appendix B. We also recognize the current FERC regulations under Title 18 CFR §380.12(h)(5) continues to incorporate NBSIR 84-2833. NBSIR 84-2833 provides guidance on classifying stationary storage containers and related safety equipment as Category I and classifying the remainder of the LNG project structures, systems, and components as either Category II or Category III, but does not provide specific guidance for the seismic design requirements for them. Absent any other regulatory requirements, this guidance recommends that other LNG project structures classified as Seismic Category II or Category III be seismically designed to satisfy the seismic requirement of the American Society of Civil Engineers (ASCE) 7-05[1] in order to demonstrate there is not a significant impact on the safety of the public. ASCE 7-05 is recommended as it is a complete American National Standards Institute (ANSI) consensus design standard, its seismic requirements are based directly on the NEHRP Recommended Provisions, and it is referenced directly by the International Building Code (IBC). Having a link directly to the IBC and ASCE 7 is important to accommodate seals by the engineer of record because the IBC is directly linked to state professional licensing laws while the NEHRP Recommended Provisions are not. Taken together, this Guidance Manual is based upon the regulatory requirements of 18 CFR §380.12, 49 CFR Part 193, and provisions in ASCE 7 and other best practices to demonstrate that the potential hazard to the public from failure of facility components resulting from natural catastrophes is addressed and that there would not be a significant impact on public safety from seismicity and other natural hazards at LNG facilities.

[1] This guidance is based on the current version 49 CFR Part 193 that was applicable at the time of its writing and is therefore consistent with NFPA 59A – 2006 for determination of seismic design ground motions. The determination of seismic ground motions using the detailed procedures of ASCE 7-05 are consistent with the seismic design ground motions defined in NFPA 59A – 2006 and are therefore utilized in this document. This guidance does not supersede or alleviate an applicant of meeting 49 CFR Part 193 or any subsequent revisions made to 49 CFR Part 193.

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# ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| AEGL | Acute Exposure Guideline Levels |
| AFFF | Aqueous Film-Forming Foam |
| ALE | Aftershock Level Earthquake |
| ANSI | American National Standards Institute |
| API | American Petroleum Institute |
| ASCE | American Society of Civil Engineers |
| ASD | allowable stress design |
| ASTM | American Society for Testing and Materials |
| BLEVE | boiling-liquid expanding-vapor explosion |
| BOG | boil-off gas |
| BPCS | basic process control system |
| Bscf | billion standard cubic feet |
| Btu | British thermal unit |
| CBR | California Bearing Ratio |
| CCTV | closed circuit television |
| CEII | Critical Energy Infrastructure Information |
| CFR | Code of Federal Regulations |
| CIDH | cast-in drill hole |
| Coast Guard | U.S. Coast Guard |
| Commission | Federal Energy Regulatory Commission |
| CPT | cone penetration test |
| DCS | distributed control system |
| DE | Design Earthquake |
| DoD | U.S. Department of Defense |
| DOT | U.S. Department of Transportation |
| DTE | design tip elevation |
| EF | Enhanced Fujita |
| EPA | U.S. Environmental Protection Agency |
| ESD | emergency shutdown |
| °F | degrees Fahrenheit |
| FAA | Federal Aviation Administration |
| FAQ | frequently asked questions |
| FAT | factory acceptance test |
| FEED | front-end engineering design |
| FEMA | Federal Emergency Management Agency |
| FERC | Federal Energy Regulatory Commission |
| FGS | fire and gas system |
| ft | foot |
| $ft^3$ | cubic foot |
| gal | U.S. gallon |

| | |
|---|---|
| gpm | U.S. gallons per minute |
| hr | hour |
| HAZID | Hazard Identification |
| HAZOP | Hazard and Operability |
| HHV | higher heating value |
| HMI | human-machine interface |
| HP | high pressure |
| HTF | heat-transfer fluid |
| HVAC | heating, ventilation, and air conditioning |
| IBC | International Building Code |
| in$H_2O$ | inches of water |
| inHg | inches of mercury |
| ISA | International Society of Automation |
| ISO | International Organization for Standardization |
| kV | kilovolt |
| kVA | kilovolt-ampere (one-thousand volt-amperes) |
| lb/hr | pounds per hour |
| LFL | lower flammability limit |
| LHV | lower heating value |
| LNG | liquefied natural gas |
| LOI | Letter of Intent |
| LOPA | Layers of Protection Analysis |
| LP | low pressure |
| $m^3$ | cubic meter |
| mbar | millibar |
| MCE | Maximum Considered Earthquake |
| MCT | Maximum Considered Tsunami |
| mil | thousandth of an inch |
| mm | millimeter |
| MMBtu | million British thermal units |
| MMscfd | million standard cubic feet per day |
| MOC | management of change |
| mph | miles per hour |
| MSE | mechanically stabilized earth |
| MTPA | million tons per annum |
| MWt | megawatt-thermal |
| NAVD | North American Vertical Datum of 1988 |
| NBSIR | National Bureau of Standards Information Report |
| NDE | non-destructive examination |
| NEHRP | National Earthquake Hazards Reduction Program |
| NEPA | National Environmental Policy Act |
| NFPA | National Fire Protection Association |
| NGA | Natural Gas Act |

| | |
|---|---|
| NGL | natural gas liquids |
| NGVD | National Geodetic Vertical Datum of 1929 |
| NIST | National Institute of Standards and Technology |
| NOAA | National Oceanic and Atmospheric Administration |
| $NO_x$ | nitrogen oxides |
| NPSH | net positive suction head |
| NRC | U.S. Nuclear Regulatory Commission |
| NTP | normal temperature and pressure |
| NVIC | Navigation and Vessel Inspection Circular |
| OBE | Operating Basis Earthquake |
| OECD | Organisation for Economic Co-operation and Development |
| P&C | privileged and confidential |
| P&IDs | piping and instrumentation drawings |
| PDA | pile driving analyzer |
| PFD | process flow diagrams |
| PHA | process hazard analysis |
| PHMSA | Pipeline and Hazardous Materials Administration |
| ppm | parts per million |
| ppb-v | parts per billion by volume |
| %-vol | percent by volume |
| psia | pounds per square inch absolute |
| psig | pounds per square inch gauge |
| PVB | pressure vessel burst |
| RAM | reliability, availability, and maintainability |
| RQD | rock quality designation |
| SAT | site acceptance test |
| scfm | standard cubic feet per minute |
| $S_{DS}$ | design earthquake spectral response acceleration at short periods |
| $S_{D1}$ | design earthquake spectral response acceleration at 1-sec period |
| SIL | Safety Integrity Level |
| SIMOPS | Simultaneous Operations |
| SIS | safety instrumented system |
| SIT | site integration test |
| $S_{MS}$ | MCE spectral response acceleration at short periods |
| $S_{M1}$ | MCE spectral response acceleration at 1-sec periods |
| SSE | Safe Shutdown Earthquake |
| STE | specified tip elevation |
| TER | transcutaneous electrical resistance |
| $T_L$ | long-period transition period |
| UFD | utility flow diagram |
| UFL | upper flammability limit |
| UPS | uninterruptible power supply |
| USGS | U.S. Geological Survey |

| | |
|---|---|
| V | volt |
| VCE | vapor cloud explosion |
| ($\phi$) | angle of internal friction |

# 1 INTRODUCTION

We[2] provide this Guidance Manual to describe information in an application for a LNG project to evaluate and address potential safety and reliability impacts and include related engineering design information[3]. This document combines, replaces, and updates the *Guidance for Filing Resource Reports 11 & 13 for LNG Facility Applications* (Dec. 2005), *Resource Report 13 Draft Preferred Submittal Format Guidance* (Apr. 2006), and the *Draft Seismic Design Guidelines and Data Submittal Requirements for LNG Facilities* (Jan. 2007).

This manual does not substitute for, amend, or supersede the Commission's regulations under the Natural Gas Act of 1938 (NGA) or the Commission's and Council on Environmental Quality's (CEQ) regulations under the National Environmental Policy Act of 1969 (NEPA). It imposes no new legal obligations and grants no additional rights. To the extent practicable, we use non-mandatory language such as "recommend," "encourage," and "may" to describe Commission staff's recommendations. We use mandatory language such as "required," "must," and "must not" to describe controlling requirements under the terms of statutes and regulations. The manual discusses our preferred format for certain documents and data presentation. However, applicants can use an alternative approach if it satisfies the requirements of the applicable statutes and regulations.

The purpose of Volume II is to facilitate our review and to assist applicants by identifying the specific information and level of detail and formatting recommended for Resource Report 11 and Resource Report 13 submitted in applications for LNG projects. These Resource Reports are required are required for proposals for new LNG facilities, expansions of existing LNG facilities, or re-commissioning of existing LNG facilities per Title 18 of the Code of Federal Regulations (CFR) Section 380.12 (18 CFR §380.12). The resource reports must contain the type of site-specific design information produced in the normal course of developing the design of an LNG project. The resource reports usually would not require abnormal details or special drawings generated solely for the Commission unless novel designs require additional detail or we request further detail.

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[2] "We," "us," and "our" refer to the environmental staff of the Federal Energy Regulatory Commission's Office of Energy Projects. "You," whether explicit or implied, refers to the applicant proposing a natural gas project or to the applicant's agent(s) who prepares, uses, or reviews these types of environmental documents.

[3] See Title 18, Chapter I of the Code of Federal Regulations (CFR) §380.12(h)(5), 18 CFR §380.12(m), and 18 CFR §380.12(o) of the Commission's regulations, which appear throughout this document. The Commission's regulations in part 380 implement the National Environmental Policy Act of 1969, with section 380.12 specifically addressing Environmental Reports for applications under the Natural Gas Act. Similarly, other agencies' regulations include a full citation, such as 49 CFR Part 193 issued by the Pipeline and Hazardous Materials Safety Administration within the U.S. Department of Transportation.

Resource Report 11 addresses the potential hazard if facility components were to fail due to accidents or natural catastrophes, how these events would affect reliability and safety, and the procedures and design features that applicants would use to reduce potential hazards. Resource Report 11 should serve as a public summary that we can use to prepare our environmental document under NEPA. Resource Report 13 contains more detailed information that supports the summarized information in Resource Report 13, which we use to verify whether the engineering design ensures adequate reliability and safety.

The level of detail to be submitted in Resource Report 13 varies based on the phase of project development. We intend to provide our input early enough in the design phase to influence the reliability and safety provisions considered in the design while minimizing associated costs with changes as shown in the relationship in Attachment 1. No matter the phase of the project development, the level of detail should include all features necessary to evaluate the design, construction, commissioning, start-up, operation, and maintenance of the facilities as identified in this guidance. The level of detail at the time of pre-filing is typically reflective of a front end engineering design (FEED) still in development. The level of detail at the time of application is typically reflective of a completed FEED. We do not expect details about the final design at the time of application, but note that this guidance also includes information that may become available during the final design phase, as indicated by an asterisk (*). The development of final design information should be discussed as identified in this guidance, but would not be expected to be developed at the time of application.

Detailed information filed on the engineering design may qualify as Critical Energy Infrastructure Information (CEII) and privileged material. All filings must be made in compliance with the 18 CFR Part 388 of the Commission's regulations concerning CEII and privileged material. If providing separate binders or electronic filings for public, CEII, and privileged versions, then the privileged version should be a complete resource report for review that includes all public and CEII information. Any CEII or privleged material should be filed as non-public and labeled **"Contains Privileged Information – Do Not Release"** (18 CFR §388.112) or **"Contains Critical Energy Infrastructure Information – Do Not Release"** (18 CFR §388.113) and should be filed separately from the remaining information which should be marked **"Public."**

## Filings

We issue this Guidance Manual to broadly address all types of LNG projects. Because each project is unique, some topics may not be appropriate for the scope of a proposed project or may not apply at all. Where a topic does not apply to the proposed facilities, applicants should note that the topic is "Not applicable" in the filing. If the applicant wishes to add to the list of topics, the applicant should make the addition at the end of the list and not as an insert.

The filings should include a complete set of drawings in electronic and hard copy format to FERC LNG staff as part of the submitted application.

Hard copies of drawings should be on 11"x17" paper in three-ring binders. The drawings must be legible (e.g., hard copies of colored drawings are to be printed in color, not black and white) with a title block and not folded. The drawings should be preceded by a master index on 8.5" x 11" paper that lists drawing number, drawing name, revision date, and revision number. Hard copies should be placed in separate binders in the format order recommended in this guidance and be separated for each Appendix. Each binder volume should be labeled, numbered, and ordered with a master index of the entire Resource Report contents. The spine of each volume should also be labeled, numbered, and ordered to reflect the contents.

Electronic copies of drawings should be filed in *.pdf* or *.docx* formats. The drawings must be legible, and the textual content should be searchable. The drawings should be preceded by a master index that lists drawing number, drawing name, revision date, and revision number matching the hard copies. Electronic copies should be bookmarked and separated into distinct electronic documents for the main text of Resource Report 11, for the main text of Resource Report 13, and for each Appendix.

# 11 RESOURCE REPORT 11 – RELIABILITY AND SAFETY

## 11.1 REGULATORY OVERSIGHT[4]

### 11.1.1 Regulatory Oversight of Reliability and Safety

**PROVIDE** a description of the regulatory oversight of reliability and safety for the proposed facilities. At a minimum, the description should describe the regulatory agencies that have oversight over the reliability and safety of the facilities, operations, and associated hazardous material transportation to and from the facilities as well as any agency coordination that has occurred. The description should reference Resource Report 13, Regulations and Permits in Appendix 13.C, and all other applicable appendices, and should describe:

11.1.1.1 U.S. Department of Transportation Pipeline and Hazardous Materials Administration

For U.S. Department of Transportation (DOT) Pipeline and Hazardous Materials Administration (PHMSA) jurisdictional facilities, discuss and include consultation on any interpretations, special permits, equivalencies, and other issuances by DOT on the project.

11.1.1.2 U.S. Coast Guard

For U.S. Coast Guard (Coast Guard) jurisdictional facilities, discuss and includeall Letter of Intent (LOI) submittals and any issuances by the Coast Guard on the project.

11.1.1.3 U.S. Environmental Protection Agency

For U.S. Environmental Protection Agency (EPA) jurisdictional facilities, discuss and include all preliminary Risk Management Plans and any correspondence or issuances by the EPA on the project.

11.1.1.4 U.S. Occupational Safety and Health Administration

For U.S. Occupational Safety and Health Administration (OSHA) jurisdictional facilities, discuss and include all Process Safety Management Plans and any correspondence or issuances by the OSHA on the project.

[4] 18 CFR §380.12(m)(1) and 18 CFR §380.12(o)(13).

#### 11.1.1.5 U.S. Department of Transportation Federal Aviation Administration

For DOT Federal Aviation Administration (FAA) jurisdictional facilities with aeronautical operations and installations that may be impacted by the proposed facilities, or by construction (e.g., cranes) or operation of the project, or by transportation to or from the project site, discuss and include any related aeronautical studies and determinations from the DOT FAA on the project.

#### 11.1.1.6 U.S. Department of Defense

For Department of Defense (DoD) military operations and installations that may be impacted by the facilities, or by construction or operation of the project, or by transportation to or from the project site, discuss and include any correspondence and issuances by the DoD on the project.

#### 11.1.1.7 U.S. Nuclear Regulatory Commission

For U.S. Nuclear Regulatory Commission (NRC) jurisdictional nuclear plants that may be impacted by the proposed facilities, or by construction or operation of the project, or by transportation to or from the project site, discuss and include any related correspondence and issuances by the NRC.

#### 11.1.1.8 State Agencies

For all proposed facilities, discuss and include any communications or correspondence with the state and local safety agencies and fire marshals.

## 11.2 HAZARD IDENTIFICATION[5]

### 11.2.1 Hazardous Materials

**PROVIDE** a description of all hazardous materials[6] that would be stored, processed, or handled onsite, including those arriving at or departing from the site by various transportation modes including pipelines. For materials whose compositions vary throughout the process, such as natural gas liquids, use the full range of properties. If any material composition would not be known until vendor selection, use conservative estimates that cover the full range of potential compositions. The description should reference any safety data sheets or calculations of mixed fluid properties submitted pursuant to Appendix 13.H, as well as any relevant details in all other applicable appendices, and should include:

11.2.1.1 List of hazardous materials

11.2.1.1.1 Hazardous material stored (capacities, U.S. gallons [gal]; temperatures, degrees Fahrenheit [°F]; pressures, pounds per square inch gauge [psig])

11.2.1.1.2 Hazardous materials processed or handled (concentration range, percent by volume (%-vol); temperature range, °F; pressure range, psig)

11.2.1.2 List of all physical properties

11.2.1.2.1 Freezing/melting temperature at normal[7] pressure (14.7 pounds per square inch absolute [psia])[8], °F

11.2.1.2.2 Boiling/condensing temperature at normal pressure (14.7 psia)[9], °F

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5 18 CFR §380.12(m)(1)-(3).

6 Proprietary mixtures may be filed as privileged and confidential, but a summary or range of the properties as public information.

7 National Institute of Standards and Technology (NIST) Handbook 44, 2016. Normal temperature and pressure (NTP) is defined as 21 °C (70 °F) and 101.325 kPa (14.696 psia).

8 American Society for Testing and Materials (ASTM) D1015, *Standard Test Method for Freezing Points of High Purity Hydrocarbons*.

9 NFPA 704, *Standard System for the Identification of the Hazards of Materials for Emergency Response*, defines boiling point as the temperature at which vapor pressure of liquid is equal to the surrounding atmospheric pressure. For mixes that do not have a constant boiling temperature, use the 20% evaporation point of a distillation performed in accordance with ASTM D86, *Standard Test Method for Distillation of Petroleum Products at Atmospheric Pressure*.

11.2.1.2.3 Vapor and liquid densities at boiling/condensing temperature and normal pressure (14.7 psia), pounds per cubic foot (lb/ft3)

11.2.1.2.4 Vapor and liquid densities at normal temperature (70 °F) and normal pressure (14.7 psia)[10], lb/ft3

11.2.1.3 List of all toxic properties

11.2.1.3.1 Maximum concentration of toxic component in process

11.2.1.3.2 Maximum amount of toxic component accumulated for disposal

11.2.1.3.3 Acute Exposure Guideline Levels (AEGL)-1, -2, -3 concentrations

11.2.1.4 List of all flammable and combustible properties

11.2.1.4.1 Flash points,[11] °F

11.2.1.4.2 Flammability ranges, upper flammability limit (UFL) and lower flammability limit (LFL),[12] %-vol

11.2.1.4.3 Stoichiometric concentrations, %-vol

11.2.1.4.4 Minimum ignition energies, millijoules (mJ)

11.2.1.4.5 Quenching distance,[13] millimeter (mm)

11.2.1.4.6 Maximum experimental safety gap, mm

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[10] ASTM D1657, *Standard Test Method for Density or Relative Density of Light Hydrocarbons by Pressure Hydrometer*;
ASTM D1298, *Standard Test Method for Density, Relative Density, or API Gravity of Crude Petroleum and Liquid Petroleum Products by Hydrometer Method*.

[11] ASTM D92, *Standard Test Method for Flash and Fire Points by Cleveland Open Cup Tester*; ASTM D1310, *Standard Test Methods for Flash Point and Fire Point of Liquids by Tag Open Cup Tester*; ASTM E502, *Standard Test Method for Selection and Use of ASTM Standards for the Determination of Flash Point of Chemicals for by Closed Cup Methods*;

ASTMD56, *Standard Test Method for Flash Point by Tag Closed Cup Tester*;

ASTM D93 *Standard Test Methods for Flash Point by Pensky-Martens Closed Cup Tester*; ASTM D3278 *Standard Test Methods for Flash Point of Liquids by Small Scale Closed-Cup Apparatus*; ASTM D3828, *Standard Test Methods for Flash Point by Small Scale Closed Cup Tester*.

[12] ASTM E681, *Standard Test Method for Concentration Limits of Flammability of Chemicals;* ASTM E918, *Standard Test Method for Determining Limits of Flammability of Chemicals at Elevated Temperature and Pressure*.

[13] ASTM E582, *Standard Test Method for Minimum Ignition Energy and Quenching Distance in Gaseous Mixtures.*

11.2.1.4.7 Auto-ignition temperatures,[14] °F

11.2.1.4.8 Heat of combustions, megajoules per kilogram (MJ/kg)

11.2.1.4.9 Laminar flame speed, meters per second (m/s)

11.2.1.5 List of all corrosive properties

11.2.1.5.1 Corrosivity of skin[15]

11.2.1.5.2 External and internal corrosion rate of metal surfaces, thousandths of an inch per year (mils/year)

11.2.1.5.3 Stress Corrosion Cracking sucetpibility or potential (e.g., active path dissolution SCC, chloride SCC, anhydrous ammonia SCC, hydrogen SCC, etc)

11.2.1.6 List of all reactivity properties with other materials in process

11.2.1.6.1 Reactivity with water

11.2.1.6.2 Reactivity with mercury (e.g. aluminum)

11.2.1.6.3 Reactivity with other materials in process

### 11.2.2 Process Hazards

**PROVIDE** a description of process hazard identification and analyses conducted to date to identify potential hazardous events possible from the hazardous materials stored, processed, and handled onsite and analyze the safeguards necessary to mitigate such hazards. The description should reference the Engineering Design Information in Appendix 13.E, Project Specifications in Appendix 13.F, and Hazard Identification in Appendices 13.G.1 and 13.G.2, and all other applicable appendices.

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[14] ASTM E659, *Standard Test Method for Autoignition Temperature of Liquid Chemicals*.

[15] OECD 404, *Acute Dermal Irritation/Corrosion;*
OECD TG 430, *In Vitro Transcutaneous Electrical Resistance Test (TER)*;
OECD 431, *In Vitro Human Skin Model Test;*
OECD TG 435, *In Vitro Membrane Barrier Test Method*.

### 11.2.3 Marine Transportation Hazards

**PROVIDE** a description of marine transportation hazard identification and analyses conducted to date to identify the potential for hazardous events and analyze the safeguards and security necessary to mitigate such events along the transit route. The description should reference the Waterway Safety and Reliability Impact Studies[16] in Appendix 13.G.3, and all other applicable appendices, and should include:

11.2.3.1 Results of the ship simulation studies

11.2.3.2 Depictions of the marine hazard zones (accidental and intentional)

11.2.3.3 Areas impacted by the marine hazard zones (e.g., populated areas, transportation infrastructure, industrial facilities, public health and safety facilities, and military facilities)

11.2.3.4 Safeguards and security necessary to mitigate impacts

### 11.2.4 Other Transportation Hazards

**PROVIDE** a description of any potential hazards from transportation activities (e.g., road, rail, air) that may impact the proposed facilities. The description should reference Appendices 13.G.4, 13.G.5, and 13.G.6, and all other applicable appendices, and should include:

11.2.4.1 Transportation within the LNG plant boundaries

11.2.4.2 Transportation alongside or through the LNG plant

11.2.4.3 Safeguards that would mitigate impacts

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[16] Waterway Suitability Assessments submitted to Coast Guard in accordance with 18 CFR §157.21(a)(1), 18 CFR §157.21(f)(13), 33 CFR §127.007, and Navigation and Vessel Inspection Circular (NVIC) 01-2011, Guidance Related to Waterfront Liquefied Natural Gas Facilities may satisfy Waterway Safety and Reliability Impact Studies in Appendix 13.G.3. This material may include Critical Energy Infrastructure Information (CEII), Security Sensitive Information (SSI), or Chemical-Terrorism Vulnerability Information (CVI) and must comply with all applicable regulations.

### 11.2.5 Crane and Lifting Hazards

**PROVIDE** a description of any potential hazards from crane and lifting activities that may impact the proposed facilities. The description should reference Appendices 13.G.7, and all other applicable appendices.

### 11.2.6 Adjacent Hazards

**PROVIDE** a description of any potential hazards from facilities adjacent to the project site and describe any safeguards that would mitigate impacts. The description should reference Appendix 13.H.3 and all other applicable appendices.

### 11.2.7 Natural Hazards

**PROVIDE** a description of natural hazard analyses conducted to date to identify the potential for hazardous events and the safeguards necessary to mitigate such events. The description should reference Appendices 13.I and 13.J, and all other applicable appendices.

### 11.2.8 Security Threats and Vulnerabilities[17]

**PROVIDE** a description of the type of threat and vulnerability analyses that have been and will be conducted to identify potential hazardous events and the safeguards and security necessary to mitigate such events. At a minimum, the description should reference security threat and vulnerability assessments that have been or will be completed as part of the development of the facility or site security plan in Section 13.31 and Appendix 13.G.8 and all other applicable appendices.

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[17] Security Threat and Vulnerability Information prepared for or submitted to Coast Guard in accordance with 33 CFR §105.305 or prepared for or submitted to Department of Homeland Security (DHS) in accordance with 6 CFR §27.215 may satisfy Security Threat and Vulnerability Analyses in Appendix 13.G.8. This material may include Critical Energy Infrastructure Information (CEII), Security Sensitive Information (SSI), or Chemical-Terrorism Vulnerability Information (CVI) and should comply with all applicable regulations.

## 11.3 HAZARD ANALYSES[18]

### 11.3.1 Hazardous Releases

**PROVIDE** a summary of the hazardous releases used for consequence modeling. The summary should demonstrate compliance with federal regulations[19] and should reference Appendix 13.H, and all other applicable appendices. The summary should tabulate:

11.3.1.1 Scenario number

11.3.1.2 Hazardous fluid

11.3.1.3 Size of hole/failure, in

11.3.1.4 Size of piping/equipment, in (piping), gal (vessels/tanks)

11.3.1.5 General location, plant area

11.3.1.6 Orientation, vertical, horizontal, other

11.3.1.7 Release height, ft

11.3.1.8 Release temperature, °F

11.3.1.9 Release pressure, psig (depressurization pressure, if applicable)

11.3.1.10 Release flow rate, lb/hr and gallons per minute (gpm)

11.3.1.11 Release duration, min or hr

11.3.1.12 Liquid rainout, %-vol

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[18] 18 CFR §380.12(m)(2), 18 CFR §380.12(m)(3), 18 CFR §380.12(m)(5).

[19] This may include distinct hazards for DOT's regulations at 49 CFR Part 193 and/or worst case and alternative scenarios for EPA's regulations at 40 CFR Part 68, as applicable.

### 11.3.2 Hot and Cold Fluid Temperature Hazard Analysis

**PROVIDE** a summary of the of hot and cold temperature hazards from contact with liquid spills and jetting fluids or inadequately mitigated cascading events. The summary should demonstrate compliance with federal regulations[20] and should reference the complete Hazard Analysis Report(s) in Appendix 13.H, and relevant details in all other applicable appendices, and should summarize:

11.3.2.1 Models, assumptions, and uncertainties used to analyze hazards

11.3.2.1.1 Description of model used to analyze hazards and uncertainty in predictions based on scientific assessment, verification and validation results

11.3.2.1.2 Description of releases or inadequately mitigated cascading events used in modeling

11.3.2.1.3 Description of terrain and other surrounding features used in modeling

11.3.2.1.4 Description of structures, equipment, piping, and other plant components used in modeling

11.3.2.2 Description of grading, curbing, trenches, impoundments, and other hazard mitigation measures used in modeling

11.3.2.3 Drawing(s) with scale depicting grading, curbing, trenches, impoundments, and other hazard mitigation measures with directions of flow and other relevant descriptive features

11.3.2.4 Drawing(s) with scale depicting extent of potential contact burns (e.g., 160 °F[21]) and thermal degradation for hot temperature hazards and potential freeze burns and embrittlement (e.g., –20 °F[22]) for cold temperature hazards, relative to equipment,

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[20] This may include design spills for DOT's regulations at 49 CFR Part 193, worst case and alternative scenarios for EPA's regulations at 40 CFR Part 68, and/or zones of concern for Coast Guard's NVIC 01-2011, as applicable.

[21] ASTM C1055, *Standard Guide for Heated System Surface Conditions that Produce Contact Burn Injuries*; ASTM C680, *Standard Practice for Estimate of the Heat Gain or Loss and the Surface temperatures of Insulated Flat, Cylindrical, and Spherical Systems by Use of Computer Programs.*

[22] Based on minimum design metal temperatures (MDMT) in ASME Code for Pressure Piping, B31.3, *Process Piping*; ASME Boiler and Pressure Vessel Code

occupied buildings, and property lines, taking into account any uncertainties of models and hazard mitigation measures[23]

### 11.3.3 Asphyxiant and Toxic Vapor Dispersion Hazards Analysis

**PROVIDE** a summary of the asphyxiant and toxic dispersion hazards from releases or inadequately mitigated cascading events. The summary should demonstrate compliance with federal regulations[24] and should reference the complete Hazard Analysis Report(s) in Appendix 13.H, and relevant details in all other applicable appendices, and should summarize:

11.3.3.1 Models, assumptions, and uncertainties used to analyze hazards

11.3.3.1.1 Description of model used to analyze hazards and uncertainty in predictions based on scientific assessment, verification and validation results[25]

11.3.3.1.2 Description of releases or inadequately mitigated cascading events used in modeling

11.3.3.1.3 Description of the toxic endpoint concentration of AEGL-1, -2, and -3 and exposure duration

11.3.3.1.4 Description of wind direction, speed, stability, turbulence, temperature, relative humidity, ambient pressure, and other weather conditions used in modeling

11.3.3.1.5 Description of terrain and surface roughness, and other surrounding features used in modeling

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[23] Hot and cold temperature hazards are typically limited by the heat transfer characteristics of the fluid. Direct contact with liquids, surfaces of equipment, or direct exposure to high momentum vapors at the release location tend to produce high enough heat transfer rates compared to vapors dispersing in low wind conditions. Referencing of properly designed spill containment and structural supports in Resource Report 13 is satisfactory to demonstrate these hot and cold temperature hazards from liquid spills will not impact the safety or reliability of the facilities. Referencing of properly designed piping and equipment thermal insulation in Resource Report 13 is satisfactory to demonstrate direct contact with surfaces of equipment would not pose a hazard. Referencing of properly done hazard modeling that shows hot and cold temperatures would not extend offsite or onto equipment or structural supports in Resource Report 13 is satisfactory to demonstrate hot and cold temperatures from vapor releases will not impact the safety or reliability of the facilities. The modeling should show this by tracking the temperature directly or by tracking the concentrations and correlating the concentrations with temperatures.

[24] This may include distinct hazards for DOT's regulations at 49 CFR Part 193 and/or worst case and alternative scenarios for EPA's regulations at 40 CFR Part 68, as applicable.

[25] Dispersion of a release with multiple toxins should discuss how all toxic components are accounted for in modeling when determining the toxic concentrations.

11.3.3.1.6 Description of structures, equipment, piping, and other plant components used in modeling

11.3.3.1.7 Description of vapor barriers (material of construction, dimensions, locations, impermeability, maintenance requirements, etc.), fans, and other hazard mitigation measures used in modeling[26]

11.3.3.2 Drawing(s) with scale depicting vapor barriers, fans, and other hazard mitigation measures with vapor barrier heights, fan capacities, and other descriptive information

11.3.3.3 Drawing(s) with scale depicting extent of 19.5 %-vol, 16 %-vol, and 12.5 %-vol oxygen concentrations[27] for asphyxiation hazards, relative to equipment, occupied buildings, and property lines taking into account any uncertainties of models and hazard mitigation measures[28]

11.3.3.4 Drawing(s) with scale depicting extent of AEGL-1, -2, and -3 based on exposure time toxicity hazards, relative to equipment, occupied buildings, property lines, and offsite areas (e.g., populated areas, transportation infrastructure, industrial facilities, public health and safety facilities, and military facilities), taking into account any uncertainties of models (e.g., ½-AEGL-1, -2, -3) and hazard mitigation measures

11.3.3.5 Description of any mitigation measures to address the impacts that would exacerbate the initial hazard, including effects from intake of toxic or oxygen depriving vapors into occupied buildings.

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[26] Active mitigation used in modeling should be supported with information on reliability of its operation and must be approved.

[27] ASNI Z88.2, *American National Standard for Respiratory Protection*, 1992.

Hightower, M., Gritzo, L., Luketa-Hanlin, A., et al, *Guidance on Risk Analysis and Safety Implications of a Large Liquefied Natural Gas (LNG) Spill Over Water*, SAND2004-6258, December 2004.

OSHA's Respiratory Protection rule, 63 Fed. Reg. 1152, 1159 (Jan. 1998).

[28] Where flammable endpoint concentrations or toxic endpoint concentrations are less than asphyxiation endpoint concentrations and are modeled and shown to not impact the public, there does not need to be further demonstration that higher asphyxiation concentrations would also not impact the public as the dispersion distance of a lower concentration will encompass the dispersion distance of a higher concentration.

### 11.3.4 Flammable Vapor Dispersion Hazards Analysis

**PROVIDE** a summary of the flammable vapor dispersion hazards from releases or inadequately mitigated cascading events. The summary should demonstrate compliance with federal regulations[29] and should reference the complete Hazard Analysis Report(s) in Appendix 13.H, and relevant details in all other applicable appendices, and should summarize:

11.3.4.1 Models, assumptions, and uncertainties used to analyze hazards

11.3.4.1.1 Description of model used to analyze hazards and uncertainty in predictions based on scientific assessment, verification and validation results

11.3.4.1.2 Description of releases or inadequately mitigated cascading events used in modeling

11.3.4.1.3 Description of wind direction, speed, stability, turbulence, temperature, relative humidity, ambient pressure, and other weather conditions used in modeling

11.3.4.1.4 Description of terrain and surface roughness, and other surrounding features used in modeling

11.3.4.1.5 Description of structures, equipment, piping, and other plant components used in modeling

11.3.4.1.6 Description of vapor barriers, fans, and other hazard mitigation measures used in modeling[30]

11.3.4.2 Drawing(s) with scale depicting vapor barriers, fans, and other hazard mitigation measures with vapor barrier heights, fan capacities, and other descriptive information

11.3.4.3 Drawing(s) with scale depicting extent of LFL and UFL concentrations for flammable vapor dispersion hazards, relative to equipment, occupied buildings, property lines, and offsite areas (e.g., populated areas, transportation infrastructure, industrial facilities, public health and safety facilities, and military facilities),

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[29] This may include exclusion zones and other distinct hazardous zones for DOT's regulations at 49 CFR Part 193, worst case and alternative scenarios for EPA's regulations at 40 CFR Part 68, and/or zones of concern for Coast Guard's NVIC 01-2011, as applicable.

[30] Active mitigation used in modeling should be supported with information about its operating reliability and must be approved to be used in modeling.

taking into account any uncertainties of models (e.g., ½-LFL) and hazard mitigation measures

11.3.4.4 Description of any mitigation measures to address the impacts that would exacerbate the initial hazard, including cascading effects from ingestion into occupied buildings, and intake into fired equipment, dispersion to confined locations or congested areas.

### 11.3.5 Vapor Cloud Overpressure Hazards Analysis

**PROVIDE** a summary of the vapor cloud explosion (VCE) overpressure hazards that could result from releases or inadequately mitigated cascading events. The summary should demonstrate compliance with federal regulations[31] and should reference the complete Hazard Analysis Report(s) in Appendix 13.H, and relevant details in all other applicable appendices, and should summarize:

11.3.5.1 Models, assumptions, and uncertainties used to analyze hazards

11.3.5.1.1 Description of model used to analyze hazards and uncertainty in predictions based on scientific assessment, verification and validation results

11.3.5.1.2 Description of releases or inadequately mitigated cascading events used in modeling

11.3.5.1.3 Description of ignition source(s) and strength(s), if applicable to the model

11.3.5.1.4 Description of fluid

11.3.5.1.5 Description of vapor cloud concentration, homogeneity, size (e.g., dimensions and flammable mass), and location used in VCE modeling

11.3.5.1.6 Description of vapor cloud reactivity and laminar flame speed used in VCE modeling

11.3.5.1.7 Description of confinement from structures, equipment, piping, and other plant components used in VCE modeling

11.3.5.1.8 Description of congestion from equipment, piping, vegetation, and other plant components and surrounding features used in VCE modeling

[31] This may include distinct hazards for DOT's regulations at 49 CFR Part 193 and/or worst case and alternative scenarios for EPA's regulations at 40 CFR Part 68, as applicable.

11.3.5.1.9 Description of structures, equipment, piping, and other plant components used in VCE modeling

11.3.5.1.10 Description of hardened structures, blast walls, and other hazard mitigation measures used in modeling

11.3.5.2 Drawing(s) with scale depicting hardened structures, blast walls, and other hazard mitigation measures with blast wall heights, ratings, and other descriptive information

11.3.5.3 Drawing(s) with scale depicting the extent of 1 psi, 3 psi, and 10 psi and projectiles (11 ft-lbf and higher) for overpressure hazards of vapor cloud explosions, relative to equipment, occupied buildings, property lines, and offsite areas (e.g., populated areas, transportation infrastructure, industrial facilities, public health and safety facilities, and military facilities), taking into account any uncertainties of models and any hazard mitigation measures

11.3.5.4 Description of any mitigation measures to address the impacts that would exacerbate the initial hazard, including cascading effects from failure of occupied buildings, more hazardous equipment, and safety related equipment.

### 11.3.6 Fire Hazards Analysis

**PROVIDE** a summary of the fireball, jet fire, and pool fire radiant heat hazards and impacts from releases or inadequately mitigated cascading events. The summary should demonstrate compliance with federal regulations[32] and should reference the complete Hazard Analysis Report(s) in Appendix 13.H, and relevant details in all other applicable appendices, and should summarize:

11.3.6.1 Models, assumptions, and uncertainties used to analyze hazards

11.3.6.1.1 Description of model used to analyze hazards and uncertainty in predictions based on scientific assessment, verification and validation results

11.3.6.1.2 Description of releases or inadequately mitigated cascading events used in modeling

[32] This may include exclusion zones and distinct hazards for DOT's regulations at 49 CFR Part 193, worst-case and alternative scenarios for EPA's regulations at 40 CFR Part 68, and/or zones of concern for Coast Guard's NVIC 01-2011, as applicable.

11.3.6.1.3 Description of wind direction, speed, stability, turbulence, temperature, relative humidity, ambient pressure, and other weather conditions used in modeling

11.3.6.1.4 Description of terrain and other surrounding features used in modeling

11.3.6.1.5 Description of structures, equipment, piping, and other plant components used in modeling

11.3.6.1.6 Description of fire walls, structural fire protection, and other hazard mitigation measures used in modeling

11.3.6.2 Drawing(s) with scale depicting fire walls, radiant heat shields, structural fire protection, mounding, and other hazard mitigation measures with fire wall heights, ratings, and other descriptive information

11.3.6.3 Drawing(s) with scale depicting the extent of equivalent 1,600 British thermal units (Btu)/$ft^2$-hr and 40-second dose for radiant heat hazards of fireballs, relative to equipment, occupied buildings, property lines, and offsite areas (e.g., populated areas, transportation infrastructure, industrial facilities, public health and safety facilities, and military facilities), taking into account any uncertainties of models and any hazard mitigation measures

11.3.6.4 Drawing(s) with scale depicting the extent of 1,600 Btu/$ft^2$-hr, 3,000 Btu/$ft^2$-hr, and 10,000 Btu/$ft^2$-hr for radiant heat hazards of jet fires, relative to equipment, occupied buildings, property lines, and offsite areas (e.g., populated areas, transportation infrastructure, industrial facilities, public health and safety facilities, and military facilities), taking into account any uncertainties of models and any hazard mitigation measures

11.3.6.5 Drawing(s) with scale depicting extent of 1,600 Btu/$ft^2$-hr, 3,000 Btu/$ft^2$-hr, and 10,000 Btu/$ft^2$-hr for radiant heat hazards of pool fires, relative to equipment, occupied buildings, property lines, and offsite areas (e.g., populated areas, transportation infrastructure, industrial facilities, public health and safety facilities, and military facilities), taking into account any uncertainties of models and any hazard mitigation measures

11.3.6.6 Description of any mitigation measures to address the impacts that would exacerbate the initial hazard, including cascading effects from failure of occupied buildings, hazardous equipment, and safety related equipment.

### 11.3.7 Vessel Overpressure Analyses

**PROVIDE** a summary of the overpressure and projectile hazards from boiling-liquid expanding-vapor explosions (BLEVEs) and pressure vessel bursts (PVBs). Evaluate a two hour fire in impoundments, unless an impoundment could not receive that amount of flammable fluid, and also evaluate any jet fires that could be sustained. Also consider BLEVEs and PVBs of transportation vessels (e.g., trucks, railcars, etc.) at transfer stations. If any details about vessel design would not be known until a vendor is selected, use conservative estimates that cover the full range of potential values. Also, provide technical justifications for any design measures to mitigate the potential for vessel BLEVE and PVB events. The summary should reference relevant details in Appendix 13.H and all other applicable appendices and should summarize:

11.3.7.1 Models, assumptions, and uncertainties used to analyze hazards

11.3.7.1.1 Description of model used to analyze BLEVE and PVB hazards and uncertainty in predictions based on scientific assessment, verification and validation results

11.3.7.1.2 Description and amount of product in vessels used in BLEVE and PVB modeling

11.3.7.1.3 Description of structures, equipment, piping, and other plant components used in BLEVE and PVB modeling

11.3.7.1.4 Description of hardened structures, blast walls, and other hazard mitigation measures used in BLEVE and PVB modeling

11.3.7.2 Drawing(s) with scale depicting hardened structures, blast walls, and other hazard mitigation measures with blast walls' heights, ratings, and other descriptive information

11.3.7.3 Drawing(s) with scale depicting extent of 1 psi, 3 psi, and 10 psi and projectiles (11 ft-lbf and higher) for overpressure hazards of BLEVEs and PVBs, relative to equipment, occupied buildings, property lines, and offsite areas (e.g., populated areas, transportation infrastructure, industrial facilities, public health and safety facilities, and military facilities) taking into account any uncertainties of models and any hazard mitigation measures

11.3.7.4 Drawing(s) with scale depicting the extent of equivalent 1,600 Btu/ft$^2$-hr and 40 second dose for radiant heat hazards of fireballs, relative to equipment, occupied buildings, property lines, and offsite areas (e.g., populated areas, transportation infrastructure, industrial facilities, public health and safety

facilities, and military facilities), taking into account any uncertainties of models and any hazard mitigation measures

11.3.7.5 Description of any mitigation measures to address impacts that would exacerbate the initial hazard, including cascading effects from failure of occupied buildings, more hazardous equipment, and safety related equipment.

### 11.3.8 Fog or Steam Hazard Analyses

**PROVIDE** a summary of visibility hazards due to water condensation (i.e., fog generation from ambient vaporizers or other cooling and heating systems or steam generation). The summary should demonstrate compliance with federal regulations and should reference the complete Hazard Analysis Report(s) in Appendix 13.H, and relevant details in all other applicable appendices, and should summarize:

11.3.8.1 Models, assumptions, and uncertainties used to analyze hazards

11.3.8.1.1 Description of model used to analyze dispersion hazards and uncertainty in predictions based on scientific assessment, verification and validation results

11.3.8.1.2 Description of fog and steam generation sources used in modeling

11.3.8.1.3 Description of wind direction, speed, stability, turbulence, temperature, relative humidity, ambient pressure, and other weather conditions used in modeling

11.3.8.1.4 Description of terrain and surface roughness, and other surrounding features used in modeling

11.3.8.1.5 Description of structures, equipment, piping, and other plant components used in modeling

11.3.8.1.6 Description of vapor barriers, fans, and other hazard mitigation measures used in modeling[33]

11.3.8.2 Drawing(s) with scale depicting vapor barriers, fans, and other hazard mitigation measures with vapor barrier heights, fan capacities, and other descriptive information

11.3.8.3 Drawing(s) with scale depicting extent of visibility hazards, relative to equipment, occupied buildings, property lines, and

[33] Active mitigation used in modeling should be supported with information on reliability of its operation and must be approved to be used in modeling.

offsite areas (e.g., populated areas, transportation infrastructure, industrial facilities, public health and safety facilities, and military facilities), taking into account any uncertainties of models and hazard mitigation measures

11.3.8.4 Description of any mitigation measures to address the impacts, including loss of visibility due to water condensation and other impacts that would exacerbate the initial hazard

### 11.3.9 Other Hazard Analyses

**PROVIDE** a summary of other hazards that may be unique to the installation and any related cascading events. The summary should demonstrate compliance with federal regulations[34] and should reference the complete Hazard Analysis Report(s) in Appendix 13.H, and relevant details in all other applicable appendices, and should summarize:

11.3.9.1 Models, assumptions, and uncertainties used to analyze hazards

11.3.9.1.1 Description of model used to analyze hazards and uncertainty in predictions based on scientific assessment, verification and validation results

11.3.9.1.2 Description of parameters used in modeling

11.3.9.2 Drawing(s) with scale depicting hazard mitigation measures with descriptive information

11.3.9.3 Drawing(s) with scale depicting the extent of hazard for reversible, irreversible, and fatal effects relative to equipment, occupied buildings, property lines, and offsite areas (e.g., populated areas, transportation infrastructure, industrial facilities, public health and safety facilities, and military facilities), taking into account any uncertainties of models and any hazard mitigation measures

### 11.3.10 Hazardous Material Disposal

**PROVIDE** a description of the disposal processes for hazardous materials, as well as the potential hazardous events that could occur and safeguards taken to prevent them. Reference all applicable appendices to Resource Report 13.

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[34] This may include exclusion zones and distinct hazards for DOT's regulations at 49 CFR Part 193, worst case and alternative scenarios for EPA's regulations at 40 CFR Part 68, and/or zones of concern for Coast Guard's NVIC 01-2011, as applicable.

## 11.4 LAYERS OF PROTECTION[35]

### 11.4.1 Layers of Protection

**PROVIDE** a summary of the basic design and various layers of protection and associated codes and standards to mitigate the risk of an incident impacting the safety or reliability of the plant's design, construction, operation, maintenance, and management. At a minimum, the summary should describe:

11.4.1.1 Structural design of the facilities and components

11.4.1.1.1 Summary of basis of design used in structural design, with reference to all applicable Resource Report 13 sections and Appendices for additional details

11.4.1.1.2 Summary of regulatory requirements used in structural design, with reference to all applicable Resource Report 13 sections and Appendices for additional details

11.4.1.1.3 Summary of primary codes and standards used in structural design, with reference to all applicable Resource Report 13 sections and Appendices for additional details

11.4.1.1.4 Summary of design to withstand structural loads, including natural hazards, with reference to all applicable Resource Report 13 sections and Appendices for additional details

11.4.1.2 Mechanical design of the facilities and components

11.4.1.2.1 Summary of basis of design used in mechanical design, with reference to all applicable Resource Report 13 sections and Appendices for additional details

11.4.1.2.2 Summary of regulatory requirements used in mechanical design, with reference to all applicable Resource Report 13 sections and Appendices for additional details

11.4.1.2.3 Summary of primary codes and standards used in mechanical design, with reference to all applicable Resource Report 13 sections and Appendices for additional details

11.4.1.2.4 Summary of provisions for (e.g. spare pump column without pump, equipment layout space for spare compressor, etc.) and installations of spare equipment and redundancies, and design to withstand internal and external pressures, temperatures,

[35] 18 CFR §380.12(m)(1), 18 CFR §380.12(m)(3) thru (5), 18 CFR §380.12(o)(1) thru (15).

expansion/contraction, corrosion, with reference to all applicable Resource Report 13 sections and Appendices for additional details

11.4.1.3 Operations and maintenance plans

11.4.1.3.1 Summary of basis of design used in development of operation and maintenance plans and procedures, with reference to all applicable Resource Report 13 sections and Appendices for additional details

11.4.1.3.2 Summary of regulatory requirements used in development of operation and maintenance plans and procedures, with reference to all applicable Resource Report 13 sections and Appendices for additional details

11.4.1.3.3 Summary of primary codes and standards used in development of operation and maintenance plans and procedures, with reference to all applicable Resource Report 13 sections and Appendices for additional details

11.4.1.3.4 Summary of the development of operation and maintenance plans and procedures, including standard operation procedures, startup and shutdown procedures, abnormal operations, safety procedures, preventive maintenance plans, work order tracking, training, and management systems, with reference to all applicable Resource Report 13 sections and Appendices for additional details

11.4.1.4 Basic plant control systems (BPCS)

11.4.1.4.1 Summary of basis of design used in control system and operating modes, with reference to all applicable Resource Report 13 sections and Appendices for additional details

11.4.1.4.2 Summary of regulatory requirements used in control systems design, developing operational procedures, and training, with reference to all applicable Resource Report 13 sections and Appendices for additional details

11.4.1.4.3 Summary of primary codes and standards used in control systems design, developing operational procedures, and training, with reference to all applicable Resource Report 13 sections and Appendices for additional details

11.4.1.4.4 Summary of the development of operating limits for flows, pressures, temperatures, and alarm management plans, with reference to all applicable Resource Report 13 sections and Appendices for additional details

11.4.1.5 Safety instrumented systems (SIS)

11.4.1.5.1 Summary of basis of design used in safety instrumented systems, with reference to all applicable Resource Report 13 sections and Appendices for additional details

11.4.1.5.2 Summary of regulatory requirements used in safety instrumented systems design, with reference to all applicable Resource Report 13 sections and Appendices for additional details

11.4.1.5.3 Summary of primary codes and standards used in safety instrumented systems design, with reference to all applicable Resource Report 13 sections and Appendices for additional details

11.4.1.5.4 Summary of the current development of alarms and shutdowns (e.g. flows, pressures, temperatures) and plans for further development, with reference to all applicable Resource Report 13 sections and Appendices for additional details

11.4.1.6 Security systems and plans

11.4.1.6.1 Summary of basis of design used in security systems, with reference to all applicable Resource Report 13 sections and Appendices for additional details

11.4.1.6.2 Summary of regulatory requirements used in security systems design, with reference to all applicable Resource Report 13 sections and Appendices for additional details

11.4.1.6.3 Summary of primary codes and standards used in security systems design, with reference to all applicable Resource Report 13 sections and Appendices for additional details

11.4.1.6.4 Summary of lighting, fencing, access control, intrusion monitoring, intrusion detection, and security plans, with reference to all applicable Resource Report 13 sections and Appendices for additional details

11.4.1.7 Physical protection devices

11.4.1.7.1 Summary of basis of design used in relief valve and flare/vent design, with reference to all applicable Resource Report 13 sections and Appendices for additional details

11.4.1.7.2 Summary of regulatory requirements used in relief valve and flare/vent design, with reference to all applicable Resource Report 13 sections and Appendices for additional details

11.4.1.7.3 Summary of primary codes and standards used in relief valve and flare/vent design, with reference to all applicable Resource Report 13 sections and Appendices for additional details

11.4.1.7.4 Summary of relief valve scenarios, set points, and capacities, with reference to all applicable Resource Report 13 sections and Appendices for additional details

11.4.1.8 Ignition controls

11.4.1.8.1 Summary of basis of design used in ignition controls, with reference to all applicable Resource Report 13 sections and Appendices for additional details

11.4.1.8.2 Summary of regulatory requirements used in ignition controls, with reference to all applicable Resource Report 13 sections and Appendices for additional details

11.4.1.8.3 Summary of primary codes and standards used in ignition controls, with reference to all applicable Resource Report 13 sections and Appendices for additional details

11.4.1.8.4 Summary of electrical area classification, hot work permits, equipment and building spacing and layouts, smoking restrictions, and static electricity (e.g., grounding/bonding, lightning protection) safeguards, with reference to all applicable Resource Report 13 sections and Appendices for additional details

11.4.1.9 Spill containment systems

11.4.1.9.1 Summary of basis of design used in spill containment design, with reference to all applicable Resource Report 13 sections and Appendices for additional details

11.4.1.9.2 Summary of regulatory requirements used in spill containment design, with reference to all applicable Resource Report 13 sections and Appendices for additional details

11.4.1.9.3 Summary of primary codes and standards used in spill containment design, with reference to all applicable Resource Report 13 sections and Appendices for additional details

11.4.1.9.4 Summary of hazardous fluids contained by spill containment; spill containment dimensions, flow, and volumetric capacities; and spacing/location of spill containment systems, with reference to all applicable Resource Report 13 sections and Appendices for additional details

11.4.1.10 Passive protection for cryogenic fluids, overpressures, projectiles, and fire

11.4.1.10.1 Summary of basis of design used in passive protection, with reference to all applicable Resource Report 13 sections and Appendices for additional details

11.4.1.10.2 Summary of regulatory requirements used in passive protection, with reference to all applicable Resource Report 13 sections and Appendices for additional details

11.4.1.10.3 Summary of primary codes and standards used in passive protection, with reference to all applicable Resource Report 13 sections and Appendices for additional details

11.4.1.10.4 Summary of passive protection philosophy and performance requirements, with reference to all applicable Resource Report 13 sections and Appendices for additional details

11.4.1.11 Hazard detection and notification systems

11.4.1.11.1 Summary of basis of design used in hazard detection, with reference to all applicable Resource Report 13 sections and Appendices for additional details

11.4.1.11.2 Summary of regulatory requirements used in hazard detection, with reference to all applicable Resource Report 13 sections and Appendices for additional details

11.4.1.11.3 Summary of primary codes and standards used in hazard detection, with reference to all applicable Resource Report 13 sections and Appendices for additional details

11.4.1.11.4 Summary of low temperature detection, flammable gas detection, fire detection, heat detection, smoke detection, oxygen deficiency detection, toxic detection, manual pushbuttons, and audible and/or visual alarms and notification, with reference to all applicable Resource Report 13 sections and Appendices for additional details

11.4.1.12 Hazard control equipment

11.4.1.12.1 Summary of basis of design used in hazard control, with reference to all applicable Resource Report 13 sections and Appendices for additional details

11.4.1.12.2 Summary of regulatory requirements used in hazard control, with reference to all applicable Resource Report 13 sections and Appendices for additional details

11.4.1.12.3 Summary of primary codes and standards used in hazard control, with reference to all applicable Resource Report 13 and Appendices for additional details

11.4.1.12.4 Summary of hand-held fire extinguishers, wheeled fire extinguishers, fire water systems, and hi-expansion foam systems, with reference to all applicable Resource Report 13 sections and Appendices for additional details

11.4.1.13 Emergency response

11.4.1.13.1 Summary of emergency responders, with reference to all applicable Resource Report 13 sections and Appendices for additional details

11.4.1.13.2 Summary of regulatory requirements used in development of emergency response plans, with reference to all applicable Resource Report 13 sections and Appendices for additional details

11.4.1.13.3 Summary of primary codes and standards used in development of emergency response plans, with reference to all applicable Resource Report 13 sections and Appendices for additional details

11.4.1.13.4 Summarize and outline the development of onsite and offsite emergency response team/capabilities and procedures, cost sharing plans, and training, with reference to all applicable Resource Report 13 sections and Appendices for additional details

## 11.5 RELIABILITY[36]

### 11.5.1 Description of Reliability

**PROVIDE** a description of the reliability of the proposed project facilities and equipment to minimize downtime and interruption of service, including a discussion of the following:

11.5.1.1 Equipment redundancies

11.5.1.2 Sparing philosophy

11.5.1.3 Warehouse philosophy

11.5.1.4 Anticipated plant reliability and availability

11.5.1.4.1 Plant reliability, availability, and maintainability (RAM) analyses with a reference to Appendix 13.E.6*

11.5.1.5 Contingency plans for failure of or impacts to major plant assets or operations due to accidental or natural disasters (e.g., cracked LNG storage tank, trucking incidents, etc.)

11.5.1.6 Design life of the facilities (e.g., 50 years) for purposes of determining time-dependent design conditions, such as fatigue cycling, corrosion allowances, sea-level rise, regional subsidence/gradual tectonic uplift or permafrost depths

[36] 18 CFR §380.12(m)(2) thru (5).

# 13 RESOURCE REPORT 13 – ENGINEERING AND DESIGN MATERIAL

## 13.1 GENERAL BACKGROUND AND PROJECT MANAGEMENT[37]

### 13.1.1 Project Facilities

**PROVIDE** a description summarizing the proposed facilities. At a minimum, the description should include the following:

13.1.1.1 Number of marine docks, and with both rated and maximum export and import rates, million standard cubic feet per day (MMscfd) and million tons per annum (MTPA)[38]

13.1.1.2 Number of LNG storage tanks, and with both net and gross storage capacity per tank, gal and cubic meter ($m^3$) and equivalent billion standard cubic feet (Bscf) of natural gas

13.1.1.3 Number of liquefaction trains, and with both rated and anticipated maximum liquefaction capacity per train, MMscfd and MTPA

13.1.1.4 Number of LNG vaporizers, and with both sustained and anticipated maximum vaporization capacities, MMscfd

13.1.1.5 Number of feed gas pipelines and interconnects, and with both rated and anticipated maximum capacities, MMscfd, and pressures, psig

13.1.1.6 Number of sendout pipelines and interconnects, and with both rated and anticipated maximum sendout rates, MMscfd

13.1.1.7 Fractionation products, and with both rated and anticipated maximum capacity rates, gpm and MMscfd

[37] 18 CFR §380.12(m), 18 CFR §380.12(m)(1), 18 CFR §380.12(m)(3) thru (5), 18 CFR §380.12(o)(8).

[38] Assumptions and supporting calculations used to determine export and import rates, including liquefaction rates, RAM studies, docking studies, and number of days assumed to be operational in a year, should be described, referenced, and included.

### 13.1.2 Location

**PROVIDE** a description of the site location of the facilities. At a minimum, the description should include:

13.1.2.1 Owned and leased property boundaries, options, easements, and rights of way with reference to Site Location Maps and Drawings in Appendix 13.A.1

### 13.1.3 Owner, Principal Contractors, and Operator

**PROVIDE** a description of the owner, principal contractors, and operator of the facility. At a minimum, the description should discuss:

13.1.3.1 Owner of the facilities with reference to the Organizational Structure in Appendix 13.A.2

13.1.3.2 Principal Contractors identified for design, engineering, procurement, and construction of the facilities with reference to any preliminary Construction Workforce Organizational Chart or Work Breakdown Structure (if available) in Appendix 13.A.3*

13.1.3.3 Operating Company of the facilities with reference to a preliminary Operating Workforce Organizational Chart in Appendix 13.A.4*

### 13.1.4 Feed and Sendout Product(s)

**PROVIDE** a description summarizing the market for all products imported, exported, and sent out by the project. At a minimum, the description should include:

13.1.4.1 Natural gas pipeline(s) sending out to

13.1.4.2 Natural gas pipelines feeding from

13.1.4.3 Fractionation product pipelines sending out to

### 13.1.5 Project Schedule

**PROVIDE** a description of the project schedule, detailing project design, construction, commissioning, and in-service schedule with milestones. At a minimum, the project schedule description should reference the Gantt Chart in Appendix 13.A.5 and should provide sufficient detail to show the feasibility of the engineering, procurement, construction, commissioning, and startup of the facilities. Phased construction and operation, tie-ins, and future plans should also be summarized and included in the project schedule.

## 13.2 SITE INFORMATION[39]

### 13.2.1 Site Conditions

**PROVIDE** a description of the site elevations. At a minimum, the description should reference the Topographic Map in Appendix 13.J.1 and should describe:

13.2.1.1 Elevation reference, North American Vertical Datum of 1988 (NAVD88) or National Geodetic Vertical Datum of 1929 (NGVD29)

13.2.1.2 Marine platform elevation, ft

13.2.1.3 LNG storage tank inner tank bottom elevation, ft

13.2.1.4 Process areas foundation elevation, ft

13.2.1.5 Impoundment floor elevation, ft

13.2.1.6 Utilities foundation elevation, ft

13.2.1.7 Buildings foundation elevation, ft

13.2.1.8 Roads elevation, ft

### 13.2.2 Shipping Channel

**PROVIDE** a description of the shipping channel. At a minimum, the description should reference the Bathymetric Chart in Appendix 13.J.2 and should describe:

13.2.2.1 Channel width, ft

13.2.2.2 Channel depth, ft

13.2.2.3 Berth depth, ft

13.2.2.4 Tidal range elevations, ft

13.2.2.5 Channel current (normal, maximum), knots

[39] 18 CFR §380.12(m), 18 CFR §380.12(m)(1), 18 CFR §380.12(m)(3) thru (5), 18 CFR §380.12(o)(3), 18 CFR §380.12(o)(7), 18 CFR §380.12(o)(8), 18 CFR §380.12(o)(14), 18 CFR §380.12(o)(15).

### 13.2.3 Climatic Conditions

**PROVIDE** a description of the climatic design conditions at the site and along the shipping channel. The description should reference the Climatic Data in Appendix 13.J.3, and all other applicable appendices, and should describe:

13.2.3.1 Temperature design basis (minimum, average, maximum), °F

13.2.3.2 Barometric pressure design basis (minimum, average, maximum), inches mercury (Hg)

13.2.3.3 Barometric pressure rate of increase design basis (minimum, average, maximum), inHg/h

13.2.3.4 Barometric pressure rate of decrease design basis (minimum, average, maximum), inHg/hr

13.2.3.5 Prevailing wind with seasonal wind rose or charts with 16 radial directions and wind speeds, mph

13.2.3.6 Rain fall rates design basis (100-year return period, 50-year return period, 10-year return period), inches per hour

13.2.3.7 Snow fall rates design basis (100-year return period, 50-year return period, 10-year period), inches per hour

13.2.3.8 Frost line depth, ft

13.2.3.9 Visibility frequency and distances, No. fog alerts per year, visibility ft

13.2.3.10 Lightning strike frequency, No. per year

### 13.2.4 Geotechnical Conditions

**PROVIDE** a description of the geotechnical conditions at the onshore and offshore permanently affixed facilities and structures as described below. The expected geotechnical testing is provided in the Appendix 13.J.4 guidance.

13.2.4.1 Groundwater conditions

13.2.4.2 Soil/rock layer description

13.2.4.3 Geotechnical cross-sections

13.2.4.4 Soil and rock parameters

## 13.3 NATURAL HAZARD DESIGN CONDITIONS[40]

### 13.3.1 Earthquakes

**PROVIDE** a description of the design against earthquakes. The description should reference the Natural Hazard Design Investigations and Design Forces in Appendix 13.I.1, and all other applicable appendices, and should describe:

13.3.1.1 Seismic design basis and criteria for Seismic Category I, II, and III structures, systems and component

13.3.1.2 Identification of structures, systems and components classified as Seismic Category I, II, and III

13.3.1.3 Maximum considered earthquake (MCE) site-specific ground motion spectral values for 5% damping

13.3.1.4 Design earthquake (DE) site-specific ground motion spectral values for 5% damping and ground motion parameters, $S_{DS}$, $S_{D1}$, $S_{MS}$, $S_{M1}$, $T_L$

13.3.1.5 Safety shutdown earthquake (SSE) site-specific ground motion spectral values for 5% damping

13.3.1.6 Operating basis earthquake (OBE) site-specific ground motion spectral values for 5% damping

13.3.1.7 Aftershock level earthquake (ALE) site-specific ground motion spectral values for 5% damping

13.3.1.8 At locations crossing active faults, design surface fault offsets (horizontal and vertical) and fault orientations

13.3.1.9 At locations where crossing growth faults, design offsets for growth faults: Provide design fault offsets for growth faults (horizontal and vertical) for the facility design life and fault orientations

13.3.1.10 Ground motions and frequencies of earthquakes at site location

13.3.1.11 Sloshing freeboard

13.3.1.12 Ground motion detection systems that alarm and shutdown

[40] 18 CFR §380.12(m), 18 CFR §380.12(m)(1), 18 CFR §380.12(m)(3) thru (5), 18 CFR §380.12(o)(3), 18 CFR §380.12(o)(7), 18 CFR §380.12(o)(8), 18 CFR §380.12(o)(14), 18 CFR §380.12(15).

### 13.3.2 Tsunamis and Seiche

**PROVIDE** a description of the design against tsunamis and seiche. The description should reference the Natural Hazard Design Investigations and Design Forces in Appendix 13.I.2, and all other applicable appendices, and should describe:

13.3.2.1 Tsunami and seiche design basis and criteria

13.3.2.2 Tsunami and seiche design inundation and run-up elevations and corresponding return periods for all structures, systems, and components

13.3.2.3 Maximum considered tsunami (MCT), MCT inundation and run-up elevations for project site, including the MCE level ground motions at the site if the MCE is the triggering source of the MCT

13.3.2.4 Discussion of inundation and run up elevations and frequencies of tsunamis and other natural hazards at site location

13.3.2.5 Design sea level rise: elevation change to be used in design to account for sea level rise at project site for the facility design life

13.3.2.6 Design regional subsidence: elevation change to be used in design to account for regional subsidence at facility site for the facility design life

13.3.2.7 Discussion of co-seismic subsidence/uplift

13.3.2.8 Discussion of expected settlement over the design life of the facilities

### 13.3.3 Hurricanes and Other Meteorological Events

**PROVIDE** a description of the design against hurricanes and other meteorological events. The description should reference the Natural Hazard Design Investigations and Design Forces in Appendix 13.I.3, and all other applicable appendices, and should describe:

13.3.3.1 Wind and storm surge design basis and criteria

13.3.3.2 Identification of design wind speeds (sustained and 3-second gusts) and corresponding return periods, wind importance factors, and storm surge design elevations for all structures, systems, and components

13.3.3.3 Sea level rise: elevation change to be used to account for sea level rise at the site for the design life

13.3.3.4 Regional subsidence: elevation change to be used to account for regional subsidence at the site for the design life

### 13.3.4 Tornados

**PROVIDE** a description of the design against tornados. The description should reference the Natural Hazard Design Investigation and Design Forces in Appendix 13.I.4, and all other applicable appendices, and should describe:

13.3.4.1 Wind speed design basis and criteria

13.3.4.2 Identification of design wind speeds (sustained and 3-second gusts) and corresponding return periods, and wind importance factors for all structures, systems, and components

### 13.3.5 Floods

**PROVIDE** a description of the design against floods. The description should reference the Natural Hazard Design Investigations and Design Forces in Appendix 13.I.5, and all other applicable appendices, and should describe:

13.3.5.1 Flood design basis and criteria

13.3.5.2 Identification of stream flows and flood design elevations and corresponding return periods for all structures, systems, and components

13.3.5.3 Discussion of streamflows, flood elevations, and frequencies of floods and other natural hazards at site location

### 13.3.6 Rain, Ice, Snow, and Related Events

**PROVIDE** a description of the design against blizzards. The description should reference the Natural Hazard Design Investigations and Design Forces in Appendix 13.I.6, and all other applicable appendices, and should describe:

13.3.6.1 Rainfall design basis and criteria

13.3.6.2 Ice load design basis and criteria

13.3.6.3 Snow load design basis and criteria

13.3.6.4 Identification of snow and ice loads and corresponding return periods for all structures, systems, and components, including snow removal for spill containment systems

13.3.6.5 Identification of stormwater flows, outfalls, and stormwater management systems for all surfaces, including spill containment system sump pumps

13.3.6.6 Discussion of snow and ice formation and frequencies of blizzards and other snow and ice events at site location

### 13.3.7 Other Natural Hazards

**PROVIDE** a description of the design against landslides, wildfires, volcanic activity, geomagnetism, and other natural hazards. The description should reference the Natural Hazard Design Investigations and Design Forces in Appendix 13.I.7, and all other applicable appendices, and should describe:

13.3.7.1 Design basis and criteria

13.3.7.2 Identification of loads and corresponding return periods for all structures, systems, and components

13.3.7.3 Discussion of natural hazards and frequencies of natural hazards at site location

## 13.4 MARINE FACILITIES[41]

### 13.4.1 LNG Vessels

**PROVIDE** a description of the LNG vessels (i.e., LNG carriers, LNG barges) that the facilities would be designed to accommodate. The description should reference the Waterway Safety and Reliability Impact Studies in Appendix 13.G.3[42], and all other applicable appendices, and should describe:

13.4.1.1 Shipping route within U.S. waters

13.4.1.2 Ship traffic

13.4.1.3 Ship simulations

13.4.1.4 Tug services, owned/leased

13.4.1.5 Tug services, full time/as required

13.4.1.6 Aids to navigation

13.4.1.7 LNG vessel size

13.4.1.8 LNG vessel draft

13.4.1.9 LNG vessel cargoes design and operating conditions and specifications for unloading and vapor recovery:

13.4.1.9.1 Molecular weight, higher heating value (HHV), lower heating value (LHV), Wobbe, specific gravity, equilibrium temperature (°F) and cargo pressure (psig), composition

13.4.1.10 LNG vessel cargoes design and operating conditions and specifications for loading and vapor recovery:

13.4.1.10.1 Cargoes' molecular weight, HHV, LHV, Wobbe, specific gravity, equilibrium temperature (°F) and cargo pressure (psig), composition

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[41] 18 CFR §380.12(m), 18 CFR §380.12(m)(1), 18 CFR §380.12(m)(3) thru (5), 18 CFR §380.12(o)(3), 18 CFR §380.12(o)(7), 18 CFR §380.12(o)(8), 18 CFR §380.12(o)(10), 18 CFR §380.12(o)(12) thru (14).

[42] Waterway Suitability Assessments submitted to Coast Guard in accordance with 18 CFR §157.21(a)(1), 18 CFR §157.21(f)(13), 33 CFR §127.007, and Navigation and Vessel Inspection Circular (NVIC) 01-2011, Guidance Related to Waterfront Liquefied Natural Gas Facilities may satisfy Waterway Safety and Reliability Impact Studies in Appendix 13.G.3. This material may include Critical Energy Infrastructure Information (CEII), Security Sensitive Information (SSI), or Chemical-Terrorism Vulnerability Information (CVI) and must comply with all applicable regulations.

13.4.1.10.2 LNG vessel pump design pressure range, psig

13.4.1.10.3 LNG vessel pump design rates, gpm

### 13.4.2 Marine Platform Design

**PROVIDE** a description of the marine platform design. The description should reference the Design Basis, Criteria, and Philosophies in Appendix 13.B, Regulations and Permits in Appendix 13.C, Codes and Standards in Appendix 13.D, Project Specifications in Appendix 13.F, Marine Facility Drawings in Appendix 13.K, and all other applicable appendices, and should describe:

13.4.2.1 Wave crests and periods, ft

13.4.2.2 Prevailing currents (normal, maximum), knots

13.4.2.3 Tidal range elevations, ft

13.4.2.4 Water depth at berth and in approach channel, ft

13.4.2.5 LNG carrier capacity range, $m^3$

13.4.2.6 LNG carrier approach velocity, knots

13.4.2.7 LNG carrier approach angle, degrees

13.4.2.8 LNG carrier unloading frequency, per year

13.4.2.9 LNG carrier unloading duration, hours

13.4.2.10 LNG carrier loading frequency, per year

13.4.2.11 LNG carrier loading duration, hours

13.4.2.12 LNG carrier port time, pilot on to pilot off, hours

13.4.2.13 Barge capacity range, $m^3$

13.4.2.14 Barge approach velocity, knots

13.4.2.15 Barge approach angle, degrees

13.4.2.16 Barge unloading frequency, per year

13.4.2.17 Barge unloading duration, hours

13.4.2.18 Barge loading frequency, per year

13.4.2.19 Barge loading duration, hours

13.4.2.20 Turning basin depth and radius, ft

13.4.2.21 Marine platform location/spacing

13.4.2.22 Jetty/trestle configuration

13.4.2.23 Number and design* of berths

13.4.2.24 Number and design* of hooks, quick release hooks

13.4.2.25 Number and design* of capstans

13.4.2.26 Number and design* of fenders

13.4.2.27 Number, arrangement, and design* of breasting dolphins

13.4.2.28 Number, arrangement, and design* of mooring dolphins

13.4.2.29 Current monitors

13.4.2.30 Vessel approach velocity monitors

13.4.2.31 Tension monitors

13.4.2.32 Marine platform other safety features

### 13.4.3 Marine Transfer Design

**PROVIDE** a description of the marine transfer design. The description should reference the Design Basis, Criteria, and Philosophies in Appendix 13.B, Regulations and Permits in Appendix 13.C, Codes and Standards in Appendix 13.D, Engineering Design Information in Appendix 13.E, Project Specifications in Appendix 13.F, and all other applicable appendices, and should describe:

13.4.3.1 LNG arms or hoses and size per dock, No., in

13.4.3.2 Vapor arms or hoses and size per dock, No., in

13.4.3.3 Hybrid arms or hoses and size per dock, No., in

13.4.3.4 LNG arms or hoses operating and design flow rate capacities (minimum, normal, maximum), gpm

13.4.3.5 LNG arms or hoses operating and design pressures (minimum, normal, maximum), psig

13.4.3.6 LNG arms or hoses operating and design temperatures at ship manifold (minimum, normal, maximum), °F

13.4.3.7 Vapor arms or hoses operating and design flow rate capacities (minimum, normal, maximum), lb/hr

13.4.3.8 Vapor arms or hoses operating and design pressures at ship manifold (minimum, normal, maximum), psig

13.4.3.9 Vapor arms or hoses operating and design temperatures at ship manifold (minimum, normal, maximum), °F

13.4.3.10 Marine transfer startup and operation

13.4.3.10.1 Marine transfer custody transfer

13.4.3.10.2 Marine transfer measurement and analysis

13.4.3.10.3 Unloading and/or loading

13.4.3.10.4 Recirculating system

13.4.3.10.5 Vapor return handling

13.4.3.10.6 Vapor return desuperheating

13.4.3.11 Marine transfer shutdown

13.4.3.12 Marine transfer piping, vessel, and equipment design and specifications

13.4.3.13 Marine transfer isolation valves, vents, and drains

13.4.3.14 Marine transfer basic process control systems

13.4.3.15 Marine transfer safety instrumented systems

13.4.3.16 Marine transfer relief valves and discharge

13.4.3.17 Marine transfer other safety features

13.4.3.17.1 Safe working envelope of transfer arms

13.4.3.17.2 Powered Emergency Release Coupling valves

13.4.3.17.3 Ship/shore communication and shutdown capability

## 13.5 FEED GAS[43]

### 13.5.1 Feed Gas Design

**PROVIDE** a description of the feed gas design. The description should reference the Design Basis, Criteria, and Philosophies in Appendix 13.B, Regulations and Permits in Appendix 13.C, Codes and Standards in Appendix 13.D, Engineering Design Information in Appendix 13.E, Project Specifications in Appendix 13.F, and all other applicable appendices, and should describe:

13.5.1.1 Feed gas battery limit operating and design flow rate capacities (minimum, normal, maximum), MMscfd

13.5.1.2 Feed gas battery limit operating and design pressures (minimum, normal, maximum), psig

13.5.1.3 Feed gas battery limit operating and design temperatures (minimum, normal, maximum), °F

13.5.1.4 Feed gas operating and design inlet gas compositions (minimum/lean/light, normal/design/average, maximum/rich/heavy), %-vol and/or parts per million (ppm)

13.5.1.5 Feed gas filters

13.5.1.6 Feed gas booster compressor(s) type[44]

13.5.1.7 Feed gas booster compressor(s), operating and spare

13.5.1.8 Feed gas booster compressor(s) flow capacities each (minimum, normal, maximum), MMscfd

13.5.1.9 Feed gas booster compressor(s) operating and design suction pressures (minimum, normal, maximum), psig

13.5.1.10 Feed gas booster compressor(s) operating and design suction temperatures (minimum, normal, maximum), °F

13.5.1.11 Feed gas booster compressor(s) operating and design discharge pressures (minimum, normal, maximum), psig

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[43] 18 CFR §380.12(m), 18 CFR §380.12(m)(1), 18 CFR §380.12(m)(3) thru (5), 18 CFR §380.12(o)(3), 18 CFR §380.12(o)(7), 18 CFR §380.12(o)(8), 18 CFR §380.12(o)(10), 18 CFR §380.12(o)(12) thru (14).

[44] Applicants can supply data for sections 13.5.1.6 to 13.5.1.12 using Equipment Data Table in Attachment 2.

13.5.1.12 Feed gas booster compressor(s) operating and design discharge temperatures (minimum, normal, maximum), °F

13.5.1.13 Feed gas startup and operation

13.5.1.13.1 Feed gas metering

13.5.1.13.2 Feed gas analysis and measurement

13.5.1.14 Feed gas shutdown

13.5.1.15 Feed gas piping, vessel, and equipment design and specifications

13.5.1.16 Feed gas isolation valves, drains, and vents

13.5.1.17 Feed gas basic process control systems

13.5.1.18 Feed gas high integrity pressure protection systems

13.5.1.19 Feed gas relief valves and discharge

13.5.1.20 Feed gas other safety features

## 13.6 FEED GAS PRETREATMENT[45]

### 13.6.1 Acid Gas Removal Design

**PROVIDE** a description of the acid gas removal design. At a minimum, the description should reference the Design Basis, Criteria, and Philosophies in Appendix 13.B, Regulations and Permits in Appendix 13.C, Codes and Standards in Appendix 13.D, Engineering Design Information in Appendix 13.E, Project Specifications in Appendix 13.F, and all other applicable appendices, and should describe:

13.6.1.1 Acid gas removal system type[46]

13.6.1.2 Acid gas removal operating and design inlet flow rate capacities (minimum, normal, maximum), MMscfd

13.6.1.3 Acid gas removal operating and design inlet gas compositions (minimum/lean/light, normal/design/average, maximum/rich/heavy), parts per million (ppm)

13.6.1.4 Acid gas removal operating and design inlet pressures (minimum, normal, maximum), psig

13.6.1.5 Acid gas removal operating and design inlet temperatures (minimum, normal, maximum), °F

13.6.1.6 Acid gas removal operating and design outlet flow rate capacities (minimum, normal, maximum), MMscfd

13.6.1.7 Acid gas removal operating and design outlet gas compositions (minimum/lean/light, normal/design/average, maximum/rich/heavy), ppm

13.6.1.8 Acid gas removal operating and design outlet pressures (minimum, normal, maximum), psig

13.6.1.9 Acid gas removal operating and design outlet temperatures (minimum, normal, maximum), °F

13.6.1.10 Acid gas disposal operating and design compositions, ppm

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[45] 18 CFR §380.12(m), 18 CFR §380.12(m)(1), 18 CFR §380.12(m)(3) thru (5), 18 CFR §380.12(o)(3), 18 CFR §380.12(o)(7), 18 CFR §380.12(o)(8), 18 CFR §380.12(o)(10), 18 CFR 380.12(o)(12) thru (14).

[46] Applicants can supply data for sections 13.6.1.1 to 13.6.1.9 using Equipment Data Table in Attachment 2.

13.6.1.11 Acid gas disposal operating and design pressures (minimum, normal, maximum), psig

13.6.1.12 Acid gas disposal operating and design outlet temperatures (minimum, normal, maximum), °F

13.6.1.13 Acid gas removal startup and operation

13.6.1.13.1 Normal startup and operation

13.6.1.13.2 Regeneration startup and operation

13.6.1.14 Acid gas removal shutdown

13.6.1.15 Acid gas removal piping, vessel, and equipment design and specifications

13.6.1.16 Acid gas removal isolation valves, drains, and vents

13.6.1.16.1 Hydrogen sulfide removal/disposal

13.6.1.16.2 Carbon dioxide removal/disposal

13.6.1.17 Acid gas removal safety instrumented systems

13.6.1.18 Acid gas removal relief valves and discharge

13.6.1.19 Acid gas removal other safety features

### 13.6.2 Mercury Removal Design

**PROVIDE** a description of the mercury removal design. The description should reference the Design Basis, Criteria, and Philosophies in Appendix 13.B, Regulations and Permits in Appendix 13.C, Codes and Standards in Appendix 13.D, Engineering Design Information in Appendix 13.E, Project Specifications in Appendix 13.F, and all other applicable appendices, and should describe:

13.6.2.1 Mercury specifications, ppm

13.6.2.2 Mercury removal type[47]

13.6.2.3 Mercury removal operating and design inlet flow rate capacities (minimum, normal, maximum), lb/hr

13.6.2.4 Mercury removal operating and design inlet gas compositions (minimum/lean/light, normal/design/average, maximum/rich/heavy), ppm

13.6.2.5 Mercury removal operating and design inlet pressures (minimum, normal, maximum), psig

13.6.2.6 Mercury removal operating and design inlet temperatures (minimum, normal, maximum), °F

13.6.2.7 Mercury removal operating and design outlet flow rate capacities (minimum, normal, maximum), lb/hr

13.6.2.8 Mercury removal operating and design outlet gas compositions (minimum/lean/light, normal/design/average, maximum/rich/heavy), ppm

13.6.2.9 Mercury removal operating and design outlet pressures (minimum, normal, maximum), psig

13.6.2.10 Mercury removal operating and design outlet temperatures (minimum, normal, maximum), °F

13.6.2.11 Mercury removal startup and operation

13.6.2.12 Mercury removal isolation valves, drains, and vents

13.6.2.12.1 Mercury removal disposal

[47] Applicants can supply data for sections 13.6.2.2 to 13.6.2.10 using Equipment Data Table in Attachment 2.

13.6.2.13 Mercury removal shutdown

13.6.2.14 Mercury removal piping, vessel, and equipment design and specifications

13.6.2.15 Mercury removal basic process control systems

13.6.2.16 Mercury removal safety instrumented systems

13.6.2.17 Mercury removal relief valves and discharge

13.6.2.18 Mercury removal other safety features

### 13.6.3 Water Removal Design

**PROVIDE** a description of the water removal design. The description should reference the Design Basis, Criteria, and Philosophies in Appendix 13.B, Regulations and Permits in Appendix 13.C, Codes and Standards in Appendix 13.D, Engineering Design Information in Appendix 13.E, Project Specifications in Appendix 13.F, and all other applicable appendices, and should describe:

13.6.3.1 Water specifications, ppm

13.6.3.2 Dehydration system type[48]

13.6.3.3 Dehydration operating and design inlet flow rates (minimum, normal, maximum), lb/hr

13.6.3.4 Dehydration operating and design inlet compositions capacities (minimum, normal, maximum), ppm

13.6.3.5 Dehydration operating and design inlet pressures (minimum, normal, maximum), psig

13.6.3.6 Dehydration operating and design inlet temperatures (minimum, normal, maximum), °F

13.6.3.7 Dehydration operating and design outlet flow rates (minimum, normal, maximum), lb/hr

13.6.3.8 Dehydration operating and design outlet gas compositions (minimum/lean/light, normal/design/average, maximum/rich/heavy), ppm

[48] Applicants can supply data for sections 13.6.3.2 to 13.6.3.10 using Equipment Data Table in Attachment 2.

13.6.3.9 Dehydration operating and design outlet pressures (minimum, normal, maximum), psig

13.6.3.10 Dehydration operating and design outlet temperatures (minimum, normal, maximum), °F

13.6.3.11 Regeneration gas operating and design flow rates (minimum/lean/light, normal/design/average, maximum/rich/heavy), lb/hr[49]

13.6.3.12 Regeneration gas operating and design temperatures to/from adsorber (minimum, normal, maximum), °F

13.6.3.13 Regeneration gas operating and design pressures to/from adsorber (minimum, normal, maximum), psig

13.6.3.14 Dehydration and regeneration startup and operation

13.6.3.15 Dehydration and regeneration isolation valves, drains, and vents

13.6.3.16 Dehydration and regeneration basic process control systems

13.6.3.17 Dehydration and regeneration safety instrumented systems

13.6.3.18 Dehydration and regeneration relief valves and discharge

13.6.3.19 Dehydration and regeneration other safety features

[49] Applicants can supply data for sections 13.6.3.11 to 13.6.3.13 using Equipment Data Table in Attachment 2.

## 13.7 NATURAL GAS LIQUIDS (NGL) REMOVAL, STORAGE, AND DISPOSITION[50]

### 13.7.1 NGL Removal Design

**PROVIDE** a description of the NGL removal design. The description should reference the Design Basis, Criteria, and Philosophies in Appendix 13.B, Regulations and Permits in Appendix 13.C, Codes and Standards in Appendix 13.D, Engineering Design Information in Appendix 13.E, Project Specifications in Appendix 13.F, and all other applicable appendices, and should describe:

13.7.1.1 NGL removal type (Demethanizer, Deethanizer, Depropanizer, Debutanizer)[51]

13.7.1.2 Number of NGL removal columns

13.7.1.3 NGL removal columns operating and design flow rate capacities (minimum, normal, maximum), gpm

13.7.1.4 NGL removal column operating and design inlet compositions (minimum/lean/light, normal/design/average, maximum/rich/heavy), %-vol

13.7.1.5 NGL removal columns operating and design pressures (minimum, normal, maximum), psig

13.7.1.6 NGL removal columns operating and design temperatures (minimum, normal, maximum), °F

13.7.1.7 NGL removal column operating and design products flow rates (minimum, normal, maximum), gpm

13.7.1.8 NGL removal column operating and design products compositions (minimum/lean/light, normal/design/average, maximum/rich/heavy), %-vol

13.7.1.9 NGL removal column operating and design products pressures (minimum, normal, maximum), psig

13.7.1.10 NGL removal column operating and design products temperatures (minimum, normal, maximum), °F

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[50] 18 CFR §380.12(m), 18 CFR §380.12(m)(1), 18 CFR §380.12(m)(3) thru (5), 18 CFR §380.12(o)(3), 18 CFR §380.12(o)(7), 18 CFR §380.12(o)(8), 18 CFR §380.12(o)(10), 18 CFR §380.12(o)(12) thru (14).

[51] Applicants can supply data for sections 13.7.1.1 to 13.7.1.10 using Equipment Data Table in Attachment 2.

13.7.1.11 NGL removal reboilers operating and design flow rate capacities (minimum, normal, maximum), gpm

13.7.1.12 NGL removal reboilers operating and design duties (minimum, normal, maximum), MMBtu/hr

13.7.1.13 NGL removal reboilers operating and design pressures (minimum, normal, maximum), psig

13.7.1.14 NGL removal reboilers operating and design inlet temperatures (minimum, normal, maximum), °F

13.7.1.15 NGL removal reboilers operating and design outlet temperatures (minimum, normal, maximum), °F

13.7.1.16 NGL removal reflux pumps operating and design flow rate capacities (minimum, normal, maximum), gpm[52]

13.7.1.17 NGL removal reflux pumps operating and design duties (minimum, normal, maximum), MMBtu/hr

13.7.1.18 NGL removal reflux pumps operating and design suction pressures (minimum, normal, maximum), psig

13.7.1.19 NGL removal reflux pumps operating and design inlet temperatures (minimum, normal, maximum), °F

13.7.1.20 NGL removal reflux pumps operating and design discharge pressures (minimum, normal, maximum), psig

13.7.1.21 NGL removal reflux pumps operating and design outlet temperatures (minimum, normal, maximum), °F

13.7.1.22 NGL removal columns startup and operation

13.7.1.23 NGL removal columns piping, vessel, and equipment design and specifications

13.7.1.24 NGL removal columns isolation valves, drains, and vents

13.7.1.25 NGL removal column basic process control systems

13.7.1.26 NGL removal columns safety instrumented systems

[52] Applicants can supply data for sections 13.7.1.16 to 13.7.1.21 using Equipment Data Table in Attachment 2.

13.7.1.27 NGL removal columns relief valves and discharge

13.7.1.28 NGL columns other safety features

### 13.7.2 NGL Storage Design

**PROVIDE** a description of the NGL storage design. The description should reference the Design Basis, Criteria, and Philosophies in Appendix 13.B, Regulations and Permits in Appendix 13.C, Codes and Standards in Appendix 13.D, Engineering Design Information in Appendix 13.E, Project Specifications in Appendix 13.F, and all other applicable appendices, and should describe:

13.7.2.1 NGL storage tank type

13.7.2.2 Number of NGL storage tanks

13.7.2.3 NGL storage tank foundation type

13.7.2.4 NGL storage tank operating and design capacities (minimum, normal, maximum), gal

13.7.2.5 NGL storage tank operating and design levels (minimum, normal, maximum), ft

13.7.2.6 NGL storage tank operating and design vacuums and pressures (minimum, normal, maximum), in$H_2O$ (vacuum) and psig

13.7.2.7 NGL storage tank operating and design temperatures (minimum, normal, maximum), °F

13.7.2.8 NGL storage tank operating and design densities (minimum, normal, maximum), specific gravity

13.7.2.9 NGL storage startup and operation

13.7.2.10 NGL storage fill shutdown

13.7.2.11 NGL storage piping, vessel, and equipment design and specifications

13.7.2.12 NGL storage isolation valves, drains, and vents

13.7.2.13 NGL storage basic process control systems

13.7.2.14 NGL storage safety instrumented systems

13.7.2.15 NGL storage relief valves, discharge, and redundancy

13.7.2.16 NGL storage tank impoundment

13.7.2.17 NGL storage other safety features

### 13.7.3 NGL Disposition Design

**PROVIDE** a description of the NGL disposition design. The description should reference the Design Basis, Criteria, and Philosophies in Appendix 13.B, Regulations and Permits in Appendix 13.C, Codes and Standards in Appendix 13.D, Engineering Design Information in Appendix 13.E, Project Specifications in Appendix 13.F, and all other applicable appendices, and should describe:

13.7.3.1 NGL final disposition (truck stations, sendout pipelines, reinjection, fuel gas, etc.)

13.7.3.2 Number of NGL truck stations or sendout pipelines

13.7.3.3 NGL truck scales or sendout metering

13.7.3.4 Number of NGL trucks, No. per year, truck capacity, gal

13.7.3.5 NGL pumps type[53]

13.7.3.6 Number of NGL pumps, operating and spare

13.7.3.7 NGL truck fill/sendout/fuel gas operating and design flow rate capacities (minimum, normal, maximum), gpm or standard cubic feet per minute (scfm)

13.7.3.8 NGL trucking/sendout/fuel gas pumps operating and design suction pressures (minimum/net positive suction head [NPSH], normal/rated, maximum), psig

13.7.3.9 NGL pumps operating and design suction temperatures (minimum, normal, maximum), °F

13.7.3.10 NGL pumps operating and design discharge pressures (minimum, normal/rated, maximum/shutoff), psig

13.7.3.11 NGL pumps operating and design discharge temperatures (minimum, normal/rated, maximum/shutoff), °F

[53] Applicants can supply data for sections 13.7.3.5 to 13.7.3.12 using Equipment Data Table in Attachment 2.

13.7.3.12 NGL pumps operating and design densities (minimum, normal, maximum), specific gravity

13.7.3.13 NGL truck/sendout startup and operation

13.7.3.14 NGL truck/sendout isolation valves, drains, and vents

13.7.3.15 NGL truck/sendout basic process control systems

13.7.3.16 NGL truck/sendout safety instrumented systems

13.7.3.17 NGL truck/sendout relief valves and discharge

13.7.3.18 NGL truck/sendout other safety features

## 13.8 HEAVIES/CONDENSATES REMOVAL, STORAGE, AND DISPOSITION[54]

### 13.8.1 Heavies/Condensates Removal Design

**PROVIDE** a description of the heavies/condensates removal design. The description should reference the Design Basis, Criteria, and Philosophies in Appendix 13.B, Regulations and Permits in Appendix 13.C, Codes and Standards in Appendix 13.D, Engineering Design Information in Appendix 13.E, Project Specifications in Appendix 13.F, and all other applicable appendices, and should describe:

13.8.1.1 Heavies/condensates removal type[55]

13.8.1.2 Heavies/condensates removal operating and design inlet flow rate capacities (minimum, normal, maximum), lb/hr

13.8.1.3 Heavies/condensates removal operating and design inlet compositions (lean, normal, rich), %-vol

13.8.1.4 Heavies/condensates removal operating and design inlet pressures (minimum, normal, maximum), psig

13.8.1.5 Heavies/condensates removal operating and design inlet temperatures (minimum, normal, maximum), °F

13.8.1.6 Heavies/condensates removal operating and design outlet product flow rates (minimum, normal, maximum), lb/hr

13.8.1.7 Heavies/condensates removal operating and design outlet product compositions (lean, normal, rich), %-vol

13.8.1.8 Heavies/condensates removal outlet operating and design outlet pressures (minimum, normal, maximum), psig

13.8.1.9 Heavies/condensates removal outlet operating and design column temperatures (minimum, normal, maximum), °F

13.8.1.10 Heavies/condensates removal startup and operation

13.8.1.11 Heavies/condensates removal isolation valves, drains, and vents

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[54] 18 CFR §380.12(m), 18 CFR §380.12(m)(1), 18 CFR §380.12(m)(3) thru (5), 18 CFR §380.12(o)(3), 18 CFR §380.12(o)(7), 18 CFR §380.12(o)(8), 18 CFR §380.12(o)(10), 18 CFR §380.12(o)(12) thru (14).

[55] Applicants can supply data for sections 13.8.1.1 to 13.8.1.9 using Equipment Data Table in Attachment 2.

13.8.1.12 Heavies/condensates removal basic process control systems

13.8.1.13 Heavies/condensates removal safety instrumented systems

13.8.1.14 Heavies/condensates removal relief valves and discharge

13.8.1.15 Heavies/condensates removal other safety features

### 13.8.2 Heavies/Condensates Storage Design

**PROVIDE** a description of the heavies/condensates storage design. The description should reference the Design Basis, Criteria, and Philosophies in Appendix 13.B, Regulations and Permits in Appendix 13.C, Codes and Standards in Appendix 13.D, Engineering Design Information in Appendix 13.E, Project Specifications in Appendix 13.F, and all other applicable appendices, and should describe:

13.8.2.1 Heavies/condensates storage tanks type

13.8.2.2 Number of heavies/condensates storage tanks

13.8.2.3 Heavies/condensates storage tanks foundation type

13.8.2.4 Heavies/condensates storage operating and design capacities (minimum, normal, maximum), gal

13.8.2.5 Heavies/condensates Storage operating and design liquid levels (minimum, normal, maximum), ft

13.8.2.6 Heavies/Condensates storage operating and design vacuums and pressures (minimum, normal, maximum), in$H_2O$ (vacuum) and psig

13.8.2.7 Heavies/condensates storage operating and design temperatures (minimum, normal, maximum), °F

13.8.2.8 Heavies/condensates storage operating and design densities (minimum, normal, maximum), specific gravity

13.8.2.9 Heavies/condensates storage startup and operation

13.8.2.10 Heavies/condensates storage isolation valves, drains, and vents

13.8.2.11 Heavies/condensates storage basic process control systems

13.8.2.12 Heavies/condensates storage safety instrumented systems

13.8.2.13 Heavies/condensates storage relief valves, discharge, and redundancy

13.8.2.14 Heavies/condensates storage impoundment

13.8.2.15 Heavies/condensates storage other safety features

### 13.8.3 Heavies/Condensates Disposition Design

**PROVIDE** a description of the heavies/condensate disposition design. The description should reference the Design Basis, Criteria, and Philosophies in Appendix 13.B, Regulations and Permits in Appendix 13.C, Codes and Standards in Appendix 13.D, Engineering Design Information in Appendix 13.E, Project Specifications in Appendix 13.F, and all other applicable appendices, and should describe:

13.8.3.1 Heavies/condensates final disposition (truck stations, sendout pipelines, reinjection, fuel gas, etc.)

13.8.3.2 Number of heavies/condensates truck stations or sendout pipelines

13.8.3.3 Heavies/condensates truck scales or sendout metering

13.8.3.4 Number of heavies/condensates trucks, No. per year, truck capacity, gal

13.8.3.5 Heavies/condensates pumps type[56]

13.8.3.6 Number of heavies/condensates pumps, operating and spare

13.8.3.7 Heavies/condensates truck fill/sendout/re-injection/fuel gas operating and design flow rate capacities (minimum, normal, maximum), gpm

13.8.3.8 Heavies/condensates trucking/sendout/fuel gas pumps operating and design suction pressures (minimum/ NPSH, normal/rated, maximum), psig

13.8.3.9 Heavies/condensates pumps operating and design suction temperatures (minimum, normal, maximum), °F

13.8.3.10 Heavies/condensates pumps operating and design discharge pressures (minimum, normal/rated, maximum/shutoff), psig

[56] Applicants can supply data for sections 13.8.3.5 to 13.8.3.12 using Equipment Data Table in Attachment 2.

13.8.3.11 Heavies/condensates pumps operating and design discharge temperatures (minimum, normal/rated, maximum/shutoff), °F

13.8.3.12 Heavies/condensates pumps operating and design densities (minimum, normal, maximum), specific gravity

13.8.3.13 Heavies/condensates truck/sendout startup and operation

13.8.3.14 Heavies/condensates truck/sendout isolation valves, drains, and vents

13.8.3.15 Heavies/condensates truck/sendout basic process control systems

13.8.3.16 Heavies/condensates truck/sendout safety instrumented systems

13.8.3.17 Heavies/condensates truck/sendout relief valves and discharge

13.8.3.18 Heavies/condensates truck/sendout other safety features

## 13.9 LIQUEFACTION SYSTEM[57]

### 13.9.1 Refrigerant Trucking/Production Design

**PROVIDE** a description of the refrigerant trucking/production design. The description should reference the Design Basis, Criteria, and Philosophies in Appendix 13.B, Regulations and Permits in Appendix 13.C, Codes and Standards in Appendix 13.D, Engineering Design Information in Appendix 13.E, Project Specifications in Appendix 13.F, and all other applicable appendices, and should describe:

13.9.1.1 Source

13.9.1.2 Number of refrigerant trucks during startup, truck capacity, gal

13.9.1.3 Number of refrigerant trucks, No. per year, truck capacity, gal

13.9.1.4 Refrigerant trucking/production operating and design compositions (minimum, normal, maximum), %-vol

13.9.1.5 Refrigerant trucking/production operating and design flow rate capacities (minimum, normal, maximum), gpm

13.9.1.6 Refrigerant trucking/production pumps operating and design suction pressures (minimum/NPSH, normal/rated, maximum), psig

13.9.1.7 Refrigerant trucking/production pumps operating and design suction temperatures (minimum, normal, maximum), °F

13.9.1.8 Refrigerant trucking/production pumps operating and design discharge pressures (minimum, normal/rated, maximum/shutoff), psig

13.9.1.9 Refrigerant trucking/production pumps operating and design discharge temperatures (minimum, normal/rated, maximum/shutoff), °F

13.9.1.10 Refrigerant trucking/production pumps operating and design densities (minimum, normal, maximum), specific gravity

13.9.1.11 Number of refrigerant truck stations

13.9.1.12 Refrigerant truck scales

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[57] 18 CFR §380.12(m), 18 CFR §380.12(m)(1), 18 CFR §380.12(m)(3) thru (5), 18 CFR §380.12(o)(3), 18 CFR §380.12(o)(7), 18 CFR §380.12(o)(8), 18 CFR §380.12(o)(10), 18 CFR §380.12(o)(12) thru (14).

13.9.1.13 Refrigerant trucking/production startup and operation

13.9.1.13.1 Truck unloading system

13.9.1.13.2 Refrigerant pretreatment system

13.9.1.13.3 Vapor handling

13.9.1.13.4 Pumps

13.9.1.13.5 Refrigerant transfer/makeup system

13.9.1.14 Refrigerant trucking/production isolation valves, drains, and vents

13.9.1.15 Refrigerant trucking/production basic process control systems

13.9.1.16 Refrigerant trucking/production safety instrumented systems

13.9.1.17 Refrigerant trucking/production relief valves and discharge

13.9.1.18 Refrigerant trucking/production other safety features

### 13.9.2 Refrigerant Storage Design

**PROVIDE** a description of the refrigerant storage design. The description should reference the Design Basis, Criteria, and Philosophies in Appendix 13.B, Regulations and Permits in Appendix 13.C, Codes and Standards in Appendix 13.D, Engineering Design Information in Appendix 13.E, Project Specifications in Appendix 13.F, and all other applicable appendices, and should describe:

13.9.2.1 Refrigerant storage tank type

13.9.2.2 Number of refrigerant storage tanks, operating and spare

13.9.2.3 Refrigerant storage tanks foundations type

13.9.2.4 Refrigerant storage operating and design capacities (minimum, normal, maximum), gal

13.9.2.5 Refrigerant storage operating and design levels (minimum, normal, maximum), ft

13.9.2.6 Refrigerant storage operating and design pressures/vacuums (minimum, normal, maximum), in$H_2O$ (vacuum) and psig

13.9.2.7 Refrigerant storage operating and design temperatures (minimum, normal, maximum), °F

13.9.2.8 Refrigerant storage operating and design densities (minimum, normal, maximum), specific gravity

13.9.2.9 Refrigerant storage startup and operation

13.9.2.10 Refrigerant storage isolation valves, drains, and vents

13.9.2.11 Refrigerant storage basic process control systems

13.9.2.12 Refrigerant storage safety instrumented systems

13.9.2.13 Refrigerant storage relief valves, discharge, and redundancy

13.9.2.14 Refrigerant storage tanks impoundment

13.9.2.15 Refrigerant storage other safety features

### 13.9.3 Refrigerant Charge/Loading Pumps Design

**PROVIDE** a description of the refrigerant charge/loading pump design. The description should reference the Design Basis, Criteria, and Philosophies in Appendix 13.B, Regulations and Permits in Appendix 13.C, Codes and Standards in Appendix 13.D, Engineering Design Information in Appendix 13.E, Project Specifications in Appendix 13.F, and all other applicable appendices, and should describe:

13.9.3.1 Refrigerant pumps type[58]

13.9.3.2 Number of refrigerant pumps, operating and spare

13.9.3.3 Refrigerant pumps operating and design flow rate capacities (minimum, normal/rated, maximum), gpm

13.9.3.4 Refrigerant pumps operating and design suction pressures (minimum/NPSH, normal/rated, maximum), psig

13.9.3.5 Refrigerant pumps operating and design suction temperatures (minimum, normal, maximum), °F

13.9.3.6 Refrigerant pumps operating and design discharge pressures (minimum, normal/rated, maximum/shutoff), psig

13.9.3.7 Refrigerant pumps operating and design discharge temperatures (minimum, normal, maximum), °F

[58] Applicants can supply data for sections 13.9.3.1 to 13.9.3.8 using Equipment Data Table in Attachment 2.

13.9.3.8 Refrigerant pumps operating and design densities (minimum, normal, maximum), specific gravity

13.9.3.9 Refrigerant pumps startup and operation

13.9.3.10 Refrigerant pumps isolation valves, drains, and vents

13.9.3.11 Refrigerant pumps basic process control systems

13.9.3.12 Refrigerant pumps safety instrumented systems

13.9.3.13 Refrigerant pumps relief valves and discharge

13.9.3.14 Refrigerant pumps other safety features

### 13.9.4 Liquefaction Design

**PROVIDE** a description of the liquefaction design. The description should reference the Design Basis, Criteria, and Philosophies in Appendix 13.B, Regulations and Permits in Appendix 13.C, Codes and Standards in Appendix 13.D, Engineering Design Information in Appendix 13.E, Project Specifications in Appendix 13.F, and all other applicable appendices, and should describe:

13.9.4.1 Feed gas precooling system

13.9.4.2 Number of liquefaction trains

13.9.4.3 Liquefaction process type (mixed refrigerant, cascade, nitrogen, etc.)

13.9.4.4 Main refrigerant heat exchangers, cold box(es), etc.

13.9.4.5 Refrigerant compressors and drivers

13.9.4.6 Liquefaction operating and design flow rate capacities (minimum, normal, maximum), MMscfd

13.9.4.7 Liquefaction operating and design inlet compositions (minimum/lean/light, normal/design/average, maximum/rich/heavy), %-vol

13.9.4.8 Liquefaction operating and design inlet pressures (minimum, normal, maximum), psig

13.9.4.9 Liquefaction operating and design inlet temperatures (minimum, normal, maximum), °F

13.9.4.10 Liquefaction final exchanger operating and design outlet pressures (minimum, normal, maximum), psig

13.9.4.11 Liquefaction final exchanger operating and design outlet temperatures (minimum, normal, maximum), °F

13.9.4.12 Liquefaction condenser operating and design inlet temperatures (minimum, normal, maximum), °F

13.9.4.13 Liquefaction condenser operating and design outlet temperatures (minimum, normal, maximum), °F

13.9.4.14 Liquefaction cooling fluid operating and design inlet temperatures (minimum, normal, maximum), °F

13.9.4.15 Liquefaction cooling fluid operating and design outlet temperatures (minimum, normal, maximum), °F

13.9.4.16 Liquefaction operating and design air temperatures (minimum, normal, maximum), °F

13.9.4.17 Refrigerant compressor operating and design flow rate capacities (minimum, normal, maximum), MMscfd

13.9.4.18 Refrigerant compressor operating and design suction pressures (minimum, normal, maximum), psig

13.9.4.19 Refrigerant operating and design discharge pressures (minimum, normal, maximum/shutoff), psig

13.9.4.20 Liquefaction system startup and operation

13.9.4.21 Liquefaction system isolation valves, drains, and vents

13.9.4.22 Liquefaction system basic process control systems

13.9.4.23 Liquefaction system safety instrumented systems

13.9.4.24 Liquefaction system relief valves and discharge

13.9.4.25 Liquefaction system other safety features

### 13.9.5 Cooling System Design

**PROVIDE** a description of the cooling system design. The description should reference the Design Basis, Criteria, and Philosophies in Appendix 13.B, Regulations and Permits in Appendix 13.C, Codes and Standards in Appendix 13.D, Engineering Design Information in Appendix 13.E, Project Specifications in Appendix 13.F, and all other applicable appendices, and should describe:

13.9.5.1 Cooling system source and type

13.9.5.2 Cooling system operating and design storage capacities (minimum, normal, maximum), gal

13.9.5.3 Cooling system operating and design flow rate capacities (minimum, normal, maximum), gpm

13.9.5.4 Cooling system operating and design delivery pressures (minimum, normal, maximum), psig

13.9.5.5 Cooling system operating and design delivery temperatures (minimum, normal, maximum), °F

13.9.5.6 Cooling system operating and design return pressures (minimum, normal, maximum), psig

13.9.5.7 Cooling system operating and design return temperatures (minimum, normal, maximum), °F

13.9.5.8 Cooling system startup and operation

13.9.5.9 Cooling system isolation valves, drains, and vents

13.9.5.10 Cooling system basic process control systems

13.9.5.11 Cooling system safety instrumented systems

13.9.5.12 Cooling system relief valves and discharge

13.9.5.13 Cooling system other safety features

## 13.10 LNG PRODUCT TRANSFER TO STORAGE[59]

### 13.10.1 LNG Transfer to Storage Design

**PROVIDE** a description of the LNG transfer system design. The description should reference the Design Basis, Criteria, and Philosophies in Appendix 13.B, Regulations and Permits in Appendix 13.C, Codes and Standards in Appendix 13.D, Engineering Design Information in Appendix 13.E, Project Specifications in Appendix 13.F, and all other applicable appendices, and should describe:

13.10.1.1 LNG Product transfer pumps type

13.10.1.2 Number of LNG Product transfer pumps, operating and spare

13.10.1.3 LNG Product transfer operating and design flow rate capacities (minimum, normal/rated, maximum), gpm

13.10.1.4 LNG Product transfer operating and design suction pressures (minimum/NPSH, normal/rated, maximum), psig

13.10.1.5 LNG Product transfer operating and design suction temperatures (minimum, normal, maximum), °F

13.10.1.6 LNG Product transfer operating and design discharge pressures (minimum, normal/rated, maximum/shutoff), psig

13.10.1.7 LNG Product transfer operating and design discharge temperatures (minimum, normal, maximum), °F

13.10.1.8 LNG Product transfer operating and design densities (minimum, normal/rated, maximum), specific gravity

13.10.1.9 LNG flash vessel operating and design inlet pressures (minimum, normal, maximum), psig

13.10.1.10 LNG flash vessel operating and design inlet temperatures (minimum, normal, maximum), °F

13.10.1.11 LNG flash vessel operating and design outlet pressures (minimum, normal, maximum), psig

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[59] 18 CFR §380.12(m), 18 CFR §380.12(m)(1), 18 CFR §380.12(m)(3) thru (5), 18 CFR §380.12(o)(3), 18 CFR §380.12(o)(7), 18 CFR §380.12(o)(8), 18 CFR §380.12(o)(10), 18 CFR §380.12(o)(12) thru (14).

13.10.1.12 LNG flash vessel operating and design outlet temperatures (minimum, normal, maximum), °F

13.10.1.13 Flash gas compressor operating and design flow rate capacities (minimum, normal, maximum), MMscfd[60]

13.10.1.14 Flash gas compressor operating and design suction pressures (minimum, normal, maximum), psig

13.10.1.15 Flash gas compressor operating and design suction temperatures (minimum, normal, maximum), °F

13.10.1.16 Flash gas compressor operating and design discharge pressures (minimum, normal, maximum/shutoff), psig

13.10.1.17 Flash gas compressor operating and design outlet temperatures (minimum, normal, maximum), °F

13.10.1.18 LNG Product transfer startup and operation

13.10.1.19 LNG Product transfer isolation valves, drains, and vents

13.10.1.20 LNG Product transfer basic process control systems

13.10.1.20.1 LNG product flow control

13.10.1.20.2 LNG flash drum pressure control

13.10.1.20.3 LNG flash vapor handling

13.10.1.21 LNG Product transfer safety instrumented systems

13.10.1.22 LNG Product transfer relief valves and discharge

13.10.1.23 LNG Product transfer other safety features

[60] Applicants can supply data for sections 13.10.1.13 to 13.10.1.17 using Equipment Data Table in Attachment 2.

## 13.11 LNG STORAGE TANKS[61]

### 13.11.1 LNG Storage Tank Design

**PROVIDE** a description of the LNG storage tank design. The description should reference the Design Basis, Criteria, and Philosophies in Appendix 13.B, Regulations and Permits in Appendix 13.C, Codes and Standards in Appendix 13.D, Engineering Design Information in Appendix 13.E, Project Specifications in Appendix 13.F, LNG Storage Tank Information in Appendix 13.L, and all other applicable appendices and should describe:

13.11.1.1 LNG storage tank type (above ground, below ground, single, double, full, membrane, etc.)

13.11.1.2 Number of LNG storage tanks

13.11.1.3 LNG storage tank foundation type

13.11.1.4 LNG storage tank insulation systems

13.11.1.5 LNG storage tanks operating and design capacities (minimum, normal, maximum), gal or $m^3$

13.11.1.6 LNG storage tanks operating and design liquid levels (minimum, normal, maximum), ft

13.11.1.7 LNG storage tanks operating and design pressures/vacuums (minimum, normal, maximum), in$H_2O$ (vacuum) and psig

13.11.1.8 LNG storage tanks operating and design temperatures (minimum, normal, maximum), °F

13.11.1.9 LNG storage tanks operating and design densities (minimum, normal, maximum), specific gravity

13.11.1.10 LNG storage tanks operating and design boil-off rate (minimum, normal, maximum), %-vol per day

13.11.1.11 LNG storage operating and design residence times, days/hours

13.11.1.12 Hydrotest water source

[61] 18 CFR §380.12(m), 18 CFR §380.12(m)(1), 18 CFR §380.12(m)(3) thru (5), 18 CFR §380.12(o)(3), 18 CFR §380.12(o)(7) thru (10), 18 CFR §380.12(o)(12) thru (14).

13.11.1.13 Hydrotest water specifications and concentrations, %-vol or ppm-v

13.11.1.14 Hydrotest water available flow rate, gpm

13.11.1.15 Hydrotest water pressure, psig

13.11.1.16 Hydrotest water discharge/treatment

13.11.1.17 LNG storage tank startup and operation

13.11.1.18 LNG storage tank isolation valves, drains, and vents

13.11.1.19 LNG storage tank piping support system

13.11.1.20 LNG storage tank basic process control systems

13.11.1.20.1 LNG storage tank cooldown sensors

13.11.1.20.2 LNG storage tank level control

13.11.1.20.3 LNG storage tank pressure control

13.11.1.20.4 LNG storage tank density/rollover control

13.11.1.21 LNG storage tank safety instrumented systems

13.11.1.21.1 LNG storage tank overfill protection

13.11.1.21.2 LNG storage tank overpressure protection

13.11.1.22 LNG storage tank relief valves and discharge

13.11.1.22.1 Calculations for sizing pressure and vacuum relief valves

13.11.1.23 LNG storage tank Impoundment System

13.11.1.23.1 LNG storage tank containment

13.11.1.23.2 LNG storage tank roof spill containment and protection

13.11.1.24 LNG storage tank other safety features

13.11.1.24.1 LNG storage tank leak detection instrumentation

13.11.1.24.2 Foundation frost heave mitigation (heaters temperature detection)

## 13.12 VAPOR HANDLING[62]

### 13.12.1 Vapor Handling Design

**PROVIDE** a description of the vapor handling design. The description should reference the Design Basis, Criteria, and Philosophies in Appendix 13.B, Regulations and Permits in Appendix 13.C, Codes and Standards in Appendix 13.D, Engineering Design Information in Appendix 13.E, Project Specifications in Appendix 13.F, and all other applicable appendices, and should describe:

13.12.1.1 Vapor return blowers type[63]

13.12.1.2 Number of vapor return blowers, operating and spare

13.12.1.3 Vapor return blowers operating and design flow rate capacities (minimum, normal/rated, maximum), lb/hr

13.12.1.4 Vapor return blowers operating and design suction pressures (minimum, normal/rated, maximum), psig

13.12.1.5 Vapor return blowers operating and design suction temperatures (minimum, normal, maximum), °F

13.12.1.6 Vapor return blowers operating and design discharge pressures (minimum, normal/rated, maximum/shutoff), psig

13.12.1.7 Vapor return blowers operating and design discharge temperatures (minimum, normal, maximum), °F

13.12.1.8 Boil-off gas (BOG) low pressure compressors type

13.12.1.9 Number of BOG low pressure compressors, operating and spare

13.12.1.10 BOG low pressure compressors operating and design flow rate capacities (minimum, normal/rated, maximum), lb/hr

13.12.1.11 BOG low pressure compressors operating and design suction pressures (minimum, normal/rated, maximum), psig

13.12.1.12 BOG low pressure compressors operating and design suction temperatures (minimum, normal, maximum), °F

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[62] 18 CFR §380.12(m), 18 CFR §380.12(m)(1), 18 CFR §380.12(m)(3) thru (5), 18 CFR §380.12(o)(3), 18 CFR §380.12(o)(7), 18 CFR §380.12(o)(8), 18 CFR §380.12(o)(10), 18 CFR §380.12(o)(12) thru (14).

[63] Applicants can supply data for sections 13.12.1.1 to 13.12.1.21 using Equipment Data Table in Attachment 2.

13.12.1.13 BOG low pressure compressors operating and design discharge pressures (minimum, normal/rated, maximum/shutoff), psig

13.12.1.14 BOG low pressure compressors operating and design discharge temperatures (minimum, normal, maximum), °F

13.12.1.15 BOG high pressure compressors type

13.12.1.16 Number of BOG high pressure compressors, operating and spare

13.12.1.17 BOG high pressure compressors operating and design flow rate capacities (minimum, normal/rated, maximum), lb/hr

13.12.1.18 BOG high pressure compressors operating and design suction pressures (minimum, normal/rated, maximum), psig

13.12.1.19 BOG high pressure compressors operating and design suction temperatures (minimum, normal, maximum), °F

13.12.1.20 BOG high pressure compressors operating and design discharge pressures (minimum, normal/rated, maximum/shutoff), psig

13.12.1.21 BOG high pressure compressors operating and design discharge temperatures (minimum, normal, maximum), °F

13.12.1.22 Vapor handling startup and operation

13.12.1.22.1 Vapor return blowers to or from the LNG vessel

13.12.1.22.2 BOG low pressure compression

13.12.1.22.3 BOG high pressure compression, including BOG holding mode compression to pipeline

13.12.1.22.4 BOG utilization

13.12.1.23 Vapor handling isolation valves, drains, and vents

13.12.1.24 Vapor handling basic process control systems

13.12.1.25 Vapor handling safety instrumented systems

13.12.1.26 Vapor handling relief valves and discharge

13.12.1.27 Vapor handling other safety features

### 13.12.2 Boil-off Gas (BOG) Re-Condensation Design

**PROVIDE** a description of the BOG re-condensation design. The description should reference the Design Basis, Criteria, and Philosophies in Appendix 13.B, Regulations and Permits in Appendix 13.C, Codes and Standards in Appendix 13.D, Engineering Design Information in Appendix 13.E, Project Specifications in Appendix 13.F, and all other applicable appendices, and should describe:

13.12.2.1 BOG recondenser type

13.12.2.2 Number of BOG recondensers, operating and spare

13.12.2.3 BOG recondensers operating and design inlet flow rate capacities (minimum, normal/rated, maximum), lb/hr

13.12.2.4 BOG recondensers operating and design inlet pressures (minimum, normal/rated, maximum), psig

13.12.2.5 BOG recondensers operating and design inlet temperatures (minimum, normal, maximum), °F

13.12.2.6 BOG recondensers operating and design outlet flow rate capacities (minimum, normal/rated, maximum), lb/hr

13.12.2.7 BOG recondensers operating and design outlet pressures (minimum, normal/rated, maximum), psig

13.12.2.8 BOG recondensers operating and design outlet temperatures (minimum, normal, maximum), °F

13.12.2.9 BOG recondenser startup and operation

13.12.2.9.1 Minimum sendout rate for recondensation

13.12.2.9.2 BOG recondensation

13.12.2.10 BOG recondenser isolation valves, drains, and vents

13.12.2.11 BOG recondenser basic process control systems

13.12.2.12 BOG recondenser safety instrumented systems

13.12.2.13 BOG recondenser relief valves and discharge

13.12.2.14 BOG recondenser other safety features

## 13.13 LNG PUMPS[64]

### 13.13.1 LNG Tank/Low Pressure (LP) Pump Design

**PROVIDE** a description of the LNG LP pump design. The description should reference the Design Basis, Criteria, and Philosophies in Appendix 13.B, Regulations and Permits in Appendix 13.C, Codes and Standards in Appendix 13.D, Engineering Design Information in Appendix 13.E, Project Specifications in Appendix 13.F, and all other applicable appendices, and should describe:

13.13.1.1 LNG tank/LP pumps type[65]

13.13.1.2 Number of LNG tank/LP pumps, operating and spare

13.13.1.3 LNG tank/LP pumps operating and design flow rate capacities (minimum, normal/rated, maximum), gpm

13.13.1.4 LNG tank/LP pumps operating and design suction pressures (minimum/NPSH, normal/rated, maximum), psig

13.13.1.5 LNG tank/LP pumps operating and design suction temperatures (minimum, normal, maximum), °F

13.13.1.6 LNG tank/LP pumps operating and design discharge pressures (minimum, normal/rated, maximum/shutoff), psig

13.13.1.7 LNG tank/LP pumps operating and design discharge temperatures (minimum, normal, maximum), °F

13.13.1.8 LNG tank/LP pumps operating and design densities (minimum, normal/rated, maximum), specific gravity

13.13.1.9 LNG tank/LP pumps startup and operation

13.13.1.9.1 LNG pump to marine transfer (LNG carrier, LNG barge, etc.)

13.13.1.9.2 LNG pump to sendout for vaporization

13.13.1.9.3 LNG pump minimum flow recycle

13.13.1.9.4 LNG pump recirculation to marine transfer

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[64] 18 CFR §380.12(m), 18 CFR §380.12(m)(1), 18 CFR §380.12(m)(3) thru (5), 18 CFR §380.12(o)(3), 18 CFR §380.12(o)(7), 18 CFR §380.12(o)(8), 18 CFR §380.12(o)(10), 18 CFR §380.12(o)(12) thru (14).

[65] Applicants can supply data for sections 13.13.1.1 to 13.13.1.8 using Equipment Data Table in Attachment 2.

13.13.1.9.5 LNG pump recirculation to sendout for vaporization

13.13.1.9.6 LNG pump inter tank transfer

13.13.1.10 LNG tank/LP pumps isolation valves, drains, and vents

13.13.1.11 LNG tank/LP pumps basic process control systems

13.13.1.11.1 LNG pump flow control

13.13.1.12 LNG tank/LP pumps safety instrumented systems

13.13.1.13 LNG tank/LP pumps relief valves and discharge

13.13.1.14 LNG tank/LP pumps other safety features

## 13.13.2 LNG Sendout/High Pressure (HP) System Design

**PROVIDE** a description of the LNG HP pump design. The description should reference the Design Basis, Criteria, and Philosophies in Appendix 13.B, Regulations and Permits in Appendix 13.C, Codes and Standards in Appendix 13.D, Engineering Design Information in Appendix 13.E, Project Specifications in Appendix 13.F, and all other applicable appendices, and should describe:

13.13.2.1 LNG HP pumps type[66]

13.13.2.2 Number of LNG HP pumps, operating and spare

13.13.2.3 LNG HP pumps operating and design flow rate capacities (minimum, normal/rated, maximum), gpm

13.13.2.4 LNG HP pumps operating and design suction pressures (minimum/NPSH, normal/rated, maximum), psig

13.13.2.5 LNG HP pumps operating and design suction temperatures (minimum, normal, maximum), °F

13.13.2.6 LNG HP pumps operating and design discharge pressures (minimum, normal/rated, maximum/shutoff), psig

13.13.2.7 LNG HP pumps operating and design discharge temperatures (minimum, normal, maximum), °F

[66] Applicants can supply data for sections 13.13.2.1 to 13.13.2.8 using Equipment Data Table in Attachment 2.

13.13.2.8 LNG HP pumps operating and design densities (minimum, normal, maximum), specific gravity

13.13.2.9 LNG HP pumps startup and operation

13.13.2.9.1 LNG pump to vaporization

13.13.2.9.2 LNG pump minimum flow recycle

13.13.2.10 LNG HP pumps isolation valves, drains, and vents

13.13.2.11 LNG HP pumps basic process control systems

13.13.2.11.1 LNG pump flow control

13.13.2.12 LNG HP pumps safety instrumented systems

13.13.2.13 LNG HP pumps relief valves and discharge

13.13.2.14 LNG HP pumps other safety features

## 13.14 LNG TRUCKING[67]

### 13.14.1 LNG Trucking Design

**PROVIDE** a description of the LNG trucking design. The description should reference the Design Basis, Criteria, and Philosophies in Appendix 13.B, Regulations and Permits in Appendix 13.C, Codes and Standards in Appendix 13.D, Engineering Design Information in Appendix 13.E, Project Specifications in Appendix 13.F, and all other applicable appendices, and should describe:

13.14.1.1 Number of LNG trucks unloaded, No. per year

13.14.1.2 LNG truck unloaded capacities, gal

13.14.1.3 Number of LNG trucks loaded, No. per year

13.14.1.4 LNG truck loaded capacities, gal

13.14.1.5 Number of LNG truck stations

13.14.1.6 LNG truck scales

13.14.1.7 LNG truck unloading operating and design flow rate capacities (minimum, normal, maximum), gpm

13.14.1.8 LNG truck loading operating and design flow rate capacities (minimum, normal, maximum), gpm

13.14.1.9 LNG truck unloading operating and design pressures (minimum, normal, maximum), psig

13.14.1.10 LNG truck loading operating and design pressures (minimum, normal, maximum), psig

13.14.1.11 LNG truck unloading operating and design temperatures (minimum, normal, maximum), °F

13.14.1.12 LNG truck loading operating and design temperatures (minimum, normal, maximum), °F

13.14.1.13 LNG truck pumps type[68]

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[67] 18 CFR §380.12(m), 18 CFR §380.12(m)(1), 18 CFR §380.12(m)(3) thru (5), 18 CFR §380.12(o)(3), 18 CFR §380.12(o)(7), 18 CFR §380.12(o)(8), 18 CFR §380.12(o)(10), 18 CFR §380.12(o)(12) thru (14).

[68] Applicants can supply data for sections 13.14.1.11 to 13.14.1.16 using Equipment Data Table in Attachment 2.

13.14.1.14 Number of LNG truck pumps, operating and spare

13.14.1.15 LNG truck pumps operating and design flow rate capacities (minimum, normal/rated, maximum), gpm

13.14.1.16 LNG truck pumps operating and design suction pressures (minimum/NPSH, normal/rated, maximum), psig

13.14.1.17 LNG truck pumps operating and design discharge pressures (minimum, normal/rated, maximum/shutoff), psig

13.14.1.18 LNG truck pumps operating and design densities (minimum, normal, maximum), specific gravity

13.14.1.19 LNG trucking startup and operation

13.14.1.19.1 LNG loading

13.14.1.19.2 LNG unloading

13.14.1.19.3 Vapor handling

13.14.1.20 LNG trucking piping, vessel, and equipment design and specifications

13.14.1.21 LNG trucking isolation valves, drains, and vents

13.14.1.22 LNG trucking basic process control systems

13.14.1.23 LNG trucking safety instrumented systems

13.14.1.24 LNG trucking relief valves and discharge

13.14.1.25 LNG trucking other safety features

## 13.15 LNG VAPORIZATION[69]

### 13.15.1 LNG Vaporizers Design

**PROVIDE** a description of the LNG vaporizers design. The description should reference the Design Basis, Criteria, and Philosophies in Appendix 13.B, Regulations and Permits in Appendix 13.C, Codes and Standards in Appendix 13.D, Engineering Design Information in Appendix 13.E, Project Specifications in Appendix 13.F, and all other applicable appendices, and should describe:

13.15.1.1 Emission design criteria

13.15.1.2 LNG vaporizers type

13.15.1.3 Number of LNG vaporizers, operating and spare

13.15.1.4 LNG vaporizers operating and design flow rate capacities (minimum, normal, maximum), MMscfd

13.15.1.5 LNG vaporizers operating and design heat duties each (minimum, rated, maximum), MMBtu/hr

13.15.1.6 LNG vaporizers operating and design pressures (minimum, normal, maximum), psig

13.15.1.7 LNG vaporizers operating and design inlet temperatures (minimum, normal, maximum), °F

13.15.1.8 LNG vaporizers operating and design outlet temperatures (minimum, normal, maximum), °F

13.15.1.9 LNG vaporizers startup and operation

13.15.1.9.1 LNG vaporizer heating system

13.15.1.9.2 LNG vaporization

13.15.1.10 LNG vaporizers isolation valves, drains, and vents

13.15.1.10.1 Generated water handling/disposal system

13.15.1.11 LNG vaporizers basic process control systems

[69] 18 CFR §380.12(m), 18 CFR §380.12(m)(1), 18 CFR §380.12(m)(3) thru (5), 18 CFR §380.12(o)(3), 18 CFR §380.12(o)(7), 18 CFR §380.12(o)(8), 18 CFR §380.12(o)(10), 18 CFR §380.12(o)(12) thru (14).

13.15.1.12 LNG vaporizers safety instrumented systems

13.15.1.13 LNG vaporizers relief valves and discharge

13.15.1.14 LNG vaporizers other safety features

## 13.16 HEAT TRANSFER FLUID (HTF) SYSTEM(S)[70]

### 13.16.1 HTF Storage Design

**PROVIDE** a description of the HTF storage design. At a minimum, the description should reference the Design Basis, Criteria, and Philosophies in Appendix 13.B, Regulations and Permits in Appendix 13.C, Codes and Standards in Appendix 13.D, Engineering Design Information in Appendix 13.E, Project Specifications in Appendix 13.F, and all other applicable appendices, and should describe:

13.16.1.1 Number of HTF trucks, No. per year

13.16.1.2 HTF truck capacities, gal

13.16.1.3 Number of HTF storage tanks, operating and spare

13.16.1.4 HTF operating and design storage capacities, gal

13.16.1.5 HTF operating and design storage pressures (minimum, normal, maximum), psig

13.16.1.6 HTF operating and design storage temperatures (minimum, normal, maximum), °F

13.16.1.7 HTF operating and design residence times, minutes

13.16.1.8 HTF system startup and operation

13.16.1.9 HTF system isolation valves, drains, and vents

13.16.1.10 HTF system basic process control systems

13.16.1.11 HTF system safety instrumented systems

13.16.1.12 HTF system relief valves and discharge

13.16.1.13 HTF system other safety features

[70] 18 CFR §380.12(m), 18 CFR §380.12(m)(1), 18 CFR §380.12(m)(3) thru (5), 18 CFR §380.12(o)(3), 18 CFR §380.12(o)(7), 18 CFR §380.12(o)(8), 18 CFR §380.12(o)(10), 18 CFR §380.12(o)(12) thru (14).

### 13.16.2 HTF Heating System Design[71]

**PROVIDE** a description of the HTF heating system design. The description should reference the Design Basis, Criteria, and Philosophies in Appendix 13.B, Regulations and Permits in Appendix 13.C, Codes and Standards in Appendix 13.D, Engineering Design Information in Appendix 13.E, Project Specifications in Appendix 13.F, and all other applicable appendices, and should describe:

13.16.2.1 HTF distribution list and usage requirement by equipment, gpm

13.16.2.2 Heating source

13.16.2.3 HTF heaters type

13.16.2.4 Number of HTF heaters, operating and spare

13.16.2.5 HTF heaters operating and design heat duty/rate each (minimum, rated, maximum), MMBtu/hr

13.16.2.6 HTF heaters operating and design pressures (minimum, normal, maximum), psig

13.16.2.7 HTF heaters operating and design inlet temperatures (minimum, normal, maximum), °F

13.16.2.8 HTF heaters operating and design outlet temperatures (minimum, normal, maximum), °F

13.16.2.9 HTF pumps type[72]

13.16.2.10 Number of HTF pumps, operating and spare

13.16.2.11 HTF pumps operating and design suction pressures (minimum/NPSH, normal/rated, maximum), psig

13.16.2.12 HTF pumps operating and design discharge pressures (minimum, normal/rated, maximum/shutoff), psig

13.16.2.13 HTF pumps operating and design flow rate capacities (minimum, normal/rated, maximum), gpm

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[71] 18 CFR §380.12(m), 18 CFR §380.12(m)(1), 18 CFR §380.12(m)(3) thru (5), 18 CFR §380.12(o)(3), 18 CFR §380.12(o)(7), 18 CFR §380.12(o)(8), 18 CFR §380.12(o)(10), 18 CFR §380.12(o)(12) thru (14).

[72] Applicants can supply data for sections 13.16.2.9 to 13.16.2.14 using Equipment Data Table in Attachment 2.

13.16.2.14 HTF pumps operating and design densities (minimum, normal, maximum), specific gravity

13.16.2.15 HTF heating system startup and operation

13.16.2.16 HTF heating system isolation valves, drains, and vents

13.16.2.17 HTF heating system basic process control systems

13.16.2.18 HTF heating system safety instrumented systems

13.16.2.19 HTF heating system relief valves and discharge

13.16.2.20 HTF heating system other safety features

## 13.17 BTU ADJUSTMENT[73]

### 13.17.1 Btu Adjustment System Design

**PROVIDE** a description of the Btu adjustment system design. The description should reference the Design Basis, Criteria, and Philosophies in Appendix 13.B, Regulations and Permits in Appendix 13.C, Codes and Standards in Appendix 13.D, Engineering Design Information in Appendix 13.E, Project Specifications in Appendix 13.F, and all other applicable appendices, and should describe:

13.17.1.1 Btu adjustment system type

13.17.1.2 Btu adjustment system mixing location

13.17.1.3 Btu adjustment system composition specifications (minimum, normal, maximum), percent volume, Wobbe

13.17.1.4 Btu adjustment system operating and design flow rate capacities (minimum, normal, maximum), MMscfd or lb/hr

13.17.1.5 Btu adjustment system operating and design pressures (minimum, normal, maximum), psig

13.17.1.6 Btu adjustment system operating and design temperatures (minimum, normal, maximum), °F

13.17.1.7 Btu adjustment system startup and operation

13.17.1.8 Btu adjustment system isolation valves, drains, and vents

13.17.1.9 Btu adjustment system basic process control systems

13.17.1.10 Btu adjustment system safety instrumented systems

13.17.1.11 Btu adjustment system relief valves and discharge

13.17.1.12 Btu adjustment system other safety features

[73] 18 CFR §380.12(m), 18 CFR §380.12(m)(1), 18 CFR §380.12(m)(3) thru (5), 18 CFR §380.12(o)(3), 18 CFR §380.12(o)(7), 18 CFR §380.12(o)(8), 18 CFR §380.12(o)(10), 18 CFR §380.12(o)(12) thru (14).

## 13.18 SENDOUT METERING SYSTEM[74]

### 13.18.1 Sendout Metering Design

**PROVIDE** a description of the sendout metering system design. The description should reference the Design Basis, Criteria, and Philosophies in Appendix 13.B, Regulations and Permits in Appendix 13.C, Codes and Standards in Appendix 13.D, Engineering Design Information in Appendix 13.E, Project Specifications in Appendix 13.F, and all other applicable appendices, and should describe:

13.18.1.1 Sendout operating and design flow rate capacities (minimum, normal, maximum), MMscfd

13.18.1.2 Sendout operating and design pressures (minimum, normal, maximum), psig

13.18.1.3 Sendout operating and design temperatures (minimum, normal, maximum), °F

13.18.1.4 Pipeline operating and design flow rate capacities (minimum, normal, maximum), MMscfd

13.18.1.5 Pipeline operating and design pressures (minimum, normal, maximum), psig

13.18.1.6 Pipeline operating and design temperatures (minimum, normal, maximum), °F

13.18.1.7 Sendout metering system startup and operation

13.18.1.8 Sendout metering system isolation valves, drains, and vents

13.18.1.9 Sendout metering system basic process control systems

13.18.1.10 Sendout metering system safety instrumented systems

13.18.1.11 Sendout metering system relief valves and discharge

13.18.1.12 Sendout metering system other safety features

[74] 18 CFR §380.12(m), 18 CFR §380.12(m)(1), 18 CFR §380.12(m)(3) thru (5), 18 CFR §380.12(o)(3), 18 CFR §380.12(o)(7), 18 CFR §380.12(o)(8), 18 CFR §380.12(o)(10), 18 CFR §380.12(o)(12) thru (14).

## 13.19 FUEL GAS[75]

### 13.19.1 Fuel Gas Design

**PROVIDE** a description of the fuel gas system design. The description should reference the Design Basis, Criteria, and Philosophies in Appendix 13.B, Regulations and Permits in Appendix 13.C, Codes and Standards in Appendix 13.D, Engineering Design Information in Appendix 13.E, Project Specifications in Appendix 13.F, and all other applicable appendices, and should describe:

13.19.1.1 Fuel gas sources

13.19.1.2 Fuel gas specifications

13.19.1.3 Fuel gas distribution list and requirement by equipment, MMscfd

13.19.1.4 Fuel gas operating and design flow rate capacities (minimum, normal/rated, maximum), lb/hr

13.19.1.5 Fuel gas operating and design pressures (minimum, normal/rated, maximum), psig

13.19.1.6 Fuel gas operating and design temperatures (minimum, normal, maximum), °F

13.19.1.7 Fuel gas operating and design densities (minimum, normal, maximum), specific gravity

13.19.1.8 Fuel gas startup and operation

13.19.1.9 Fuel gas isolation valves, drains, and vents

13.19.1.10 Fuel gas basic process control systems

13.19.1.11 Fuel gas safety instrumented systems

13.19.1.12 Fuel gas relief valves and discharge

13.19.1.13 Fuel gas other safety features

13.19.1.13.1 Fuel gas odorant system

[75] 18 CFR §380.12(m), 18 CFR §380.12(m)(1), 18 CFR §380.12(m)(3) thru (5), 18 CFR §380.12(o)(3), 18 CFR §380.12(o)(6) thru (8), 18 CFR §380.12(o)(10), 18 CFR §380.12(o)(12) thru (14).

## 13.20 NITROGEN AND INERT GAS[76]

### 13.20.1 Nitrogen Design

**PROVIDE** a description of the nitrogen system design. The description should reference the Design Basis, Criteria, and Philosophies in Appendix 13.B, Regulations and Permits in Appendix 13.C, Codes and Standards in Appendix 13.D, Engineering Design Information in Appendix 13.E, Project Specifications in Appendix 13.F, and all other applicable appendices, and should describe:

13.20.1.1 Nitrogen source

13.20.1.1.1 Number of liquid nitrogen trucks and truck capacity, gal

13.20.1.1.2 Nitrogen production system and production rate, gpm

13.20.1.2 Nitrogen distribution list of continuous and intermittent users or usage factors, including leakage, and usage requirement by equipment, scfm

13.20.1.3 Number of liquid nitrogen storage tanks, operating and spare

13.20.1.4 Liquid nitrogen storage capacity, gal

13.20.1.5 Number of nitrogen vaporizers, operating and spare

13.20.1.6 Liquid nitrogen vaporizer type

13.20.1.7 Number of nitrogen receivers, operating and spare

13.20.1.8 Liquid nitrogen vaporizer operating and design flow rate capacities, scfm

13.20.1.9 Nitrogen receivers operating and design storage capacities, scf

13.20.1.10 Nitrogen receivers operating and design storage pressures (minimum, normal, maximum), psig

13.20.1.11 Nitrogen receivers residence times, minutes

13.20.1.12 Nitrogen system startup and operation

13.20.1.13 Nitrogen system shutdown

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[76] 18 CFR §380.12(m), 18 CFR §380.12(m)(1), 18 CFR §380.12(m)(3) thru (5), 18 CFR §380.12(o)(3), 18 CFR §380.12(o)(7), 18 CFR §380.12(o)(8), 18 CFR §380.12(o)(10), 18 CFR §380.12(o)(12) thru (14).

13.20.1.14 Liquid nitrogen truck loading

13.20.1.15 Nitrogen system isolation valves, drains, and vents

13.20.1.16 Nitrogen system basic process control systems

13.20.1.17 Nitrogen system safety instrumented systems

13.20.1.18 Nitrogen system relief valves and discharge

13.20.1.19 Nitrogen system other safety features

### 13.20.2 Inert Gas Design

**PROVIDE** a description of the inert gas system design. The description should reference the Design Basis, Criteria, and Philosophies in Appendix 13.B, Regulations and Permits in Appendix 13.C, Codes and Standards in Appendix 13.D, Engineering Design Information in Appendix 13.E, Project Specifications in Appendix 13.F, and all other applicable appendices, and should describe:

13.20.2.1 Inert gas distribution list of continuous and intermittent users or usage factors, including leakage, and usage requirement by equipment, scfm

13.20.2.2 Inert gas compressors type

13.20.2.3 Number of inert gas compressors, operating and spare

13.20.2.4 Number of inert gas receivers, operating and spare

13.20.2.5 Inert gas source

13.20.2.6 Inert gas specifications

13.20.2.7 Inert gas compressor operating and design flow rate capacities (minimum, normal/rated, maximum), scfm

13.20.2.8 Inert gas compressor operating and design discharge pressures (minimum, normal/rated, maximum), psig

13.20.2.9 Inert gas receivers operating and design storage capacities, scf

13.20.2.10 Inert gas receivers operating and design storage pressures (minimum, normal, maximum), psig

13.20.2.11 Inert gas receivers residence times, minutes

13.20.2.12 Inert gas startup and operation

13.20.2.13 Inert gas isolation valves, drains, and vents

13.20.2.14 Inert gas basic process control systems

13.20.2.15 Inert gas safety instrumented systems

13.20.2.16 Inert gas relief valves and discharge

13.20.2.17 Inert gas other safety features

## 13.21 INSTRUMENT AND PLANT/UTILITY AIR[77]

### 13.21.1 Instrument Air Design

**PROVIDE** a description of the instrument air system design. The description should reference the Design Basis, Criteria, and Philosophies in Appendix 13.B, Regulations and Permits in Appendix 13.C, Codes and Standards in Appendix 13.D, Engineering Design Information in Appendix 13.E, Project Specifications in Appendix 13.F, and all other applicable appendices, and should describe:

13.21.1.1 Instrument air distribution list of continuous and intermittent users or usage factors, including leakage, and usage requirement by equipment, scfm

13.21.1.2 Instrument air specifications, dew point, particulates

13.21.1.3 Number of filters, operating and spare

13.21.1.4 Instrument air compressors type

13.21.1.5 Number of instrument air compressors, operating and spare

13.21.1.6 Instrument air compressor operating and design flow rate capacities (minimum, normal/rated, maximum), scfm

13.21.1.7 Instrument air compressor operating and design discharge pressures (minimum, normal/rated, maximum), psig

13.21.1.8 Instrument air drying system type

13.21.1.9 Number of instrument air dryers, operating and spare

13.21.1.10 Instrument air dryers operating and design dew point temperatures, °F

13.21.1.11 Number of air receivers, operating and spare

13.21.1.12 Air receiver operating and design storage capacities, scf

13.21.1.13 Instrument air receiver operating and design storage pressures (minimum, normal, maximum), psig

[77] 18 CFR §380.12(m), 18 CFR §380.12(m)(1), 18 CFR §380.12(m)(3) thru (5), 18 CFR §380.12(o)(3), 18 CFR §380.12(o)(7), 18 CFR §380.12(o)(8), 18 CFR §380.12(o)(10), 18 CFR §380.12(o)(12) thru (14).

13.21.1.14 Air receiver residence times, sec

13.21.1.15 Instrument air startup and operation

13.21.1.16 Instrument air isolation valves, drains, and vents

13.21.1.17 Instrument air basic process control systems

13.21.1.18 Instrument air safety instrumented systems

13.21.1.19 Instrument air relief valves and discharge

13.21.1.20 Instrument air other safety features

### 13.21.2 Plant/Utility Air Design

**PROVIDE** a description of the plant/utility air system design. The description should reference the Design Basis, Criteria, and Philosophies in Appendix 13.B, Regulations and Permits in Appendix 13.C, Codes and Standards in Appendix 13.D, Engineering Design Information in Appendix 13.E, Project Specifications in Appendix 13.F, and all other applicable appendices, and should describe:

13.21.2.1 Plant/utility air compressors type

13.21.2.2 Number of plant/utility air compressors, operating and spare

13.21.2.3 Plant/utility air distribution list of continuous and intermittent users or usage factors, including leakage, and usage requirement by equipment, scfm

13.21.2.4 Plant/utility air specifications

13.21.2.5 Plant/utility air compressors operating and design flow rate capacities (minimum, normal/rated, maximum), scfm

13.21.2.6 Plant/utility air compressors operating and design discharge pressures (minimum, normal/rated, maximum), psig

13.21.2.7 Number of plant/utility air receivers, operating and spare

13.21.2.8 Plant/utility air receivers operating and design storage capacities, scf

13.21.2.9 Plant/utility air receivers operating and design storage pressures (minimum, normal, maximum), psig

13.21.2.10 Plant/utility air receivers operating and design residence times, minutes

13.21.2.11 Plant/utility air startup and operation

13.21.2.12 Plant/utility air isolation valves, drains, and vents

13.21.2.13 Plant/utility air basic process control systems

13.21.2.14 Plant/utility air safety instrumented systems

13.21.2.15 Plant/utility air relief valves and discharge

13.21.2.16 Plant/utility air other safety features

## 13.22 UTILITY WATER AND OTHER UTILITIES[78]

### 13.22.1 Utility Water Design

**PROVIDE** a description of the utility water system design. The description should reference the Design Basis, Criteria, and Philosophies in Appendix 13.B, Regulations and Permits in Appendix 13.C, Codes and Standards in Appendix 13.D, Engineering Design Information in Appendix 13.E, Project Specifications in Appendix 13.F, and all other applicable appendices, and should describe:

13.22.1.1 Utility water type (service water, potable water, demineralized water, steam, chemical treatment. scavengers)

13.22.1.2 Utility water sources

13.22.1.3 Utility water distribution list and usage requirement by equipment, gpm

13.22.1.4 Utility water operating and design storage capacities (minimum, normal, maximum), gal

13.22.1.5 Utility water operating and design flow rate capacities (minimum, normal, maximum), gpm

13.22.1.6 Utility water operating and design pressures (minimum, normal, maximum), psig

13.22.1.7 Utility water startup and operation

13.22.1.8 Utility water isolation valves, drains, and vents

13.22.1.9 Utility water basic process control systems

13.22.1.10 Utility water safety instrumented systems

13.22.1.11 Utility water relief valves and discharge

13.22.1.12 Utility water other safety features

[78] 18 CFR §380.12(m), 18 CFR §380.12(m)(1), 18 CFR §380.12(m)(3) thru (5), 18 CFR §380.12(o)(3), 18 CFR §380.12(o)(7), 18 CFR §380.12(o)(8), 18 CFR §380.12(o)(10), 18 CFR §380.12(o)(12) thru (14).

### 13.22.2 Other Utilities Design[79]

**PROVIDE** a description of other utility systems design. The description should reference the Design Basis, Criteria, and Philosophies in Appendix 13.B, Regulations and Permits in Appendix 13.C, Codes and Standards in Appendix 13.D, Engineering Design Information in Appendix 13.E, Project Specifications in Appendix 13.F, and all other applicable appendices, and should describe:

13.22.2.1 Other utilities type (amine solutions, water glycol solutions, aqueous ammonia, etc.)

13.22.2.2 Other utility distribution list and usage requirement by equipment, gpm

13.22.2.3 Other utility sources

13.22.2.4 Number of other utility truck stations

13.22.2.5 Other utility operating and design storage capacities (minimum, normal, maximum), gal

13.22.2.6 Other utility operating and design flow rate capacities (minimum, normal, maximum), gpm

13.22.2.7 Other utility operating and design pressures (minimum, normal, maximum), psig

13.22.2.8 Utility truck scales

13.22.2.9 Utilities startup and operation

13.22.2.10 Utilities isolation valves, drains, and vents

13.22.2.11 Utilities basic process control systems

13.22.2.12 Utilities safety instrumented systems

13.22.2.13 Utilities relief valves and discharge

13.22.2.14 Utilities other safety features

[79] 18 CFR §380.12(m), 18 CFR §380.12(m)(1), 18 CFR §380.12(m)(3) thru (5), 18 CFR §380.12(o)(3), 18 CFR §380.12(o)(7), 18 CFR §380.12(o)(8), 18 CFR §380.12(o)(10), 18 CFR §380.12(o)(12) thru (14).

## 13.23 PIPING AND VALVES[80]

### 13.23.1 Piping and Valve Design

**PROVIDE** a description of the piping and valve design. At a minimum, the description should reference the Design Basis, Criteria, and Philosophies in Appendix 13.B, Regulations and Permits in Appendix 13.C, Codes and Standards in Appendix 13.D, Engineering Design Information in Appendix 13.E, Project Specifications in Appendix 13.F, Piping, Vessel, Equipment, and Building Information in Appendix 13.M, and all other applicable appendices, and should describe:

13.23.1.1 Piping and valve list(s)

13.23.1.2 Tie-in list(s)

13.23.1.3 Isolation, vent and drain philosophies

13.23.1.4 Car seal and lock philosophy

13.23.1.5 Piping layout

13.23.1.6 Pipe supports and pipe racks

13.23.1.7 Piping, valve, flange, and insulation design and specifications

13.23.1.7.1 Conditions and loads (e.g. pressures, temperatures, vibration, internal and external corrosion, etc.)

13.23.1.7.2 Material of construction temperature limits

13.23.1.7.3 Material of construction allowable stress limits

13.23.1.7.4 Material of construction corrosivity potential and corrosion allowance

13.23.1.7.5 Cathodic protection

13.23.1.8 Positive Material Identification Requirements*

13.23.1.9 Post Weld Heat Treatment*

13.23.1.10 Non-destructive examination (NDE)*

13.23.1.10.1 Weld radiographic/ultrasonic testing

13.23.1.10.2 Magnetic particle or liquid penetrant examination

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[80] 18 CFR §380.12(m), 18 CFR §380.12(m)(1), 18 CFR §380.12(m)(3) thru (5), 18 CFR §380.12(o)(7), 18 CFR §380.12(o)(8), 18 CFR §380.12(o)(14).

13.23.1.10.3 Pneumatic/hydrostatic leak testing medium and pressure

13.23.1.10.4 Other

13.23.1.11 Piping and valve preventive maintenance*

13.23.1.11.1 Internal and external examination

13.23.1.11.2 Corrosion under insulation

13.23.1.11.3 Metal thickness tests

## 13.24 PROCESS VESSELS[81]

### 13.24.1 Process Vessel Design

**PROVIDE** a description of the process vessel design. At a minimum, the description should reference the Design Basis, Criteria, and Philosophies in Appendix 13.B, Regulations and Permits in Appendix 13.C, Codes and Standards in Appendix 13.D, Engineering Design Information in Appendix 13.E, Project Specifications in Appendix 13.F, Piping, Vessel, Equipment, and Building Information in Appendix 13.M, and all other applicable appendices, and should describe:

13.24.1.1 Process vessel list

13.24.1.2 Process vessel layout

13.24.1.3 Process vessel support

13.24.1.4 Process vessel and insulation design and specifications

13.24.1.4.1 Conditions and loads (e.g. pressures, temperatures, vibration, internal and external corrosion, etc.)

13.24.1.4.2 Material of construction allowable stress limits

13.24.1.4.3 Material of construction temperature limits

13.24.1.4.4 Material of construction corrosivity potential and corrosion allowance

13.24.1.4.5 Cathodic protection

13.24.1.5 NDE

13.24.1.5.1 Magnetic particle or liquid penetrant examination

13.24.1.5.2 Full or spot radiographic or ultrasonic testing

13.24.1.5.3 Pneumatic or hydrostatic leak testing pressure

13.24.1.6 Process vessel preventive maintenance

13.24.1.6.1 Internal and external examination

13.24.1.6.2 Corrosion under insulation

13.24.1.6.3 Metal thickness tests

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[81] 18 CFR §380.12(m), 18 CFR §380.12(m)(1), 18 CFR §380.12(m)(3) thru (5), 18 CFR §380.12(o)(7), 18 CFR §380.12(o)(8), 18 CFR §380.12(o)(14).

## 13.25 ROTATING EQUIPMENT[82]

### 13.25.1 Rotating Equipment Design*

**PROVIDE** a description of the rotating equipment design. At a minimum, the description should reference the Design Basis, Criteria, and Philosophies in Appendix 13.B, Regulations and Permits in Appendix 13.C, Codes and Standards in Appendix 13.D, Engineering Design Information in Appendix 13.E, Project Specifications in Appendix 13.F, Piping, Vessel, Equipment, and Building Information in Appendix 13.M, and all other applicable appendices, and should describe:

13.25.1.1 Rotating equipment and drivers list

13.25.1.2 Rotating equipment layout

13.25.1.3 Rotating equipment support

13.25.1.4 Rotating equipment design and specifications

13.25.1.4.1 Conditions and loads (e.g. pressures, temperatures, vibration, internal and external corrosion, etc.)

13.25.1.4.2 Performance curves

13.25.1.4.3 Material of construction allowable stress limits

13.25.1.4.4 Material of construction temperature limits

13.25.1.4.5 Material of construction corrosivity potential and corrosion allowance

13.25.1.4.6 Cathodic protection

13.25.1.5 Machinery Monitoring System

13.25.1.6 Rotating equipment preventive maintenance

13.25.1.6.1 Performance monitoring and tests

[82] 18 CFR §380.12(m), 18 CFR §380.12(m)(1), 18 CFR §380.12(m)(3) thru (5), 18 CFR §380.12(o)(7), 18 CFR §380.12(o)(8), 18 CFR §380.12(o)(14).

## 13.26 FIRED EQUIPMENT[83]

### 13.26.1 Fired Equipment Design*

**PROVIDE** a description of the fired equipment design. At a minimum, the description should reference the Design Basis, Criteria, and Philosophies in Appendix 13.B, Regulations and Permits in Appendix 13.C, Codes and Standards in Appendix 13.D, Engineering Design Information in Appendix 13.E, Project Specifications in Appendix 13.F, Piping, Vessel, Equipment, and Building Information in Appendix 13.M, and all other applicable appendices, and should describe:

13.26.1.1 Fired equipment list

13.26.1.2 Fired equipment layout

13.26.1.3 Fired equipment support

13.26.1.4 Fired equipment design and specifications

13.26.1.4.1 Conditions and loads (e.g. pressures, temperatures, vibration, internal and external corrosion, etc.)

13.26.1.4.2 Duty

13.26.1.4.3 Material of construction allowable stress limits

13.26.1.4.4 Material of construction temperature limits

13.26.1.4.5 Material of construction corrosivity potential and corrosion allowance

13.26.1.4.6 Cathodic protection

13.26.1.5 Burner Management System

13.26.1.6 Fired equipment preventive maintenance

13.26.1.6.1 Performance monitoring and tests

[83] 18 CFR §380.12(m), 18 CFR §380.12(m)(1), 18 CFR §380.12(m)(3) thru (5), 18 CFR §380.12(o)(7), 18 CFR §380.12(o)(8), 18 CFR §380.12(o)(14).

## 13.27 BUILDINGS AND STRUCTURES[84]

### 13.27.1 Buildings and Structures Design

**PROVIDE** a description of the building and structure design. At a minimum, the description should reference the Design Basis, Criteria, and Philosophies in Appendix 13.B, Regulations and Permits in Appendix 13.C, Codes and Standards in Appendix 13.D, Engineering Design Information in Appendix 13.E, Project Specifications in Appendix 13.F, Piping, Vessel, Equipment, and Building Information in Appendix 13.M, and all other applicable appendices, and should describe:

13.27.1.1 Buildings list with dimensions and purpose

13.27.1.2 Building and structure design and specifications

13.27.1.3 Building layout and siting

[84] 18 CFR §380.12(m), 18 CFR §380.12(m)(1), 18 CFR §380.12(m)(3) thru (5), 18 CFR §380.12(o)(7), 18 CFR §380.12(o)(8), 18 CFR §380.12(o)(14).

## 13.28 ELECTRICAL[85]

### 13.28.1 Electrical System Design

**PROVIDE** a description of the electrical design. At a minimum, the description should reference the Design Basis, Criteria, and Philosophies in Appendix 13.B, Regulations and Permits in Appendix 13.C, Codes and Standards in Appendix 13.D, Engineering Design Information in Appendix 13.E, Project Specifications in Appendix 13.F, Electrical Design Information in Appendix 13.N, and all other applicable appendices, and should describe:

13.28.1.1 Power requirements

13.28.1.2 Main power supply, utility/generated

13.28.1.3 Electrical Equipment layout drawings*

13.28.1.4 Cable routing drawings*

13.28.1.5 Main power generators, type

13.28.1.6 Number of main power generators, including any black start generators

13.28.1.7 Main power supply voltage, kilovolt (kV)

13.28.1.8 Main power supply capacity, kilovolt ampere (kVA)

13.28.1.9 Emergency power supply, utility/generated

13.28.1.10 Emergency power generators, type

13.28.1.11 Number of emergency power generators, No.

13.28.1.12 Emergency power voltage, kV

13.28.1.13 Emergency power capacity, kVA

13.28.1.14 UPS services, voltage, size and capacity, V, kVA, hr

13.28.1.15 Transformer type, dry/oil

13.28.1.16 Number of transformers

[85] 18 CFR §380.12(m), 18 CFR §380.12(m)(1), 18 CFR §380.12(m)(3) thru (5), 18 CFR §380.12(o)(7), 18 CFR §380.12(o)(8), 18 CFR §380.12(o)(11), 18 CFR §380.12(o)(14).

13.28.1.17 Electrical distribution system

13.28.1.18 Distribution and voltage levels

13.28.1.19 Uninterruptible power supply, battery backup system

13.28.1.20 Electrical cable schedule/list*

13.28.1.21 Electrical cable design and specification

13.28.1.22 Cathodic protection

13.28.1.23 Hazardous area classifications

13.28.1.24 Ignition control setbacks and separation

13.28.1.25 Electrical pass-through seals and vents to the atmosphere

## 13.29 PLANS AND PROCEDURES[86]

### 13.29.1 Operation and Maintenance Plans

**PROVIDE** a description of the proposed operation and maintenance procedures. Sufficient information should be included to demonstrate that the facilities would be operated and maintained to meet the federal regulations and the level of safety is consistent with the design of the facilities. The description should reference the Organizational Chart in Appendix 13.A.4, Plans and Procedures in Appendix 13.O, and all other applicable appendices, and should describe:

13.29.1.1 Operation procedure development

13.29.1.2 Safety procedures (e.g., hot work and other work permit procedures, etc.)

13.29.1.3 Maintenance plan and procedure development

13.29.1.4 Operations and maintenance structure

13.29.1.5 Number of operation and maintenance personnel*

13.29.1.6 Location of operation and maintenance personnel*

13.29.1.7 Operation and maintenance personnel training*

13.29.1.8 Training plans and procedures*

13.29.1.9 Management procedures (e.g., alarm management, shift procedures/fatigue management, management of change procedures, etc.)*

[86] 18 CFR §380.12(m), 18 CFR §380.12(m)(1), 18 CFR §380.12(m)(3) thru (5), 18 CFR §380.12(o)(7), 18 CFR §380.12(o)(8), 18 CFR §380.12(o)(10), 18 CFR §380.12(o)(14).

## 13.30 INSTRUMENTATION AND CONTROLS[87]

### 13.30.1 Basic Process Control System Design (BPCS)

**PROVIDE** a description of the BPCS design, including all PLCs and DCS. At a minimum, the description should reference the Design Basis, Criteria, and Philosophies in Appendix 13.B, Regulations and Permits in Appendix 13.C, Codes and Standards in Appendix 13.D, Engineering Design Information in Appendix 13.E, Project Specifications in Appendix 13.F, Process Control and Instrumentation Information in Appendix 13.P, and all other applicable appendices, and should describe:

13.30.1.1 Instrument list

13.30.1.2 Instrumentation design and specifications

13.30.1.3 BPCS philosophy

13.30.1.4 BPCS architecture

13.30.1.5 BPCS design and specifications

13.30.1.6 Number of servers, operating and backup

13.30.1.7 Number of historians, operating and backup

13.30.1.8 Distributed control systems (DCS) block diagrams

13.30.1.9 PLC and DCS software

13.30.1.10 Control communication types

13.30.1.11 Number of lines of communication to control room, operating and backup

13.30.1.12 Control power sources, operating and backup

13.30.1.13 Human machine interface (HMI) local and control room displays, type

13.30.1.14 Number of HMI control room displays

[87] 18 CFR §380.12(m), 18 CFR §380.12(m)(1), 18 CFR §380.12(m)(3) thru (5), 18 CFR §380.12(o)(7), 18 CFR §380.12(o)(8), 18 CFR §380.12(o)(10), 18 CFR §380.12(o)(14).

## 13.31 SAFETY INSTRUMENTED SYSTEMS[88]

### 13.31.1 Safety Instrumented System (SIS) Design

**PROVIDE** a description of the SIS design, including emergency shutdown (ESD) and fire and gas system (FGS). At a minimum, the description should reference the Design Basis, Criteria, and Philosophies in Appendix 13.B, Regulations and Permits in Appendix 13.C, Codes and Standards in Appendix 13.D, Engineering Design Information in Appendix 13.E, Project Specifications in Appendix 13.F, Shutoff Valve Information in Appendix 13.Q, and all other applicable appendices, and should describe:

13.31.1.1 SIS, FGS, ESD and depressurization philosophies

13.31.1.2 SIS and FGS architecture

13.31.1.3 SIS, FGS, and ESD cause and effect matrices

13.31.1.4 SIS, FGS, and ESD design and specifications

13.31.1.5 Number of SIS and FGS servers, operating and backup*

13.31.1.6 Number of SIS and FGS historians, operating and backup*

13.31.1.7 SIS and FGS block diagrams

13.31.1.8 SIS and FGS software*

13.31.1.9 List of ESD valves

13.31.1.10 ESD valve spacing*

13.31.1.11 ESD closure times*

13.31.1.12 SIS, FGS, and ESD Safety Integrity Levels (SIL)*

[88] 18 CFR §380.12(m), 18 CFR §380.12(m)(1), 18 CFR §380.12(m)(3) thru (5), 18 CFR §380.12(o)(3), 18 CFR §380.12(o)(7), 18 CFR §380.12(o)(8), 18 CFR §380.12(o)(14).

## 13.32 SECURITY PLANS[89]

### 13.32.1 Physical Security Plans

**PROVIDE** a general description of the proposed security that addresses the principal concerns for physical security. Identify who would be involved in the development of the physical security plan during the design phase of the project. Applicants should include sufficient information to demonstrate that the facilities would be designed, installed, and operated to meet federal regulations and that the level of security and safety is consistent with the security threats and vulnerabilities at the project location. At a minimum, the description should reference Design Basis, Criteria, and Philosophies in Appendix 13.B, Regulations and Permits in Appendix 13.C, Codes and Standards in Appendix 13.D, Engineering Design Information in Appendix 13.E, Project Specifications in Appendix 13.F, the Security Threat and Vulnerability Analyses in Appendix 13.G.8[90], and all other applicable appendices, and should describe:

13.32.1.1 Security plan developments

13.32.1.2 Lighting

13.32.1.3 Physical barriers (e.g. fences, vehicle barriers, etc.)

13.32.1.4 Site and onsite access controls

13.32.1.5 Intrusion monitoring

13.32.1.6 Intrusion detection

13.32.1.7 Site security communication

13.32.1.8 Site security service and number of site security personnel

13.32.1.9 Site security use of force

13.32.1.10 Site security training

13.32.1.11 Setbacks, blast walls, hardened structures, and blast resistant designs

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[89] 18 CFR §380.12(m), 18 CFR §380.12(m)(1), 18 CFR §380.12(m)(3) thru (5), 18 CFR §380.12(o)(7), 18 CFR §380.12(o)(8), 18 CFR §380.12(o)(14).

[90] Security Threat and Vulnerability Information prepared for or submitted to Coast Guard in accordance with 33 CFR §105.305 or prepared for or submitted to Department of Homeland Security (DHS) in accordance with 6 CFR §27.215 may satisfy Security Threat and Vulnerability Analyses in Appendix 13.G.8. This material may include Critical Energy Infrastructure Information (CEII), Security Sensitive Information (SSI), or Chemical-Terrorism Vulnerability Information (CVI) and must comply with all applicable regulations.

### 13.32.2 Cybersecurity Plans

**PROVIDE** a general description of the proposed security that addresses the principal concerns for cybersecurity. Identify who would be involved in the development of the cyber security plan during the design phase of the project. Applicants should describe their consideration of cybersecurity threats and vulnerabilities and compliance with federal regulations. At a minimum, the description should reference Regulations and Permits in Appendix 13.C, Codes and Standards in Appendix 13.D, Project Specifications in Appendix 13.F, the Security Threat and Vulnerability Analyses in Appendix 13.G.8[91], and all other applicable appendices, and should describe:

13.32.2.1 Cybersecurity Plan developments

13.32.2.2 Physical access to control systems

13.32.2.3 Computer and network access controls

13.32.2.4 Intrusion monitoring

13.32.2.5 Intrusion detection

13.32.2.6 Cybersecurity personnel and response teams

13.32.2.7 Cybersecurity awareness and training

13.32.2.8 Air gaps, waterfalls, and firewalls

[91] Security Threat and Vulnerability Information prepared for or submitted to Coast Guard in accordance with 33 CFR §105.305 or prepared for or submitted to Department of Homeland Security (DHS) in accordance with 6 CFR §27.215 may satisfy Security Threat and Vulnerability Analyses in Appendix 13.G.8. This material may include Critical Energy Infrastructure Information (CEII), Security Sensitive Information (SSI), or Chemical-Terrorism Vulnerability Information (CVI) and must comply with all applicable regulations.

## 13.33 RELIEF VALVE AND FLARE/VENT SYSTEMS[92]

### 13.33.1 Relief Valves and Flare/Vent Systems Design

**PROVIDE** a description of the relief valve and flare/vent design. At a minimum, the description should reference the Design Basis, Criteria, and Philosophies in Appendix 13.B, Regulations and Permits in Appendix 13.C, Codes and Standards in Appendix 13.D, Engineering Design Information in Appendix 13.E, Project Specifications in Appendix 13.F, Relief Valve and Flare/Vent System Information in Appendix 13.R, and all other applicable appendices, and should describe:

13.33.1.1 List of relief valves

13.33.1.2 Relief valve philosophy

13.33.1.3 Relief valve studies

13.33.1.4 Vent stack philosophy

13.33.1.5 Vent stack type

13.33.1.6 Number of vent stacks

13.33.1.7 Vent stack height and diameter

13.33.1.8 Vent stack studies

13.33.1.9 Vent sources

13.33.1.10 Vent stack operating and design flow rate capacities (minimum, normal/rated, maximum), MMscfd

13.33.1.11 Vent stack operating and design pressures (minimum, normal/rated, maximum), psig

13.33.1.12 Vent stack operating and design temperatures (minimum, normal, maximum), °F

13.33.1.13 Vent stack operating and design densities (minimum, normal, maximum), specific gravity

13.33.1.14 Flare philosophy

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[92] 18 CFR §380.12(m), 18 CFR §380.12(m)(1), 18 CFR §380.12(m)(3) thru (5), 18 CFR §380.12(o)(7), 18 CFR §380.12(o)(8), 18 CFR §380.12(o)(14).

13.33.1.15 Flare type

13.33.1.16 Number of flares

13.33.1.17 Flare height and diameter

13.33.1.18 Flare studies

13.33.1.19 Flare sources

13.33.1.20 Flare operating and design flow rate capacities (minimum, normal/rated, maximum), MMscfd

13.33.1.21 Flare operating and design pressures (minimum, normal/rated, maximum), psig

13.33.1.22 Flare operating and design temperatures (minimum, normal, maximum), °F

13.33.1.23 Flare operating and design densities (minimum, normal, maximum), specific gravity

13.33.1.24 Flare operating and design radiant heat (maximum), Btu/$ft^2$-hr

13.33.1.25 Flare operating and design decibel (maximum), decibels on the A-weighted scale

## 13.34 SPILL CONTAINMENT[93]

### 13.34.1 Spill Containment System Design

**PROVIDE** a description of the spill containment system design. Include a description of the spill locations and spill containment system, including curbing, grading, trenches, troughs downcomers, impoundments sub-impoundments, and dikes, for each hazardous fluid that could be spilled. The description should contain the location, design configuration, dimensions, capacity and materials of construction. The description should also include details of the water removal system, basis of design and flow rate required to be removed. Each spill containment system, trough, trench, sump and impoundment should be clearly referenced to the drawings At a minimum, the description should reference the Design Basis, Criteria, and Philosophies in Appendix 13.B, Regulations and Permits in Appendix 13.C, Codes and Standards in Appendix 13.D, Engineering Design Information in Appendix 13.E, Project Specifications in Appendix 13.F, Spill, Toxic, Fire, and Explosion Protection Information in Appendix 13.S, and all other applicable appendices, and should describe:

13.34.1.1 Spill containment philosophy

13.34.1.2 Spill locations and flows

13.34.1.3 Impoundment volumetric capacities

13.34.1.4 Trench and trough volumetric flow capacities

13.34.1.5 Downcomer volumetric flow capacities

13.34.1.6 Impoundment system water removal

13.34.1.7 Storm water flow design basis

13.34.1.8 Storm water drainage calculations

13.34.1.9 Impoundment system snow and ice removal

13.34.1.10 Snow and ice load basis of design and removal

[93] 18 CFR §380.12(m), 18 CFR §380.12(m)(1), 18 CFR §380.12(m)(3) thru (5), 18 CFR §380.12(o)(4), 18 CFR §380.12(o)(7), 18 CFR §380.12(o)(8), 18 CFR §380.12(o)(14).

## 13.35 PASSIVE PROTECTION SYSTEMS[94]

### 13.35.1 Passive Protection Design

**PROVIDE** a description of the passive protection design. At a minimum, the description should reference the Design Basis, Criteria, and Philosophies in Appendix 13.B, Regulations and Permits in Appendix 13.C, Codes and Standards in Appendix 13.D, Engineering Design Information in Appendix 13.E, Project Specifications in Appendix 13.F, Spill, Toxic, Fire, and Explosion Protection Information in Appendix 13.S, and all other applicable appendices, and should describe:

13.35.1.1 Passive protection philosophy

13.35.1.2 Cryogenic structural protection

13.35.1.3 Vapor barriers

13.35.1.4 Equipment layout setbacks and separation

13.35.1.5 Blast walls, hardened structures, and blast resistant design

13.35.1.6 Fire-proofing, firewalls, and radiant heat shields design

13.35.1.7 Other passive protection (e.g. mounding, elevated heating, ventilation, and air conditioning [HVAC] intakes; foam glass blocks; etc.)

[94] 18 CFR §380.12(m), 18 CFR §380.12(m)(1), 18 CFR §380.12(m)(3) thru (5), 18 CFR §380.12(o)(7), 18 CFR §380.12(o)(8), 18 CFR §380.12(o)(14).

## 13.36 HAZARD DETECTION SYSTEMS[95]

### 13.36.1 Hazard Detection System Design

**PROVIDE** a description of the hazard detection design. At a minimum, the description should reference the Design Basis, Criteria, and Philosophies in Appendix 13.B, Regulations and Permits in Appendix 13.C, Codes and Standards in Appendix 13.D, Engineering Design Information in Appendix 13.E, Project Specifications in Appendix 13.F, Spill, Toxic, Fire, and Explosion Protection Information in Appendix 13.S, and all other applicable appendices, and should describe:

13.36.1.1 Hazard detection philosophies (selection, layout, alarm, activation, and/or shutdown setpoints, voting logic, voting degradation logic)

13.36.1.2 Hazard detection design and performance criteria (e.g., minimum detector spacing, maximum detection time, etc.)

13.36.1.3 Low temperature detectors

13.36.1.4 Oxygen deficiency detectors

13.36.1.5 Toxic gas detectors

13.36.1.6 Flammable/combustible gas detectors

13.36.1.7 Flame detectors

13.36.1.8 Heat detectors

13.36.1.9 Smoke/products of combustion detectors

13.36.1.10 Manual pull stations

13.36.1.11 Audible and visual notification systems for field, control room, plant wide, and offsite

13.36.1.12 Other hazard detectors (e.g., rate of rise temperature detectors, acoustic leak detectors, closed-circuit television [CCTV] detectors, carbon monoxide, etc.)

[95] 18 CFR §380.12(m), 18 CFR §380.12(m)(1), 18 CFR §380.12(m)(3) thru (5), 18 CFR §380.12(o)(3), 18 CFR §380.12(o)(7), 18 CFR §380.12(o)(8), 18 CFR §380.12(o)(14).

## 13.37 HAZARD CONTROL SYSTEMS[96]

### 13.37.1 Hazard Control System Design

**PROVIDE** a description of the hazard control design. At a minimum, the description should reference the Design Basis, Criteria, and Philosophies in Appendix 13.B, Regulations and Permits in Appendix 13.C, Codes and Standards in Appendix 13.D, Engineering Design Information in Appendix 13.E, Project Specifications in Appendix 13.F, Spill, Toxic, Fire, and Explosion Protection Information in Appendix 13.S, and all other applicable appendices, and should describe:

13.37.1.1 Hazard control philosophies (selection, layout, activation)

13.37.1.2 Performance criteria (e.g., minimum flow and capacity, maximum travel distance/spacing, etc.)

13.37.1.3 Portable fire extinguishers design and layout with reference to drawings in Appendix 13.S

13.37.1.4 Fixed dry chemical systems design and layout with reference to drawings in Appendix 13.S

13.37.1.5 Clean agent systems design and layout with reference to drawings in Appendix 13.S

13.37.1.6 Carbon dioxide systems design and layout with reference to drawings in Appendix 13.S

13.37.1.7 Other hazard control systems (e.g., nitrogen snuffing, dispersive fans, building ventilation, etc.) design and layout with reference to drawings in Appendix 13.S

[96] 18 CFR §380.12(m), 18 CFR §380.12(m)(1), 18 CFR §380.12(m)(3) thru (5), 18 CFR §380.12(o)(2), 18 CFR §380.12(o)(7), 18 CFR §380.12(o)(8), 18 CFR §380.12(o)(14).

## 13.38 FIRE WATER SYSTEM[97]

### 13.38.1 Fire Water Design

**PROVIDE** a description of the fire water system design. At a minimum, the description should reference the Design Basis, Criteria, and Philosophies in Appendix 13.B, Regulations and Permits in Appendix 13.C, Codes and Standards in Appendix 13.D, Engineering Design Information in Appendix 13.E, Project Specifications in Appendix 13.F, Spill, Toxic, Fire, and Explosion Protection Information in Appendix 13.S, and all other applicable appendices, and should describe:

13.38.1.1 Fire water philosophy

13.38.1.2 Fire water system design cases, demands, calculations, and basis of sizing

13.38.1.3 Main fire water supply and back up supply (e.g., fire water tank, pond, ocean, wells, city, etc.)

13.38.1.4 Fire water supply pressure, psig

13.38.1.5 Fire water storage type and capacity, gal

13.38.1.6 Main fire water pumps and driver type

13.38.1.7 Number of main fire water pumps, operating and standby

13.38.1.8 Main fire water pumps operating and design flow rate capacities (minimum, rated, maximum), gpm

13.38.1.9 Main fire water pumps operating and design pressures (minimum, rated, maximum)

13.38.1.10 Jockey/make up water source

13.38.1.11 Jockey/make up water operating and design flow rate capacities (minimum, rated, maximum), gpm

13.38.1.12 Jockey/make up water operating and design pressures (minimum, rated, maximum), psig

[97] 18 CFR §380.12(m), 18 CFR §380.12(m)(1), 18 CFR §380.12(m)(3) thru (5), 18 CFR §380.12(o)(2), 18 CFR §380.12(o)(7), 18 CFR §380.12(o)(8), 18 CFR §380.12(o)(14).

13.38.1.13 Fire water piping design and layout with reference to drawings in Appendix 13.S

13.38.1.13.1 Freeze protection (burial depth below frost depth, aboveground heat tracing, etc.)

13.38.1.14 Fire water hydrants design and layout with reference to drawings in Appendix 13.S

13.38.1.15 Fire water monitors design and layout with reference to drawings in Appendix 13.S

13.38.1.16 Hose reels design and layout with reference to drawings in Appendix 13.S

13.38.1.17 Water screens and deluge systems design and layout with reference to drawings in Appendix 13.S

13.38.1.18 Expansion foam philosophy

13.38.1.19 Expansion foam system design cases, demands, calculations, and basis of sizing

13.38.1.20 Expansion foam water supply

13.38.1.21 Expansion foam supply

13.38.1.22 Expansion foam type (e.g. low expansion Aqueous Film-Forming Foam [AFFF], high expansion foam, etc.)

13.38.1.23 Expansion foam concentration, percent volume

13.38.1.24 Expansion foam storage type and capacity, gal

13.38.1.25 Expansion foam pumps and driver type

13.38.1.26 Number of expansion foam pumps, operating and standby

13.38.1.27 Expansion foam pumps operating and design flow rate capacities (minimum, rated, maximum), gpm

13.38.1.28 Expansion foam pumps operating and design pressures (minimum, rated, maximum)

13.38.1.29 Expansion foam piping design and layout with reference to drawings in Appendix 13.S

13.38.1.29.1 Freeze protection (burial depth below frost depth, aboveground heat tracing, etc.)

13.38.1.30 Expansion foam generators design and layout with reference to drawings in Appendix 13.S

13.38.1.31 Expansion foam hose reels design and layout with reference to drawings in Appendix 13.S

13.38.1.32 External impact protection (bollards)

## 13.39 EMERGENCY RESPONSE PLAN[98]

### 13.39.1 Emergency Response Plan

**PROVIDE** a description of the Emergency Response Plan development, planned coordination, and a summary of utilization of onsite personnel and offsite personnel and equipment in response to fires. At a minimum, the description should include:

13.39.1.1 Incident Command System organizational chart for emergency response

13.39.1.2 Proximity of emergency response, fire brigades/departments, mutual aid, and local law enforcement

13.39.1.3 Number of emergency response personnel

13.39.1.4 Number and type of emergency response apparatus

13.39.1.5 Response to emergencies and deployment of resources

13.39.1.6 Public and onsite notification and communication

13.39.1.7 Multiple access and egress locations and roadways, internal and external to site

13.39.1.8 Preliminary evacuation routes within and adjacent to plant and LNG vessel route

13.39.1.9 Proposed frequency and type of security and emergency response training and drills for onsite personnel and emergency responders

13.39.1.10 Contact and communications with the Coast Guard, including LOI and submittal of preliminary Waterway Suitability Assessment (at time of pre-filing), and submittal of a Follow-on Waterway Suitability Assessment (at time of application)[99]

13.39.1.11 Contact and communications with the State Fire Marshal

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[98] 18 CFR §380.12(m), 18 CFR §380.12(m)(1), 18 CFR §380.12(m)(3) thru (5), 18 CFR §380.12(o)(7), 18 CFR §380.12(o)(8), 18 CFR §380.12(o)(14).

[99] Waterway Suitability Assessments submitted to Coast Guard in accordance with 18 CFR §157.21(a)(1), 18 CFR §157.21(f)(13), 33 CFR §127.007, and Navigation and Vessel Inspection Circular (NVIC) 01-2011, Guidance Related to Waterfront Liquefied Natural Gas Facilities may satisfy this provision and Waterway Safety and Reliability Impact Studies in Appendix 13.G.3. This material may include Critical Energy Infrastructure Information (CEII), Security Sensitive Information (SSI), or Chemical-Terrorism Vulnerability Information (CVI) and must comply with all applicable regulations.

13.39.1.12 Contacts and communications with all other appropriate agencies

13.39.1.13 Preliminary Cost-Sharing Plans with any state and local agencies and responders to fund security, emergency management, and training costs

13.39.1.14 Schedule for any future actions, studies or meetings to develop the Emergency Response Plan and Cost-Sharing Plan

# RESOURCE REPORT 13 APPENDICES

## 13.A APPENDIX 13.A, PROJECT MANAGEMENT[100]

### 13.A.1 Site Location Maps and Drawing

**PROVIDE** area location maps and drawings detailing the plant and surrounding areas. The maps and drawings should show: owned and leased property boundaries, easements, and rights of ways; water bodies and sensitive resources, such as streams, ponds, marshes, and wetlands; existing site features that would be removed or demolished, including existing vegetation, structures, foundations, equipment, and containers; populated areas, such as residential communities, business districts, schools, day care centers, religious facilities, and recreational areas; transportation infrastructure, such as roads and highways, railroads and rail yards, waterlines, sewer lines, and storm culverts, hazardous pipelines, electric lines, marinas, and airports; industrial facilities, such as power plants, nuclear facilities, wastewater facilities, and petrochemical and processing facilities; public health and safety facilities, such as police and fire departments, hospitals, and mutual aid facilities; and military facilities, such as bases, test sites, restricted areas, and research areas.

### 13.A.2 Owner Organizational Structure

**PROVIDE** an Organizational Chart detailing the structure of the ownership of the project. The structure should include the owner of the project, parent companies, and subsidiaries.

### 13.A.3 Construction Workforce Organizational Chart(s)*

**PROVIDE** an organizational chart for the construction workforce.

### 13.A.4 Operation Workforce Organizational Chart(s)*

**PROVIDE** an organizational chart for the operational plant. At a minimum, the organizational chart should include the structure and number of all staff for operations, maintenance, engineering, safety, security, health, environment, management, and administration.

[100] 18 CFR §380.12(m), 18 CFR §380.12(m)(1), 18 CFR §380.12(m)(3) thru (5), 18 CFR §380.12(o)(7), 18 CFR §380.12(o)(8).

### 13.A.5 Gantt Chart

**PROVIDE** a preliminary Gantt chart of the project schedule that should include general milestones for the following:

13.A.5.1 Front-end engineering design and reviews, including milestones for completed:

13.A.5.1.1 Hazard Identification (HAZID) or Preliminary Hazard and Operability (HAZOP)

13.A.5.1.2 Piping and Instrumentation Drawings (P&IDs)

13.A.5.1.3 Fire protection evaluation

13.A.5.1.4 FEED

13.A.5.2 Regulatory Permits and Approvals, including milestones for submittals and authorizations/permits for:

13.A.5.2.1 U.S. Army Corps of Engineers
13.A.5.2.2 U.S. Environmental Protection Agency
13.A.5.2.3 U.S. Department of Energy
13.A.5.2.4 FERC
13.A.5.2.5 State agencies

13.A.5.3 Site Preparation, including milestones for starting and completing:

13.A.5.3.1 Mobilization
13.A.5.3.2 Soil stabilization
13.A.5.3.3 Grading
13.A.5.3.4 Electric Power
13.A.5.3.5 Waterlines
13.A.5.3.6 Underground piping and systems
13.A.5.3.7 Access roads
13.A.5.3.8 Laydown areas
13.A.5.3.9 Dredging

13.A.5.4 Detailed/Final Engineering, including milestones for starting and completing:

13.A.5.4.1 Process Hazard Analyses (PHA) (e.g., HAZOP, SIL verification, Layers of Protection Analysis [LOPA], etc.)
13.A.5.4.2 Issued for construction P&IDs
13.A.5.4.3 Structural design

13.A.5.4.4 Fire protection evaluation

13.A.5.5 Procurement, including milestones for completing:

13.A.5.5.1 Procurement of long-lead equipment
13.A.5.5.2 Transit/delivery of major equipment
13.A.5.5.3 Receipt of bulk materials/fluids

13.A.5.6 Construction, including milestones for starting and completing:

13.A.5.6.1 Piling
13.A.5.6.2 Foundations
13.A.5.6.3 Fabrication/erection of structural steel
13.A.5.6.4 Major pieces of equipment
13.A.5.6.5 Storage tanks
13.A.5.6.6 Vessels
13.A.5.6.7 Piping
13.A.5.6.8 Tie-ins
13.A.5.6.9 Electrical and instrumentation
13.A.5.6.10 Insulation
13.A.5.6.11 Equipment tagging
13.A.5.6.12 Labeling
13.A.5.6.13 Signage

13.A.5.7 Pre-Commissioning and Commissioning, including milestones for starting and completing:

13.A.5.7.1 Cleanout
13.A.5.7.2 Purging
13.A.5.7.3 Dryout
13.A.5.7.4 Leak/pneumatic testing
13.A.5.7.5 Hydrotests
13.A.5.7.6 Equipment alignment checks
13.A.5.7.7 Mechanical completion
13.A.5.7.8 Loop checks
13.A.5.7.9 Alarm/trip checks
13.A.5.7.10 Commissioning plans and procedures
13.A.5.7.11 Electrical tests
13.A.5.7.12 Factory acceptance tests (FAT)
13.A.5.7.13 Site acceptance tests (SAT)
13.A.5.7.14 Site integration tests (SIT)
13.A.5.7.15 Functional tests and commissioning demonstration tests
13.A.5.7.16 Introduction of hazardous fluids
13.A.5.7.17 Ready for Startup documentation

13.A.5.8 Startup, including milestones for starting and completing:

13.A.5.8.1 Training of personnel
13.A.5.8.2 Startup and cooldown procedures

13.A.5.9 Commencement of operations, including milestones for starting and completing:

13.A.5.9.1 Operation procedures
13.A.5.9.2 Maintenance plans
13.A.5.9.3 Performance tests
13.A.5.9.4 Turnover

## 13.B APPENDIX 13.B, DESIGN BASIS, CRITERIA, AND PHILOSOPHIES[101]

### 13.B.1 Basis of Design and Criteria

**PROVIDE** the basis of the engineering design that justifies, explains, or clarifies the design criteria. Items to be considered should include, but are not limited to: feed gas pipeline conditions, LNG ship/import criteria, guarantee conditions, venting and flaring requirements, fire water, sendout pipeline criteria, LNG ship/export criteria. As applicable, the overall Design Basis and criteria should address:

13.B.1.1 Marine platform
13.B.1.2 Marine transfer
13.B.1.3 Feed gas system
13.B.1.4 Acid gas removal
13.B.1.5 Mercury removal
13.B.1.6 Water removal
13.B.1.7 Heavies/condensates removal, storage, and disposition
13.B.1.8 NGL fractionation, storage, and disposition
13.B.1.9 Refrigerant
13.B.1.10 Liquefaction
13.B.1.11 Cooling water
13.B.1.12 LNG transfer
13.B.1.13 LNG storage tank
13.B.1.14 Vapor handling
13.B.1.15 LNG trucking
13.B.1.16 LNG vaporization
13.B.1.17 HTF storage and heating
13.B.1.18 Btu adjustment
13.B.1.19 Sendout metering
13.B.1.20 Electrical
13.B.1.21 Fuel gas
13.B.1.22 Nitrogen
13.B.1.23 Inert gas
13.B.1.24 Instrument air
13.B.1.25 Plant/utility air
13.B.1.26 Piping
13.B.1.27 Process vessel
13.B.1.28 Buildings and structures
13.B.1.29 Basic process control system
13.B.1.30 Safety Instrument System
13.B.1.31 Relief valve and flare/vent systems

[101] 18 CFR §380.12(m), 18 CFR §380.12(m)(1), 18 CFR §380.12(m)(3) thru (5), 18 CFR §380.12(o)(7), 18 CFR §380.12(o)(8), 18 CFR §380.12(o)(14).

13.B.1.32 Spill containment
13.B.1.33 Passive protection
13.B.1.34 Hazard detection
13.B.1.35 Hazard control
13.B.1.36 Fire water system

### 13.B.2 Design and Control Philosophies

**PROVIDE** design and control philosophy of operation of all systems/facilities. At a minimum, the design and control philosophies should include the following systems:

13.B.2.1 Sparing philosophy
13.B.2.2 Warehouse philosophy
13.B.2.3 Marine transfer system philosophy
13.B.2.4 Acid gas removal system philosophy
13.B.2.5 Mercury removal system philosophy
13.B.2.6 Dehydration and regeneration gas system philosophy
13.B.2.7 Heavies/condensates removal, storage, and disposition systems philosophy
13.B.2.8 NGL removal, storage, and disposition system philosophy
13.B.2.9 Liquefaction system philosophy
13.B.2.10 Cooling system philosophy
13.B.2.11 LNG transfer system philosophy
13.B.2.12 LNG storage tank system philosophy
13.B.2.13 Vapor handling system philosophy
13.B.2.14 LNG vaporization system philosophy
13.B.2.15 Btu adjustment system philosophy
13.B.2.16 Material selection philosophy
13.B.2.17 Isolation, drain, and vent philosophies
13.B.2.18 Car seal and lock philosophy
13.B.2.19 BPCS philosophy
13.B.2.20 SIS, FGS, ESD, and depressurization philosophies
13.B.2.21 Relief valve philosophy
13.B.2.22 Vent/Flare system philosophy
13.B.2.23 Spill containment philosophy
13.B.2.24 Passive protection philosophy
13.B.2.25 Hazard detection philosophy
13.B.2.26 Hazard control philosophy
13.B.2.27 Fire water philosophy
13.B.2.28 Expansion foam philosophy

## 13.C APPENDIX 13.C, REGULATIONS AND PERMITS[102]

### 13.C.1 Table of Regulatory Agencies, Permits, and Approvals

**PROVIDE** a table of the government regulations and permits required for the design, construction, and operation of the facilities. At a minimum, the table should include all permits or approvals from local, state, Federal, or Native American groups or Indian agencies required prior to and during construction of the plant, and the status of each, including the date filed, the date issued, and any known obstacles to approval. This section may reference Resource Report 1.

### 13.C.2 Regulatory Agency Correspondence

**PROVIDE** copies of all correspondence and submissions relating to all required safety and reliability related permits and approvals. Correspondence should resolve any potential safety impacts, including hazards to or from surrounding areas of the project site and shipping route. At a minimum, correspondence should be provided for the following agencies:

13.C.2.1 Coast Guard
13.C.2.2 DOT
13.C.2.3 FAA
13.C.2.4 Other (e.g., EPA, OSHA, DoD, NRC, state, etc.)[103]

### 13.C.3 Regulatory Compliance Matrix

**PROVIDE** a code compliance matrix that clearly describes how each applicable requirement in 49 CFR Part 193 and incorporated National Fire Protection Association (NFPA) 59A LNG Standards has been satisfied. The specific location of relevant supporting information contained in the application should also be provided. For new facilities, the siting requirements of 49 CFR Part 193, Subpart B, must be given special attention. Hazards for releases over water should also be presented to ensure compliance with the Coast Guard's LNG regulations in 33 CFR Part 127, if applicable.

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[102] 18 CFR §380.12(o)(13) and 18 CFR §380.12(o)(14).

[103] DoD should be consulted if the facilities, operations, or potential incidents could impact DoD military operations or facilities. NRC should be consulted if the facilities, operations, or potential incidents could impact NRC jurisdictional nuclear operations or facilities. State safety agencies should be consulted for any safety concerns expressed by the state.

## 13.D APPENDIX 13.D, CODES AND STANDARDS[104]

### 13.D.1 List of Codes and Standards

**PROVIDE** a list of the codes, standards, and other recognized and general accepted good engineering practices with editions[105] under which the Project will be designed, constructed, and operated. The list should be ordered alphabetically by standard body and numerically for standards. Codes and Standards should include, but should not be limited to the following standard and code bodies/organizations:

13.D.1.1 American Concrete Institute (ACI)
13.D.1.2 American Gas Association (AGA)
13.D.1.3 American Institute of Steel Construction (AISC)
13.D.1.4 American Petroleum Institute (API)
13.D.1.5 American Society of Civil Engineers (ASCE)
13.D.1.6 American Society of Mechanical Engineers (ASME)
13.D.1.7 American Society for Testing and Materials (ASTM)
13.D.1.8 American Welding Society (AWS)
13.D.1.9 Gas Processors Association (GPA)
13.D.1.10 International Code Council (ICC)
13.D.1.11 International Electrotechnical Commission (IEC)
13.D.1.12 Institute of Electrical and Electronics Engineers (IEEE)
13.D.1.13 International Society of Automation (ISA)[106]
13.D.1.14 National Association of Corrosion Engineers (NACE)
13.D.1.15 National Electrical Manufacturers Association (NEMA)
13.D.1.16 National Fire Protection Association (NFPA)
13.D.1.17 Oil Companies International Marine Forum (OCIMF)
13.D.1.18 Society of International Gas Tanker and Terminal Operators (SIGTTO)
13.D.1.19 Steel Structures Painting Council (SSPC)
13.D.1.20 Tubular Exchanger Manufacturers Association (TEMA)
13.D.1.21 Underwriter Laboratories (UL)

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[104] 18 CFR §380.12(m), 18 CFR §380.12(m)(1), 18 CFR §380.12(m)(3) thru (5), 18 CFR §380.12(o)(7), 18 CFR §380.12(o)(8), 18 CFR §380.12(o)(12), 18 CFR §380.12(o)(14).

[105] For multiple codes and standards, applicants can summarize editions (e.g. latest edition at time of application unless otherwise noted).

[106] Previously, Instrumentation Systems and Automation Society.

## 13.E APPENDIX 13.E, ENGINEERING DESIGN INFORMATION[107]

### 13.E.1 Block Diagram of Facilities

**PROVIDE** up-to-date overall schematics of the project facilities. Block Diagrams should show all major systems and should be legible.

### 13.E.2 Process Flow Diagrams

**PROVIDE** up-to-date diagrams of the facilities. Process flow diagrams should show all major process equipment and conditions used as the basis for equipment design. The diagrams should be keyed to the material and energy balances. At a minimum, the process flow diagrams should show stream designations upstream and downstream of each major piece of process equipment, including but not limited to:

13.E.2.1 Pipelines
13.E.2.2 Acid gas removal units
13.E.2.3 Mercury removal units
13.E.2.4 Dehydrators
13.E.2.5 Distillation columns
13.E.2.6 Fired heaters
13.E.2.7 Compressors
13.E.2.8 Pumps
13.E.2.9 Heat exchangers
13.E.2.10 Storage containers
13.E.2.11 Transfer areas

### 13.E.3 Utility Flow Diagrams

**PROVIDE** up-to-date diagrams of the facilities. Utility flow diagrams should show all major plant utility equipment and conditions used as the basis for equipment design. At a minimum, the utility flow diagrams should show stream designations upstream and downstream of each major piece of utility equipment including but not limited to:

13.E.3.1 Instrument air
13.E.3.2 Plant air
13.E.3.3 Nitrogen
13.E.3.4 Service water
13.E.3.5 Potable water
13.E.3.6 Steam

[107] 18 CFR §380.12(m), 18 CFR §380.12(m)(1), 18 CFR §380.12(m)(3) thru (5), 18 CFR §380.12(o)(1), 18 CFR §380.12(o)(6) thru (8), 18 CFR §380.12(o)(10), 18 CFR §380.12(o)(14).

### 13.E.4 Heat and Material Balances

**PROVIDE** up-to-date heat and material balances of the facilities. heat and material balances should be included for each operating mode (e.g., holding, loading, unloading, liquefying, vaporizing, etc.) and range of compositions and conditions that give the maximum and minimum operating parameters. The heat and material balances should include:

13.E.4.1 Design rating case
13.E.4.2 Average composition, average ambient conditions
13.E.4.3 Lean composition, cold ambient conditions
13.E.4.4 Lean composition, warm ambient conditions
13.E.4.5 Rich composition, cold ambient conditions
13.E.4.6 Rich composition, warm ambient conditions

### 13.E.5 Piping and Instrumentation Drawings

**PROVIDE** up-to-date drawings of the facilities. P&IDs should be included with a Master Drawing List, Legends and Symbols with Drawing Labeling Conventions, and Drawing Revision Number and Dates. The piping legend and symbol key should be in accordance with accepted practice (e.g., ISA 5.1). At a minimum, the P&IDs should include:

13.E.5.1 All equipment, including packaged equipment, labeled with tag number, name, size, duty, capacity and design conditions

13.E.5.2 All equipment power devices, controls, and monitoring, including motor type and local or remote operation and instrumentation

13.E.5.3 All equipment insulation and pipe connections and penetrations with size and pertinent interior arrangement (e.g. trays, weirs, demisters) and labeled nozzles or nozzle schedule

13.E.5.4 All piping, including vent, drain, cooldown and recycle piping, labeled with line number, piping class spec, size and insulation

13.E.5.5 All special notes indicating minimum or maximum slopes, distances, straight lengths, no pockets, and symmetrical arrangements

13.E.5.6 All reducers, including eccentric or concentric

13.E.5.7 All flanges, including isolation flanges, insulating flanges, and blinds

13.E.5.8 All valves including control, isolation, check, vent, drain, and others for operation, start-up, and maintenance, labeled with tag number, type, valve operator type, normal position, and fail position

13.E.5.9 All car seals and locks

13.E.5.10 All instrumentation, including local, panel, and control room, with tag number, type, control loops, and software connections

13.E.5.11 All shutdown interlocks

13.E.5.12 All relief devices, including depressurization valves, vacuum relief valves, pressure relief valves, rupture discs, and rupture pins, labeled with tag number, set point, valve inlet and outlet piping size

13.E.5.13 All breaks and limits, including piping spec breaks and insulation limits, and battery limits between parties (e.g. contractor and vendor)

### 13.E.6 Plant and Equipment Layouts

**PROVIDE** overall plot plans, unit plot plans, and elevation drawings. Overall project plot plans should show owned/leased property lines, the location of all major components to be installed, as listed below. Unit plot plans should be included for each process area or system and should show the locations of all equipment and piperacks. Each area and piece of equipment should be clearly labeled. The unit plot plans should be detailed enough to allow for measurement of distances between various components to verify the safe spacing of all equipment and buildings as required by federal regulations and other codes and standards. Specifically, the smallest scale used should be 1-inch to 100-feet (1:1200). Elevation drawing should be included for each process area and should show the elevations of all major process equipment and major pipe racks.

Consideration should be given for allowing clearance above, below, and between equipment for planning access and maintenance, including access to manual valves; calibration of instrumentation and hazard detection; lifting arrangements for pumps, heavy valves, and other equipment; pulling heat exchanger tube bundles; and labeling, painting, and cleaning piping.

13.E.6.1 Overall project plot plans

- 13.E.6.1.1 Feed gas pipeline metering station
- 13.E.6.1.2 Feed gas pretreatment equipment
- 13.E.6.1.3 Heavies/condensates removal columns, storage, and sendout
- 13.E.6.1.4 NGL fractionation columns, storage, and sendout
- 13.E.6.1.5 Refrigerant systems and storage
- 13.E.6.1.6 Liquefaction equipment

13.E.6.1.7 Marine facilities
13.E.6.1.8 Long transfer piping
13.E.6.1.9 LNG storage
13.E.6.1.10 Truck transfer areas
13.E.6.1.11 Pumps
13.E.6.1.12 LNG vaporizers
13.E.6.1.13 Btu stabilization equipment
13.E.6.1.14 Compressors and blowers
13.E.6.1.15 Boil-off gas recondensation
13.E.6.1.16 Vent stacks and flare stacks
13.E.6.1.17 Sendout metering (gas and liquids)
13.E.6.1.18 Buildings
13.E.6.1.19 Power generation
13.E.6.1.20 Major utility systems
13.E.6.1.21 Auxiliary and appurtenant service facilities
13.E.6.1.22 Emission control equipment
13.E.6.1.23 Spill impoundments and dikes
13.E.6.1.24 Fire water systems and storage
13.E.6.1.25 Access and egress roads, access control, emergency routing
13.E.6.1.26 Property and fence lines
13.E.6.1.27 Tie-in points
13.E.6.1.28 Any other significant equipment or features

13.E.6.2 Unit plot plans

13.E.6.3 Section and elevation drawings of major equipment, pipe racks, and typical piping support system

13.E.6.4 Three dimensional plant model*

### 13.E.7 Plant Reliability, Availability, and Maintainability (RAM) Analyses*

**PROVIDE** copies of any conducted plant RAM analyses. At a minimum, the RAM analyses should support the guarantee conditions, if known, or design conditions and should justify the number of docks, liquefaction equipment, tanks, vaporizers, and sparing philosophy of rotating equipment, relief valves, and other critical equipment. Consideration should be given to the preventive and routine maintenance, storage/warehousing philosophy, and obsolescence plans for the life of the facilities.

## 13.F APPENDIX 13.F, SPECIFICATIONS[108]

### 13.F.1 Civil Specifications

**PROVIDE** a list of the specifications that would be used to design, construct and test the facilities prior to initial operation. Specifications to clarify the proposed design should include:

13.F.1.1 Site preparation specifications

13.F.1.1.1 Excavation
13.F.1.1.2 Fill and backfill
13.F.1.1.3 Stabilization
13.F.1.1.4 Trenching
13.F.1.1.5 Dewatering
13.F.1.1.6 Stormwater and sewers
13.F.1.1.7 Other site preparation specifications

13.F.1.2 Design load specifications

13.F.1.2.1 Live*
13.F.1.2.2 Dead*
13.F.1.2.3 Operational*
13.F.1.2.4 Seismic[109]
13.F.1.2.5 Wind
13.F.1.2.6 Storm surge
13.F.1.2.7 Tsunami
13.F.1.2.8 Snow and ice
13.F.1.2.9 Impact
13.F.1.2.10 Blast
13.F.1.2.11 Thermal*
13.F.1.2.12 Transport*
13.F.1.2.13 Erection/construction*
13.F.1.2.14 Load combinations and factors
13.F.1.2.15 Other design load specifications

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[108] 18 CFR §380.12(m), 18 CFR §380.12(m)(1), 18 CFR §380.12(m)(3) thru (5), 18 CFR §380.12(o)(5), 18 CFR §380.12(o)(7), 18 CFR §380.12(o)(8), 18 CFR §380.12(o)(14), 18 CFR §380.12(o)(15).

[109] Provide seismic specifications for Seismic Category I, II, and III equipment items that are to be procured. Separate specifications can be provided for Seismic Category I, II, and III items and/or other subsets of equipment as deemed practicable. Seismic Category I seismic specifications should be in accordance with NBSIR 84-2833 and Seismic Category II and III equipment items should be in accordance with ASCE 7-05.

13.F.1.3 Piling specifications

13.F.1.4 Foundation mat/slab specifications

13.F.1.5 Marine platform specifications

13.F.1.6 Structural steel specifications

13.F.1.7 Building specifications

13.F.1.7.1 Control buildings
13.F.1.7.2 Electrical buildings
13.F.1.7.3 Compressor buildings
13.F.1.7.4 Storage buildings
13.F.1.7.5 Pressurized buildings
13.F.1.7.6 Ventilated buildings
13.F.1.7.7 Blast resistant buildings

13.F.1.8 Other civil specifications

### 13.F.2 Mechanical Specifications

**PROVIDE** a list of the specifications that would be used to design, construct and test the facilities prior to initial operation. Specifications to clarify the proposed design should include:

13.F.2.1 Piping specifications

13.F.2.1.1 General piping
13.F.2.1.2 Process piping
13.F.2.1.3 Vacuum insulated piping
13.F.2.1.4 Branch connections
13.F.2.1.5 Flanged connections
13.F.2.1.6 Pipe supports and pipe racks
13.F.2.1.7 Other piping specifications

13.F.2.2 Valve specifications

13.F.2.2.1 Control valves
13.F.2.2.2 Pressure regulators
13.F.2.2.3 Remotely actuated valves
13.F.2.2.4 Emergency shutdown (ESD) valves
13.F.2.2.5 On/Off or isolation valves
13.F.2.2.6 Pressure relief valves
13.F.2.2.7 Vacuum relief valves

13.F.2.2.8 Check valves
13.F.2.2.9 Firesafe valves
13.F.2.2.10 Other valves

13.F.2.3 Insulation specifications

13.F.2.3.1 Hot insulation
13.F.2.3.2 Cold insulation
13.F.2.3.3 Cryogenic insulation
13.F.2.3.4 Fireproofing insulation
13.F.2.3.5 Other insulation specifications

13.F.2.4 Rotating equipment specifications*

13.F.2.4.1 Canned pumps
13.F.2.4.2 Centrifugal pumps
13.F.2.4.3 Vertical turbine pumps
13.F.2.4.4 Reciprocating compressors
13.F.2.4.5 Centrifugal compressors
13.F.2.4.6 Other rotating equipment specifications

13.F.2.5 Heat exchanger specifications*

13.F.2.5.1 Submerged combustion exchangers
13.F.2.5.2 Shell and tube exchangers
13.F.2.5.3 Ambient air exchangers
13.F.2.5.4 Fin-fan exchangers
13.F.2.5.5 Plate exchangers
13.F.2.5.6 Direct-fired heaters
13.F.2.5.7 Distillation columns
13.F.2.5.8 Other heat exchanger specifications

13.F.2.6 Storage tank and vessel specifications

13.F.2.6.1 Non-LNG atmospheric storage tanks[110]
13.F.2.6.2 Internal floating roof storage tanks
13.F.2.6.3 External floating roof storage tanks
13.F.2.6.4 Fixed roof storage tanks
13.F.2.6.5 Pressure vessels
13.F.2.6.6 Other storage tank and vessel specifications

[110] LNG atmospheric storage tank specifications should be provided in Appendix 13.L.1.

13.F.2.7 Other specialized equipment specifications

13.F.2.7.1 Filters and coalescers
13.F.2.7.2 Pig traps
13.F.2.7.3 Vent stacks
13.F.2.7.4 Flare stacks
13.F.2.7.5 Flame arrestors
13.F.2.7.6 Transfer arms/hoses
13.F.2.7.7 Other specialized equipment specifications

### 13.F.3 Electrical and Instrumentation Specifications

**PROVIDE** a list of the specifications that would be used to design, construct and test the facilities prior to initial operation. Specifications to clarify the proposed design should include:

13.F.3.1 Power system specifications

13.F.3.1.1 Switchgear
13.F.3.1.2 Transformers
13.F.3.1.3 Uninterruptible power supply (UPS)
13.F.3.1.4 Other power system specifications

13.F.3.2 Control system specifications

13.F.3.2.1 Basic process control system
13.F.3.2.2 Flow measurement
13.F.3.2.3 Level measurement
13.F.3.2.4 Pressure measurement
13.F.3.2.5 Temperature measurement
13.F.3.2.6 Gas concentration measurement
13.F.3.2.7 Human machine interface (HMI)
13.F.3.2.8 Other control system specifications

13.F.3.3 Safety instrument system (SIS) specifications

13.F.3.4 Cable specifications

13.F.3.4.1 Power cables*
13.F.3.4.2 Instrumentation cables*
13.F.3.4.3 Cable tray specification*
13.F.3.4.4 Fire resistant cable
13.F.3.4.5 Electric and instrument cable seals
13.F.3.4.6 Other cable specifications*

13.F.3.5 Other electrical and instrumentation specifications

13.F.3.5.1 Electrical heat tracing
13.F.3.5.2 Grounding and earthing
13.F.3.5.3 Other electrical and instrumentation specifications

## 13.F.4 Security and Fire Safety Specifications

**PROVIDE** a list of the specifications that would be used to design, construct and test the facilities prior to initial operation. Specifications to clarify the proposed design should include:

13.F.4.1 Security Specifications

13.F.4.1.1 Lighting
13.F.4.1.2 Fencing
13.F.4.1.3 Access control
13.F.4.1.4 Vehicular barriers
13.F.4.1.5 Intrusion monitoring systems
13.F.4.1.6 Intrusion detection systems
13.F.4.1.7 Other security system specifications

13.F.4.2 Passive Protection Specifications

13.F.4.2.1 Spill containment
13.F.4.2.2 Cryogenic structural protection
13.F.4.2.3 Vapor barriers
13.F.4.2.4 Blast walls and hardened structures
13.F.4.2.5 Fireproofing/fire insulation
13.F.4.2.6 Mounding
13.F.4.2.7 Fire walls and radiant heat shields
13.F.4.2.8 Other passive protection specifications

13.F.4.3 Hazard Detection Specifications

13.F.4.3.1 Low temperature detectors
13.F.4.3.2 Oxygen deficiency detectors
13.F.4.3.3 Toxic gas detectors
13.F.4.3.4 Flammable/combustible gas detectors
13.F.4.3.5 Flame detectors
13.F.4.3.6 Heat and high temperature detectors
13.F.4.3.7 Smoke or products of combustion detectors
13.F.4.3.8 Manual pull stations
13.F.4.3.9 Audible and visual notification systems for field, control room, plant wide, and offsite

13.F.4.3.10 Other hazard detector specifications

13.F.4.4 Hazard control specifications

13.F.4.4.1 Portable fire extinguishers
13.F.4.4.2 Fixed dry chemical systems
13.F.4.4.3 Clean agent systems
13.F.4.4.4 Carbon dioxide systems
13.F.4.4.5 Other hazard control system specifications

13.F.4.5 Fire water specifications

13.F.4.5.1 Fire water piping
13.F.4.5.2 Fire hydrants
13.F.4.5.3 Fire monitors
13.F.4.5.4 Fire hose
13.F.4.5.5 Water curtains
13.F.4.5.6 Deluge systems
13.F.4.5.7 Sprinkler systems
13.F.4.5.8 Mist systems
13.F.4.5.9 Foam system
13.F.4.5.10 Other fire water system specifications

## 13.G APPENDIX 13.G, HAZARD IDENTIFICATION[111]

### 13.G.1 Process Hazard Analyses and Recommendations

**PROVIDE** copies of preliminary process hazard analysis (PHA) design reviews. The PHA should include lists of the recommendations and status of implementation. The design reviews should, at a minimum, include the requirements for siting, equipment layout and spacing, process controls, and ignition controls applicable during all phases of commissioning, startups, shutdowns, operation and maintenance. Recommendations resulting from the PHA (e.g., HAZID and/or preliminary HAZOP) reviews performed during the FEED phase of the project should be included in the design submitted with the application. The PHA should list the participants and years of relevant experience.

### 13.G.2 Simultaneous Operation Studies

**PROVIDE** descriptions or plans to develop any Simultaneous Operations (SIMOPS) studies to be used during project construction near operational facilities or during phased startup of multiple project stages.

### 13.G.3 Waterway Safety and Reliability Impact Studies[112]

**PROVIDE** an analysis that addresses potential safety and reliability impacts of proposed LNG vessels (i.e., LNG carriers, LNG barges, etc.) loaded or unloaded at the project facilities and from current commercial and recreational waterway traffic with reference to other Resource Reports (e.g. Resource Report 8). The safety and reliability analysis should include studies that take into account tides, currents, waves, winds, ice, visibility, day/night conditions, passing vessels direction, passing vessels sizes and speeds, and LNG vessel sizes and speeds. An evaluation of the LNG vessel transit route and berthing should be provided that includes local pilot participation and comments and that addresses:

13.G.3.1 Potential occurrence, potential effects, and mitigation of watercraft alliding and colliding with the transiting LNG vessel, moored LNG vessel, and marine facilities

13.G.3.2 Potential occurrence, potential effects, and mitigation for LNG vessel grounding, alliding, and colliding with ground, marine platform and coastal structures, and other watercraft based on LNG vessel route,

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[111] 18 CFR §380.12(m), 18 CFR §380.12(m)(1), 18 CFR §380.12(m)(3) thru (5), 18 CFR §380.12(o)(7), 18 CFR §380.12(o)(8), 18 CFR §380.12(o)(14).

[112] Waterway Suitability Assessments submitted to Coast Guard in accordance with 18 CFR §157.21(a)(1), 18 CFR §157.21(f)(13), 33 CFR §127.007, and Navigation and Vessel Inspection Circular (NVIC) 01-2011, Guidance Related to Waterfront Liquefied Natural Gas Facilities may satisfy Waterway Safety and Reliability Impact Studies in Appendix 13.G.3. This material may include Critical Energy Infrastructure Information (CEII), Security Sensitive Information (SSI), or Chemical-Terrorism Vulnerability Information (CVI) and must comply with all applicable regulations.

shipping channel depths and harbor bottom type, widths, turning basins, and berthing arrangement

13.G.3.3 Tug requirements, security escorts, and speed limits to safely and securely transport, berth, and unberth LNG vessel

13.G.3.4 Maneuvers to berth and unberth LNG vessel

13.G.3.5 Hydrodynamic effect of slips on passing vessels

13.G.3.6 Hydrodynamic effect of passing ships on moored LNG vessels

13.G.3.7 Potential occurrence, potential effects, and mitigation for intentional acts involving LNG vessel during transit and marine transfer

### 13.G.4 Road Safety and Reliability Impact studies

**PROVIDE** an analysis that addresses potential safety and reliability impacts from proposed tanker trucks loaded or unloaded at the project facilities and from commercial and recreational roadway traffic with reference to other Resource Reports (e.g. Resource Report 8). The safety and reliability analysis should include studies that take into account visibility, day/night conditions, passing vehicle direction, passing vehicle contents, sizes, and speeds, and tanker truck contents, sizes, and speeds. An evaluation of external and internal roadways at the project site should be included that addresses:

13.G.4.1 Potential occurrence, potential effects, and mitigation of vehicles and proposed tanker trucks' impacts, such as collisions from vehicles on external roadways

13.G.4.2 Potential occurrence, potential effects, and mitigation for collisions of vehicle and tanker trucks with other vehicles and equipment based on entrances, routes, road grades, road widths, turn around areas, and exit ways within the plant

13.G.4.3 Vehicle and tanker trucks access control, vehicle barriers, bollards, clearance heights, and speed limits to safely and securely receive, load, and unload tanker trucks

13.G.4.4 Potential occurrence, potential effects, and mitigation for intentional acts involving tanker trucks during transit and truck transfer.

### 13.G.5 Rail Safety and Reliability Impact Studies

**PROVIDE** an analysis that addresses potential safety and reliability impacts from proposed rail cars loaded or unloaded at the project facilities and from current commercial and passenger rail traffic with reference to other Resource Reports (e.g. Resource Report 8). The safety and reliability analysis should include studies that take into account visibility, day/night conditions, frequency, passing rail car direction, contents, sizes, and speeds. An evaluation of external and internal railways at the project site should be provided that addresses:

13.G.5.1 Potential occurrence, potential effects, and mitigation of rail cars on railways outside the plant accidentally colliding with the facilities

13.G.5.2 Potential occurrence, potential effects, and mitigation of rail car derailments and collisions with equipment based on rail car entrances, routes, grades, switchyards, and exit ways within the plant

13.G.5.3 Rail car access control, barriers, clearance heights, and speed limits to safely and securely receive, load, and unload rail cars

13.G.5.4 Potential occurrence, potential effects, and mitigation for intentional acts involving rail cars during transit and rail transfer

### 13.G.6 Air Safety and Reliability Impact studies

**PROVIDE** an analysis that addresses potential safety and reliability impacts from current commercial, military, and recreational air traffic near the facility and along the LNG vessel route. with reference to other Resource Reports (e.g. Resource Report 8). The safety and reliability analysis should include studies that take into account visibility, day/night conditions, flight paths, and aircraft sizes and speeds. An evaluation of facility equipment (including construction equipment) and LNG vessel heights should be included that addresses:

13.G.6.1 Potential occurrence, potential effects, and mitigation of an aircraft accidentally colliding with the facilities or LNG vessels.

13.G.6.2 Potential occurrence, potential effects, and mitigation for intentional acts involving aircraft during transit to airports.

## 13.G.7 Crane and Lifting Impact studies

**PROVIDE** an analysis that addresses potential safety and reliability impacts from cranes and lifting devices within the facility from construction and maintenance activities. The analysis should include the location, capacity, size, and lifting paths of all crane and other lifting devices and discuss the use of mobile lifting equipment and any procedures or provisions to minimize impact. The analysis should include the weight of equipment to be lifted, lifting path and height, and should address:

13.G.7.1 Potential occurrence, potential effects, and mitigation of slips and drops from a crane or lifting device impacting the facilities or LNG vessels.

13.G.7.2 Potential occurrence, potential effects, and mitigation of cranes accidentally colliding with the facilities or LNG vessels (e.g., extended bucket trucks colliding with overhead piperacks).

## 13.G.8 Security Threat and Vulnerability Analyses[113]

**PROVIDE** security related drawings and any associated security threat and vulnerability analyses. At a minimum, the security threat and vulnerability analysis should cover the potential physical and cyber security threats and vulnerability of the facility and related transportation. At a minimum, drawings should include:

13.G.8.1 Security fencing, site and onsite access control, bollard, vehicle barrier, and other physical barrier layout and drawings

13.G.8.2 Lighting layout and drawings

13.G.8.3 Intrusion monitoring (e.g., camera) and intrusion detection layout and drawings

[113] Security Threat and Vulnerability Information prepared for or submitted to Coast Guard in accordance with 33 CFR §105.305 or prepared for or submitted to Department of Homeland Security (DHS) in accordance with 6 CFR §27.215 may satisfy Security Threat and Vulnerability Analyses in Appendix 13.G.8. This material may include Critical Energy Infrastructure Information (CEII), Security Sensitive Information (SSI), or Chemical-Terrorism Vulnerability Information (CVI) and must comply with all applicable regulations.

## 13.H APPENDIX 13.H, HAZARD ANALYSES[114]

### 13.H.1 Safety Data Sheets

**PROVIDE** safety data sheets for hazardous materials that would be stored, processed, and handled at the facility and transported to or from the facility.

### 13.H.2 Hazardous Release List

**PROVIDE** a full list of considered hazardous releases and the bounding scenarios for all hazardous fluids areas[115]. A piping and equipment inventory table of LNG plant components in hazardous or flammable fluid service should be provided. The piping and equipment inventory table should be submitted in Excel (*.XL*) format. Separate tabs or lists should be used for each type of hazardous fluid, as well as a separate tab or list to present all of the final selections. At a minimum, the list should include:

13.H.2.1 Line segment or component number to identify potential releases

13.H.2.2 Hazardous fluid service (LNG, natural gas, refrigerants [such as ammonia, propane, ethane, mixed refrigerant]), natural gas liquids or gas condensate, hydrogen sulfide, benzene, etc.) for each component

13.H.2.3 General plant area or service (e.g. liquefaction train, refrigerant storage, marine area, etc.), unless the entire project is confined to one area

13.H.2.4 Unit plot plan drawing number reference(s) for each component

13.H.2.5 Beginning point location (e.g., exchanger outlet flange) for each line

13.H.2.6 Ending point location (e.g., pump suction nozzle) for each line

13.H.2.7 P&IDs and drawing number reference(s) for each component

13.H.2.8 Piping line designation or equipment tag number on P&ID

13.H.2.9 Pipe diameter or pipe size, volume of container, or size of equipment

13.H.2.10 Length of piping (feet and meters) or number of components (each)

13.H.2.11 Maximum connection diameter in the piping segment

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[114] 18 CFR §380.12(m), 18 CFR §380.12(m)(1), 18 CFR §380.12(m)(3) thru (5), 18 CFR §380.12(o)(14).

[115] Refer to PHMSA's LNG Plant Requirements: Frequently Asked Questions http://primis.phmsa.dot.gov/lng/faqs.htm (visited September, 20, 2016) ..

13.H.2.12 Failure type or mode selected from the failure rate table

13.H.2.13 Corresponding nominal failure rates per meter or unit

13.H.2.14 Calculated failure rate based on pipe length or number of units and failure rates per meter or unit listed in the failure rate table

13.H.2.15 Comparison of calculated failure rate to a failure rate criterion of $3x10^{-5}$ failures per year

13.H.2.16 Process or storage conditions (e.g., fluid phase [liquid or vapor], density [$lb/ft^3$], pressure [psig], temperature [°F], flow rate, [lb/hr], compositions)

13.H.2.17 Process flow diagram and corresponding heat and material balance stream number

13.H.2.18 Heat and material design case (e.g., rich, lean, average, etc.)

13.H.2.19 Calculated equivalent hole size based on failure modes listed in the failure rate table

13.H.2.20 Calculated release flow rates

13.H.2.21 Scenarios selected with release duration, de-inventory duration, height, direction, orientation, rainout percentage, flashing and jetting vapor mass flow rate, pool vaporization mass flow rate, and total vapor mass flow rate

### 13.H.3 Hazard Analysis Reports

**PROVIDE** hazard analysis report(s) detailing the governing release scenarios and sensitivity tests (e.g., hole size, wind speed, and site-specific conditions) to evaluate hot and cold temperature hazards, asphyxiant and toxic dispersion hazards, flammable vapor dispersion hazards, VCE, BLEVE, and pressure vessel burst (PVB) overpressure hazards, fireball, pool fire, jet fire, and fireball radiant heat hazards from releases and cascading events.[116] Input and Output files should accompany all modeling runs. The hazard analysis

[116] Hazards that extend offsite should describe the impacts to: (1) populated areas, including number of people, residential communities, business districts, schools, day care centers, religious facilities, and recreational facilities; (2) transportation infrastructure, including roads and highways, railroads and rail yards, pipelines, electric lines, marinas, airports, space launch sites; (3) industrial facilities, including power plants, nuclear facilities, wastewater facilities, and other hazardous facilities; (4) public health and safety facilities, including police and fire departments, and hospitals; and (5) military facilities, including military bases, test sites, and research areas.

report should also discuss whether the safety and reliability of the proposed LNG facilities could be impacted by adjacent facilities, operations, or potential hazardous releases.

### 13.H.4 Meteorological Data

**PROVIDE** meteorological data supporting the wind speed, atmospheric temperature, and humidity used in all hazard analyses. At a minimum, the meteorological data should be representative of the site and should cite the source of the weather data.

## 13.I APPENDIX 13.I, NATURAL HAZARD DESIGN INVESTIGATIONS AND FORCES[117]

### 13.I.1 Earthquakes

13.I.1.1 Seismic evaluation

**PROVIDE** a seismic hazard evaluation for the LNG project site. Include all supporting information and data for the seismic hazard evaluation of the site and seismic design of the proposed project as specified in NBSIR 84-2833, 49 CFR Part 193, and incorporated NFPA 59A and ASCE 7 Standards. At a minimum, the Seismic Hazard Evaluation should address geologic and seismic setting, seismic hazard investigation. The geologic and seismic setting should include the project site's local geologic and seismic setting including faults and seismic sources. Both seismic and growth faults should be investigated and addressed including recommendations for design vertical and horizontal offset and fault orientations were facilities or pipelines cross faults. The seismic hazard evaluation should include site-specific determinations of the MCE, DE, SSE ,OBE, and the ALE. The SSE and OBE should be based on 49 CFR Part 193 and the incorporated NFPA 59A Standard. As such, the SSE is taken equivalent to the MCE as determined in accordance with the site-specific procedures of the incorporated ASCE 7 and the OBE is taken as the ground motion with a 10% probability of exceedance within a 50-year period (475-year return period). The seismic hazard evaluation should also include detailed assessments of surface rupture and fault offset displacements including recommended offset values to be considered for design. If present, the following should be addressed in detail with estimated settlements without and with proposed ground improvement: liquefaction potential, liquefaction-related settlement, potential for sand boils and other surface manifestation of liquefaction, lateral spreading, seismic slope stability, seismic compaction, and need for ground improvement to mitigate liquefaction hazard,. Recommended values to be considered for design after ground improvement should also be included. Seismic Categories should include detailed description, sizes, loads, and relative locations and designate the Seismic Category I, II, or III of major structures such as LNG tanks, containment systems, buildings, storage tanks, vaporizers, liquefaction trains, power plant structures, and other plant components including unloading and

[117] 18 CFR §380.12(m), 18 CFR §380.12(m)(1), 18 CFR §380.12(m)(3) thru (5), 18 CFR §380.12(o)(7), 18 CFR §380.12(o)(8), 18 CFR §380.12(o)(14), 18 CFR §380.12(o)(15).

docking facilities. Reference should be made to the Geotechnical Investigation in Appendix 13.J. See Attachment 3 for more details.

13.I.1.1.1 Geologic and seismic setting

13.I.1.1.2 Development of design earthquakes

13.I.1.1.3 MCE site-specific ground motion spectral values for 5% damping

13.I.1.1.4 DE site-specific ground motion spectral values for 5% damping and ground motion parameters, $S_{DS}$, $S_{D1}$, $S_{MS}$, $S_{M1}$, $T_L$

13.I.1.1.5 SSE site-specific ground motion spectral values for 5% damping

13.I.1.1.6 OBE site-specific ground motion spectral values for 5% damping

13.I.1.1.7 ALE site-specific ground motion spectral values for 5% damping

13.I.1.1.8 At locations crossing active faults, design surface fault offsets (horizontal and vertical) and fault orientations

13.I.1.1.9 At locations where crossing growth faults, design offsets for growth faults: Provide design fault offsets for growth faults (horizontal and vertical) for the design life of the facilities and fault orientations

13.I.1.1.10 Ground motions and frequencies of earthquakes at site location.

13.I.1.1.11 Sloshing freeboard

13.I.1.1.12 Ground motion detection systems that alarm and shutdown.

13.I.1.2 Seismic Categories of LNG facility structures, components, equipment and systems

**PROVIDE** the Seismic Category assignments for all LNG facility structures, components, equipment, and systems associated with the project. The seismic category assignments should be all-inclusive and should be in accordance with the definitions provided in NBSIR 84-

2833. If only a portion of structures and systems are Category I or II, they should be listed and, where necessary for clarity, the boundaries of Category I and II portions should be shown on piping and instrumentation drawings. An example of a categorized list for an LNG project is included in Attachment 4.

13.I.1.2.1 List of structures, systems and components classified as Seismic Category I

13.I.1.2.2 List of structures, systems and components classified as Seismic Category II.

13.I.1.2.3 List of structures, systems and components classified as Seismic Category III.

13.I.1.3 Seismic design basis and criteria of LNG facility structures, components, equipment and systems

**PROVIDE** the Seismic Category design basis and criteria for all Seismic Categories. The seismic design basis and criteria for Seismic Category I, II, or III structures, components, equipment and systems should include information or references needed to perform a design including design response spectra, seismic design coefficients, load combinations, damping values, damping value reduction factors, ductility or inelastic reduction factors to be used with the OBE and SSE, the allowable stresses, strength capacities and φ-factors for each load combination, intended methods of analysis, building codes and material standards to be used and all other criteria necessary to perform the design of each structure, component, and system. The seismic design criteria should, at a minimum, satisfy 49 CFR Part 193 and the incorporated edition of NFPA 59A. Items to be considered in preparing the seismic design criteria documents are included in Attachment 5. The seismic design criteria should also include the incorporated ASCE 7 design earthquake seismic coefficients and seismic design parameters that should be used in the design of structures, systems and components that are assigned Seismic Category II and III. In addition, In addition, the criteria should consider the guidance included in NBSIR 84-2833 and the following:

13.I.1.3.1 Seismic Category I design basis and criteria, including

13.I.1.3.1.1 SSE and OBE response spectra

13.I.1.3.1.2 Damping values, ductility or inelastic reduction factors (if any), to be used with SSE and OBE

13.I.1.3.1.3 Load combinations, load factors, allowable stress or capacity increases (if any), and angle of internal friction ($\phi$)-factors for each load combination

13.I.1.3.1.4 Intended methods of analysis

13.I.1.3.1.5 Codes and standards and specifications that are intended to be used and all other criteria necessary to perform the seismic design of each Seismic Category I structure, component, equipment, and system.

13.I.1.3.2 Seismic Category II design basis and criteria

13.I.1.3.2.1 MCE and DE response spectra

13.I.1.3.2.2 Ground motion seismic design parameters

13.I.1.3.2.3 Occupancy classification to individual structures and non-building structures

13.I.1.3.2.4 Seismic design category assigned to individual structures and non-building structures

13.I.1.3.2.5 The importance factors for structures, non-building structures and nonstructural components and systems

13.I.1.3.2.6 The inelastic seismic coefficients for structures, non-building structures and nonstructural components and systems

13.I.1.3.2.7 Load combinations, load factors, allowable stress or capacity increases (if any) and ($\phi$)-factors for each load combination

13.I.1.3.2.8 Intended methods of analysis

13.I.1.3.2.9 Codes and standards and specifications that are intended to be used and all other criteria necessary to perform the seismic design of each Seismic Category II structure, component, equipment and system.

13.I.1.3.3 Seismic Category III design basis and criteria

13.I.1.3.3.1 MCE and DE response spectra

13.I.1.3.3.2 Ground motion seismic design parameters

13.I.1.3.3.3 Occupancy classification to individual structures and non-building structures

13.I.1.3.3.4 Seismic design category assigned to individual structures and non-building structures

13.I.1.3.3.5 The importance factors for structures, non-building structures and nonstructural components and systems

13.I.1.3.3.6 The inelastic seismic coefficients for structures, non-building structures and nonstructural components and systems

13.I.1.3.3.7 Load combinations, load factors, allowable stress or capacity increases (if any) and ($\phi$)-factors for each load combination

13.I.1.3.3.8 Intended methods of analysis

13.I.1.3.3.9 Codes and standards and specifications that are intended to be used and all other criteria necessary to perform the seismic design of each Seismic Category III structure, component, equipment and system.

13.I.1.3.4 Hazardous fluid piping design basis and criteria

13.I.1.3.4.1 The OBE response spectra and seismic parameter $S_{DS}$

13.I.1.3.4.2 Load combinations, load factors, allowable stress or capacity increases (if any) and ($\phi$)-factors for each load combination

13.I.1.3.4.3 Intended methods of analysis

13.I.1.3.4.4 Codes and standards and specifications that are intended to be used and all other criteria necessary to perform the seismic design of each Seismic Category III structure, component, equipment, and system.

13.I.1.3.5 Provide seismic criteria for small LNG containers with capacities less than 70,000 gallons. The criteria should satisfy the seismic requirements of federal regulations including 49 CFR Part 193 and any incorporations by reference. The criteria should include:

13.I.1.3.5.1 DE seismic design ground motion parameters occupancy classification to individual structures and non-building structures

13.I.1.3.5.2 Seismic Category assigned to the containers

13.I.1.3.5.3 The importance factor assigned to the containers

13.I.1.3.5.4 The inelastic seismic coefficients assigned to the containers

13.I.1.3.5.5 Load combinations, load factors, allowable stress or capacity increases (if any) and ($\phi$)-factors for each load combination

13.I.1.3.5.6 Intended methods of analysis

13.I.1.3.5.7 Codes and standards that are intended to be used and all other criteria necessary to perform the seismic design of the small containers.

13.I.1.4 Seismic instrumentation:

**PROVIDE** a description (make and model) of the proposed seismic instrumentation that will be installed at the LNG project site and the location of both the instrument and the sensors. The purpose of the instrumentation is to permit a comparison of measured responses of Seismic Category I structures and selected components against predetermined results of analyses that predict when damage might occur. This also permits plant operators to understand the possible extent of damage within the plant immediately following an earthquake and to be able to determine when an SSE event has occurred that would require the emptying of the tank(s) for inspection as specified in Section 4.1.3.6 (c) of NFPA 59A-2001. If the instrument already exists at the site, include a description of the existing equipment and location of the instrument and the sensors. The seismic instrumentation section should be in accordance with NBSIR 84-2833. Seismic recording instrumentation should be triaxial digital systems that record accelerations versus time accurately for periods between 0 and 10 seconds. Recorders should have rechargeable batteries such that if there is a loss of power, recording will still occur. The instrumentation should be housed in appropriate weather and creature-proofed enclosures. At all LNG facilities, at a minimum, one recorder should be located in the free field mounted on rock or competent ground generally representative of the site. In addition, at sites classified as Seismic Design Category D, E, or F in accordance with Chapter 11 of ASCE 7-05 (assuming Occupancy Category IV) recorders should be located and attached to the foundations and roofs of LNG tanks, and in the control room. The systems should have the capability to also produce response spectra for each recorded time history. At a minimum, the seismic instrumentation information should include:

13.I.1.4.1 Description and basis for selection and location of Seismic Instrumentation that will be installed to provide detection, alarms, emergency response, and post-event

verification of structural integrity in selected Category I structures and on the selected Category I components[118].

13.I.1.4.1.1 Triaxial peak accelerographs
13.I.1.4.1.2 Triaxial time history accelerographs
13.I.1.4.1.3 Triaxial spectrum recorders.

13.I.1.4.2 Control room operator notification

13.I.1.4.2.1 Emergency Response Plans for responding to seismic alarms and data, including reference to post-processed seismic instrumentation data (e.g., peak acceleration or spectral response data).

13.I.1.4.3 Comparison of measured and predicted responses

13.I.1.4.3.1 Criteria and procedures that will be used to compare measured responses of Category I structures and of selected components in the event of an earthquake against the predetermined results of predictive analyses of the seismic system and subsystem

## 13.I.2 Tsunami and Seiche

**PROVIDE** details on the facilities design being proposed to handle potential tsunamis, seiche, or other seismic hydrologic effects (e.g., site elevation, shoreline stabilization, jetty design and operation). Include information to confirm why and how the overall project (LNG storage tanks and critical equipment, cryogenic transfer piping; marine/cargo unloading platforms; primary and emergency electrical power; boil-off gas compression; and control systems) would adequately withstand conditions from potential tsunamis, seiche, or other seismic hydrologic events. Indicate the water-borne debris with their size and speed that the facilities will be designed to withstand. Indicate the procedures that will be used to evaluate whether the design of LNG facilities is adequate. In addition, describe the design water inundation elevations for the project site and their bases for both still water and with wind/wave effects considering site-specific studies. Include all project elevations for dikes, storm surge walls, piers, docks, unloading and loading arms and other pier and dock facilities, and other elevated features of the project, their design basis and demonstrate how they would conform to industry and Federal standards and would protect critical equipment or ensure minimal consequences. Include the historical or scientific

[118] For example, see NRC Regulatory Guide 1.12: Nuclear Power Plant Instrumentation for Earthquakes

basis for wind and storm surge conditions used as design criteria. Compare with 100- and 500-, 1,000-, 2,500- and 10,000-year return period elevations. Include in these elevations the effects of sea level rise and regional subsidence considering the design life of project facilities for time dependent severe natural hazards.

13.I.2.1 Tsunami and seiche design basis and criteria

13.I.2.2 Identification of tsunami and seiche design inundation and run-up elevations and corresponding return periods for all structures, systems, and components

13.I.2.3 Maximum considered tsunami (MCT) inundation and run-up elevations for project site, including the MCE level ground motions at the site if the MCE is the triggering source of the MCT

13.I.2.4 Comparison of design tsunami and seiche water inundation elevations with inundation elevations corresponding to:

13.I.2.4.1 10,000-year return period
13.I.2.4.2 1,000-year return period
13.I.2.4.3 500-year return period
13.I.2.4.4 100-year return period

13.I.2.5 Discussion of inundation and run up elevations and frequencies of tsunamis and other natural hazards at site location

13.I.2.6 Design sea level rise: elevation change to be used in design to account for sea level rise at project site for the design life of the facilities

13.I.2.7 Design regional subsidence: elevation change to be used in design to account for regional subsidence at project site for the design life of the facilities

13.I.2.8 Discussion of co-seismic subsidence/uplift

13.I.2.9 Discussion of expected settlement over the design life of the facilities

### 13.I.3 Hurricanes and Other Meteorological Events

**PROVIDE** details on the facilities design that are being proposed to handle potential regional hurricane activity or other storm effects (e.g., site elevation, shoreline stabilization, jetty design and operation, stormwater management and spill retention). Include information to confirm why and how the overall project (LNG storage tanks and critical equipment, cryogenic transfer piping; marine/cargo unloading platforms; primary and emergency electrical power; boil-off gas compression; and control systems) would

adequately withstand conditions from potential wind and storm surge of hurricanes and similar meteorological events. Describe the design wind speeds (both sustained and 3-second gust) and their basis for all LNG facilities, including LNG containers, LNG containers with capacities less than 70,000 gallons, and all other equipment as required per 49 CFR §193.2067. Supply an all-inclusive list of facilities (structures, systems, equipment and components) that need to be designed for these wind speeds consistent with the PHMSA LNG frequently asked questions (FAQ). Include the codes or standards that were used to convert the design wind speeds into design forces for each wind speed situation. In addition, for each wind speed and situation, include the wind importance factor, allowable stress design (ASD) and Strength Load Combinations, Load Factors and permitted allowable stress increase factors consistent with the codes and standards to be used for design. Indicate the wind-borne debris and their wind speed that will be design per the requirements of 49 CFR §193.2067 and the procedures that will be used to evaluate whether the design of LNG facilities is adequate. In addition, describe the design storm surge elevations for the project site and their basis for both still water and with wind/wave effects conditions considering site-specific studies. Include all project elevations for dikes, storm surge walls, piers, docks, unloading and loading arms and other pier and dock facilities, and other elevated features of the project, their design basis, and demonstrate how they will conform to industry and Federal standards and protect critical equipment or ensure minimal consequences. Include the historical or scientific basis for wind and storm surge conditions used as design criteria. Compare with 100- and 500-, 1,000-, and 10,000-year return period elevations and NOAA storm surge elevations for hurricane prone areas at the site for Category 1, 2, 3, 4 and 5 hurricanes. Include in these elevations the effects of sea level rise and regional subsidence considering the design life of the facilities for time dependent severe natural hazards.

13.I.3.1 Wind and storm surge design basis and criteria

13.I.3.2 Identification of design wind speeds (sustained and 3-second gusts) and corresponding return periods, wind importance factors, and storm surge design elevations for all structures, systems, and components

13.I.3.3 Comparison of design wind speeds (sustained and 3-second gusts) and storm surge (still water, wind/wave run-up effects, crest elevations) with hurricane and other meteorological event wind speeds corresponding to:

13.I.3.3.1 10,000-year return period
13.I.3.3.2 1,000-year return period
13.I.3.3.3 500-year return period
13.I.3.3.4 100-year return period

13.I.3.4 Discussion of wind speeds (sustained and 3-second gusts) and storm surge elevations (still water, wind/wave run-up effects, crest elevations)

and frequencies of hurricanes, and other meteorological events at site location:

13.I.3.4.1 Hurricane Saffir-Simpson Category 5 (>156 mph sustained, >195 mph 3-second gust)

13.I.3.4.2 Hurricane Saffir-Simpson Category 4 (130-156 mph sustained, 166-195 mph 3-second gust)

13.I.3.4.3 Hurricane Saffir-Simpson Category 3 (111-129 mph sustained, 141-165 mph 3-second gust)

13.I.3.4.4 Hurricane Saffir-Simpson Category 2 (96-110 mph sustained, 117-140 mph 3-second gust)

13.I.3.4.5 Hurricane Saffir-Simpson Category 1 (74-95 mph sustained, 91-116 mph 3-second gust)

13.I.3.5 Design sea level rise: elevation change to be used in design to account for sea level rise at project site for the design life of the facilities

13.I.3.6 Design regional subsidence: elevation change to be used in design to account for regional subsidence at project site for the design life of the facilities

13.I.3.7 Discussion of expected settlement over the design life of the facilities

### 13.I.4 Tornados

**PROVIDE** details on the facilities design being proposed to handle potential tornados. Include information to confirm why and how the overall project (LNG storage tanks and critical equipment, cryogenic transfer piping; primary and emergency electrical power; boil-off gas compression; and control systems) would adequately withstand conditions from potential tornados. Describe the design wind speeds (both sustained and 3-second gust) with their design basis for all LNG facilities, including LNG containers, LNG containers with capacities less than 70,000 gallons, and all other equipment. Supply an all-inclusive list of facilities (structures, systems, equipment and components) that would be designed for these wind speeds. Include the codes or standards that were used to convert the design wind speeds into design forces for each wind speed situation. In addition, for each wind speed and situation, include the wind importance factor, allowable stress design (ASD) and Strength Load Combinations, Load Factors and permitted allowable stress increase factors consistent with the codes and standards to be used for design. Indicate the wind-borne debris with their wind speed that would be designed against. Indicate the procedures that will be used to evaluate whether the design of LNG facilities is adequate. Include the historical or scientific basis for wind conditions used as

design criteria. Compare with 100- and 500-, 1,000-, and 10,000-year return period elevations and wind speeds for Enhanced Fujita (EF) Categories 0, 1, 2, 3, 4 and 5 tornados.

13.I.4.1 Wind speed design basis and criteria

13.I.4.2 Identification of design wind speeds (sustained and 3-second gusts) and corresponding return periods, and wind importance factors for all structures, systems, and components

13.I.4.3 Comparision of design tornado wind speeds (sustained and 3-second gusts) with tornado wind speeds corresponding to:

13.I.4.3.1 10,000-year return period
13.I.4.3.2 1,000-year return period
13.I.4.3.3 500-year return period
13.I.4.3.4 100-year return period

13.I.4.4 Discussion of wind speeds (sustained and 3-second gusts) and frequencies of tornados at site location:

13.I.4.4.1 Tornados Category Enhanced Fujita (EF) Category 5 EF5 (>134 mph sustained, >200 mph 3-second gust),

13.I.4.4.2 Tornados Category EF4 (111-134 mph sustained, 166-200 mph 3-second gust),

13.I.4.4.3 Tornados Category EF3 (91-111 mph sustained, 136-166 mph 3-second gust),

13.I.4.4.4 Tornados Category EF2 (75-91 mph sustained, 111-135 mph 3-second gust),

13.I.4.4.5 Tornados Category EF1 (58-74 mph sustained, 86-110 mph 3-second gust),

13.I.4.4.6 Tornados Category EF0 (44-57 mph sustained, 65-85 mph 3-second gust).

## 13.I.5 Floods

**PROVIDE** details on the facilities design being proposed to handle potential regional flooding (e.g., site elevation, shoreline stabilization, jetty design and operation, stormwater management and spill retention). Include information to confirm why and how the overall project (LNG storage tanks and critical equipment, cryogenic transfer piping; marine/cargo unloading platforms; primary and emergency electrical power; boil-off gas compression; and control systems) would adequately withstand conditions from potential flooding. Describe the streamflows and flood elevations for the project site with their bases considering Federal Emergency Management Agency (FEMA) flood hazard maps and any conducted site-specific studies. Include all project elevations for dikes, storm surge walls, piers, docks, unloading and loading arms and other pier and dock facilities, and other elevated features of the project, their design basis, and demonstrate how they would conform to industry and Federal standards and would protect critical equipment or ensure minimal consequences. Include the historical or scientific basis for flooding conditions used as design criteria. Compare with 100- and 500-, 1,000-, and 10,000-year return period. Include in these elevations the effects of sea level rise, regional subsidence, and other time-dependent severe natural hazards considering the design life of the facilities.

13.I.5.1 Flood design basis and criteria

13.I.5.2 Identification of stream flows and flood design elevations and corresponding return periods for all structures, systems, and components

13.I.5.3 Comparison of design stream flows and flood elevations with stream flows and flood elevations corresponding to:

13.I.5.3.1 10,000-year return period
13.I.5.3.2 1,000-year return period
13.I.5.3.3 500-year return period
13.I.5.3.4 100-year return period

13.I.5.4 Discussion of streamflows and flood elevations and frequencies of floods and other natural hazards at site location

13.I.5.5 Design sea level rise: Provide elevation change to be used in design to account for sea level rise at project site for the design life of the facilities

13.I.5.6 Design regional subsidence: Provide elevation change to be used in design to account for regional subsidence at project site for the design life of the facilities

13.I.5.7 Discussion of expected settlement over the design life of the facilities

### 13.I.6 Rain, Ice, and Snow

**PROVIDE** details on the facilities design being proposed to handle potential rain, ice, and snow (e.g., site elevation, tank and equipment design loads, jetty design and operation, stormwater management and spill retention). Include information to confirm why and how the overall project (LNG storage tanks and critical equipment, cryogenic transfer piping; marine/cargo unloading platforms; primary and emergency electrical power; boil-off gas compression; and control systems) would adequately withstand rain, freezing rain, ice, and snow. Describe the design loads and stormwater and snowfall management for the project site with their design basis, considering hazard maps and any conducted site-specific studies. Include all project elevations for dikes, storm surge walls, piers, docks, unloading and loading arms and other pier and dock facilities, and other elevated features of the project, their design basis, and demonstrate how they would conform to industry and Federal standards, including 49 CFR Part 193 for rainfall removal for impoundments, and would protect critical equipment or ensure minimal consequences. Include the historical or scientific basis for rain, ice, and snow conditions used as design criteria. Compare with 100- and 500-, 1,000-, and 10,000-year return periods.

13.I.6.1 Rain, ice, and snow design basis and criteria

13.I.6.2 Identification of stormwater flows, outfalls, and stormwater management systems for all surfaces, including spill containment system sump pumps

13.I.6.3 Identification of snow and ice loads and corresponding return periods for all structures, systems, and components, including snow removal for spill containment systems

13.I.6.4 Comparision of design rain, ice, and snow events with rainfall rates, snow, and ice loads corresponding to:

13.I.6.4.1 10,000-year return period
13.I.6.4.2 1,000-year return period
13.I.6.4.3 500-year return period
13.I.6.4.4 100-year return period

13.I.6.5 Discussion of ice and snow and frequencies of blizzards and other ice and snow events at site location.

## 13.I.7 Other Natural Hazards

**PROVIDE** details on the facilities design being proposed to handle other potential natural hazards (e.g., site elevation, tank and equipment design loads, jetty design and operation, stormwater management and spill retention). Include information to confirm why and how the overall project would adequately withstand other natural hazards, such as landslides, wildfires, volcanic activity, and geomagnetism. Describe the design loads (e.g. landslides, volcanic ash, etc.) and management for the project site with their design basis, considering hazard maps and any conducted site-specific studies. Include all project elevations for dikes, storm surge walls, piers, docks, unloading and loading arms and other pier and dock facilities, and other elevated features of the project, their design basis, and demonstrate how they would conform to industry and Federal standards and would protect critical equipment or ensure minimal consequences. Include the historical or scientific basis used as design criteria. Compare with 100- and 500-, 1,000-, and 10,000-year return period.

13.I.7.1 Design basis and criteria

13.I.7.2 Identification of loads and corresponding return periods for all structures, systems, and components

13.I.7.3 Comparison of design loads with loads corresponding to:

- 13.I.7.3.1 10,000-year return period
- 13.I.7.3.2 1,000-year return period
- 13.I.7.3.3 500-year return period
- 13.I.7.3.4 100-year return period

13.I.7.4 Discussion of natural hazards and frequencies of natural hazards at site location.

## 13.J APPENDIX 13.J, SITE INVESTIGATION AND CONDITIONS, AND FOUNDATION DESIGN[119]

### 13.J.1 Topographic Map

**PROVIDE** a topographic map with 1- to 2-foot contours showing the current and proposed elevations of the site location.

### 13.J.2 Bathymetric Chart

**PROVIDE** a bathymetric chart showing the current and proposed bathymetry of the shipping channel and berthing area and also indicate the type of harbor bottom.

### 13.J.3 Climatic Data

**PROVIDE** the data and analysis used to support the climatic conditions for the site and along the shipping channel.

### 13.J.4 Geotechnical Investigation

**PROVIDE** a geotechnical investigation and foundation recommendation report. The scope of field investigation should be developed so that it is adequate for FEED-level design. Pre-FEED investigations may not be adequate for the geotechnical report. The boring/cone penetration test (CPT)/testing in the following sections are provided as guidelines for typical LNG projects. Depending on the site conditions or soils encountered, some type of investigations, such as CPTs in dense gravelly soils or rock coring at soil sites, may not be needed

Typically a minimum of 5 borings/CPTs should be performed at each LNG tank location. In each Liquefaction Train area and other process areas the borings/CPTs should be spaced at a minimum of 200 to 300 foot spacing. It is suggested that a proposed boring/CPT plan be submitted to FERC for review prior to undertaking the field investigation. Geotechnical information should be supplied that is needed to establish the Site Class in accordance with Chapters 11 and 20 of ASCE 7-05. Evaluations should also be supplied that predict how the geotechnical information will change for any ground improvement options that are recommended in the report. Site Classes should be determined and supplied for all Seismic Category II and III structures at the site based on Chapters 11 and 20 of ASCE 7-05 for the various ground improvement options that are included in the report. Subsidence due to earthquake, ground water, and oil withdrawal should also be evaluated. Presence of poor or unusual soil conditions, such as highly compressible or highly expansive soils, corrosive soils, collapsible soils, erodible soils, liquefaction-susceptible soils, frost-heave susceptible soils, frozen soils, or sanitary landfill

[119] 18 CFR §380.12(m), 18 CFR §380.12(m)(1), 18 CFR §380.12(m)(3) thru (5), 18 CFR §380.12(o)(7), 18 CFR §380.12(o)(8), 18 CFR §380.12(o)(14), 18 CFR §380.12(o)(15).

etc. should be identified and remedial measures including ground improvement methods should be recommended, if such soils are present. See Attachment 6 for more details. The geotechnical investigation should include the applicable tests conducted and results for the following:

13.J.4.1 Geotechnical data

13.J.4.1.1 Soil borings
13.J.4.1.2 Standard penetration tests
13.J.4.1.3 Rock coring
13.J.4.1.4 Test pits
13.J.4.1.5 Cone penetration tests
13.J.4.1.6 Seismic refraction
13.J.4.1.7 Downhole/crosshole seismic velocity measurements
13.J.4.1.8 Other in-situ measurements.

13.J.4.2 Soil identification tests

13.J.4.2.1 Moisture content
13.J.4.2.2 Dry density
13.J.4.2.3 Gradation
13.J.4.2.4 Plasticity index
13.J.4.2.5 Specific gravity

13.J.4.3 Strength tests

13.J.4.3.1 Direct shear
13.J.4.3.2 Unconfined compression
13.J.4.3.3 Pocket penetrometer
13.J.4.3.4 Torvane
13.J.4.3.5 Triaxial

13.J.4.4 Compressibility tests

13.J.4.4.1 Consolidation
13.J.4.4.2 Expansion index
13.J.4.4.3 Collapse potential

13.J.4.5 Corrosivity tests

13.J.4.5.1 pH
13.J.4.5.2 Electrical resistivity
13.J.4.5.3 Stray electrical ground currents
13.J.4.5.4 Sulfates
13.J.4.5.5 Chlorides

13.J.4.5.6 Recommended mitigation for corrosive soils

13.J.4.6 California Bearing Ratio (CBR)/ R-value.

13.J.4.7 Site surface conditions

13.J.4.7.1 Site elevations
13.J.4.7.2 Overall relief
13.J.4.7.3 Topography
13.J.4.7.4 Drainage

13.J.4.8 Site subsurface conditions

13.J.4.8.1 Groundwater conditions
13.J.4.8.2 Soils/rock layer description
13.J.4.8.3 Geotechnical cross-sections
13.J.4.8.4 Representative soil parameters.

## 13.J.5 Foundation Recommendations

**PROVIDE** a foundation recommendations report for each major foundation type, including foundation recommendations for buildings, tanks, re-gasification facilities, liquefaction facilities, containment berms, flood protection walls / berms, power generation equipment, walls including mechanically stabilized earth (MSE) walls, pipe supports, and other foundations and foundation loading. Provide a summary of anticipated range of foundation sizes for major equipment and structures along with cross sections and plan views of proposed project protective berms and walls. The foundation recommendation report should discuss and provide recommendations for ground improvement. Recommendations should be provided for pavement design for both asphalt and Portland cement concrete pavements for the plant. Effects of ground improvements on soil properties, liquefaction and lateral spreading, and seismic ground motions should be addressed. Structures where total liquefaction settlement is greater than 3 inches should be supported on piles designed for down-drag due to settlement; or be designed to mitigate the liquefaction hazard by ground improvement; or a combination of both. Evaluations of both static and seismic stability, including effects of dredged slopes should be provided for the stability of the tanks, storm surge walls and berms, and other safety related structures. The foundation recommendations should address the applicable items for the following:

13.J.5.1 Shallow foundation

13.J.5.1.1 Ultimate bearing capacity
13.J.5.1.2 Factor of safety
13.J.5.1.3 Allowable bearing capacity
13.J.5.1.4 Settlement criteria
13.J.5.1.5 Mat foundations

13.J.5.1.6 Total and differential settlements
13.J.5.1.7 Liquefaction settlements
13.J.5.1.8 Settlement monitoring
13.J.5.1.9 Lateral resistance

13.J.5.2 Deep foundation

13.J.5.2.1 Axial pile capacity
13.J.5.2.2 Lateral pile capacity
13.J.5.2.3 Group effects
13.J.5.2.4 Settlement of pile groups
13.J.5.2.5 Lateral movement of pile groups
13.J.5.2.6 Pile installation
13.J.5.2.7 Load tests
13.J.5.2.8 Dynamic pile testing
13.J.5.2.9 Indicator pile and load test programs

13.J.5.3 Details of applicable ground improvement options being considered, such as:

13.J.5.3.1 Surcharge
13.J.5.3.2 Stone columns
13.J.5.3.3 Vibroflotation
13.J.5.3.4 Soil-cement columns
13.J.5.3.5 Dynamic compaction
13.J.5.3.6 Other types of ground improvement

13.J.5.4 Slope stability

13.J.5.4.1 Calculation of static and seismic stability
13.J.5.4.2 Safety factor

## 13.J.6 Structural Design Basis and Criteria

**PROVIDE** a structural design basis and criteria document that compiles and summarizes the structural design criteria to be used in the design of structures (including non-building structures) and their foundations. The structural design basis and criteria document should include the severe natural hazard loading parameters to be used, the ASD and strength load combinations, load factors and permitted ASD allowable increases. The document should also include the acceptance criteria to be used to determine an acceptable design. Reference should be made to other design basis documents in Appendix 13.B and natural hazard design criteria documents in Appendix 13.I.

## 13.J.7 Foundation and Support Drawings and Calculations

**PROVIDE** a foundation and support drawings. Preliminary design drawings and structural calculations should be provided for the LNG tanks, containment structures and their proposed foundations. Particular attention should be given to providing a physical description of the storage tanks and impounding systems, including plan and section views in sufficient detail to define the primary structural aspects. If the bottom of the tank is steel and the surface is not continuous, the method of anchorage of the steel shell walls to the concrete base slab should be described. Other major structural attachments should also be described. At a minimum, the foundation and support drawings and calculations should include:

13.J.7.1 Typical foundation drawings
13.J.7.2 Equipment support drawings
13.J.7.3 Static stability calculations
13.J.7.4 Seismic stability calculations
13.J.7.5 Settlement calculations

## 13.K APPENDIX 13.K, MARINE SYSTEMS[120]

### 13.K.1 Marine Facility Drawings

**PROVIDE** marine facility drawings. At a minimum, the marine facility drawings should include:

13.K.1.1 Marine platform layout
13.K.1.2 Berthing layout
13.K.1.3 Mooring arrangements
13.K.1.4 Jetty to marine platform layout
13.K.1.5 Jetty to marine platform elevations showing high and low water levels
13.K.1.6 Platform piling plan and section
13.K.1.7 Trestle piping plan
13.K.1.8 Pipe trestle sections and details

[120] 18 CFR §380.12(m)(1), 18 CFR §380.12(m)(3) thru (5), 18 CFR §380.12(o)(5), 18 CFR §380.12(o)(7), 18 CFR §380.12(o)(8), 18 CFR §380.12(o)(14).

## 13.L APPENDIX 13.L, LNG TANK INFORMATION[121]

### 13.L.1 LNG Tank Specifications

**PROVIDE** a complete specification of the proposed LNG tank and foundation system. In the event that the LNG tank supplier has not been selected, the LNG tank specifications should include all details of the design that the selected tank supplier would be required to incorporate.

### 13.L.2 LNG Tank Drawings.

**PROVIDE** preliminary LNG tank drawings with dimensions. At a minimum, the LNG tank drawings should include:

13.L.2.1 Overall tank drawing with dimensions and design data
13.L.2.2 Foundations and piles
13.L.2.3 Elevation section
13.L.2.4 Insulation systems
13.L.2.5 Corner thermal protection
13.L.2.6 Piping penetrations and schedule of openings
13.L.2.7 Piping support structure
13.L.2.8 Tank roof spill containment and protection
13.L.2.9 Tank base spill protection
13.L.2.10 Top and bottom fill piping
13.L.2.11 In-tank pump column and support arrangement
13.L.2.12 Relief valve and discharge orientation
13.L.2.13 Temperature sensors and locations
13.L.2.14 Foundation heating system
13.L.2.15 Inclinometer
13.L.2.16 Cathodic protection
13.L.2.17 LNG level and density instruments

### 13.L.3 LNG Tank and Foundation Structural Design

**PROVIDE** preliminary structural design drawings and calculation for the LNG tank and foundation system considering both wind and seismic loadings.

[121] 18 CFR §380.12(m)(1), 18 CFR §380.12(m)(3) thru (5), 18 CFR §380.12(o)(7), 18 CFR §380.12(o)(8), 18 CFR §380.12(o)(9), 18 CFR §380.12(o)(14).

## 13.M APPENDIX 13.M, PIPING, VESSEL, EQUIPMENT, AND BUILDINGS[122]

### 13.M.1 Piping and Valve List*

**PROVIDE** a list of piping and valves with design conditions. Design conditions should include; P&ID reference, line connection (from and to), diameter, fluid service, fluid phase, design density, flow, pressure, and temperature conditions, insulation, material of construction, corrosion allowance, leak test pressure and medium, and whether the line would be designed to withstand full vacuum, and any special notes or features (e.g. pipe in pipe, PWHT).

### 13.M.2 Tie-in List*

**PROVIDE** a list of all tie-in points to existing piping.

### 13.M.3 Equipment List

**PROVIDE** a list of equipment with anticipated design conditions. Design conditions should be appropriate for the type of equipment and should include as applicable: design pressure and temperature conditions, equipment dimensions, corrosion allowance, rated and normal flow capacity, rated and normal heating capacity, heat transfer area, and motor horsepower or voltage.

### 13.M.4 Equipment Process, Mechanical, and Thermal Data Sheets

**PROVIDE** equipment process, mechanical, and thermal data sheets for each equipment item.

### 13.M.5 Manufacturer's Data

**PROVIDE** typical manufacturer's information for major process equipment items. Where more than one manufacturer is under consideration and meets specifications, the equipment specifications and design data need not be repeated.

### 13.M.6 List of Buildings and Structures

**PROVIDE** a list of buildings and structures. At a minimum, include a description of the building or structure, dimensions, occupancy, and any special features, such as HVAC shutdowns, pressurization, blast resistance, or fire resistance.

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[122] 18 CFR §380.12(m)(1), 18 CFR §380.12(m)(3) thru (5), 18 CFR §380.12(o)(7), 18 CFR §380.12(o)(8), 18 CFR §380.12(o)(14).

### 13.M.7 Building Siting Analysis

**PROVIDE** an analysis of the location of occupied buildings and housing relative to hazards. At a minimum, the analysis should evaluate permanent and temporary/construction buildings and structures (e.g., API 752 and API 753).

### 13.M.8 Building Drawings

**PROVIDE** preliminary plans for the proposed buildings and structures. At a minimum, the drawings should include:

13.M.8.1 Preliminary building plan and elevation drawings

## 13.N APPENDIX 13.N, ELECTRICAL DESIGN INFORMATION[123]

### 13.N.1 Electrical Load List

**PROVIDE** a list of anticipated power requirements for equipment for each operating mode.

### 13.N.2 Transformer List

**PROVIDE** list of transformers with tag number, size, and location

### 13.N.3 Single Line Drawings

**PROVIDE** single line drawings for power distribution and emergency load supply and distribution

13.N.3.1 Single line drawings power distribution
13.N.3.2 Single line drawings of emergency load supply and distribution

### 13.N.4 UPS Drawings

**PROVIDE** a UPS distribution block diagram.

13.N.4.1 UPS distribution block diagram

### 13.N.5 Electrical Area Classification Drawings

**PROVIDE** overall plan drawings, area plan drawings, and elevation drawings depicting the electrical area classifications for Class 1, Division 1 and Class 1, Division 2. Elevation drawings should be provided for pipe racks, flammable fluid storage tanks, major pieces of equipment, and impoundments.

13.N.5.1 Electrical area classification overall plan drawing
13.N.5.2 Electrical area classification area plan drawings
13.N.5.3 Electrical area classification elevation drawings

### 13.N.6 Electrical Seal Drawings

**PROVIDE** typical drawings of the electrical pass through seal and vents for services such as pumps/expanders and instrumentation.

13.N.6.1 Electrical pass-through seal drawings

[123] 18 CFR §380.12(m)(1), 18 CFR §380.12(m)(3) thru (5), 18 CFR §380.12(o)(3), 18 CFR §380.12(o)(8), 18 CFR §380.12(o)(11), 18 CFR §380.12(o)(14).

## 13.O APPENDIX 13.O, PLANS AND PROCEDURES[124]

### 13.O.1 Management of Change Procedures and Forms*

**PROVIDE** a description of the management of change (MOC) system, review process, and sample forms used during final design and construction. **PROVIDE** MOC procedures and sample forms for changes after operation of the project has commenced.*

### 13.O.2 QA/QC Plans and Procedures*

**PROVIDE** a description of the quality assurance and quality control (QA/QC) system used during construction*

### 13.O.3 Commissioning Plans*

**PROVIDE** a description of the plans and procedures to achieve a safe and successful startup. These procedures should reference the schedule in Appendix 13.A.5.7. At a minimum, the plans should detail key activities such as:

13.O.3.1 Roles and responsibilities of commissioning teams

13.O.3.2 Production of documentation (e.g., operating manuals, maintenance manuals, training manuals, testing procedures, etc.)

13.O.3.3 Testing the integrity of on-site mechanical installation (e.g., tightness, pressure testings, leak tests, etc.)

13.O.3.4 Functional tests for hazard detectors, instrumentation, ESD systems, DCS, SIS, etc.

13.O.3.5 Pre-startup safety reviews

13.O.3.6 Approval for introduction of hazardous fluids following purging/cleanout, dry out, inerting of process systems, and cooldown plans

13.O.3.7 Demonstration/performance tests

13.O.3.8 Placing facilities into service

[124] 18 CFR §380.12(m)(1), 18 CFR §380.12(m)(3) thru (5), 18 CFR §380.12(o)(3), 18 CFR §380.12(o)(8), 18 CFR §380.12(o)(10), 18 CFR §380.12(o)(14).

### 13.O.4 Operating Plans and Procedures*

**PROVIDE** the operating plans and procedures that include a description of each system, startup procedures, details control and operation of each system, safe shutdown, emergency shutdown, abnormal operations, etc. These plans should reference applicable drawings and plant documents.

### 13.O.5 Maintenance Plans and Procedures*

**PROVIDE** a description of the maintenance plans that includes procedures for corrective, preventive, predictive maintenance, and mechanical integrity to ensure equipment is installed and maintained to design specifications and is consistent with manufacturer's instructions. The maintenance plans and procedures should include isolation procedures, deinventorying, purging practices and procedures, cold and hot tap procedures, and other associated plans, practices, and procedures.

### 13.O.6 Safety Procedures*

**PROVIDE** a description of the applicable safety procedures at the plant such as safe work permits, hot work permits, lockout/tagout, car seal philosophy, near misses, Incident investigations, etc. The plans should include details on how the plant would monitor contractor access and activities.

## 13.P APPENDIX 13.P, PROCESS CONTROL AND INSTRUMENTATION[125]

### 13.P.1 Instrument Lists

**PROVIDE** an instrument index for all facilities. At a minimum, the instrument list should include:

13.P.1.1 P&ID reference
13.P.1.2 Instrument tag number
13.P.1.3 Measurement (e.g., flow, temperature, pressure, composition, etc.)
13.P.1.4 Location (e.g., local, PLC, DCS, SIS, etc.)
13.P.1.5 I/O Type (e.g., AI, DO, etc.)*
13.P.1.6 Signal range (e.g., 4-20mA, 0-100 ohm, etc.)*
13.P.1.7 Loop Fluid Service
13.P.1.8 Instrument Range*
13.P.1.9 Calibration*
13.P.1.10 Alarm set points*
13.P.1.11 Shutdown set points*
13.P.1.12 Voting logic
13.P.1.13 Voting degradation logic*
13.P.1.14 Safety Integrity Level (SIL)*
13.P.1.15 Notes

### 13.P.2 System Architecture drawings

**PROVIDE** system architecture drawings of all facilities. At a minimum, the system architecture drawings should include:

13.P.2.1 HMIs
13.P.2.2 CPUs
13.P.2.3 RIEs
13.P.2.4 JBs

[125] 18 CFR §380.12(m)(1), 18 CFR §380.12(m)(3) thru (5), 18 CFR §380.12(o)(3), 18 CFR §380.12(o)(5), 18 CFR §380.12(8), 18 CFR §380.12(o)(10), 18 CFR §380.12(o)(14).

## 13.Q APPENDIX 13.Q, SAFETY INSTRUMENTED SYSTEMS AND SHUT-OFF VALVES[126]

### 13.Q.1 Cause & Effect Matrices

**PROVIDE** cause and effect matrices. The cause and effect matrices should indicate all alarm, shutdown, and hazard control activations with set points and voting logic:

13.Q.1.1 ESD cause and effect matrices
13.Q.1.2 FGS cause and effect matrices

### 13.Q.2 Block Diagrams

**PROVIDE** block diagrams for the DCS, SIS, and FGS:

13.Q.2.1 DCS block diagrams
13.Q.2.2 SIS block diagram
13.Q.2.3 FGS block diagram

### 13.Q.3 List of Shutoff Valves

**PROVIDE** a list of the emergency shutdown (ESD) valves. At a minimum, the list should include:

13.Q.3.1 P&ID reference
13.Q.3.2 Interlock tag and/or ESD designation
13.Q.3.3 Shutoff valve tag number
13.Q.3.4 Shutoff valve type
13.Q.3.5 Shutoff valve actuator type
13.Q.3.6 Shutoff valve fail position
13.Q.3.7 Shutoff valve leakage class
13.Q.3.8 Shutoff valve actuation/closure time*
13.Q.3.9 Special features required (e.g., fire safe)

### 13.Q.4 Drawing of ESD Manual Activation Devices

**PROVIDE** a layout showing the locations of ESD manual activation devices.

### 13.Q.5 Shutoff Valve Manufacturer's Data

**PROVIDE** typical manufacturer's specifications, drawings, and literature on the fail-safe shut-off valves and actuators.

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[126] 18 CFR §380.12(m)(1), 18 CFR §380.12(m)(3) thru (5), 18 CFR §380.12(o)(3), 18 CFR §380.12(5), 18 CFR §380.12(o)(8), 18 CFR §380.12(o)(14).

## 13.R APPENDIX 13.R, RELIEF VALVES AND FLARE/VENT SYSTEMS[127]

### 13.R.1 Relief Valves Capacities and Sizing

**PROVIDE** a list and calculation sheets* of the vacuum and pressure relief valves. At a minimum, the list and calculation sheets should include:

13.R.1.1 P&ID reference
13.R.1.2 Relief valve tag number
13.R.1.3 Relief valve service
13.R.1.4 Relief valve type*
13.R.1.5 Relief valve size
13.R.1.6 Relief valve capacity
13.R.1.7 Relief valve set point
13.R.1.8 Relief valve discharge location*
13.R.1.9 Relief valve leakage class*
13.R.1.10 Special features required (e.g., fire safe)

### 13.R.2 Flaring Load and Venting Capacities and Sizing

**PROVIDE** a list and calculation sheets of the flares and vents. At a minimum, the list and calculation sheets should detail:

13.R.2.1 Criteria for sizing
13.R.2.2 Capacity case description
13.R.2.3 Capacity case load
13.R.2.4 Capacity calculations
13.R.2.5 Sizing case description
13.R.2.6 Sizing case load
13.R.2.7 Sizing calculations
13.R.2.8 Flare radiant heats and sound at ground level and nearby structures,
13.R.2.9 Vent concentrations at ground level and nearby elevated ignition sources

[127] 18 CFR §380.12(m)(1), 18 CFR §380.12(m)(3) thru (5), 18 CFR §380.12(o)(3), 18 CFR §380.12(o)(8), 18 CFR §380.12(o)(14).

## 13.S APPENDIX 13.S, SPILL, TOXIC, FIRE, AND EXPLOSION PROTECTION[128]

### 13.S.1 Preliminary Fire Protection Evaluation

**PROVIDE** the preliminary fire protection evaluation according to incorporated editions of NFPA 59A Standards. This evaluation should support the design of the hazard detection and control systems.

### 13.S.2 Spill Containment Matrix

**PROVIDE** a matrix of all spill containment impoundments with sizing spill and volumetric capacity. The sizing spill should demonstrate the ability to contain the largest vessel serving the impoundment and the largest flow from any single pipe for 10 minutes and should account for pump runout and piping deinventory. Fire water used to cool adjacent equipment should also be accounted for if it can discharge into the same impoundment. At a minimum, the spill containment matrix should include:

13.S.2.1 LNG marine transfer equipment and piping
13.S.2.2 Pretreatment equipment and piping (Amine)
13.S.2.3 Heavies/Condensates removal equipment and piping
13.S.2.4 Heavies/Condensates storage, equipment, and piping
13.S.2.5 NGL fractionation equipment and piping
13.S.2.6 NGL storage, equipment and piping
13.S.2.7 NGL truck transfer equipment and piping
13.S.2.8 HTF storage, equipment and piping
13.S.2.9 Refrigerant truck transfer equipment and piping
13.S.2.10 Refrigerant storage, equipment, and piping
13.S.2.11 Liquefaction process equipment and piping
13.S.2.12 LNG storage, equipment, and piping
13.S.2.13 LNG truck transfer equipment and piping
13.S.2.14 LNG pumps and piping
13.S.2.15 Liquid nitrogen storage, equipment, and piping
13.S.2.16 Diesel storage, equipment and piping
13.S.2.17 Other hazardous fluid storage and piping

[128] 18 CFR §380.12(m)(1), 18 CFR §380.12(m)(3) thru (5), 18 CFR §380.12(o)(2) thru (4), 18 CFR §380.12(o)(10), 18 CFR §380.12(o)(14).

### 13.S.3 Spill Containment Drawings and Calculations

**PROVIDE** drawings clearly showing the location of each spill containment system, direction of flow, material of construction, and the equipment served by each system. At a minimum, the drawings should show all curbing, grading, trenches, troughs, down comers, impoundments, sumps, dikes, water removal systems. It may be necessary to provide separate drawings for each process area and show underground to aboveground transitions of piping.

13.S.3.1 Spill containment plan drawings

13.S.3.2 Spill containment cross sections and details

13.S.3.3 Impoundment usable volumetric capacity calculations, including volume of largest containers contained by impoundment and largest flow rates and durations for piping (inventory and runout) contained by impoundment

13.S.3.4 Trench/trough volumetric flow capacity calculations

13.S.3.5 Downcomers volumetric flow capacity calculations

13.S.3.6 Storm water drainage calculations

### 13.S.4 Passive Protection Drawings

**PROVIDE** unit plot plan drawings clearly showing the location of each passive protection system. At a minimum, the passive protection drawings should include:

13.S.4.1 Passive cryogenic structural protection drawings

13.S.4.2 Passive fire structural protection drawings

13.S.4.3 Passive blast structural protection drawings

13.S.4.4 Other passive protection drawings (e.g. vapor barriers, firewalls, and radiant heat shields)

### 13.S.5 Hazard Detection Matrix

**PROVIDE** a matrix of all detection equipment with tag number, location, elevation*, detector type, calibration gas*, set points for alarms, shutdowns, and automatic activations of hazard control or fire water equipment. At a minimum, the matrix should include:

13.S.5.1 Hazard zones

13.S.5.2 Low temperature detectors
13.S.5.3 Oxygen deficiency detectors
13.S.5.4 Toxic detectors
13.S.5.5 Flammable and combustible gas detectors
13.S.5.6 High temperature and heat detectors
13.S.5.7 Smoke/products of combustion detectors
13.S.5.8 Fire detectors
13.S.5.9 Other hazard detectors (e.g., acoustic leak detectors, CCTV detectors, carbon monoxide, etc.)

### 13.S.6 Hazard Detection Drawings

**PROVIDE** a layout of the hazard detection system showing the location of low temperature detectors, toxic gas detectors, oxygen deficiency detectors, combustible-gas detectors, fire detectors, heat detectors, smoke or products of combustion detectors, and manual pull stations. Separate plot plans should be created where necessary to provide clarity. In addition, **PROVIDE** a drawing showing all combustion/ventilation air intake equipment, the detectors covering the air intake and the distances to any possible hydrocarbon release (LNG, flammable refrigerants, flammable liquids and flammable gases).

13.S.6.1 Zones
13.S.6.2 Hazard detector layout plans
13.S.6.3 Manual pull stations
13.S.6.4 Combustion/ventilation air intake locations

### 13.S.7 Hazard Control Matrix

**PROVIDE** a matrix of hazard control equipment. At a minimum, the matrix should include tag number, location and area covered, type, size, discharge flow rates, activation, or remote control capabilities and manufacturer/model* for all dry chemical equipment. The matrix should provide similar information for other types of hazard control systems used at the site.

### 13.S.8 Hazard Control Drawings

**PROVIDE** a detailed layout of the hazard control system showing the type of unit and the area of coverage. The legend should indicate the type of each unit and the quantity of suppressant.

13.S.8.1 Dry chemical equipment and other systems location plans
13.S.8.2 Dry chemical equipment and other systems coverage plans

### 13.S.9 Fire Water Matrix

**PROVIDE** tag number, location and area covered, type, size, discharge conditions, activation, or remote control capabilities and manufacturer/model* for all fire water equipment including deluge systems, sprinklers, high expansion foam systems, monitors, hydrants, and hose stations.

### 13.S.10 Fire Water Drawings and Calculations

**PROVIDE** drawings and calculations of the fire water system. Drawings should include P&IDs, system and equipment layouts, and coverage plans. Calculations should include firewater demand calculations based on the most demanding scenarios using minimum water densities that mitigate the hazard and hydraulic calculations for the most hydraulically demanding scenarios*. The layout of the fire protection system should show the location of fire water pumps, piping, hydrants, hose reels, high and low expansion foam systems, deluge systems, sprinkler systems, water mist systems, water screens, and other fire water-based systems and auxiliary or appurtenant service facilities. The plan drawings should show the fire water supply, the sizing of the fire water mains, and how they are arranged in either a loop or grid system throughout the site. Isolation valves to allow water flow in case a portion of the system is damaged should be shown. They should also show monitors, hydrants, hose stations and post indicator valves. Coverage areas for each system should be clearly depicted showing the coverage circle. Where buildings, or equipment block the line of sight of the monitor the non-covered area should be indicated.

13.S.10.1 Fire water P&IDs
13.S.10.2 Fire water piping and equipment layout
13.S.10.3 Fire water coverage plans

## 13.T APPENDIX 13.T, TECHNOLOGY, PROCESS, AND EQUIPMENT SELECTION AND ALTERNATIVES[129]

### 13.T.1 Design Studies and Alternatives

**PROVIDE** copies of company, engineering firm, or consultant studies that show the engineering planning or design approach to the construction of new facilities or plants. Include studies that support a design decision such as selecting a specific type of equipment where other alternatives were available. Studies that were used to develop unique design features that differ from currently operating facilities should also be supported. Alternative processes, technologies, and equipment that should be considered and evaluated include, but are not limited to, the following:

13.T.1.1 LNG Storage Tanks: Single, membrane, double, and full containment above-ground or below-ground LNG storage tank designs, including any LNG Storage Tank Risk Assessment Studies (e.g., API 625), Security Vulnerability Assessments[130], or other studies that led to the proposed selection

13.T.1.2 Vents/Flares: Derrick mounted or guy-wired elevated or vent stacks or flares, and ground flare designs, including any visual impact analyses, flare radiation analyses, maintainability studies, or other studies that led to the proposed selection

13.T.1.3 Vaporization: Ambient air vaporizers, shell and tube, or submerged combustion vaporizer designs, including any emission studies, fog dispersion studies, reliability studies, or other studies that led to the proposed selection

13.T.1.4 Liquefaction: Pre-cooled single mixed refrigerant, cascade, single mixed refrigerant, nitrogen expansion cycle, or other liquefaction systems, including any efficiency studies, or other studies that led to the proposed selection

13.T.1.5 Inherently safer refrigerants and intermediate heat transfer fluids, such as ethane versus ethylene in mixed refrigerant cycle, anhydrous ammonia versus propane as a pre-cooler refrigerant, or water ethylene glycol versus water propylene glycol mixtures for an intermediate heat

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[129] 18 CFR §380.12(m)(1), 18 CFR §380.12(m)(3) thru (5), 18 CFR §380.12(o)(7).

[130] Security Threat and Vulnerability Information prepared for or submitted to Coast Guard in accordance with 33 CFR §105.305 or prepared for or submitted to Department of Homeland Security (DHS) in accordance with 6 CFR §27.215 may satisfy Security Threat and Vulnerability Analyses in Appendix 13.G.8. This material may include Critical Energy Infrastructure Information (CEII), Security Sensitive Information (SSI), or Chemical-Terrorism Vulnerability Information (CVI) and must comply with all applicable regulations.

transfer fluid, including any hazard analyses, efficiency studies, or other studies that led to the proposed selection

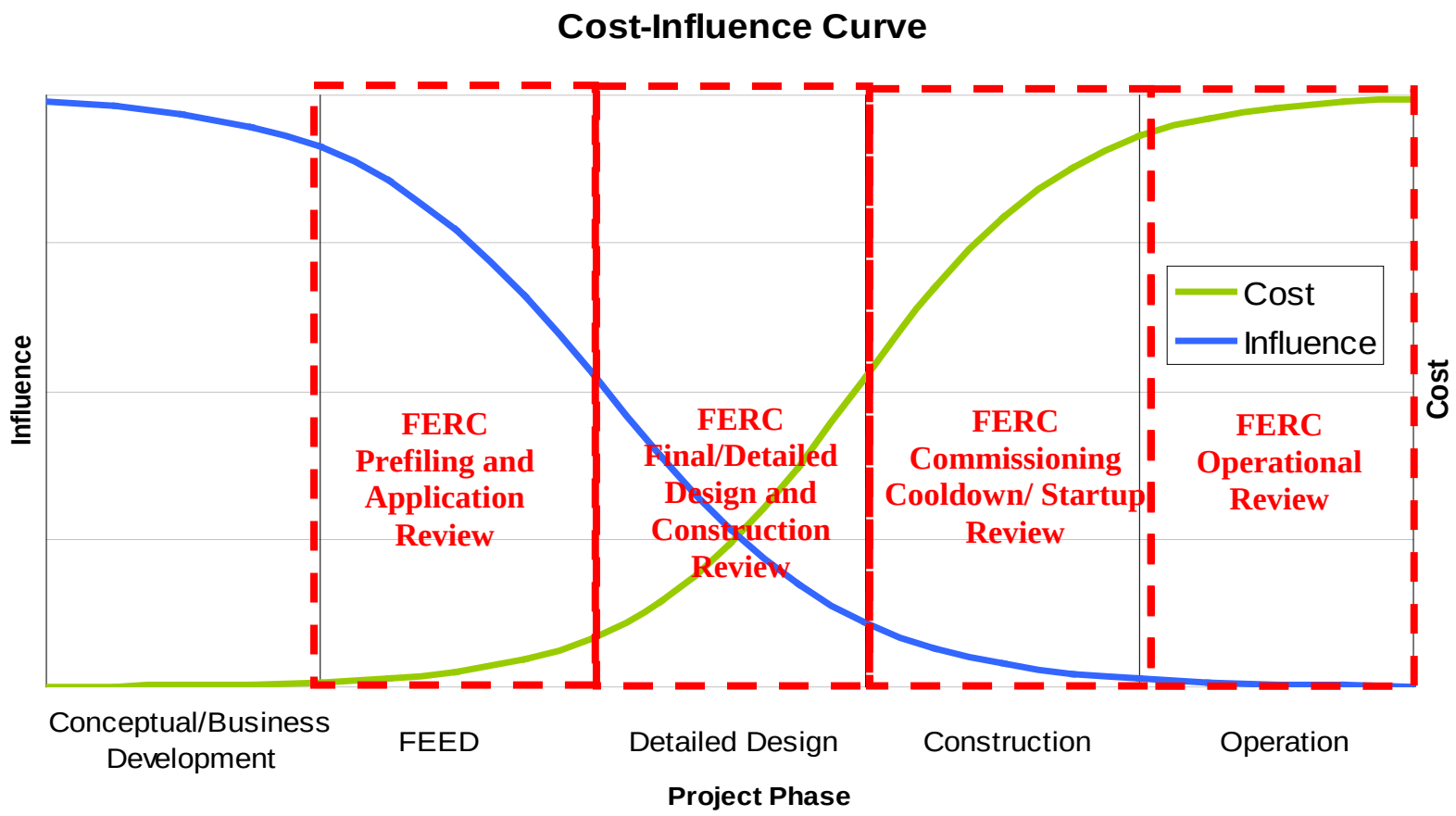
13.T.1.6 Transformers: Dry type transformers versus liquid insulated transformers, including hazard analyses, or other studies that led to the proposed selection

13.T.1.7 Motors: Electric motor driven equipment and associated power lines and offsite power generation versus combustion engines or turbines with various emission control technologies and/or onsite power generation, including emission studies, reliability studies, or other studies that led to the proposed selection

13.T.1.8 Water Supply: Water storage/supply and use for potable, utility, firefighting water, including reliability studies, or other studies that led to the proposed selection

# ATTACHMENTS

## ATTACHMENT 1 – TYPICAL COST-INFLUENCE CURVE OF A LNG FACILITY AND FERC REVIEW



# ATTACHMENT 2 – EQUIPMENT DATA TABLE

| A. Process Pumps |
|---|
| 1. Type |
| 2. Number, operating and spare |
| 3. Operating and design flow rate capacities (minimum, normal/rated, maximum), gpm |
| 4. Operating and design duties (minimum, normal, maximum), MMBtu/h |
| 5. Operating and design suction pressures (minimum/net positive suction head [NPSH], normal/rated, maximum), psig |
| 6. Operating and design suction temperatures (minimum, normal, maximum), °F |
| 7. Operating and design discharge pressures (minimum, normal/rated, maximum/shutoff), psig |
| 8. Operating and design discharge temperatures (minimum, normal, maximum/shutoff), °F |
| 9. Operating and design densities (minimum, normal, maximum), specific gravity |

| B. Compressors and Blowers |
|---|
| 1. Type |
| 2. Number, operating and spare |
| 3. Operating and design flow rate capacities (minimum, normal/rated, maximum), MMscfd |
| 4. Operating and design suction pressures (minimum/net positive suction head [NPSH], normal/rated, maximum), psig |
| 5. Operating and design suction temperatures (minimum, normal, maximum), °F |
| 6. Operating and design discharge pressures (minimum, normal/rated, maximum/shutoff), psig |
| 7. Operating and design discharge temperatures (minimum, normal, maximum/shutoff), °F |
| 8. Operating and design densities (minimum, normal/rated, maximum), specific gravity |

| C. Gas Purification Systems |
|---|
| 1. Type |
| 2. Operating and design inlet flow rate capacities (minimum, normal, maximum), MMscfd or lb/hr |
| 3. Operating and design inlet compositions (minimum/lean/light, normal/design/average, maximum/rich/heavy), %-vol or ppm |
| 4. Operating and design inlet pressures (minimum, normal, maximum), psig |
| 5. Operating and design inlet temperatures (minimum, normal, maximum), °F |
| 6. Operating and design outlet product flow rates (minimum, normal, maximum), MMscfd or lb/hr (gpm for NGLs and Condensates) |
| 7. Operating and design outlet compositions (minimum/lean/light, normal/design/average, maximum/rich/heavy), %-vol or ppm |
| 8. Operating and design outlet pressures (minimum, normal, maximum), psig |
| 9. Operating and design outlet temperatures (minimum, normal, maximum), °F |

# ATTACHMENT 3 – SAMPLE SEISMIC GROUND MOTION HAZARD EVALUATION CONTENTS

## 1. General

A seismic ground motion hazard analysis study should be performed to determine the site-specific OBE and SSE ground motions in accordance with 49 CFR Part 193 and the incorporated NFPA 59A requirements and to determine the MCE and DE ground motions in accordance with the incorporated ASCE 7 requirements.

In addition to the specific data needed to support and justify the site-specific ground motion recommendations, the study should include geologic and seismic data requested in this Attachment and a discussion of other seismic hazards such as fault rupture, tsunamis, and seiche.

The geotechnical report should address in detail the following hazards, if present, and the need for ground improvement to mitigate them: liquefaction potential, liquefaction-related settlement, potential for sand boils and other surface manifestation of liquefaction, lateral spreading, seismic slope stability, and seismic compaction. Follow the outline in Attachment 6.

## 2. Geology

In addition to standard geotechnical information needed to develop foundation recommendations, the additional geologic information requested herein should be provided in the seismic ground motion hazard study report. Information obtained from published reports, maps, private communications, or other sources should be referenced. Information from surveys, geophysical investigations, borings, trenches, or other investigations should be adequately documented by descriptions of techniques, graphic logs, photographs, laboratory results, identification of principal investigators, and other data necessary to assess the adequacy of the information.

### 2.1 Regional Geology

Discuss all geologic, seismic, and manmade hazards within the site region and relate them to the regional physiography, tectonic structures and tectonic provinces, geomorphology, stratigraphy, lithology, and geologic and structural history and geochronology. This information should be discussed and shown on maps needed to illustrate actual or potential hazards such as landslides, subsidence, uplift, or collapse resulting from natural features such as tectonic depressions and cavernous or karst terrains that are significant to the site.

Identify and describe tectonic structures such as folds, faults, basins, and domes underlying the region surrounding the site, and include a discussion of their geologic history. A regional tectonic map showing the structures of significance to the site should

be provided. The detailed analyses of faults to determine their capacity for generating ground motions at the site and to determine the potential for surface faulting should be included. Refer to Section 3 of this Attachment for additional detail.

Provide geologic profiles showing the relationship of the regional and local geology to the site location. The geologic province within which the site is located and the relation to other geologic provinces within 100 miles of the site should be indicated. Regional geologic maps indicating the site location and showing both surface and bedrock geology should also be included.

## 2.2 Site Geology

A site topographic map showing the locations of the principal plant facilities should be included. Regional hazard identified in Section 2.1, e.g., landslides, should be evaluated for the site. The thicknesses, physical characteristics, origin, and degree of consolidation of each lithologic unit should also be described for the site, including a local stratigraphic column. Furnish summary logs of borings and excavations such as trenches used in the geologic evaluation. Boring logs included in Attachment 6, Section 2.1, may be referenced.

A detailed discussion of the structural geology in the vicinity of the site should be provided with particular attention to specific structural units of significance to the site such as folds, faults, synclines, anticlines, domes, and basins. Provide a large-scale structural geology map (1:5,000) of the site showing bedrock surface contours and including the locations of Seismic Category I structures. A large-scale geologic map (1:24,000) of the region within 5 miles of the site that shows surface geology and that includes the locations of major structures of the LNG plant, including all Seismic Category I structures, embankments, and pipelines should be described in detail. Areas of bedrock outcrop from which geologic interpretation has been extrapolated should be distinguished from areas in which bedrock is not exposed at the surface. When the interpretation differs substantially from the published geologic literature on the area, the differences should be noted and documentation for the new conclusions presented.

Include an evaluation from an engineering-geology standpoint of the local geologic features that affect the plant structures. Deformational zones such as shears, joints, fractures, and folds, or combinations of these features should be identified and evaluated relative to structural foundations. Describe and evaluate zones of alteration or irregular weathering profiles, zones of structural weakness, unrelieved residual stresses in bedrock, and all rocks or soils that might be unstable because of their mineralogy or unstable physical or chemical properties. The effects of man's activities in the area of the site should be evaluated; for example, withdrawal or addition of subsurface fluids or mineral extraction. Site groundwater conditions should be described.

## 3. Faulting

### 3.1 Investigation of Quaternary Faults

Identified faults, any part of which is within 5 miles of the site, should be investigated in sufficient detail, using geological and geophysical techniques of sufficient sensitivity that demonstrate the age of the most recent movement on each. The type and extent of investigation varies from one geologic province to another and depends on site-specific conditions.

For Quaternary faults, any part of which is within 5 miles of the site, determine the following:

1) length of the fault;
2) relationship to regional tectonic structures;
3) nature, amount, and geologic displacement along the fault; and
4) outer limits of the fault zone.

### 3.2 Determination of Active Faults

Determine the geologic evidence of fault offset at or near the ground surface at or near the site. Any lineaments identified on topographic maps, aerial photos, or satellite imagery linears identified as part of this study should be discussed.

List all historically reported earthquakes that can be reasonably associated with faults, any part of which is within 5 miles of the site. A plot of earthquake epicenters superimposed on a map showing the local tectonic structures should be provided.

The structure and genetic relationship between the site area faulting and regional tectonic framework should be discussed. In tectonically active regions, any detailed geologic and geophysical investigations conducted to demonstrate the structural relationships of site area faults with regional faults known to be seismically active should be discussed.

### 3.3 Fault Rupture Investigation

A detailed faulting investigation should be conducted within one mile of the storage tank(s) foundation(s) and, as necessary, along any active faults identified under Section 3.2 of this Attachment that reasonably have a potential for affecting faulting on the site or provide significant information concerning such faulting. This investigation should be in sufficient detail to determine the potential for faulting and the magnitude of possible displacement impacting the safety-related facilities of the plant. The report of the faulting investigation should be coordinated with the investigation and report under Sections 3.1 and 3.2 of this Attachment and should include information in the form of boring logs,

detailed geologic maps, geophysical data, maps and logs of trenches, remote sensing data, and seismic refraction and reflection data. If faulting exists, it should be defined as to its attitudes, orientations, width of shear zone, amount and sense of movement, and age of movements. Site surface and subsurface investigations conducted to determine the absence of faulting should be reported, including information on the detail and areal extent of the investigation. The geologic studies included in a Fault Rupture Investigation should conform to established guidelines such as California Division of Mines and Geology, Note 49 (Ref. 22).

Based on geologic studies, if it is determined that there is a potential for fault rupture hazard, and the structure is to be located either within 500 feet of a known fault or the possibility of a fault rupture passing through the proposed structure cannot be excluded, then seismic fault rupture analysis should be performed. This may include, but not be limited to magnitude, slip rates and recurrence models, type of fault (e.g., strike slip, normal), horizontal and vertical components of offset, and style of faulting.

## 4. Ground Motions

### 4.1 Historic Seismicity

A complete list of all historically reported earthquakes affecting the region surrounding the site should be provided. The listing should include, as a minimum, all earthquakes of Modified Mercalli Intensity greater than IV or magnitude greater than 3.0. A map should also be provided that shows all listed earthquake epicenters. The following information describing each earthquake should be provided whenever it is available:

1) epicenter coordinates,
2) depth of focus,
3) origin time,
4) highest intensity,
5) magnitude (including moment magnitude),
6) source mechanism,
7) source dimensions,
8) stress drop,
9) any strong motion recordings relevant to a determination of the ground motion or design response spectra, and
10) references from which the specified information was obtained.

In addition, any earthquake-induced geologic hazards (e.g., liquefaction, landsliding, land spreading, or lurching) that have been reported on or within 5 miles of the site should be described in detail, including the level of strong motion that induced failure and the properties of the materials involved.

This discussion should include identification of the methods used to locate the earthquake epicenters and an estimate of their accuracy.

## 4.2 Geologic Structures and Tectonic Activity

Identify the regional geologic structures and tectonic activity that are significant in determining regional earthquake potential. All tectonic provinces any part of which could govern the design ground motions at the site should be identified. The identification should include a description of those characteristics of geologic structure, tectonic history, present and past stress regimes, and seismicity that distinguish the various tectonic provinces and particular areas within those provinces where historical earthquakes have occurred. Alternative models of regional tectonic activity from available literature sources should be discussed. The discussion in this section should be augmented by a regional-scale map showing the tectonic provinces, earthquake epicenters, the locations of geologic structures and other features that characterize the provinces, and the locations of any Quaternary faults.

When an earthquake epicenter cannot be reasonably correlated with geologic structures, the epicenter should be discussed in relation to tectonic provinces. Subdivision of tectonic provinces should be supported on the basis of evaluations that consider, but should not be limited to, detailed seismicity studies, differences in geologic history, and differences in stress regime.

## 4.3 Maximum Earthquake Potential

The largest earthquake or earthquakes associated with each geologic structure or tectonic province should be identified. Where the earthquakes are associated with a geologic structure, the largest earthquake that could occur on that structure should be evaluated based on considerations such as the nature of faulting, fault length, fault displacement, and earthquake history. The largest historical earthquakes within the province should be identified and, whenever reasonable, the return period for the earthquakes should be estimated. A table of faults with fault length, type of fault, distance at closest point to the site, maximum earthquake, etc. should be provided.

## 4.4 Near-Fault Effects

For each set of conditions describing the occurrence of the maximum potential earthquakes, determined in Section 5.3 above, the types of seismic waves (such as

directivity, fault normal, and fault parallel) producing the maximum ground motion and the significant frequencies at the site should be determined.

## 4.5 Determination of Site Class

Site Class definitions are provided in ACSE 7-05 (Chapter 20) or IBC 2006 (Table 1613.5.2). Site classes range from Class A for hard rock to Class F for liquefiable or other very poor soil conditions. Site Class should be determined by seismic velocity data and other geotechnical data provided in the geotechnical report in accordance with the procedure in Sections 1613.5.5 and 1613.5.5.1 of IBC 2006 or Chapter 20 of ASCE 7-05.

## 4.6 Deterministic Seismic Hazard Analysis

A deterministic seismic hazard analysis should be performed which computes the peak ground horizontal acceleration and spectral response accelerations for periods of at least 0.2s and 1.0s from the maximum earthquake on each of the faults found within 100 miles from the site. The computation of the peak acceleration and spectral accelerations is based on the closest distance between the site and each fault and the selected attenuation relationships. In general, a minimum of three attenuation relationships should be used consistent with the geologic and seismic setting of the site and type of faulting. The closest active fault and the fault generating the maximum acceleration at the site should be identified. Differences between the selected attenuations and the attenuations used in the latest USGS National Seismic Hazard Maps should be discussed.

## 4.7 Probabilistic Hazard Analysis

Probabilistic seismic hazard evaluation involves obtaining, through a formal mathematical process, the level of ground motion parameters that have a selected probability of being exceeded during a specified time interval.

The probabilistic approach incorporates the contributions from historical seismicity and all faults and considers the likelihood of the occurrence of earthquakes at any point on the fault. It also incorporates the contributions from various magnitude earthquakes up to and including the maximum earthquake. This approach is described in a number of sources such as Cornell, 1968 (Ref. 25), Algermissen et al, 1976 (Ref. 27) and Frankel, 1996, 2002 (Ref. 26).

A probabilistic seismic hazard analysis should be performed using at least three attenuation relationships consistent with the geologic and seismic setting of the site. Differences between the selected attenuations and the attenuations used in the latest USGS National Seismic Hazard Maps should be discussed. Based on the site-specific probabilistic analyses, two levels of site ground motions, the OBE and SSE ground motions should be developed in accordance with the guidelines provided in Section 5.2 of Part I of this document.

## 4.8 Code Values of Ground Motions

The code values of ground motions should be determined using either ASCE 7-05 or IBC since both of these yield identical results. Two levels of shaking are identified as follows:

### Maximum Considered Earthquake (MCE) Ground Motion

MCE ground motions have a 2 percent probability of exceedance within a 50-year period (2475-year return period) with deterministic limits. These ground motions may be read from the published maps in ASCE 7-05 or IBC adjusted for site class. These ground motions may also be obtained using a ground motion calculator that is available at the USGS web site (http://earthquake.usgs.gov/research/hazmaps/design/). A site-specific MCE may be developed in accordance with Chapter 21 of ASCE 7-05 including the 80% limits.

### Design Earthquake (DE) Ground Motion

DE ground motions are 2/3 of the MCE motions as defined above adjusted for Site Class.

## ATTACHMENT 4 – SAMPLE CATEGORIZATION OF LNG STRUCTURES, COMPONENTS, AND SYSTEMS

### 1. Seismic Categorization

For purposes of design, all structures, components and systems important to normal operation of the LNG project operations should be classified into one of the three Seismic Categories that are defined below.

### 1.1 Seismic Category I

NBSIR 84-2833 defines Category I as all structures, components, and systems which perform a vital safety related function such as containment of LNG and fire control. Title 49 CFR Part 193 incorporates NFPA 59A 2001 edition with the exception of NFPA 59A 2006 edition for seismic design of field fabricated LNG storage tanks. Section 4.1.3.3 of NFPA 59A (2001) and Section 7.2.2.5 of NFPA 59A (2006) indicate the following structures should be designed to withstand an OBE and SSE: (1) LNG storage containers and their impounding systems; (2) System components required to isolate the LNG container and maintain it in a safe shutdown condition; and (3) Structures and systems, including fire protection systems, the failure of which could affect the integrity of (1) or (2) above. This would include:

LNG storage tanks, foundations, and containment dikes
Emergency Power Generator(s) and Fuel Supply
Emergency Lighting
Fire protection systems:
- Sprinkler Systems
- Clean Agent Systems
- Fixed Dry Chemical Units
- Expansion Foam Units
- Fire Water Piping
- Fire Water Intakes
- Fire Water Tanks
- Fire Water Pump Structure
- Fire Water Pumps
- Fire Hydrants
- Fire Water velocity cap
- Interconnecting wiring

Hazard detection systems:
- Low Temperature Detectors
- Flammable/Combustible Gas Detectors
- Oxygen Deficiency Detectors
- Toxic Gas Detectors
- Heat Detectors

Fire Detectors
Smoke Detectors
Fire Alarm Boxes
Hazard Detection Panels in control room
Interconnecting wiring
Radio Communications System
All permanent mounted wireless radios
Shutdown Systems:
Emergency Shutdown Valves
Safety Instrumented Systems
Related SIS Panels
Interconnecting wiring
Uninterruptible Power System (U.P.S.)
Batteries (in rack)
Battery Charger
U.P.S. Inverter
Vent and relief system
All liquid and vapor relief valves in natural gas service
Vent and Flare Stacks

## 1.2 Seismic Category II

NBSIR 84-2833 defines Category II as all structures, components, and systems other than those in Category I, which are required to maintain safe plant operation. This would include:

LNG sendout system controls
Liquefaction trains
Vaporizers
Fuel gas system for fired equipment Instrumentation
Interconnecting piping systems
Metering system
Odorizing system
Hazardous Liquid pumps
Trim heater
Vapor absorber
LNG unloading and transfer system controls
Instrumentation
LNG recirculation system
Offshore piping from dock to abutment
Onshore piping systems from abutment to storage tanks
Unloading and Loading arms
Control Building
Electrical distribution systems fire station/warehouse

Instrument & utility air system
After Filter
Air Receiver
Compressors
Controls
Dryer
Instrumentation
Piping systems
Main control panel and components
Marine trestle and dock (includes structures such as unloading and loading platform, service platform, trestle, dock operator's building and control tower on dock)
Nitrogen systems
Power generation system controls
Fuel gas heater
Fuel gas system Instrumentation
Power generation building Standby power generators
Seawater supply and return system controls instrumentation
Piping to vaporizers
Seawater pumps
Seawater return line screening equipment
Standby plant lighting
Substation buildings
Vapor compression system
Compressor suction drum controls instrumentation
Interconnecting piping systems
Unloading compressors

## 1.3 Seismic Category III

NBSIR 84-2833 defines Category III as facilities which are essential operational support facilities not required for operation, shutdown, or maintenance of a safe shutdown condition. This would include all other facilities not in Category I or II, including:

Administration Building
Bunker Fuel System
Diesel Fuel System except as needed for Category I or II equipment
Dock Service Equipment
Incoming Electrical Power Systems including switchyard normal plant lighting system
Waste Treatment Building

## 2. Supporting Elements and Enclosures

A structure, component, or system of a given Seismic Category may be supported or enclosed by a structure classified in a different category, provided it is demonstrated that the supported item can maintain its functional requirements specified by its Seismic Category.

## 3. Seismic Performance Goals by Category

The following are the seismic performance goals for each category:

### 3.1 Seismic Category I

At a minimum and in accordance with 49 CFR Part 193 and incorporated NFPA 59A, these structures, components and systems should be designed to remain operable during and after the OBE design ground motion (NFPA 59A, 2006 edition, Section 7.2.2.5 A). The design should provide for no loss of containment capability of the primary container and it should be possible to isolate and maintain the LNG container during and after the SSE design ground motion (NFPA 59A, 2006 edition, Section 7.2.2.6 D).

At a minimum and in accordance with 49 CFR Part 193 and incorporated NFPA 59A, the impounding system should be designed to withstand an SSE while empty and an OBE while holding maximum operating volume of the LNG container (NFPA 59A, [2001 edition], Section 4.1.3.2 and NFPA 59A, [2006 edition], Section 7.2.2.6). After an OBE or SSE, there should be no loss of containment capability (NFPA 59A, 2001 edition, Section 4.1.3.4 and NFPA 59A, 2006 edition, Section 7.2.2.7).

### 3.2 Seismic Category II

At a minimum and in accordance with 49 CFR Part 193 and incorporated NFPA 59A, piping systems and components for flammable liquids and gases and service temperatures below −20 °F should be designed to withstand an OBE (NFPA 59A, [2001 edition], Section 6.1.1 and 6.1.2). These systems and components should be designed to meet the seismic performance goals of the IBC for “hazardous” facilities. For hazardous facilities, it is expected that the damage from the DE ground motion defined in the incorporated ASCE 7 would not be so severe as to preclude continued occupancy and function of the project facilities.

### 3.3 Seismic Category III

These structures, components and systems should be designed to meet the seismic performance goals of the IBC and ASCE 7 for normal “non-essential” facilities. For normal facilities, it is expected that structures designed and constructed according to ASCE 7, would sustain repairable damage when subjected to DE ground motions although it may not be economical to do so.

## ATTACHMENT 5 – SAMPLE SEISMIC DESIGN INFORMATION CONTENTS

### 1. General

A seismic design criteria document (also called design basis document) that specifies in detail the seismic criteria to be used in the design of Category I, II and III structures, components and systems should be provided. It should include all seismic design coefficients and inelastic reduction factors, load combinations and allowable stress/strength factors and φ-factors permitted for each load combination. The additional information requested in this Attachment should be included in the document.

### 2. Seismic Design

### 2.1 Design Response Spectra

Design response spectra for the OBE, SSE, MCE, and DE should be provided. The response spectra applied at the finished grade in the free field or at the various foundation locations of Category I structures should be provided. The ASCE 7-05 seismic design parameters that should be used at the various locations of Category II and III structures should also be provided.

### 2.2 Design Time History

For the time history analyses, the response spectra derived from the actual or synthetic earthquake time-motion records should be provided. A comparison of the response spectra obtained in the free field at the finished grade level and the foundation level (obtained from an appropriate time history at the base of the soil/structure interaction system) with the design response spectra should be submitted for each of the damping values to be used in the design of structures, systems, and components. Alternatively, if the design response spectra for the OBE and SSE are applied at the foundation levels of Category I structures in the free field, a comparison of the free-field response spectra at the foundation level (derived from an actual or synthetic time history) with the design response spectra should be provided for each of the damping values to be used in the design. The period intervals at which the spectral values were calculated should be identified.

### 2.3 Critical Damping Values

The specific percentage of critical damping values used for Category I structures, systems, and components and soil should be provided for both the OBE and SSE (e.g., damping values for the type of construction or fabrication such as prestressed concrete and welded pipe). The basis for any proposed damping values should be included.

## 2.4 Supporting Media for Category I Structures

A description of the supporting media for each Category I structure should be provided. Include in this description foundation embedment depth, depth of soil over bedrock, soil layering characteristics, width of the structural foundation, total structural height, and soil properties such as shear wave velocity, shear modulus, and density. This information is needed to permit evaluation of the suitability of using either a finite difference or lumped spring approach for soil/structure interaction analysis, if necessary.

# 3. Seismic System Analysis for Category I Structures

## 3.1 Seismic Analysis Methods

The applicable methods of seismic analysis (e.g., modal analysis response spectra, modal analysis time history, equivalent static load) should be identified and described. Descriptions (sketches) of typical mathematical models used to determine the response should be provided. Indicate how the dynamic system analysis method includes in the model consideration of foundation torsion, rocking, and translation. The method chosen for selection of significant modes and adequate number of masses or degrees of freedom should be specified. The manner in which consideration is given in the seismic dynamic analysis to maximum relative displacement among supports should be indicated. In addition, other significant effects that are accounted for in the seismic analysis (e.g., hydrodynamic effects and nonlinear response) should be indicated. If tests or empirical methods are used in lieu of analysis, the testing procedure, load levels, and acceptance bases should also be provided.

## 3.2 Natural Frequencies and Response Modes

The significant natural frequencies and response modes determined by seismic system analyses should be provided for Category I structures. In addition, the response spectra at critical Category I elevations and points of support should be specified.

## 3.3 Procedure Used for Modeling

The criteria and procedures used for modeling in the seismic system analyses should be provided. Include the criteria and bases used to determine whether a component or structure should be analyzed as part of a system analysis or independently as a subsystem.

## 3.4 Soil/Structure Interaction

As applicable, the methods of soil/structure interaction analysis used in the seismic system analysis and their bases should be provided. The following information should be included:

a) the extent of embedment
b) the depth of soil over rock, and
c) layering of the soil strata.

If the finite difference approach is used, the criteria for determining the location of the bottom boundary and side boundary should be specified. The procedure by which strain dependent soil properties (e.g., damping and shear modulus) are incorporated in the analysis should also be specified. The material given in Section 2.4 of this Attachment may be referenced in this section.

If lumped spring methods are used, the parameters used in the analysis should be discussed. Describe the procedures by which strain-dependent soil properties, layering, and variation of soil properties are incorporated into the analysis. The suitability of a lumped spring method used for the particular site conditions should also be discussed.

Any other methods used for soil/structure interaction analysis or the basis for not using soil/structure interaction analysis should be provided.

The procedures used to consider effects of adjacent structures on structural response in soil/structure interaction analysis should be provided.

## 3.5 Development of Floor Response Spectra

The procedures for developing floor response spectra considering the three components of earthquake motion should be described. If a modal response spectrum method of analysis is used to develop floor response spectra, the basis for its conservatism and equivalence to a time history method should be provided.

## 3.6 Three Components of Earthquake Motion

Identify the procedures for considering the three components of earthquake motion in determining the seismic response of structures, systems, and components.

## 3.7 Combination of Modal Responses

When a response spectra method is used, a description of the procedure for combining modal responses (shears, moments, stresses, deflections, and accelerations) should be provided.

### 3.8 Interaction of Non-Category I Structures with Category I Structures

Provide the design criteria used to account for the seismic motion of non-Category I structures or portions thereof in the seismic design of Category I structures or portions thereof. In addition, describe the design criteria that will be applied to ensure protection of Category I structures from the structural failure of non-Category I structures due to seismic effects.

### 3.9 Effects of Parameter Variations on Floor Response Spectra

The procedures that will be used to consider the effects of expected variations of structural properties, damping, soil properties, and soil/structure interaction on floor response spectra (e.g., peak width and period coordinates) and time histories should be described.

### 3.10 Use of Constant Vertical Static Factors

Where applicable, identify and justify the application of constant static factors as vertical response loads for the seismic design of Category I structures, systems, and components in lieu of a vertical seismic system dynamic analysis method.

### 3.11 Method Used to Account for Torsional Effects

The method used to consider the torsional effects in the seismic analysis of the Category I structures should be described. Where applicable, discuss and justify the use of static factors or any other approximate method in lieu of a combined vertical, horizontal, and torsional system dynamic analysis to account for torsional accelerations in the seismic design of Category I structures.

### 3.12 Comparison of Responses

Where both modal response and time history methods are applied, the responses obtained from both methods at selected points in major Category I structures should be provided, together with a discussion of the comparative responses.

### 3.13 Determination of Category I Structure Overturning Moments

A description of the dynamic methods and procedures used to determine Category I structure overturning moments should be provided.

### 3.14 Analysis Procedure for Damping

The analysis procedure used to account for the damping in different elements of the model of a coupled system should be described.

## 4. Design and Analysis Procedures

The procedures that will be used in the design and analysis of all internal Category I structures should be described, including the assumptions made and the identification of boundary conditions. The expected behavior under load and the mechanisms for load transfer to these structures and then to the foundations should be provided. Computer programs that are used should be referenced to permit identification with published programs. Proprietary computer programs should be described to the maximum extent practical to establish the applicability of the program and the measures taken to validate the programs with solutions derived from other acceptable programs or with solutions of classical problems.

## 5. Structural Acceptance Criteria

The acceptance criteria relating stresses, strains, gross deformations, and other parameters that identify quantitatively the margins of safety should be specified. The information provided should address the containment as an entire structure, and it should also address the margins of safety related to the major important local areas of the Category I structures important to the safety function. For each applicable loading condition listed below, the allowable limits should be provided, as appropriate for stresses, strains, deformation, and factors of safety against structural failure. The extent of compliance with the various applicable codes should be presented. The load conditions to consider include but are not limited to:

a) Loads encountered during seasonal plant startup, including dead loads, live loads, thermal loads due to operating temperature, and hydrostatic loads.

b) Loads that would be sustained in the event of severe environmental conditions, including those induced by the OBE.

c) Loads that would be sustained in the event of extreme environmental conditions, including those that would be induced by the SSE.

## ATTACHMENT 6 – SAMPLE GEOTECHNICAL REPORT CONTENTS

### 1. Contents of Report

### 1.1 Plant Description

The general arrangement of major structures and equipment should be indicated by the use of plan and elevation drawings in sufficient number and detail to provide a reasonable understanding of the general layout of the plant. The sizes and loading of the critical structures should be provided.

### 1.2 Summary of Site Investigation and Project Status

The current status of the site evaluation study should be documented and additional planned investigations should also be described. The current design status of the project should include whether the phase of design, such as conceptual design or final design, and should identify what level of computations have been performed to arrive at the current design stage and what studies, data gathering, calculations and documentation remains to be done. Such items as unusual site characteristics, solutions to particularly difficult engineering problems, and significant extrapolation in technology represented by the design should be highlighted.

### 2. Exploration

Discuss the type, quantity, extent, and purpose of all explorations. Provide plot plans that graphically show the location of all site explorations such as borings, trenches, borrow pits, seismic lines, cone penetration tests, piezometers, wells, geologic profiles, and the limits of required construction excavations. The locations of the Seismic Category I, II, and III facilities should be superimposed on the plot plan. Also, furnish selected geologic cross-sections and profiles that indicate the location of borings and other site exploration features, groundwater elevations, and final foundation grades. The location of safety-related foundations should be superimposed on these sections and profiles.

Logs of all borings and test pits should be provided. Furnish logs and maps of exploratory trenches and geologic maps and photographs of the excavations for the facilities of the LNG plant.

### 2.1 Logs of Borings/Cone Penetration Tests (CPT)

Present the logs of borings, CPTs, test pits and trenches that were completed for the evaluation of foundations, slopes, and borrow materials to be used for slopes.

Logs should indicate elevations, depths, soil and rock classification information, groundwater levels, exploration and sampling methods, recovery, rock quality designation

(RQD), and blow counts from standard penetration tests. Provide specific details of how the Standard Penetration Test was performed. Discuss drilling and sampling procedures and indicate where samples were taken on the logs. In areas where liquefaction potential is high, borings should be performed by rotary drilling method in accordance with the requirements for obtaining standard penetration blow count N-values outlined by Youd, et al., 2001 (Ref.11) and Martin & Lew, 1999 (Ref. 21). Cone penetration tests should be performed to define the soil profile accurately and to use both N-values and CPT data for evaluation of liquefaction potential and settlements due to liquefaction. Typically a minimum of five (5) explorations (borings / CPTs) should be performed under each LNG tank and the depth of the exploration should be 20 feet deeper than deepest anticipated foundations. The borings and CPTs should also be sufficiently deep to sample the zone of influence for settlements and liquefaction potential (at least 100 feet if bedrock is not encountered). For large tanks more than 5 explorations may be necessary to adequately characterize the sub-surface conditions.

All local, state, and Federal environmental regulations regarding obtaining permits for the geotechnical borings and wells, clearing of underground utilities, disposal of cuttings and drilling mud should be followed.

Where groundwater is present at depths which could affect the foundations or liquefaction potential, selected borings should be converted into wells to define stabilized groundwater. Historic high groundwater should be determined from published literature for liquefaction evaluation.

### 2.2 Geophysical Surveys

Results of compressional and shear wave velocity surveys performed to evaluate the occurrence and characteristics of the foundation soils and rocks should be provided in tables and profiles. Discuss other geophysical methods used to define foundation conditions. The depth of explorations for performing downhole or cross-hole shear wave velocity measurements should be at least 100 feet.

## 3. Laboratory Testing

### 3.1 General

Laboratory testing should include the following tests. Actual tests should depend on the type of soil encountered. All testing should be performed in accordance with the most recent ASTM standards (Ref. 30), where applicable. Adequate number and type of tests should be performed on representative samples in order to characterize the subsurface soils and to develop representative strength, compressibility, and corrosivity properties of the soils as indicated in this specification.

### 3.2 Identification Tests

Moisture Content (ASTM D2216)
Unit Weight
Specific Gravity (ASTM D854)
Sieve Analysis (AS TM D422)
Atterberg Limits (ASTM D4318)

### 3.3 Engineering Property Characterization Tests

Compaction (ASTM D1557, or D698)
California Bearing Ratio (ASTM D1883)
R-value (ASTM D2844)
Unconfined Compression Test of Cohesive Soils (ASTM D2166)
Unconsolidated-Undrained Triaxial Compression Test (ASTM D2850)
Consolidation Test with time readings (ASTM D2435)
Swell Test (ASTM D4546)
Expansion Index Test (ASTM D4829)
Collapse test (ASTM D 5333)
Consolidated-Drained Triaxial Compression Test
Consolidated-Undrained Triaxial Compression Test with Pore Pressure Measurements (ASTM D4767)
Direct Shear Test (ASTM D3080)
Soil Permeability (ASTM D5084 and D2434)
Corrosivity (Chloride, Sulfate, Electrical Resistivity)
pH Value for Soil Corrosivity (ASTM G51)

## 4. Geologic and Seismic Setting

This section of the report should discuss general geologic and seismic information relevant to foundation design such as geologic setting, regional geology, site geology, faulting. Specific geologic features that may affect site stability and foundation design such as the following should be discussed.

1) Areas of actual or potential surface or subsurface subsidence, uplift, or collapse and the causes of these conditions;

2) Previous loading history of the foundation materials, i.e., history of deposition and erosion, groundwater levels, and glacial or other preloading influences on the soil;

3) Rock bedding and jointing pattern and distribution, depth of weathering, zones of alteration or irregular weathering, and zones of structural weakness composed of crushed or disturbed materials such as slickensides, shears,

joints, fractures, faults, folds, or a combination of these features. Especially note seams and lenses of weak materials such as clays and weathered shales;

4) Unrelieved residual stresses in bedrock;

5) Rocks or soils that may be hazardous, or may become hazardous, to the plant because of their lack of consolidation or induration, inhomogeneity, variability, high water content, solubility, or undesirable response to natural or induced site conditions; and

6) Requirements of the detailed site geology, seismicity, and faulting as they relate to site Ground Motion Study are provided in Attachment 3.

## 5. Site Conditions

### 5.1 Surface Conditions

The surface conditions at the site should be described. Presence of any unusual site features should be identified. Site topography including existing contours should be provided. Site drainage should be discussed. Include a current aerial photograph of the site, and if available, provide historic aerial photographs of the site that demonstrate any past conditions or uses of the site relevant to the proposed project design.

### 5.2 Subsurface Soil Conditions

Site subsurface conditions should be described in detail. Generalized subsurface profiles including various soil strata should be presented in various cross-sections across the site specifically through the LNG tank area. Soil properties assigned to each strata should be tabulated for bearing capacity, settlement, pile capacity, and slope stability calculations. The basis for selected soil parameters (laboratory testing, blow counts, CPT data, experience) should be stated. A discussion on the selection of engineering parameters is required. When published correlation relationships are used to determine the engineering parameters, references should be given.

A conversion ratio between blow counts from penetration tests not performed per ASTM D 1586 (standard penetration test) should be discussed and provided, if applicable. This includes nonstandard samplers, nonstandard hammer energy delivery systems, and considerations of hammer efficiency.

### 5.3 Groundwater Conditions

The analysis of groundwater at the site should include the following points:

1) A discussion of groundwater conditions relative to the stability of Seismic Category I safety-related facilities;

2) A discussion of design criteria for the control of groundwater levels or collection and control of seepage;

3) Requirements for dewatering during construction and a discussion of how dewatering will be accomplished;

4) Records of field and laboratory permeability tests;

5) History of groundwater fluctuations, including those due to flooding and recommended design groundwater level for the plant and for liquefaction analyses;

6) Information related to the periodic monitoring of local wells and piezometers;

7) Direction of groundwater flow, gradients, and velocities; and

8) Discussion of or reference to the groundwater monitoring program during the life of the plant to assess the potential for subsidence.

## 6. Seismic Hazards

Seismic hazards include fault rupture, ground motions, liquefaction, lateral spreading, seismic slope stability, seismic compaction, tsunamis and seiche. Details of fault rupture, ground motions, tsunamis, and seiche, should be provided in the site-specific seismic ground motion report. These items should be summarized in the geotechnical report.

Liquefaction potential, liquefaction-related settlement, potential for sand boils and other surface manifestation of liquefaction, lateral spreading, seismic slope stability, seismic compaction, and need for ground improvement to mitigate these hazards, if present, should be addressed in detail in the geotechnical report.

### 6.1 Fault Rupture

Distances from significant faults should be identified and potential for fault rupture should be discussed in the geotechnical report. The site-specific ground motion report should be referenced for more details.

### 6.2 Site Class

Site Class should be identified per ASCE 7 or IBC.

## 6.3 Ground Motions

A seismic hazard study should be performed to establish ground motions for the site for four levels of shaking, the OBE, the SSE, the MCE, and the DE. Details of the requirements for the determination of the ground motions are presented in Attachment 3.

## 6.4 Seismic Slope Stability

The LNG tanks should have a minimum calculated static factor of safety of 1.5 for slope stability with respect to any nearby slopes of berthing slips or other existing or future slopes. Pseudo-static screening analyses may be used to determine seismic slope stability, provided the soils are not liquefiable or expected to lose shear strength significantly during deformation. Detailed deformation analyses should be performed where pseudo-static screening analyses indicate that factor of safety is less than 1.0.

## 6.5 Liquefaction Evaluation

When the field investigation reveals that potentially liquefiable soils and conditions including lateral spreading exist and they pose a hazard to the project site, a quantitative geotechnical evaluation of such a potential should be conducted. In-situ testing, soil sampling, and laboratory testing on potentially liquefiable soils must be properly planned and conducted to obtain reliable data for the geotechnical evaluation. If liquefaction is likely to occur, its consequences should be assessed, its impact on foundations should be addressed, and mitigation measures should be specified. Elevations of the liquefiable layer(s) should be presented in the Foundation Report. Assumptions, analytical or empirical methods used, and conclusions for liquefaction evaluation should be stated with relevant data and analysis attached in Appendices. Potential for surface manifestation of liquefaction in form of sand boils and surface displacement should be identified. Total and differential settlements due to liquefaction should be estimated and provided. If liquefaction settlements are beyond the tolerance of the proposed structures, remedial measures to mitigate liquefaction potential should be provided. All liquefaction evaluations should be performed in accordance with latest published guidelines (e.g., Youd, T. L., et. al., 2001 (Ref. 11), and Martin, G. R., and Lew, M., 1999 (Ref. 21)).

## 6.6 Lateral Spreading

If liquefaction potential exists, potential for lateral spreading should be evaluated and calculations of lateral movements made by Newmark simplified approach (Makdisi, F. I., and Seed H.B, 1978 and by Bartlett & Youd (1995)) method. The effects of calculated

lateral spreading movements on the stability of the plant structures should be evaluated and remedial measures proposed, if the movements exceed the design criteria.

### 6.7 Subsidence

Subsidence due to earthquakes, groundwater or oil withdrawal is a significant geologic/seismic risk. Areal movements due to these effects should be evaluated and their effects on the differential settlement of the plant structures, or general effects on the site (e.g., should be evaluated.

## 7. Poor Soil Conditions

Presence of poor or unusual soil conditions, such as highly compressible or highly expansive soils, corrosive soils, collapsible soils, erodible soils, liquefaction-susceptible soils, frost heave susceptible soils, frozen soils, or sanitary landfill etc. should be identified and remedial measures including ground improvement methods should be recommended, if such soils are present.

## 8. Foundation Recommendations

Complete, concise, and definite foundation recommendations should be provided for various categories (Seismic Categories I, II, and II) structures. The selection of a specific foundation type depends on factors such as surface and subsurface conditions at the site, geotechnical capacity, dynamic and static demands, environmental concerns, economics, and construction issues. The recommended foundation type should be cost-effective, performance-proven, and constructible.

Alternative foundation types should be discussed and the reasons why those alternatives are not recommended should be stated. Solutions to potential construction problems should be discussed. A sufficient and adequate geotechnical evaluation for the recommended foundation should be performed.

In general, any foundation design should meet four essential requirements: (1) adequate geotechnical capacity of soil/rock surrounding the foundation with a specified safety against ultimate failure; (2) acceptable total or differential settlements under static and dynamic loads; (3) adequate overall stability of slopes in the vicinity of a footing/mat; and (4) constructability with solutions for anticipated problems.

### 8.1 LNG Tanks

#### 8.1.1 Tank Loading and Settlement Criteria

For LNG tanks the loading from the tanks and criteria for adequate factor of safety against bearing capacity failure and settlement should be discussed.

### 8.1.2 Shallow Foundations

LNG tanks supported on shallow foundations are generally supported on a mat. Ultimate bearing capacity of the mat should be calculated and should provide a minimum factor of safety of 3.0 for the applied tank loading during hydrotest. Effects of adjacent slopes, if present, on the bearing capacity should be evaluated. The reduction of the factor of safety due to liquefaction or other effects should be evaluated and addressed. Total and differential settlement of the mat foundation should be calculated under various applied loads such as during hydrotest, operation, and seismic conditions including liquefaction, if present.

Recommendations for monitoring of the settlements during hydrotest should be provided. Lateral stability of the tanks under seismic and wind loads should be calculated and it should be demonstrated that an adequate factor of safety is present. If lateral spreading is a seismic issue, lateral stability of the tanks due to lateral spreading movements should be demonstrated. Overall lateral stability of the foundation for static and seismic conditions including any adjacent slopes, if present, should be evaluated.

### 8.1.3 Deep Foundations

For Deep Foundations, the report should address, but not be limited to, the following when applicable:

1. Pile Types, Axial Compressive and Tensile, and Settlement

    a. Recommended pile types should be identified as driven Precast Prestressed Reinforced Concrete piles, Steel H or Pipe piles, cast-in drilled hole (CIDH) piles, Auger Cast Piles or others. Alternatives should be discussed and the reasons why those alternatives are not recommended should be stated.

    b. Whether compressive and/or tensional geotechnical capacities are derived from skin friction, end bearing, or a combination of both for a single or group pile(s) should be discussed.

    c. Pile design tip elevations (DTE) may be controlled by demands from compression, tension, lateral loads, scour potential, or liquefaction. The pile Specified Tip Elevation (STE) equals the lowest pile DTE as estimated above.

    d. The portion of the axial capacities for pile foundations in and above liquefiable soils should be neglected.

    e. Negative skin friction (down-drag) on pile shaft due to settlements of new fills or compressible soil layers should be eliminated by use of

preloading/surcharge with or without wick drains prior to pile installation or piles should be designed for downdrag associated with these settlements. Downdrag from settlements due to liquefaction should also be calculated.

f. When a situation such as liquefaction potential exists that does not allow for mitigation and elimination of negative skin friction, the magnitude of the downdrag forces should be estimated and provided to the structural designer for him/her to incorporate those forces into Design Loading. The magnitude of estimated settlement should also be provided to the structural engineer.

g. Lateral pile capacity should be estimated using the p-y method or equivalent. Group reduction factors depending on soil types, pile spacing, and anticipated lateral movement should be considered when evaluating lateral capacity for a group of piles. Formulation of p-y curves for liquefiable soils and weak rocks, effects of pile diameters on lateral soil modulus and soil strain parameters, evaluation of liquefaction or lateral spreading forces imposed on pile, and reduced moment of inertia for concrete piles should be addressed.

h. The single and/or group pile settlement should not exceed the tolerable amount as established by the structural designer.

2. Special Considerations for Cast-In Drilled Hole (CIDH) Piles

a. When battered piles are required, CIDH piles should not be used because of the increased risk of caving and the difficulty of placing concrete in a sloping hole.

b. If pile tips are below the groundwater table or wet construction method is used, CIDH piles should be designed at a diameter equal to or greater than 24 in.

c. When CIDH piles are used under water, no end bearing should be used unless positive measures to verify the end bearing are recommended.

3. Installation of Driven Piles

Pile drivability should be evaluated by wave equation analyses. An indicator pile program including pile driving analyzer (PDA) measurements should be planned to verify the pile drivability and the estimated capacity. A load test program should be developed to verify the capacity of selected piles both under axial and lateral conditions.

4. Installation of Drilled or Auger Cast Piles

Gamma-Gamma testing should be performed on CIDH piles installed underwater by the wet method to verify the integrity of the piles.

An axial and lateral load test program should be implemented to verify the axial and lateral capacity of the piles. Pile Load Test can be used for determining pile capacity at failure (ultimate capacity), and for establishing field acceptance criteria. A load test remains the definitive way to determine whether the professional's estimate of capacity and specified tip elevations is appropriate in design and to determine whether the production piles meet the specifications during construction. The equipment and procedures for conducting pile axial compressive load tests can be found in literature such as ASTM D 1143. Static axial tension tests should be performed per ASTM D 3689. Static lateral load tests should be performed per ASTM D 3966.

### 8.1.4 Ground Improvement

Ground Improvement should discuss the need for ground improvement, type(s) of ground improvement, surcharge, stone columns, vibroflotation, soil-cement columns, dynamic compaction, and other types of ground improvement. The discussion should address the effects of ground improvements on soil properties and seismic ground motions.

## 9. Corrosion

An assessment of the corrosiveness of a site based on the review of relevant corrosion test data should be made. Corrosion test data should include pH, electrical resistivity, stray electrical ground currents, water soluble sulfates and chlorides. Sufficient information regarding the number and location of soil borings for corrosion testing should be included to allow a thorough review of the recommendations. Recommendations regarding concrete and metals in contact with onsite soils should be provided.

## 10. Pavement Design

Recommendations for design of asphalt and Portland cement concrete pavements for the plant area should be provided based on the onsite soil R-value or CBR.

## ATTACHMENT 7 – SAMPLE FOUNDATION DESIGN CRITERIA CONTENTS

### 1. General

A foundation design criteria document should be provided that states how Seismic Category I, II and III structures will be designed. This document will be consistent with recommendations provided in the geotechnical report. In addition, the foundation criteria document should include the items requested in this attachment.

### 2. Foundation Design

All Seismic Category I and II structures constructed of materials other than soil for the purpose of transferring loads and forces to the basic supporting media should be addressed in more detail. In particular, the information described below should be provided.

### 2.1 Description of the Foundations

This section should provide descriptive information, including plan and section views of each foundation, to define the primary structural aspects and elements relied upon to perform the foundation function. The relationship between adjacent foundations, including any separation provided and the reasons for such separation, should be described. In particular, the type of foundation and its structural characteristics should be discussed. The general arrangement of each foundation should be provided with emphasis on the methods of transferring horizontal shears, such as those seismically induced, to the foundation media. If shear keys are used for such purposes, the general arrangement of the keys should be included. If waterproofing membranes are used, their effect on the capability of the foundation to transfer shears should be discussed.

Information should be provided to adequately describe other types of foundation structures such as pile foundations, caisson foundations, retaining walls, abutments, and rock and soil anchorage systems.

### 2.2 Applicable Codes, Standards, and Specifications

This section should provide information on the applicable codes, standards and specifications used in the design foundations of all Seismic Category I, II, and III structures.

### 2.3 Loads and Load Combinations

This section should provide information, as applicable, on the load combinations that should be used in conjunction with the foundation recommendations for all Category I, II, and III structures.

## 2.4 Design and Analysis Procedures

This section should provide information, as applicable, on the foundations of all Category I , II, and III structures. In particular, the assumptions made on boundary conditions and the methods by which lateral loads and forces and overturning moments, thereof, are transmitted from the structure to the foundation media should be discussed, along with the methods by which the effects of settlement are taken into consideration.

## 2.5 Structural Acceptance Criteria

This section should provide information applicable to foundations of all Category I, II, and III structures. In particular, the design limits imposed on the various parameters that serve to define the structural stability of each structure and its foundations should be indicated, including differential settlements and factors of safety against overturning and sliding.

## 2.6 Materials, Quality Control, and Special Construction Techniques

This section should provide materials, quality control, and special construction techniques for the foundations of all Category I, II, and III structures.