FEDERAL ENERGY REGULATORY COMMISSION

Office of Energy Projects

GUIDANCE MANUAL FOR ENVIRONMENTAL REPORT PREPARATION

Volume II

LNG Facility Resource Reports 11 & 13 Supplemental Guidance

DRAFT

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PREAMBLE

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 193) that existed and the edition of National Fire Protection Association (NFPA) Standard 59A that was referenced by 49 CFR 193 at that time.

When FERC began receiving applications for liquefied natural gas (LNG) import terminals in the early- and mid-2000s, FERC staff developed a series of guidance documents to assist in the preparation and review of applications. Specially, on December 15, 2005, FERC staff issued *Draft Guidance on Resource Report 11 and 13* to assist in interpretation of its regulations under 18 CFR 380.12(m) and 18 CFR 380.12(o) for LNG applications. On April 12, 2006, FERC staff subsequently issued the *Draft Preferred Format Submittal Guidance* to further assist in the format of material to be submitted to aid in more efficiently, effectively, and expediently reviewing LNG import applications. Finally, on January 23, 2007, FERC staff 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, which in 2003 adopted the 2001 edition of NFPA 59A, needed to: contain information reflected in NBSIR 84-2833 requirements per 18 CFR 380.12(h)(5); demonstrate facilities are designed to address the potential hazard to the public from failure of facility components resulting from natural catastrophes per the requirements of 18 CFR 380.12(m); and demonstrate facilities are designed in accordance with DOT and NFPA 59A requirements per 18 CFR 380.12(o)(14).

The *Draft Guidance on Resource Report 11 and 13* and *Draft Preferred Format Submittal Guidance* were based upon what was understood to be the requirements and practices of LNG facilities at the time. However, in 2010 additional interpretations on the requirements to meet the exclusion zones and siting requirements in 49 CFR 193 have been issued by DOT and in 2011 additional hazard modeling considerations and programs have been approved by DOT to demonstrate compliance with the 49 CFR 193 siting regulations. This has resulted in refinements and clarifications on the level of information needed for FERC staff review in evaluating the hazards associated with LNG facilities per 18 CFR 380.12(m) and 18 CFR 380.12(o).

This document includes information needed to comply with: 18 CFR 380.12(h)(5) to demonstrate information reflected in NBSIR 84-2833; 18 CFR 380.12(m) to demonstrate that the potential hazard to the public from failure of facility components resulting from natural catastrophes; and 18 CFR 380.12(o)(14) to demonstrate the proposed design would likely comply with the regulatory requirements in 49 CFR 193.

The current 18 CFR 380.12(h)(5) continues to incorporate NBSIR 84-2833, which provides guidance of what structures, systems, and components are to be designed for the Safe Shutdown Earthquake (SSE) and Operating Basis Earthquake (OBE) and it classifies these items as Category I. The current 49 CFR 193 seismic requirements for LNG facilities as reflected in

NFPA 59A-2001 and NFPA 59A-2006 are also clear on which structures, systems and components are to be seismically designed for the SSE and OBE design earthquake ground motions. NFPA 59A-2001 also requires piping with cold contents (-20°F or lower) to be designed dynamically for the OBE or statically 0.60 Sc (maximum spectral acceleration of the Design Earthquake which equals 2/3rd of the Maximum Considered Earthquake [MCE]) as specified in the National Earthquake Hazards Reduction Program (NEHRP) Recommended Provisions. The suggested seismic design for the remainder of the LNG facilities are included in NFPA 59A-2001, Appendix B.5.2, which references the NEHRP Recommended Provisions, but these are in non-mandatory Appendix B. This, in essence, results in no regulatory design requirements in 49 CFR 193 for any equipment or piping other than stationary LNG storage tanks and other than piping with flammable fluids or gases below -20°F.

However, NBSIR 84-2833 provides guidance classifying the remainder of the LNG facility structures, systems, and components as either Category II or Category III, but does not provide specific guidance for the specific seismic design requirements for them. While not a regulatory requirement, absent any other regulatory requirements, this guidance suggests that other LNG facility structures classified as Seismic Category II or III be seismically designed to satisfy the seismic requirement of the American Society of Civil Engineers (ASCE) 7-05 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 7-05 is important to accommodate seals by the engineer of record because the IBC is directly linked to state professional licensing laws while the NEHRP Provisions are not. Therefore, the guidance is based upon the regulatory requirements of 18 CFR 380, 49 CFR 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 there would not be a significant impact on the public due to the seismicity and other natural hazards.

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ACRONYMS AND ABBREVIATIONS

AEGL	Acute Exposure Guideline Levels
ALE	Aftershock Level Earthquake
API	American Petrolium Institute
ASCE	American Society of Civil Engineers
ASTM	American Society for Testing and Materials
BLEVE	boiling-liqued expanding-vapor explosion
BOG	boil-off gas
Btu	British thermal unit
CCTV	closed circuit television
CEII	Critical Energy Infrastructure Information
CFR	Code of Federal Regulations
Coast Guard	U.S. Coast Guard
Commission	Federal Energy Regulatory Commission
CPT	Cone Penetration Tests
DCS	Distributed Control System
DoD	U.S. Department of Defense
DOT	U.S. Department of Transportation
EPA	U.S. Environmental Protection Agency
ERPG	Emergency Response Planning Guidelines
ESD	emergency shutdown
°F	degrees Fahrenheit
FAA	Federal Aviation Administration
FEED	front end engineering design
FERC	Federal Energy Regulatory Commission
ft	feet
gal	U.S. gallons
gpm	U.S. gallons per minute
hr	hour(s)
HAZID	Hazard Identification

HAZOP	Hazard and Operability
HHV	higher heating value
HMI	Human Machine Interface
HP	high pressure
HTF	heat transfer fluid
IBC	International Building Code
inches H_2O	inches of water
inches Hg	inches of mercury
ISO	International Organization for Standardization
Kts	knots
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 meters
MAOP	maximum allowable operating pressure
MAWP	maximum allowable working pressure
mbar	millibar
MCE	maximum considered earthquake
MCT	maximum considered tsunami
MMbtu	million British thermal units
MMscfd	million standard cubic feet per day
mph	miles per hour
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
NFPA	National Fire Protection Association
NGA	Natural Gas Act
NGL	Natural Gas Liquids
NGVD	National Geodetic Vertical Datum of 1929
NOI	Notice of Intent
NO2	nitrogen dioxide
NOX	nitrogen oxides
NPSH	net positive suction head
NVIC	Navigation and Vessel Inspection Circular
NRC	Nuclear Regulatory Commission
OBE	Operating Basis Earthquake
OEP	Office of Energy Projects
P&C	Privileged and Confidential
P&IDs	Piping and Instrumentation Drawings
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
psia	pounds per square inch absolute
psig	pounds per square inch gauge
PUC	Public Utility Commission
PVB	pressure vessel burst
RAM	reliability, availability, and maintainability
scfm	standard cubic foot (feet) per minute
SIL	Safety Integrity Level
SIMOPS	Simultaneous Operations
SIS	safety instrumented system

SSE	Safe Shutdown Earthquake
UPS	uninterruptible power supply
V	voltage
VCE	vapor cloud explosion
(ϕ)	Angle of Internal Friction

INTRODUCTION

This document is intended to assist applicants by identifying the specific information and level of detail recommended for Resource Report 11 and Resource Report 13 for LNG facility applications, as required by Title 18 of the Code of Federal Regulations (CFR) Part 380.12 (18 CFR 380.12). To promote an efficient staff review of the proposal, this document contains a standard format to be completed. Filings that are complete and organized will facilitate staff review of the proposed design with respect to operability, reliability, and safety.

This document combines, replaces, and updates the *Guidance for Filing Resource Reports 11 & 13 for LNG Facility Applications, Resource Report 13 Draft Preferred Submittal Format Guidance* (AD06-4-000), and the *Draft Seismic Design Guidelines and Data Submittal Requirements for LNG Facilities*.

Resource Report 11 and Resource Report 13 are required for proposal of new LNG facilities, expansions to existing LNG facilities, or the re-commissioning of existing LNG facilities. The resource reports should contain site-specific design information produced in the normal course of developing the design of a facility. Special drawings and additional details should not normally be required, unless novel designs require additional detail or the FERC staff requests further detail.

Resource Report 11 addresses the potential hazard from failure of facility components resulting from accidents or natural catastrophes, how these events would affect safety and reliability, and the procedures and design features that would be used to reduce potential hazards. Resource Report 11 often serves as a public summary that can be used in preparation of the National Environmental Policy Act of 1969 document. Resource Report 13 contains more detailed information that can be used to review the adequacy of the reliability and safety of the engineering design.

The level of detail to be submitted in Resource Report 13 will require front end engineering design (FEED) of the complete facility. The FEED should include all features necessary to evaluate the design, construction, commissioning, start-up, operation, and maintenance of the facility to the extent that detailed design will not result in changes to the siting considerations, basis of design, major equipment, safety and security systems, or operating conditions.

The format and guidelines are intended to address all types of LNG facilities and, therefore, not all of the topics will apply to all facilities. Where the topics do not apply to a proposed facility, the submitter should note that the topic is “Not applicable.” In the event that the applicant wishes to add to the list of topics, the addition should be made at the end of the list and not as an insert.

All filings must be made in compliance with the Commission’s 18 CFR 388 regulations or guidance concerning Critical Energy Infrastructure Information (CEII) and Privileged and Confidential (P&C) Information. If providing separate binders or electronic filings for public, CEII, and P&C versions, then the P&C version should include all public and CEII information, in addition to the labeled P&C information, so that this version is a complete resource report for review.

A complete set of drawings should be provided in electronic and hard copy format.

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 of colored drawings) on 11”x17” paper 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 and separated for each Appendix. Binder volumes 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 with the contents.

The electronic filing should be in .pdf or .docx format. The drawings must be legible and 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[1]

11.1.1 Regulatory Oversight of Reliability and Safety

PROVIDE a description of the regulatory oversight of reliability and safety for the facility. At a minimum, the description should describe the regulatory agencies that have oversight over the reliability and safety of the facility, operations, and associated hazardous material transportation to and from the facility and any agency coordination that has occurred. Department of Transportation (DOT) jurisdictional facilities should discuss and include consultation on any interpretations, special permits, equivalencies, and other issuances by DOT on the project. U.S. Coast Guard (Coast Guard) jurisdictional facilities should discuss and include all Letter of Intent (LOI) submittals, or other issuances by the Coast Guard on the project. Nuclear facilities that may be impacted by the facilities, operation, or construction of the project or by transportation to or from the project should be identified and should describe and include any correspondence and issuances by the Nuclear Regulatory Commission. Aeronautical operations and installations that may be impacted by the facilities, operation, or by transportation to or from the project should be identified and should describe and include any studies and determinations from the Federal Aviation Administration (FAA). Military operations and installations that may be impacted by the facilities, operation, or construction of the project or by transportation to or from the project should be identified and include any correspondence and issuances by the U.S. Department of Defense (DoD). Facilities should discuss and include correspondence with the state safety agencies and state fire marshal. References should be made to Resource Report 13 and Appendix 13.C for more details.

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

11.2 HAZARDS[2]

11.2.1 Hazardous Materials at the Facility

PROVIDE a description of all hazardous materials stored, processed, or handled at the LNG facility or transported to/from the LNG facility. At a minimum, the description should reference any safety data sheets in Appendix 13.H for details, but should include:

11.2.1.1 List of all physical properties

- 11.2.1.1.1 freezing/melting temperature at normal pressure (14.7 pounds per square inch, absolute [psia])[3], °F
- 11.2.1.1.2 boiling/condensing temperature at normal pressure (14.7 psia)[4], °F
- 11.2.1.1.3 vapor and liquid densities at boiling/condensing temperature and normal pressure (14.7 psia), lb/ft^3
- 11.2.1.1.4 vapor and liquid densities at normal temperature (70°F) and normal pressure (14.7 psia)[5], lb/ft^3
- 11.2.1.1.5 operating temperatures (minimum, normal, maximum) in process and storage, °F
- 11.2.1.1.6 operating pressures (minimum, normal, maximum) in process and storage, pounds per square inch gauge (psig)
- 11.2.1.1.7 operating densities (minimum, normal, maximum) in process and storage, lb/ft^3
- 11.2.1.1.8 expansion ratio range between operating densities (minimum, normal, maximum),

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2 *18 CFR 380.12(m)(2).*

3 *American Society for Testing Materials (ASTM) D1015 Standard Test Method for Freezing Points of Hugh Purity Hydrocarbons.*

4 *NFPA 704 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 the 20% evaporation point of a distillation performed in accordance with ASTM D86 Standard Test Method for Distillation of Petroleum Products at Atmospheric Pressure shall be used as the boiling point.*

5 *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.*

and normal temperature (70°F) and pressure (14.7 psia)

11.2.1.2 List of all asphyxiant and toxic properties

11.2.1.2.1 max concentration of toxic component in process

11.2.1.2.2 asphyxiation concentration

11.2.1.2.3 acute exposure guidance levels (AEGL)-1, -2, -3 or emergency response planning guidelines (ERPG)-1, -2, -3 concentrations

11.2.1.3 List of all flammable and combustible properties

11.2.1.3.1 flash points[6], °F

11.2.1.3.2 flammability ranges, upper flammable limit (UFL) and lower flammable limit (LFL)[7], percent volume, including for mixed hydrocarbon streams as a composite rather than individual components

11.2.1.3.3 stoichiometric concentrations, percent volume

11.2.1.3.4 minimum ignition energies, millijoules

11.2.1.3.5 quenching distance[8], mm

11.2.1.3.6 Maximum experimental safety gap, mm

11.2.1.3.7 auto ignition temperatures[9], °F

11.2.1.3.8 heat of combustions, megajoules/kilograms (kg)

11.2.1.3.9 laminar flame speed, meters/second (m/s)

11.2.1.4 List of all corrosive properties

11.2.1.4.1 Corrosion rate of skin

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6 *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,
ASTM D93 Standard Test Methods for Flash Point by Pensky-Martens Closed Cup Tester.

7 *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.

8 *ASTM E582 Standard Test Method for Minimum Ignition Energy and Quenching Distance in Gaseous Mixtures.*

9 *ASTM E659 Standard Test Method for Autoignition Temperature of Liquid Chemicals.*

11.2.1.4.2 Corrosion rate of metal surfaces

11.2.2 **Hazards from Release of Hazardous Materials**

PROVIDE a description of all potential hazardous events from the hazardous materials stored, processed, or handled at the LNG facility or transported to/from the LNG facility. At a minimum, the description should include:

11.2.2.1 High or low temperature hazards from liquid, vapor, and gaseous releases, including cryogenic liquid spills and potential effects of exceeding spill containment areas and volumes or compromising structural supports of equipment/vessels or pipe racks

11.2.2.2 Toxicity and asphyxiation hazards from ingestion, inhalation, or contact of toxic liquid, vapor, and gaseous releases, including potential to disperse to occupied buildings and any areas of accumulation and disposal methods

11.2.2.3 Overpressure and projectile hazards from vapor cloud explosions, boiling liquid expanding vapor explosions, and pressure vessel bursts, including potential to compromise the structural integrity of equipment/vessels, pipe racks, or occupied buildings

11.2.2.4 Radiant heat hazards from vapor cloud flash fires, fireballs, pool fires and jet fires, including potential to compromise the structural integrity of equipment/vessels, pipe racks, or occupied buildings

11.2.2.5 Cascading event hazards from failures of facility components from the initial hazard that could exacerbate the initial hazard, such as damage to equipment critical to the safe shutdown and control of a hazard (e.g., control rooms, emergency backup generators, uninterruptable power supplies, emergency shutdown systems, fire water systems, etc.)

11.3 HAZARD IDENTIFICATION[10]

11.3.1 Process Hazard Identification and Analyses

PROVIDE a description of process hazard identification analyses conducted to date to identify potential hazardous events possible from the hazardous materials stored, processed, and handled onsite and along the waterway and the safeguards necessary to mitigate such releases. At a minimum, the description should reference the Engineering Design Information in Appendix 13.E, Project Specifications in Appendix 13.F, and Hazard Identification in Appendix 13.G.

11.3.2 Transportation Hazard Identification and Analyses

PROVIDE a description of transportation hazard identification analyses to determine the potential for hazardous releases and the safeguards and security necessary to mitigate such releases. At a minimum, the description should reference the Vehicle Traffic and Impact Studies in Appendix 13.G.

11.3.3 Security Threat and Vulnerability Assessments

PROVIDE a general description of threat and vulnerability analyses to determine the potential for hazardous releases and the safeguards and the security necessary to mitigate such releases. At a minimum, the description should reference security threat and vulnerability assessments that will be completed as part of the development of the Facility Security Plan.

11.3.4 Natural Hazard Assessments

PROVIDE a description of natural hazard analyses to determine the potential for hazardous releases and the safeguards necessary to mitigate such releases. At a minimum, the description should reference the Natural Hazard Assessments in Appendix 13.I and Geotechnical Assessments in Appendix 13.J.

[10] *18 CFR 380.12(m)(1), 18 CFR 380.12(m)(2), 18 CFR 380.12(m)(3).*

11.4 HAZARD ANALYSES[11]

11.4.1 Design Spills/Releases

PROVIDE a summary of the design spills/releases used for hazard analyses modeling. At a minimum, the summary should demonstrate compliance with federal regulations[12] and should reference the complete Design Spill/Release List and other supportive information (e.g. hole sensitivity analyses) in Appendix 13.H and should tabulate:

11.4.1.1 scenario number
11.4.1.2 hazardous fluid
11.4.1.3 size of hole/failure, in
11.4.1.4 size of piping/equipment, in (piping), gal (vessels/tanks)
11.4.1.5 general location, plant area
11.4.1.6 orientation, vertical, horizontal, other
11.4.1.7 release height, ft
11.4.1.8 release temperature, °F
11.4.1.9 equilibrium pressure, psig
11.4.1.10 release flow rate, lb/hr and gallons per minute (gpm)
11.4.1.11 release duration, min or hr
11.4.1.12 liquid rainout, vol% or mass%

11.4.2 Hot and Cold Temperature Hazard Analysis

PROVIDE a summary of the of hot and cold temperature hazards from design spills/releases or cascading damage. At a minimum, the summary should demonstrate compliance with federal regulations[13] and should reference the complete Hazard Analysis Report(s) in Appendix 13.H and should summarize:

11.4.2.1 Models, assumptions, and uncertainties used to analyze hazards
11.4.2.1.1 Description of model used to analyze hazards and uncertainty in predictions based on scientific assessment,

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[11] 18 CFR §380.12(m)(2), 18 CFR §380.12(m)(3), 18 CFR §380.12(m)(5).
[12] This may include distinct hazards for 49 CFR 193 and/or worst case and alternative scenarios for 40 CFR 68.
[13] This may include design spills for 49 CFR 193, worst case and alternative scenarios for 40 CFR 68, and/or zones of concern for NVIC 01-2011.

verification and validation results

11.4.2.1.2 Description of design spills/releases or cascading event used in modeling

11.4.2.1.3 Description of terrain and other surrounding features used in modeling

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

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

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

11.4.2.4 Drawing(s) depicting cross sections of trenches and impoundments and other hazard mitigation measures with dimensions for calculating usable volumes and other relevant details

11.4.2.5 Drawing(s) depicting extent of 160°F and 110°F for hot temperature hazards and 30°F and -20°F for cold temperature hazards relative to equipment, occupied buildings, and property lines taking into account any uncertainties of models and hazard mitigation measures[14]

11.4.2.6 Drawing(s) depicting extent of visibility impacts for cold temperature hazards due to water condensation (i.e., fog generation) relative to equipment, occupied buildings, and property lines taking into account any uncertainties of models and hazard mitigation measures

11.4.2.7 Description of any cascading effects from embrittlement of structural members, loss of visibility

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[14] *Cold and hot temperature hazards are typically limited by the heat transfer characteristics of the fluid. Direct contact with liquids, surfaces of equipment, or direct exposure to vapors at the release location tend to produce high enough heat transfer rates compared to vapors dispersing in low wind conditions. Fog generation may require additional analyses for ambient vaporizers or other cooling and heating systems (e.g. cooling towers, steam generation, etc.).*

due to water condensation (i.e., fog generation) and other impacts that would exacerbate the initial hazard, and any mitigation to prevent such escalation

11.4.3 **Asphyxiate and Toxic Vapor Dispersion Hazards Analysis**

PROVIDE a summary of the asphyxiant and toxic dispersion hazards from design spills/releases or cascading damage. At a minimum, the summary should demonstrate compliance with federal regulations[15] and should reference the complete Hazard Analysis Report(s) in Appendix 13.H and should summarize:

11.4.3.1 Models, assumptions, and uncertainties used to analyze hazards

11.4.3.1.1 Description of model used to analyze hazards and uncertainty in predictions based on scientific assessment, verification and validation results.[16]

11.4.3.1.2 Description of design spills/releases or cascading event used in modeling

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

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

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

11.4.3.1.6 Description of vapor barriers (material of construction, dimensions, locations, impermeability, maintenance requirements, etc.), fans, and other

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[15] *This may include distinct hazards for 49 CFR 193 and/or worst case and alternative scenarios for 40 CFR 68.*

[16] *Dispersion of streams with multiple toxins should discuss how all toxic components are accounted for in modeling when determining the toxic concentrations.*

hazard mitigation measures used in modeling[17]

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

11.4.3.3 Drawing(s) depicting extent of 19.5 percent volume, 16percent volume, and 12.5 percent volume oxygen concentrations for asphyxiate hazards relative to equipment, occupied buildings, and property lines taking into account any uncertainties of models and hazard mitigation measures[18]

11.4.3.4 Drawing(s) depicting extent of AEGL-1, -2, and -3 based on exposure time or ERPG -1, -2, and -3 60 minute exposure time toxicity hazards relative to equipment, occupied buildings, and property lines taking into account any uncertainties of models and hazard mitigation measures

11.4.3.5 Description of any cascading effects from ingestion of vapors into occupied buildings, and other impacts that would exacerbate the initial hazard, and any mitigation to prevent such escalation.

11.4.4 Flammable Vapor Dispersion Hazards Analysis

PROVIDE a summary of the flammable vapor dispersion hazards from design spills/releases or cascading damage. At a minimum, the summary should demonstrate compliance with federal regulations[19] and should reference the complete Hazard Analysis Report(s) in Appendix 13.H and should summarize:

11.4.4.1 Models, assumptions, and uncertainties used to analyze hazards

11.4.4.1.1 Description of model used to analyze hazards and uncertainty in predictions

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

[18] *Where flammable concentrations or toxic concentrations are less than asphyxiation 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.*

[19] *This may include exclusion zones and other distinct hazardous zones for 49 CFR 193, worst case and alternative scenarios for 40 CFR 68, and/or zones of concern for NVIC 01-2011.*

based on scientific assessment, verification and validation results.

11.4.4.1.2 Description of design spills/releases or cascading event used in modeling

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

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

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

11.4.4.1.6 Description of vapor barriers, fans, and other hazard mitigation measures used in modeling[20]

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

11.4.4.3 Drawing(s) depicting extent of LFL and UFL concentrations for flammable vapor dispersion hazards relative to equipment, occupied buildings, and property lines taking into account any uncertainties of models and hazard mitigation measures[21]

11.4.4.4 Description of any cascading effects from ingestion into occupied buildings, ingestion into fired equipment, dispersion to confined locations or heavily congested areas, and other impacts that would exacerbate the initial hazard, and any mitigation to prevent such escalation.

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

[21] *Where toxic concentrations are less than flammable concentrations and toxic concentrations and are modeled and shown to not impact the public, there does not need to be further demonstration that higher flammable concentrations would also not impact the public, but there may still need to be a demonstration that flammable concentrations would not disperse into areas that create other types of cascading effects that toxic vapors would not (e.g., dispersion to confined or congested areas, ingestion into combustion intakes, etc.).*

11.4.5 Overpressure Hazards Analysis

PROVIDE a summary of the vapor cloud explosion (VCE), boiling-liquid expanding-vapor explosion (BLEVE), and pressure vessel burst (PVB) overpressure hazards from design spills/releases or cascading damage. At a minimum, the summary should demonstrate compliance with federal regulations[22] and should reference the complete Hazard Analysis Report(s) in Appendix 13.H and should summarize:

11.4.5.1 Models, assumptions, and uncertainties used to analyze hazards

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

11.4.5.1.2 Description of design spills/releases or cascading event used in modeling

11.4.5.1.3 Description of ignition source(s) and strength(s)

11.4.5.1.4 Description of vessel dimensions, materials, design pressures, elevation, and location used in BLEVE and PVB modeling

11.4.5.1.5 Description of fluid, temperature, pressure, amount of product in vessels used in BLEVE and PVB modeling

11.4.5.1.6 Description of vapor cloud concentration, homogeneity, size, and location used in VCE modeling

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

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

11.4.5.1.9 Description of congestion from equipment, piping, vegetation, and other

[22] *This may include distinct hazards for 49 CFR 193 and/or worst case and alternative scenarios for 40 CFR 68.*

plant components and surrounding features used in VCE modeling

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

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

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

11.4.5.3 Drawing(s) depicting extent of 1 psi, 3 psi, and 10 psi and projectiles for overpressure hazards of vapor cloud explosions relative to equipment, occupied buildings, and property lines taking into account any uncertainties of models and any hazard mitigation measures

11.4.5.4 Drawing(s) depicting extent of 1 psi, 3 psi, and 10 psi and projectiles for overpressure hazards of BLEVEs relative to equipment, occupied buildings, and property lines taking into account any uncertainties of models and any hazard mitigation measures

11.4.5.5 Drawing(s) depicting extent of 1 psi, 3 psi, and 10 psi and projectiles for overpressure hazards of PVBs relative to equipment, occupied buildings, and property lines taking into account any uncertainties of models and any hazard mitigation measures

11.4.5.6 Description of any cascading effects from failure of occupied buildings, more hazardous equipment, safety related equipment, and other impacts that would exacerbate the initial hazard, and any mitigation to prevent such escalation.

11.4.6 Fire Hazards Analysis

PROVIDE a summary of the fireball, jet fire, and pool fire radiant heat hazards from design spills/releases or cascading damage. At a minimum, the summary should demonstrate compliance with federal regulations[23] and should reference the complete Hazard Analysis Report(s) in Appendix 13.H and should summarize:

11.4.6.1 Models, assumptions, and uncertainties used to analyze hazards

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

11.4.6.1.2 Description of design spills/releases or cascading event used in modeling

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

11.4.6.1.4 Description of terrain and other surrounding features used in modeling

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

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

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

11.4.6.3 Drawing(s) depicting 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, and property lines

[23] *This may include exclusion zones and distinct hazards for 49 CFR 193, worst case and alternative scenarios for 40 CFR 68, and/or zones of concern for NVIC 01-2011.*

taking into account any uncertainties of models and any hazard mitigation measures

11.4.6.4 Drawing(s) 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 jet fires relative to property line taking into account any uncertainties of models and any hazard mitigation measures

11.4.6.5 Drawing(s) depicting extent of 1,600 Btu/ft^2-hr, 3,000 Btu/ft^2-hr, and 10,000Btu/ft^2-hr for radiant heat hazards of pool fires relative to property line taking into account any uncertainties of models and any hazard mitigation measures

11.4.6.6 Description of any cascading effects from failure of occupied buildings, more hazardous equipment, safety related equipment, and other impacts that would exacerbate the initial hazard, and any mitigation to prevent such escalation.

11.5 LAYERS OF PROTECTION[24]

11.5.1 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 design, construction, operation, maintenance, and management of the facility. At a minimum, the description should describe:

11.5.1.1 Structural Design of the facility and its components

- 11.5.1.1.1 summary of basis of design used in structural design with reference to Resource Report 13 and Appendix 13.B for additional details
- 11.5.1.1.2 summary of regulatory requirements used in structural design with reference to Resource Report 13 and Appendix 13.C for additional details
- 11.5.1.1.3 summary of primary codes and standards used in structural design with reference to Resource Report 13 and Appendix 13.D for additional details
- 11.5.1.1.4 summary of design to withstand structural loads, including natural hazards, with reference to Resource Report 13 and Appendices for additional details

11.5.1.2 Mechanical Design of the facility and its components

- 11.5.1.2.1 summary of basis of design used in mechanical design with reference to Resource Report 13 and Appendix 13.B for additional details
- 11.5.1.2.2 summary of regulatory requirements used in mechanical design with reference

[24] *18 CFR 380.12(m)(1), 18 CFR 380.12(m)(3), 18 CFR 380.12(m)(4) , 18 CFR 380.12(m)(5), 18 CFR 380.12(o)(3), 18 CFR 380.12(o)(1), 18 CFR 380.12(o)(2), 18 CFR 380.12(o)(3), 18 CFR 380.12(o)(4), 18 CFR 380.12(o)(5), 18 CFR 380.12(o)(6), 18 CFR 380.12(o)(7), 18 CFR 380.12(o)(8), 18 CFR 380.12(o)(9), 18 CFR 380.12(o)(10), 18 CFR 380.12(o)(11), 18 CFR 380.12(o)(12), 18 CFR 380.12(o)(13), 18 CFR 380.12(o)(14), 18 CFR 380.12(o)(15)*

to Resource Report 13 Appendix 13.C for additional details

11.5.1.2.3 summary of primary codes and standards used in mechanical design with reference to Resource Report 13 and Appendix 13.D for additional details

11.5.1.2.4 summary of spare equipment and redundancies, and design to withstand internal and external pressures, temperatures, expansion/contraction, corrosion, with reference to Resource Report 13 and Appendices for additional details

11.5.1.3 Operations and Maintenance Plans

11.5.1.3.1 summary of basis of design used in development of operation and maintenance plans and procedures with reference to Resource Report 13 and Appendix 13.B for additional details

11.5.1.3.2 summary of regulatory requirements used in development of operation and maintenance plans and procedures with reference to Resource Report 13 Appendix 13.C for additional details

11.5.1.3.3 summary of primary codes and standards used in development of operation and maintenance plans and procedures with reference to Resource Report 13 and Appendix 13.D for additional details

11.5.1.3.4 summary of operation and maintenance plans and procedures, including standard operation procedures, startup and shutdown procedures, abnormal operations, safety procedures, preventative maintenance plans, work order tracking, training, and management systems with reference to Resource Report 13 and Appendices for additional details

11.5.1.4 Basic Plant Control Systems

11.5.1.4.1 summary of basis of design used in control system and operating modes with reference to Resource Report 13 and Appendix 13.B for additional details

11.5.1.4.2 summary of regulatory requirements used in control systems design, developing operational procedures, and training with reference to Resource Report 13 Appendix 13.C for additional details

11.5.1.4.3 summary of primary codes and standards used in control systems design, developing operational procedures, and training with reference to Resource Report 13 and Appendix 13.D for additional details

11.5.1.4.4 summary of operating limits for flows, pressures, temperatures, and alarm management plans with reference to Resource Report 13 and Appendices for additional details

11.5.1.5 Safety Instrumented Systems

11.5.1.5.1 summary of basis of design used in safety instrumented systems with reference to Resource Report 13 and Appendix 13.B for additional details

11.5.1.5.2 summary of regulatory requirements used in safety instrumented systems design with reference to Resource Report 13 Appendix 13.C for additional details

11.5.1.5.3 summary of primary codes and standards used in safety instrumented systems design with reference to Resource Report 13 and Appendix 13.D for additional details

11.5.1.5.4 summary of alarms and shutdowns for flows, pressures, temperatures with reference to Resource Report 13 and Appendices for additional details

11.5.1.6 Security Systems and Plans

11.5.1.6.1 summary of basis of design used in security systems with reference to Resource Report 13 and Appendix 13.B for additional details

11.5.1.6.2 summary of regulatory requirements used in security systems design with reference to Resource Report 13 Appendix 13.C for additional details

11.5.1.6.3 summary of primary codes and standards used in security systems design with reference to Resource Report 13 and Appendix 13.D for additional details

11.5.1.6.4 summary of lighting, fencing, access control, intrusion monitoring, intrusion detection, and security plans with reference to Resource Report 13 and Appendices for additional details

11.5.1.7 Physical Protection Devices

11.5.1.7.1 summary of basis of design used in relief valve and flare/vent design with reference to Resource Report 13 and Appendix 13.B for additional details

11.5.1.7.2 summary of regulatory requirements used in relief valve and flare/vent design with reference to Resource Report 13 Appendix 13.C for additional details

11.5.1.7.3 summary of primary codes and standards used in relief valve and flare/vent design with reference to Resource Report 13 and Appendix 13.D for additional details

11.5.1.7.4 summary of relief valve scenarios, set points, and capacities with reference to Resource Report 13 and Appendices for additional details

11.5.1.8 Ignition Controls

11.5.1.8.1 summary of basis of design used in ignition controls with reference to Resource Report 13 and Appendix 13.B for additional details

11.5.1.8.2 summary of regulatory requirements used in ignition controls with reference to Resource Report 13 Appendix 13.C for additional details

11.5.1.8.3 summary of primary codes and standards used in ignition controls with reference to Resource Report 13 and Appendix 13.D for additional details

11.5.1.8.4 summary of electrical area classification, hot work permits, equipment and building spacing and layouts, smoking restrictions, and static electricity safeguards with reference to Resource Report 13 and Appendices for additional details

11.5.1.9 Spill Containment Systems

11.5.1.9.1 summary of basis of design used in spill containment design with reference to Resource Report 13 and Appendix 13.B for additional details

11.5.1.9.2 summary of regulatory requirements used in spill containment design with reference to Resource Report 13 Appendix 13.C for additional details

11.5.1.9.3 summary of primary codes and standards used in spill containment design with reference to Resource Report 13 and Appendix 13.D for additional details

11.5.1.9.4 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 Resource Report 13 and Appendices for additional details

11.5.1.10 Passive Protection from cryogenic fluids, overpressures, projectiles, and fire

11.5.1.10.1 summary of basis of design used in passive protection with reference to Resource Report 13 and Appendix 13.B for additional details

11.5.1.10.2 summary of regulatory requirements used in passive protection with reference to Resource Report 13 Appendix 13.C for additional details

11.5.1.10.3 summary of primary codes and standards used in passive protection with reference to Resource Report 13 and Appendix 13.D for additional details

11.5.1.10.4 summary of passive protection philosophy and performance requirements with reference to Resource Report 13 and Appendices for additional details

11.5.1.11 Hazard Detection Systems

- 11.5.1.11.1 summary of basis of design used in hazard detection with reference to Resource Report 13 and Appendix 13.B for additional details
- 11.5.1.11.2 summary of regulatory requirements used in hazard detection with reference to Resource Report 13 Appendix 13.C for additional details
- 11.5.1.11.3 summary of primary codes and standards used in hazard detection with reference to Resource Report 13 and Appendix 13.D for additional details
- 11.5.1.11.4 summary of low temperature detection, flammable gas detection, fire detection, heat detection, smoke detection, and manual pushbuttons, and audible and visual alarms with reference to Resource Report 13 and Appendices for additional details

11.5.1.12 Hazard Control Equipment

- 11.5.1.12.1 summary of basis of design used in hazard control with reference to Resource Report 13 and Appendix 13.B for additional details
- 11.5.1.12.2 summary of regulatory requirements used in hazard control with reference to Resource Report 13 Appendix 13.C for additional details
- 11.5.1.12.3 summary of primary codes and standards used in hazard control with reference to Resource Report 13 and Appendix 13.D for additional details
- 11.5.1.12.4 summary of hand-held fire extinguishers, wheeled fire extinguishers, fire water systems, and hi-expansion foam systems with reference to Resource Report 13 and Appendices for additional details

11.5.1.13 Emergency Response

- 11.5.1.13.1 summary of emergency responders with reference to Resource Report 13 and Appendix 13.B for additional details
- 11.5.1.13.2 summary of regulatory requirements used in development of emergency response plans with reference to Resource Report 13 Appendix 13.C for additional details
- 11.5.1.13.3 summary of primary codes and standards used in development of emergency response plans with reference to Resource Report 13 and Appendix 13.D for additional details
- 11.5.1.13.4 summary of onsite and offsite emergency response team/capabilities and procedures, cost sharing plans, and training with reference to Resource Report 13 and Appendices for additional details

11.6 RELIABILITY[25]

11.6.1 Description of Reliability

PROVIDE a description of the reliability of the proposed Project facilities and equipment to minimize interruption of service and downtime, including:

11.6.1.1 Equipment Redundancies
11.6.1.2 Sparing Philosophy
11.6.1.3 Warehouse Philosophy
11.6.1.4 Anticipated plant reliability and availability
  11.6.1.4.1 Plant Reliability, Availability, and Maintainability (RAM) Analyses
11.6.1.5 Contingency plans
11.6.1.6 Facility Design Life: Provide facility design life (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.

[25] *18 CFR 380.12(m)(2), 18 CFR 380.12(m)(3) , 18 CFR 380.12(m)(4) , 18 CFR 380.12(m)(5).*

13 RESOURCE REPORT 13 – ENGINEERING AND DESIGN MATERIAL

13.1 GENERAL BACKGROUND AND PROJECT MANAGEMENT[1]

13.1.1 Facility

PROVIDE a description summarizing the facility. At a minimum, the description should include the following:

13.1.1.1 Number of marine docks, and rated and maximum export and import rates, million standard cubic feet per day (MMscfd) and million tons per annum (MTPA)
13.1.1.2 Number of LNG storage tanks, and net and gross storage capacity per tank, gal and billion cubic feet
13.1.1.3 Number of liquefaction trains, and rated and maximum liquefaction capacity per train, MMscfd and MTPA
13.1.1.4 Number of LNG vaporizers, and sustained and maximum vaporization capacities, MMscfd
13.1.1.5 Number of feed gas pipelines and interconnects, and rated capacity, MMscfd, and pressure, psig
13.1.1.6 Number of sendout pipelines and interconnects, and rated sendout rates, MMscfd
13.1.1.7 Fractionation products, and rated and maximum capacity rates, gpm and MMscfd

13.1.2 Location

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

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

[1] *18 CFR 380.12(m), 18 CFR 380.12(m)(1), 18 CFR 380.12(m)(3), 18 CFR 380.12(m)(4), 18 CFR 380.12(m)(5), 18 CFR 380.12(o)(8).*

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 for design, engineering, procurement, and construction of the facilities with reference to the Construction Workforce Organizational Chart in Appendix 13.A.3

13.1.3.3 Operating Company of the facilities with reference to the Operating Workfoce 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 facility. 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

13.1.4.4 Drawing(s) of natural gas and product destinations (pipeline routes, shipping routes, etc.) in Appendix 13.A.5

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.6 and should provide sufficient detail to show the feasibility of the engineering, procurement, construction, commissioning, and startup of the facility. Phased construction and operation, tie-ins, and future plans should also be summarized and included in the project schedule.

13.2 SITE INFORMATION[2]

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, 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 (Kts)

13.2.3 Climatic Conditions

PROVIDE a description of the climatic conditions at the site and along the shipping channel. At a minimum, the description should reference the Climatic Data in Appendix 13.J.3 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) (millibar [mbar])

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[2] *18 CFR 380.12(m), 18 CFR 380.12(m)(1), 18 CFR 380.12(m)(3), 18 CFR 380.12(m)(4), 18 CFR 380.12(m)(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).*

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

13.2.3.4 Barometric pressure rate of decrease design basis (minimum, average, maximum), inches Hg/h (mbar/h)

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 Water table depth, ft

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

13.2.3.11 Lightning strike frequency, No. per year

13.2.4 Geotechnical Information

PROVIDE a description of the climatic conditions at the site and along the shipping channel. At a minimum, the description should reference the Geotechnical Reports in Appendix 13.J.4 and should describe:

13.2.4.1 Field explorations conducted, including: soil borings, standard penetration tests, cone penetration tests, rock coring, test pits, and other in-situ measurements.

13.2.4.2 Soil Conditions, including: soil identification, moisture content dry density, gradation, plasticity index, and specific gravity.

13.2.4.3 Soil Strength, including: direct shear, unconfined compression, pocket penetrometer, torvane, triaxial.

13.2.4.4 Soil Compressibility, including: consolidation, expansion index, and collapse potential.

13.2.4.5 Soil Corrosivity, including: pH, electrical resistivity, sulfates, and chlorides.

13.2.4.6 Soil Improvement, including: remedial measures for highly compressible or expansive soils, corrosive soils, collapsible soils, erodible soils, liquefaction susceptible soils, frost heave susceptible soils, frozen soils, or sanitary landfill soils.

13.3 NATURAL HAZARD DESIGN CONDITIONS[3]

13.3.1 Earthquakes

PROVIDE a description of the design against earthquakes. At a minimum, the description should reference the Natural Hazard Design Investigations and Design Forces in Appendix 13.I.1 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 site specific MCE Ground Motion Spectral Values for 5% damping

13.3.1.4 Design Earthquake site specific DE 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 site specific SSE Ground Motion Spectral Values for 5% damping

13.3.1.6 Operating Basis Earthquake (OBE) site specific OBE Ground Motion Spectral Values for 5% damping

13.3.1.7 Aftershock Level Earthquake (ALE) site-specific Ground Motion Spectral Values for 5percent damping

13.3.1.8 Design Surface Fault Offsets (horizontal and vertical) and fault orientations at locations crossing active faults

13.3.1.9 Design Offsets for Growth Faults: Provide design fault offsets for growth faults (horizontal and vertical) for the facility design life and fault orientations at locations where crossing growth faults

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.

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[3] *18 CFR 380.12(m), 18 CFR 380.12(m)(1), 18 CFR 380.12(m)(3), 18 CFR 380.12(m)(4), 18 CFR 380.12(m)(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. At a minimum, the description should reference the Natural Hazard Design Investigations and Design Forces in Appendix 13.I.2 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 for all structures, systems, and components

13.3.2.3 Maximum Considered Tsunami (MCT), MCT inundation and run-up elevations for facility 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: Provide elevation change to be used in design to account for sea level rise at facility site for the facility design life

13.3.2.6 Design Regional Subsidence: Provide 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 facility

13.3.3 Hurricanes and Other Meteorological Events

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

13.3.3.1 Wind and Storm Surge Design Basis and Criteria

13.3.3.2 Identification of design wind speeds (1 minute sustained and 3 second gusts), wind importance factors, and storm surge design elevations for all structures, systems, and components

13.3.3.3 Wind speeds (1 minute sustained and 3 second gusts) and storm surge (still water, wind/wave run-up effects, crest elevations) corresponding to

- 13.3.3.3.1 10,000 year return period
- 13.3.3.3.2 1,000 year return period
- 13.3.3.3.3 500 year return period
- 13.3.3.3.4 100 year return period

13.3.3.4 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:

- 13.3.3.4.1 Hurricane Saffir-Simpson Category 5 (>156 mph sustained, >195 mph 3 second gust)
- 13.3.3.4.1 Hurricane Saffir-Simpson Category 4 (130-156 mph sustained, 166-195 mph 3 second gust)
- 13.3.3.4.2 Hurricane Saffir-Simpson Category 3 (111-129 mph sustained, 141-165 mph 3 second gust)
- 13.3.3.4.3 Hurricane Saffir-Simpson Category 2 (96-110 mph sustained, 117-140 mph 3 second gust)
- 13.3.3.4.4 Hurricane Saffir-Simpson Category 1 (74-95 mph sustained, 91-116 mph 3 second gust)

13.3.3.5 Sea Level Rise: Provide elevation change to be used to account for sea level rise at the site for the design life

13.3.3.6 Regional Subsidence: Provide 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. At a minimum, the description should reference the Natural Hazard Design Investigation and Design Forces in Appendix 13.I.4 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 wind importance factors for all structures, systems, and components

13.3.4.3 Wind speeds (sustained and 3 second gusts) corresponding to:

- 13.3.4.3.1 10,000 year return period
- 13.3.4.3.2 1,000 year return period
- 13.3.4.3.3 500 year return period
- 13.3.4.3.4 100 year return period

13.3.4.4 Discussion of wind speeds (sustained and 3 second gusts) and frequencies of tornados at site location:

- 13.3.4.4.1 Tornados Enhanced Fujita Category EF5 (>134 mph sustained, >200 mph 3 second gust),
- 13.3.4.4.2 Tornados Enhanced Fujita Category EF4 (111-134 mph sustained, 166-200 mph 3 second gust),
- 13.3.4.4.3 Tornados Enhanced Fujita Category EF3 (91-111 mph sustained, 136-166 mph 3 second gust),
- 13.3.4.4.4 Tornados Enhanced Fujita Category EF2 (75-91 mph sustained, 111-135 mph 3 second gust),
- 13.3.4.4.5 Tornados Enhanced Fujita Category EF1 (58-74 mph sustained, 86-110 mph 3 second gust),
- 13.3.4.4.6 Tornados Enhanced Fujita Category EF0 (44-57 mph sustained, 65-85 mph 3 second gust).

13.3.5 Floods

PROVIDE a description of the design against floods. At a minimum, the description should reference the Natural Hazard Design Investigations and Design Forces in Appendix 13.I.5 and should describe:

13.3.5.1 Flood design basis and criteria
13.3.5.2 Identification of stream flows and flood design elevations for all structures, systems, and components
13.3.5.3 Floods corresponding to:
- 13.3.5.3.1 10,000 year return period
- 13.3.5.3.2 1,000 year return period
- 13.3.5.3.3 500 year return period
- 13.3.5.3.4 100 year return period

13.3.5.4 Discussion of streamflows and 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. At a minimum, the description should reference the Natural Hazard Design Investigations and Design Forces in Appendix 13.I.6 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 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 Snow and ice loads corresponding to:
- 13.3.6.6.1 10,000 year return period,
- 13.3.6.6.2 1,000 year return period,
- 13.3.6.6.3 500 year return period,
- 13.3.6.6.4 100 year return period.

13.3.6.7 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. At a minimum, the description should reference the Natural Hazard Design Investigations and Design Forces in Appendix 13.I.7 and should describe:

13.3.7.1 Design Basis and Criteria

13.3.7.2 Identification of Loads for all structures, systems, and components

13.3.7.3 Loads corresponding to:

- 13.3.7.3.1 10,000 year return period,
- 13.3.7.3.2 1,000 year return period,
- 13.3.7.3.3 500 year return period,
- 13.3.7.3.4 100 year return period.

13.3.7.4 Discussion of natural hazards and frequencies of natural hazards at site location.

13.4 MARINE FACILITIES[4]

13.4.1 LNG Vessels

PROVIDE a description of the LNG vessels that the facility would be designed to accommodate. At a minimum, the description should reference the Ship Traffic Analysis and Impacts in Appendix 13.H, and should describe:

- 13.4.1.1 Shipping Route
- 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 carrier cargos 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 carrier cargos design and operating conditions and specifications for loading and vapor recovery:
  - 13.4.1.10.1 Molecular weight, HHV, LHV, Wobbe, specific gravity, equilibrium temperature (°F) and cargo pressure (psig), composition
- 13.4.1.11 LNG carrier cargos design and operating equilibrium pressures (minimum, normal, maximum), psig
- 13.4.1.12 LNG Vessel Pump Design Rates, gpm

4 *18 CFR 380.12(m), 18 CFR 380.12(m)(1), 18 CFR 380.12(m)(3), 18 CFR 380.12(m)(4), 18 CFR 380.12(m)(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), 18 CFR 380.12(o)(13), 18 CFR 380.12(o)(14).*

13.4.2 Marine Platform Design

PROVIDE a description of the design basis. 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, Project Specifications in Appendix 13.F, and Marine Facility Drawings in Appendix 13.K, and should describe:

13.4.2.1 Wave Crests and Periods, ft
13.4.2.2 Prevailing Currents (normal, maximum), Kts
13.4.2.3 Tidal Range elevations, ft
13.4.2.4 Water Depth at Berth and in Approach Channel
13.4.2.5 LNG vessel capacity range, m^3
13.4.2.6 LNG vessel approach velocity
13.4.2.7 LNG vessel approach angle
13.4.2.8 LNG vessel unloading frequency, per year
13.4.2.9 LNG vessel unloading duration, hours
13.4.2.10 LNG vessel loading frequency, per year
13.4.2.11 LNG vessel loading duration, hours
13.4.2.12 LNG vessel port time, pilot on to pilot off, hours
13.4.2.13 Barge capacity range, m^3
13.4.2.14 Barge unloading frequency, per year
13.4.2.15 Barge unloading duration, hours
13.4.2.16 Barge loading frequency, per year
13.4.2.17 Barge loading duration, hours
13.4.2.18 Turning Basin Depth and Radius
13.4.2.19 Marine Platform location/spacing
13.4.2.20 Jetty/Trestle configuration
13.4.2.21 Number of Berths
13.4.2.22 Number of Hooks, Quick Release Hooks
13.4.2.23 Number of Capstans
13.4.2.24 Number of Fenders
13.4.2.25 Arrangement and Number of Breasting Dolphins
13.4.2.26 Arrangement and Number of Mooring Dolphins
13.4.2.27 Current Monitors
13.4.2.28 Vessel Approach Velocity Monitors
13.4.2.29 Tension Monitors
13.4.2.30 Marine Platform Other Safety Features

13.4.3 Marine Transfer Design

PROVIDE a description of the design basis. 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, and Project Specifications in Appendix 13.F, and should describe:

- 13.4.3.1 LNG arms and size per dock, No., in
- 13.4.3.2 Vapor arms and size per dock, No., in
- 13.4.3.3 Hybrid arms and size per dock, No., in
- 13.4.3.4 LNG Arms operating and design flow rate capacities (minimum, normal, maximum), gpm
- 13.4.3.5 LNG Arms operating and design pressures (minimum, normal, maximum), psig
- 13.4.3.6 LNG Arms operating and design temperatures at ship manifold (minimum, normal, maximum), °F
- 13.4.3.7 Vapor Arms operating and design flow rate capacities (minimum, normal, maximum), lb/hr
- 13.4.3.8 Vapor Arms operating and design pressures at ship manifold (minimum, normal, maximum), psig
- 13.4.3.9 Vapor Arms 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 Basic Process Control Systems
- 13.4.3.12 Marine Transfer Isolation Valves, Vents, and Drains
- 13.4.3.13 Marine Transfer Basic Safety Instrumented Systems
- 13.4.3.14 Marine Transfer Relief Valves and Discharge
- 13.4.3.15 Marine Transfer Piping, Vessel, and Equipment Design and Specifications
- 13.4.3.16 Marine Transfer Other Safety Features
    - 13.4.3.16.1 Safe Working Envelope of Transfer Arms
    - 13.4.3.16.2 Powered Emergency Release Coupling Valves

13.4.3.16.3 Ship/shore communication and shutdown capability

13.5 FEED GAS[5]

13.5.1 Feed Gas Design

PROVIDE a description of the design basis. 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, and Project Specifications in Appendix 13.F, 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 Filters
13.5.1.5 Feed Gas Booster Compressor(s) type
13.5.1.6 Feed Gas Booster Compressor(s), operating and spare
13.5.1.7 Feed Gas Booster Compressor(s) flow capacities each (minimum, normal, maximum), MMscfd
13.5.1.8 Feed Gas Booster Compressor(s) operating and design suction pressures (minimum, normal, maximum), psig
13.5.1.9 Feed Gas Booster Compressor(s) operating and design suction pressures (minimum, normal, maximum), °F
13.5.1.10 Feed Gas Booster Compressor(s) operating and design discharge pressures (minimum, normal, maximum), psig
13.5.1.11 Feed Gas Booster Compressor(s) operating and design discharge pressures (minimum, normal, maximum), °F
13.5.1.12 Feed Gas Startup and Operation
- 13.5.1.12.1 Feed Gas Metering
- 13.5.1.12.2 Feed Gas Analysis and Measurement

13.5.1.13 Feed Gas Basic Process Control Systems
13.5.1.14 Feed Gas Isolation Valves, Drains, and Vents

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5 *18 CFR 380.12(m), 18 CFR 380.12(m)(1), 18 CFR 380.12(m)(3), 18 CFR 380.12(m)(4), 18 CFR 380.12(m)(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), 18 CFR 380.12(o)(13), 18 CFR 380.12(o)(14).*

13.5.1.15 Feed Gas Piping, Vessel, and Equipment Design and Specifications
13.5.1.16 Feed Gas High Integrity Pressure Protection Systems
13.5.1.17 Feed Gas Relief Valves and Discharge
13.5.1.18 Feed Gas Other Safety Features

13.6 FEED GAS PRETREATMENT[6]

13.6.1 Acid Gas Removal Design

PROVIDE a description of the design basis. 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, and Project Specifications in Appendix 13.F, and should describe:

13.6.1.1 Acid Gas Removal operating and design inlet flow rate capacities (minimum, normal, maximum), MMscfd

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

13.6.1.3 Acid Gas Removal operating and design inlet pressures (minimum, normal, maximum), psig

13.6.1.4 Acid Gas Removal operating and design inlet temperatures (minimum, normal, maximum), °F

13.6.1.5 Acid Gas Removal operating and design outlet flow rate capacities (minimum, normal, maximum), MMscfd

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

13.6.1.7 Acid Gas Removal operating and design outlet pressures (minimum, normal, maximum), psig

13.6.1.8 Acid Gas Removal operating and design outlet temperatures (minimum, normal, maximum), °F

13.6.1.9 Acid Gas Disposal operating and design compositions, ppm

13.6.1.10 Acid Gas Disposal operating and design pressures (minimum, normal, maximum), psig

13.6.1.11 Acid Gas Disposal operating and design outlet temperatures (minimum, normal, maximum), °F

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6 *18 CFR 380.12(m), 18 CFR 380.12(m)(1), 18 CFR 380.12(m)(3), 18 CFR 380.12(m)(4), 18 CFR 380.12(m)(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), 18 CFR 380.12(o)(13), 18 CFR 380.12(o)(14).*

13.6.1.12 Acid Gas Removal System type
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 Basic Process Control Systems
13.6.1.15 Acid Gas Removal Isolation Valves, Drains, and Vents
13.6.1.15.1 Hydrogen Sulfide Disposal
13.6.1.16 Acid Gas Removal Piping, Vessel, and Equipment Design and Specifications
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 design basis. 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, and Project Specifications in Appendix 13.F, and should describe:

13.6.2.1 Mercury Specifications, ppm
13.6.2.2 Mercury Removal operating and design inlet flow rate capacities (minimum, normal, maximum), lb/hr
13.6.2.3 Mercury Removal operating and design inlet gas compositions (minimum/lean/light, normal/design/average, maximum/rich/heavy), ppm
13.6.2.4 Mercury Removal operating and design inlet pressures (minimum, normal, maximum), psig
13.6.2.5 Mercury Removal operating and design inlet temperatures (minimum, normal, maximum), °F
13.6.2.6 Mercury Removal operating and design outlet flow rate capacities (minimum, normal, maximum), lb/hr
13.6.2.7 Mercury Removal operating and design outlet gas compositions (minimum/lean/light, normal/design/average, maximum/rich/heavy), ppm
13.6.2.8 Mercury Removal operating and design outlet pressures (minimum, normal, maximum), psig
13.6.2.9 Mercury Removal operating and design outlet temperatures (minimum, normal, maximum), °F
13.6.2.1 Mercury Removal type
13.6.2.2 Mercury Removal Startup and Operation
13.6.2.3 Mercury Removal Basic Process Control Systems
13.6.2.4 Mercury Removal Isolation Valves, Drains, and Vents

13.6.2.4.1 Mercury Removal Disposal

13.6.2.5 Mercury Removal Piping, Vessel, and Equipment Design and Specifications

13.6.2.6 Mercury Removal Safety Instrumented Systems

13.6.2.7 Mercury Removal Relief Valves and Discharge

13.6.2.8 Mercury Removal Other Safety Features

13.6.3 Water Removal Design

PROVIDE a description of the design basis. 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, and Project Specifications in Appendix 13.F, and should describe:

13.6.3.1 Water Specifications, ppm

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

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

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

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

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

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

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

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

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

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

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

13.6.3.13 Dehydration System type

13.6.3.14 Dehydration and Regeneration Startup and Operation

13.6.3.15 Dehydration Basic Process Control Systems

13.6.3.16 Dehydration and Regeneration Isolation Valves, Drains, and Vents
13.6.3.17 Water Removal and Regeneration Piping, Vessel, and Equipment Design and Specifications
13.6.3.18 Water Removal Safety Instrumented Systems
13.6.3.19 Water Removal Relief Valves and Discharge
13.6.3.20 Water Removal Other Safety Features

13.7 HEAVIES/CONDENSATES REMOVAL, STORAGE, AND DISPOSITION[7]

13.7.1 Heavies/Condensates Removal Design

PROVIDE a description of the design basis. 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, and Project Specifications in Appendix 13.F, and should describe:

13.7.1.1 Heavies/Condensates Removal operating and design inlet flow rate capacities (minimum, normal, maximum), lb/hr

13.7.1.2 Heavies/Condensates Removal operating and design inlet compositions (lean, normal, rich), percent volume

13.7.1.3 Heavies/Condensates Removal operating and design inlet pressures (minimum, normal, maximum), psig

13.7.1.4 Heavies/Condensates Removal operating and design inlet temperatures (minimum, normal, maximum), °F

13.7.1.5 Heavies/Condensates Removal operating and design outlet product flow rates (minimum, normal, maximum), lb/hr

13.7.1.6 Heavies/Condensates Removal operating and design outlet product compositions (lean, normal, rich), percent volume

13.7.1.7 Heavies/Condensates Removal outlet operating and design outlet pressures (minimum, normal, maximum), psig

13.7.1.8 Heavies/Condensates Removal outlet operating and design column temperatures (minimum, normal, maximum), °F

13.7.1.9 Heavies/Condensates Removal Startup and Operation

13.7.1.10 Heavies/Condensates Removal Basic Process Control Systems

13.7.1.11 Heavies/Condensates Removal Isolation Valves, Drains, and Vents

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[7] *18 CFR §380.12(m), 18 CFR §380.12(m)(1), 18 CFR §380.12(m)(3), 18 CFR §380.12(m)(4), 18 CFR §380.12(m)(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), 18 CFR 380.12(o)(13), 18 CFR 380.12(o)(14).*

13.7.1.12 Heavies/Condensates Removal Piping, Vessel, and Equipment Design and Specifications

13.7.1.13 Heavies/Condensates Removal Safety Instrumented Systems

13.7.1.14 Heavies/Condensates Removal Relief Valves and Discharge

13.7.1.15 Heavies/Condensates Removal Other Safety Features

13.7.2 Heavies/Condensates Storage Design

PROVIDE a description of the design basis. 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, and Project Specifications in Appendix 13.F, and should describe:

13.7.2.1 Heavies/Condensates Storage operating and design capacities (minimum, normal, maximum), gal

13.7.2.2 Heavies/Condensates Storage operating and design liquid levels (minimum, normal, maximum), ft (m)

13.7.2.3 Heavies/Condensates Storage operating and design vacuums and pressures (minimum, normal, maximum), inches H_2O (vacuum) and psig

13.7.2.4 Heavies/Condensates Storage operating and design temperatures (minimum, normal, maximum), °F

13.7.2.5 Heavies/Condensates Storage operating and design densities (minimum, normal, maximum), specific gravity

13.7.2.6 Number of Heavies/Condensates Storage Tanks

13.7.2.7 Heavies/Condensates Storage Tanks type

13.7.2.8 Heavies/Condensates Storage Tanks Foundation type

13.7.2.9 Heavies/Condensates Storage Startup and Operation

13.7.2.10 Heavies/Condensates Storage Basic Process Control Systems

13.7.2.11 Heavies/Condensates Storage Isolation Valves, Drains, and Vents

13.7.2.12 Heavies/Condensates Storage Piping, Vessel, and Equipment Design and Specifications

13.7.2.13 Heavies/Condensates Storage Safety Instrumented Systems

13.7.2.14 Heavies/Condensates Storage Relief Valves, Discharge, and Redundancy

13.7.2.15 Heavies/Condensates Storage Impoundment

13.7.2.16 Heavies/Condensates Storage Other Safety Features

13.7.3 Heavies/Condensates Disposition Design

PROVIDE a description of the design basis. 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, and Project Specifications in Appendix 13.F, and should describe:

13.7.3.1 Heavies/Condensates Final Disposition (Truck Stations, Sendout Pipelines, Reinjection, Fuel Gas, etc.)

13.7.3.2 Number of Heavies/Condensates Trucks, No. per year

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

13.7.3.4 Heavies/Condensates Trucking/Sendout/Fuel Gas Pumps operating and design suction pressures (minimum/net positive suction head (NPSH), normal/rated, maximum), psig

13.7.3.5 Heavies/Condensates Pumps operating and design suction temperatures (minimum, normal, maximum), °F

13.7.3.6 Heavies/Condensates Pumps operating and design discharge pressures (minimum, normal/rated, maximum/shutoff), psig

13.7.3.7 Heavies/Condensates Pumps operating and design discharge temperatures (minimum, normal/rated, maximum/shutoff), °F

13.7.3.8 Heavies/Condensates Pumps operating and design densities (minimum, normal, maximum), specific gravity

13.7.3.9 Number of Heavies/Condensates Truck Stations or Sendout Pipelines

13.7.3.10 Heavies/Condensates Truck Weighing or Sendout Metering

13.7.3.11 Number of Heavies/Condensates Pumps, operating and spare

13.7.3.12 Heavies/Condensates Pumps type

13.7.3.13 Heavies/Condensates Truck/Sendout Startup and Operation

13.7.3.14 Heavies/Condensates Truck/Sendout Basic Process Control Systems

13.7.3.15 Heavies/Condensates Truck/Sendout Isolation Valves, Drains, and Vents
13.7.3.16 Heavies/Condensates Truck/Sendout Piping, Vessel, and Equipment Design and Specifications
13.7.3.17 Heavies/Condensates Truck/Sendout Safety Instrumented Systems
13.7.3.18 Heavies/Condensates Truck/Sendout Relief Valves and Discharge
13.7.3.19 Heavies/Condensates Truck/Sendout Other Safety Features

13.8 NATURAL GAS LIQUIDS (NGL) FRACTIONATION[8]

13.8.1 NGL Fractionation Design

PROVIDE a description of the design basis. 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, and Project Specifications in Appendix 13.F, and should describe:

13.8.1.1 NGL Fractionation columns operating and design flow rate capacities (minimum, normal, maximum), gpm

13.8.1.2 NGL Fractionation column operating and design inlet compositions (minimum/lean/light, normal/design/average, maximum/rich/heavy), percent volume

13.8.1.3 NGL Fractionation columns operating and design pressures (minimum, normal, maximum), psig

13.8.1.4 NGL Fractionation columns operating and design temperatures (minimum, normal, maximum), °F

13.8.1.5 NGL Fractionation Reboilers operating and design flow rate capacities (minimum, normal, maximum), gpm

13.8.1.6 NGL Fractionation Reboilers operating and design duties (minimum, normal, maximum), MMBtu/h

13.8.1.7 NGL Fractionation Reboilers operating and design pressures (minimum, normal, maximum), psig

13.8.1.8 NGL Fractionation Reboilers operating and design inlet temperatures (minimum, normal, maximum), °F

13.8.1.9 NGL Fractionation Reboilers operating and design outlet temperatures (minimum, normal, maximum), °F

13.8.1.10 NGL Fractionation Reflux Pumps operating and design flow rate capacities (minimum, normal, maximum), gpm

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[8] *18 CFR 380.12(m), 18 CFR 380.12(m)(1), 18 CFR 380.12(m)(3), 18 CFR 380.12(m)(4), 18 CFR 380.12(m)(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), 18 CFR 380.12(o)(13), 18 CFR 380.12(o)(14).*

13.8.1.11 NGL Fractionation Reflux Pumps operating and design duties (minimum, normal, maximum), MMBtu/h
13.8.1.12 NGL Fractionation Reflux Pumps operating and design suction pressures (minimum, normal, maximum), psig
13.8.1.13 NGL Fractionation Reflux Pumps operating and design discharge pressures (minimum, normal, maximum), psig
13.8.1.14 NGL Fractionation Reflux Pumps operating and design inlet temperatures (minimum, normal, maximum), °F
13.8.1.15 NGL Fractionation Reflux Pumps operating and design outlet temperatures (minimum, normal, maximum), °F
13.8.1.16 NGL Fractionation column operating and design products flow rates (minimum, normal, maximum), gpm
13.8.1.17 NGL Fractionation column operating and design products compositions (minimum/lean/light, normal/design/average, maximum/rich/heavy), percent volume
13.8.1.18 NGL Fractionation column operating and design products pressures (minimum, normal, maximum), psig
13.8.1.19 NGL Fractionation column operating and design products temperatures (minimum, normal, maximum), °F
13.8.1.20 Number of NGL fractionation columns
13.8.1.21 NGL Fractionation type (Demethanizer, Deethanizer, Depropanizer, Debutanizer)
13.8.1.22 NGL Fractionation Columns Startup and Operation
13.8.1.23 NGL Fractionation Column Basic Process Control Systems
13.8.1.24 NGL Fractionation Columns Isolation Valves, Drains, and Vents
13.8.1.25 NGL Fractionation Columns Piping, Vessel, and Equipment Design and Specifications
13.8.1.26 NGL Fractionation Columns Safety Instrumented Systems
13.8.1.27 NGL Fractionation Columns Relief Valves and Discharge
13.8.1.28 NGL Fractionation Columns Other Safety Features

13.8.2 NGL Storage Design

PROVIDE a description of the design basis. 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, and Project Specifications in Appendix 13.F, and should describe:

13.8.2.1 NGL storage tank operating and design capacities (minimum, normal, maximum), gal
13.8.2.2 NGL storage tank operating and design levels (minimum, normal, maximum), ft
13.8.2.3 NGL storage tank operating and design vacuums and pressures (minimum, normal, maximum), inches H_2O (vacuum) and psig
13.8.2.4 NGL storage tank operating and design temperatures (minimum, normal, maximum), °F
13.8.2.5 NGL storage tank operating and design densities (minimum, normal, maximum), specific gravity
13.8.2.6 Number of NGL Storage Tanks
13.8.2.7 NGL Storage Tank type
13.8.2.8 NGL Storage Tank foundation type
13.8.2.9 NGL Storage Startup and Operation
13.8.2.10 NGL Storage Basic Process Control Systems
13.8.2.11 NGL Storage Isolation Valves, Drains, and Vents
13.8.2.12 NGL Storage Piping, Vessel, and Equipment Design and Specifications
13.8.2.13 NGL Storage Relief Valves, Discharge, and Redundancy
13.8.2.14 NGL Storage Tank Impoundment
13.8.2.15 NGL Storage Other Safety Features

13.8.3 NGL Disposition Design

PROVIDE a description of the design basis. 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, and Project Specifications in Appendix 13.F, and should describe:

13.8.3.1 NGL Final Disposition (Truck Stations, Sendout Pipelines, Reinjection, Fuel Gas, etc.)
13.8.3.2 Number of NGL Trucks, No. per year
13.8.3.3 NGL truck fill/sendout/fuel gas operating and design flow rate capacities (minimum, normal, maximum), gpm
13.8.3.4 NGL Trucking/Sendout/Fuel Gas Pumps operating and design suction pressures (minimum/NPSH, normal/rated, maximum), psig
13.8.3.5 NGL Pumps operating and design suction temperatures (minimum, normal, maximum), °F
13.8.3.6 NGL Pumps operating and design discharge pressures (minimum, normal/rated, maximum/shutoff), psig
13.8.3.7 NGL Pumps operating and design discharge temperatures (minimum, normal/rated, maximum/shutoff), °F
13.8.3.8 NGL Pumps operating and design densities (minimum, normal, maximum), specific gravity
13.8.3.9 Number of NGL Truck Stations or Sendout Pipelines
13.8.3.10 NGL Truck Weighing or Sendout Metering
13.8.3.11 Number of NGL Pumps, operating and spare
13.8.3.12 NGL Pumps type
13.8.3.13 NGL Truck/Sendout Startup and Operation
13.8.3.14 NGL Truck/Sendout Basic Process Control Systems
13.8.3.15 NGL Truck/Sendout Isolation Valves, Drains, and Vents
13.8.3.16 NGL Truck/Sendout Piping, Vessel, and Equipment Design and Specifications
13.8.3.17 NGL Truck/Sendout Safety Instrumented Systems
13.8.3.18 NGL Truck/Sendout Relief Valves and Discharge
13.8.3.19 NGL Truck/Sendout Other Safety Features

13.9 LIQUEFACTION SYSTEM[9]

13.9.1 Refrigerant Trucking/Production Design

PROVIDE a description of the design basis. 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, and Project Specifications in Appendix 13.F, and should describe:

13.9.1.1 Source
13.9.1.2 Number of Refrigerant Trucks during startup
13.9.1.3 Number of Refrigerant Trucks, No. per year
13.9.1.4 Refrigerant Trucking/Production operating and design compositions (minimum, normal, maximum), percent volume
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/NPSH, normal/rated, 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 Weighing

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9 *18 CFR 380.12(m), 18 CFR 380.12(m)(1), 18 CFR 380.12(m)(3), 18 CFR 380.12(m)(4), 18 CFR 380.12(m)(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), 18 CFR 380.12(o)(13), 18 CFR 380.12(o)(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 Basic Process Control Systems

13.9.1.15 Refrigerant Trucking/Production Isolation Valves, Drains, and Vents

13.9.1.16 Refrigerant Trucking/Production Piping, Vessel, and Equipment Design and Specifications

13.9.1.17 Refrigerant Trucking/Production Safety Instrumented Systems

13.9.1.18 Refrigerant Trucking/Production Relief Valves and Discharge

13.9.1.19 Refrigerant Trucking/Production Other Safety Features

13.9.2 **Refrigerant Storage Design**

PROVIDE a description of the design basis. 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, and Project Specifications in Appendix 13.F, and should describe:

13.9.2.1 Refrigerant Storage operating and design capacities (minimum, normal, maximum), gal

13.9.2.2 Refrigerant Storage operating and design levels (minimum, normal, maximum), ft (m)

13.9.2.3 Refrigerant Storage operating and design pressures/vacuums (minimum, normal, maximum), inches H_2O (vacuum) and psig

13.9.2.4 Refrigerant Storage operating and design temperatures (minimum, normal, maximum), °F

13.9.2.5 Refrigerant Storage operating and design densities (minimum, normal, maximum), specific gravity

13.9.2.6 Number of Refrigerant Storage Tanks, operating and spare

13.9.2.7 Refrigerant Storage Tank type

13.9.2.8 Refrigerant Storage Tanks foundations type

13.9.2.9 Refrigerant Storage Startup and Operation

13.9.2.10 Refrigerant Storage Basic Process Control Systems

13.9.2.11 Refrigerant Storage Isolation Valves, Drains, and Vents
13.9.2.12 Refrigerant Storage Piping, Vessel, and Equipment Design and Specifications
13.9.2.13 Refrigerant Storage Safety Instrumented Systems
13.9.2.14 Refrigerant Storage Relief Valves, Discharge, and Redundancy
13.9.2.15 Refrigerant Storage Tanks Impoundment
13.9.2.16 Refrigerant Storage Other Safety Features

13.9.3 Refrigerant Charge/Loading Pumps Design

PROVIDE a description of the design basis. 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, and Project Specifications in Appendix 13.F, and should describe:

13.9.3.1 Refrigerant Pumps operating and design flow rate capacities (minimum, normal/rated, maximum), gpm
13.9.3.2 Refrigerant Pumps operating and design suction pressures (minimum/NPSH, normal/rated, maximum), psig
13.9.3.3 Refrigerant Pumps operating and design discharge pressures (minimum, normal/rated, maximum/shutoff), psig
13.9.3.4 Refrigerant Pumps operating and design densities (minimum, normal, maximum), specific gravity
13.9.3.5 Number of Refrigerant Pumps, operating and spare
13.9.3.6 Refrigerant Pumps type
13.9.3.7 Refrigerant Pumps Startup and Operation
13.9.3.8 Refrigerant Pumps Basic Process Control Systems
13.9.3.9 Refrigerant Pumps Isolation Valves, Drains, and Vents
13.9.3.10 Refrigerant Pumps Piping, Vessel, and Equipment Design and Specifications
13.9.3.11 Refrigerant Pumps Safety Instrumented Systems
13.9.3.12 Refrigerant Pumps Relief Valves and Discharge
13.9.3.13 Refrigerant Pumps Other Safety Features

13.9.4 **Liquefaction Design**

PROVIDE a description of the design basis. 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, and Project Specifications in Appendix 13.F, 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 (APCI, Cascade, Nitrogen)
13.9.4.4 Main Refrigerant Heat Exchangers
13.9.4.5 Refrigerant Compressors and Drivers
13.9.4.6 Liquefaction operating and design flow rate capacities (minimum, normal, maximum), MMcfd
13.9.4.7 Liquefaction operating and design inlet compositions (minimum/lean/light, normal/design/average, maximum/rich/heavy), percent volume
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

13.9.5 Cooling System Design

PROVIDE a description of the design basis. 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, and Project Specifications in Appendix 13.F, 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 Basic Process Control Systems
13.9.5.10 Cooling System Isolation Valves, Drains, and Vents
13.9.5.11 Cooling System Piping, Vessel, and Equipment Design and Specifications
13.9.5.12 Cooling System Safety Instrumented Systems
13.9.5.13 Cooling System Relief Valves and Discharge
13.9.5.14 Cooling System Other Safety Features

13.10 LNG PRODUCT TRANSFER TO STORAGE[10]

13.10.1 LNG Transfer to Storage Design

PROVIDE a description of the design basis. 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, and Project Specifications in Appendix 13.F, and should describe:

13.10.1.1 Number of LNG Product Transfer Pumps, operating and spare

13.10.1.2 LNG Product Transfer Pumps type

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

13.10.1.12 LNG Flash Vessel operating and design outlet temperatures (minimum, normal, maximum), °F

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[10] *18 CFR 380.12(m), 18 CFR 380.12(m)(1), 18 CFR 380.12(m)(3), 18 CFR 380.12(m)(4), 18 CFR 380.12(m)(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), 18 CFR 380.12(o)(13), 18 CFR 380.12(o)(14).*

13.10.1.13 Flash Gas Compressor operating and design flow rate capacities (minimum, normal, maximum), MMscfd

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 outlet 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 Basic Process Control Systems

- 13.10.1.19.1 LNG product flow control
- 13.10.1.19.2 LNG flash drum pressure control
- 13.10.1.19.3 LNG flash vapor handling

13.10.1.20 LNG Product Transfer Isolation Valves, Drains, and Vents

13.10.1.21 LNG Product Transfer Piping, Vessel, and Equipment Design and Specifications

13.10.1.22 LNG Product Transfer Safety Instrumented Systems

13.10.1.23 LNG Product Transfer Relief Valves and Discharge

13.10.1.24 LNG Product Transfer Other Safety Features

13.11 LNG STORAGE TANKS[11]

13.11.1 LNG Storage Tank Design

PROVIDE a description of the design basis. 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 LNG Storage Tank Information in Appendix 13.L and should describe:

13.11.1.1 Number of LNG Storage Tanks
13.11.1.2 LNG Storage Tank type (above ground, below ground, single, double, full, membrane, etc.)
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), inches 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), percent per day
13.11.1.11 LNG Storage operating and design residence times, days/hours
13.11.1.12 Hydrotest water source
13.11.1.13 Hydrotest water specifications, pecent volume, ppm
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

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[11] *18 CFR 380.12(m), 18 CFR 380.12(m)(1), 18 CFR 380.12(m)(3), 18 CFR 380.12(m)(4), 18 CFR 380.12(m)(5), 18 CFR 380.12(o)(3), 18 CFR 380.12(o)(7), 18 CFR 380.12(o)(8), 18 CFR 380.12(o)(9), 18 CFR 380.12(o)(10), 18 CFR 380.12(o)(12), 18 CFR 380.12(o)(13), 18 CFR 380.12(o)(14).*

13.11.1.17 LNG Storage Tank Startup and Operation
13.11.1.18 LNG Storage Tank Basic Process Control Systems
- 13.11.1.18.1 LNG Storage Tank Cooldown sensors
- 13.11.1.18.2 LNG Storage Tank Level Control
- 13.11.1.18.3 LNG Storage Tank Pressure Control
- 13.11.1.18.4 LNG Storage Tank Density/Rollover Control

13.11.1.19 LNG Storage Tank Isolation Valves, Drains, and Vents
13.11.1.20 LNG Storage Tank Piping and Storage Tank Design and Specifications
13.11.1.21 LNG Storage Tank Piping Support System
13.11.1.22 LNG Storage Tank Safety Instrumented Systems
- 13.11.1.22.1 LNG Storage Tank Overfill Protection
- 13.11.1.22.2 LNG Storage Tank Overpressure Protection

13.11.1.23 LNG Storage Tank Relief Valves and Discharge
- 13.11.1.23.1 Calculations for sizing pressure and vacuum relief valves

13.11.1.24 LNG Storage Tank Impoundment System
- 13.11.1.24.1 LNG Storage Tank Containment
- 13.11.1.24.2 LNG Storage Tank Roof Spill Containment and Protection

13.11.1.25 LNG Storage Tank Other Safety Features
- 13.11.1.25.1 LNG Storage Tank Leak Detection Instrumentation
- 13.11.1.25.2 Foundation Heaters Temperature Detection

13.12 VAPOR HANDLING[12]

13.12.1 Vapor Handling Design

PROVIDE a description of the design basis. 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, and Project Specifications in Appendix 13.F, and should describe:

13.12.1.1 Number of Vapor Return Blowers, operating and spare
13.12.1.2 Vapor Return Blowers type
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/NPSH, 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 Number of Boil-off Gas Low Pressure Compressors, operating and spare
13.12.1.9 Boil-off Gas Low Pressure Compressors type
13.12.1.10 Boil-off Gas Low Pressure Compressors operating and design flow rate capacities (minimum, normal/rated, maximum), lb/hr
13.12.1.11 Boil-off Gas Low Pressure Compressors operating and design suction pressures (minimum, normal/rated, maximum), psig
13.12.1.12 Boil-off Gas Low Pressure Compressors operating and design suction temperatures (minimum, normal, maximum), °F

12 *18 CFR 380.12(m), 18 CFR 380.12(m)(1), 18 CFR 380.12(m)(3), 18 CFR 380.12(m)(4), 18 CFR 380.12(m)(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), 18 CFR 380.12(o)(13), 18 CFR 380.12(o)(14).*

13.12.1.13 Boil-off Gas Low Pressure Compressors operating and design discharge pressures (minimum, normal/rated, maximum/shutoff), psig

13.12.1.14 Boil-off Gas Low Pressure Compressors operating and design discharge temperatures (minimum, normal, maximum), °F

13.12.1.15 Number of Boil-off Gas High Pressure Compressors, operating and spare

13.12.1.16 Boil-off Gas High Pressure Compressors type

13.12.1.17 Boil-off Gas High Pressure Compressors operating and design flow rate capacities (minimum, normal/rated, maximum), lb/hr

13.12.1.18 Boil-off Gas High Pressure Compressors operating and design suction pressures (minimum, normal/rated, maximum), psig

13.12.1.19 Boil-off Gas High Pressure Compressors operating and design suction temperatures (minimum, normal, maximum), °F

13.12.1.20 Boil-off Gas High Pressure Compressors operating and design discharge pressures (minimum, normal/rated, maximum/shutoff), psig

13.12.1.21 Boil-off Gas 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 Boil-off Gas Low Pressure Compression
- 13.12.1.22.3 Boil-off Gas High Pressure Compression, including Boil-off Gas Holding Mode Compression to pipeline
- 13.12.1.22.4 Boil-off Gas Utilization

13.12.1.23 Vapor Handling Basic Process Control Systems

13.12.1.24 Vapor Handling Isolation Valves, Drains, and Vents

13.12.1.25 Vapor Handling Piping, Vessel, and Equipment Design and Specifications

13.12.1.26 Vapor Handling Safety Instrumented Systems

13.12.1.27 Vapor Handling Relief Valves and Discharge

13.12.1.28 Vapor Handling Other Safety Features

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

PROVIDE a description of the design basis. 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, and Project Specifications in Appendix 13.F, and should describe:

13.12.2.1 Number of BOG Recondensers, operating and spare

13.12.2.2 BOG Recondenser type

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

13.12.2.2 BOG Recondensers operating and design inlet pressures (minimum, normal/rated, maximum), psig

13.12.2.3 BOG Recondensers operating and design inlet temperatures (minimum, normal, maximum), °F

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

13.12.2.5 BOG Recondensers operating and design outlet pressures (minimum, normal/rated, maximum), psig

13.12.2.6 BOG Recondensers operating and design outlet temperatures (minimum, normal, maximum), °F

13.12.2.7 BOG Recondenser Startup and Operation

- 13.12.2.7.1 Minimum Sendout Rate for Recondensation
- 13.12.2.7.2 Boil-off Gas Recondensation

13.12.2.8 BOG Recondenser Basic Process Control Systems

13.12.2.9 BOG Recondenser Isolation Valves, Drains, and Vents

13.12.2.10 BOG Recondenser Piping, Vessel, and Equipment Design and Specifications

13.12.2.11 BOG Recondenser Safety Instrumented Systems

13.12.2.12 BOG Recondenser Relief Valves and Discharge

13.12.2.13 BOG Recondenser Other Safety Features

13.13 LNG PUMPS[13]

13.13.1 LNG Tank/Low Pressure (LP) Pump Design

PROVIDE a description of the design basis. 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, and Project Specifications in Appendix 13.F, and should describe:

13.13.1.1 Number of LNG Tank LP Pumps, operating and spare
13.13.1.2 LNG Tank LP Pumps type
13.13.1.1 LNG Tank LP Pumps operating and design flow rate capacities (minimum, normal/rated, maximum), gpm
13.13.1.2 LNG Tank LP Pumps operating and design suction pressures (minimum/NPSH, normal/rated, maximum), psig
13.13.1.3 LNG Tank LP Pumps operating and design discharge pressures (minimum, normal/rated, maximum/shutoff), psig
13.13.1.4 LNG Tank LP Pumps operating and design densities (minimum, normal/rated, maximum), specific gravity
13.13.1.5 LNG Tank LP Pumps Startup and Operation
- 13.13.1.5.1 LNG Pump to marine transfer
- 13.13.1.5.2 LNG Pump to sendout for vaporization
- 13.13.1.5.3 LNG Pump minimum flow recycle
- 13.13.1.5.4 LNG Pump recirculation to marine transfer
- 13.13.1.5.5 LNG Pump recirculation to sendout for vaporization
- 13.13.1.5.6 LNG Pump inter tank transfer

13.13.1.6 LNG Tank LP Pumps Basic Process Control Systems
- 13.13.1.6.1 LNG Pump flow control

13.13.1.7 LNG Tank LP Pumps Isolation Valves, Drains, and Vents

[13] *18 CFR 380.12(m), 18 CFR 380.12(m)(1), 18 CFR 380.12(m)(3), 18 CFR 380.12(m)(4), 18 CFR 380.12(m)(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), 18 CFR 380.12(o)(13), 18 CFR 380.12(o)(14).*

13.13.1.8 LNG Tank LP Pumps Piping, Vessel, and Equipment Design and Specifications
13.13.1.9 LNG Tank LP Pumps Safety Instrumented Systems
13.13.1.10 LNG Tank LP Pumps Relief Valves and Discharge
13.13.1.11 LNG Tank LP Pumps Other Safety Features

13.13.2 LNG Sendout/High Pressure (HP) System Design

PROVIDE a description of the design basis. 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, and Project Specifications in Appendix 13.F, and should describe:

- 13.13.2.1 Number of LNG HP Pumps, operating and spare
- 13.13.2.2 LNG HP Pumps type
- 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 discharge pressures (minimum, normal/rated, maximum/shutoff), psig
- 13.13.2.6 LNG HP Pumps operating and design densities (minimum, normal, maximum), specific gravity
- 13.13.2.7 LNG HP Pumps Startup and Operation
  - 13.13.2.7.1 LNG Pump to vaporization
  - 13.13.2.7.2 LNG Pump minimum flow recycle
- 13.13.2.8 LNG HP Pumps Basic Process Control Systems
  - 13.13.2.8.1 LNG Pump flow control
- 13.13.2.9 LNG HP Pumps Isolation Valves, Drains, and Vents
- 13.13.2.10 LNG HP Pumps Piping, Vessel, and Equipment Design and Specifications
- 13.13.2.11 LNG HP Pumps Safety Instrumented Systems
- 13.13.2.12 LNG HP Pumps Relief Valves and Discharge
- 13.13.2.13 LNG HP Pumps Other Safety Features

13.14 LNG TRUCKING[14]

13.14.1 LNG Trucking Design

PROVIDE a description of the design basis. 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, and Project Specifications in Appendix 13.F, and should describe:

13.14.1.1 Number of LNG trucks unloaded, No. per year
13.14.1.2 Number of LNG trucks loaded, No. per year
13.14.1.3 Number of LNG Truck Stations
13.14.1.4 LNG Truck Weighing
13.14.1.5 Number of LNG Trucking Pumps, operating and spare
13.14.1.6 LNG Trucking Pumps type
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 Number of LNG truck pumps, operating and spare
13.14.1.14 LNG truck pumps type
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

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[14] *18 CFR 380.12(m), 18 CFR 380.12(m)(1), 18 CFR 380.12(m)(3), 18 CFR 380.12(m)(4), 18 CFR 380.12(m)(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), 18 CFR 380.12(o)(13), 18 CFR 380.12(o)(14).*

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 Basic Process Control Systems

13.14.1.21 LNG Trucking Pump flow control

13.14.1.22 LNG Trucking Isolation Valves, Drains, and Vents

13.14.1.23 LNG Trucking Piping, Vessel, and Equipment Design and Specifications

13.14.1.24 LNG Trucking Safety Instrumented Systems

13.14.1.25 LNG Trucking Relief Valves and Discharge

13.14.1.26 LNG Trucking Other Safety Features

13.15 LNG VAPORIZATION[15]

13.15.1 LNG Vaporizers Design

PROVIDE a description of the design basis. 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, and Project Specifications in Appendix 13.F, and should describe:

13.15.1.1 Emission Design Criteria
13.15.1.2 Number of LNG vaporizers, operating and spare
13.15.1.3 LNG Vaporizers type
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/h
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 Basic Process Control Systems
13.15.1.11 LNG Vaporizers Isolation Valves, Drains, and Vents
  13.15.1.11.1 Generated water handling/disposal system
13.15.1.12 LNG Vaporizers Piping, Vessel, and Equipment Design and Specifications
13.15.1.13 LNG Vaporizers Safety Instrumented Systems
13.15.1.14 LNG Vaporizers Relief Valves and Discharge
13.15.1.15 LNG Vaporizers Other Safety Features

[15] *18 CFR 380.12(m), 18 CFR 380.12(m)(1), 18 CFR 380.12(m)(3), 18 CFR 380.12(m)(4), 18 CFR 380.12(m)(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), 18 CFR 380.12(o)(13), 18 CFR 380.12(o)(14).*

13.16 HEAT TRANSFER FLUID (HTF) SYSTEM(S)[16]

13.16.1 HTF Storage Design

PROVIDE a description of the design basis. 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, and Project Specifications in Appendix 13.F, and should describe:

13.16.1.1 HTF Source
13.16.1.2 HTF Consumers/Users
13.16.1.3 Number of HTF Trucks, No. per year
13.16.1.4 Number of HTF Storage Tanks, operating and spare
13.16.1.5 HTF operating and design storage capacities, gal
13.16.1.6 HTF operating and design storage pressures (minimum, normal, maximum), psig
13.16.1.7 HTF operating and design storage temperatures (minimum, normal, maximum), °F
13.16.1.8 HTF operating and design residence times, minutes
13.16.1.9 HTF System Startup and Operation
13.16.1.10 HTF System Basic Process Control Systems
13.16.1.11 HTF System Isolation Valves, Drains, and Vents
13.16.1.12 HTF System Piping, Vessel, and Equipment Design and Specifications
13.16.1.13 HTF System Safety Instrumented Systems
13.16.1.14 HTF System Relief Valves and Discharge
13.16.1.15 HTF System Other Safety Features

[16] *18 CFR 380.12(m), 18 CFR 380.12(m)(1), 18 CFR 380.12(m)(3), 18 CFR 380.12(m)(4), 18 CFR 380.12(m)(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), 18 CFR 380.12(o)(13), 18 CFR 380.12(o)(14).*

13.16.2 **HTF Heating System Design**[17]

PROVIDE a description of the design basis. 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, and Project Specifications in Appendix 13.F, and should describe:

13.16.2.1 HTF consumers/users
13.16.2.1 Heating source
13.16.2.2 Number of HTF Heaters, operating and spare
13.16.2.3 HTF Heaters type
13.16.2.4 Number of HTF Pumps, operating and spare
13.16.2.5 HTF Pumps type
13.16.2.6 HTF heaters operating and design heat duty/rate each (minimum, rated, maximum), MMbtu/h
13.16.2.7 HTF heaters operating and design pressures (minimum, normal, maximum), psig
13.16.2.8 HTF heaters operating and design inlet temperatures (minimum, normal, maximum), °F
13.16.2.9 HTF heaters operating and design outlet temperatures (minimum, normal, maximum), °F
13.16.2.10 HTF pumps operating and design flow rate capacities (minimum, normal/rated, maximum), gpm
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 densities (minimum, normal, maximum), specific gravity
13.16.2.14 HTF Heating System Startup and Operation
13.16.2.15 HTF Heating System Basic Process Control Systems
13.16.2.16 HTF Heating System Isolation Valves, Drains, and Vents

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[17] *18 CFR 380.12(m), 18 CFR 380.12(m)(1), 18 CFR 380.12(m)(3), 18 CFR 380.12(m)(4), 18 CFR 380.12(m)(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), 18 CFR 380.12(o)(13), 18 CFR 380.12(o)(14).*

13.16.2.17 HTF Heating System Piping, Vessel, and Equipment Design and Specifications
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[18]

13.17.1 BTU Adjustment System Design

PROVIDE a description of the design basis. 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, and Project Specifications in Appendix 13.F, 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 Basic Process Control Systems
13.17.1.9 Btu Adjustment System Isolation Valves, Drains, and Vents
13.17.1.10 Btu Adjustment System Piping, Vessel, and Equipment Design and Specifications
13.17.1.11 Btu Adjustment System Safety Instrumented Systems
13.17.1.12 Btu Adjustment System Relief Valves and Discharge
13.17.1.13 Btu Adjustment System Other Safety Features

[18] *18 CFR 380.12(m), 18 CFR 380.12(m)(1), 18 CFR 380.12(m)(3), 18 CFR 380.12(m)(4), 18 CFR 380.12(m)(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), 18 CFR 380.12(o)(13), 18 CFR 380.12(o)(14).*

13.18 SENDOUT METERING SYSTEM[19]

13.18.1 Sendout Metering Design

PROVIDE a description of the design basis. 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, and Project Specifications in Appendix 13.F, 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 pressures (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 Basic Process Control Systems
- 13.18.1.9 Sendout Metering System Isolation Valves, Drains, and Vents
- 13.18.1.10 Sendout Metering System Piping Design and Specifications
- 13.18.1.11 Sendout Metering System Safety Instrumented Systems
- 13.18.1.12 Sendout Metering System Relief Valves and Discharge
- 13.18.1.13 Sendout Metering System Other Safety Features

[19] *18 CFR 380.12(m), 18 CFR 380.12(m)(1), 18 CFR 380.12(m)(3), 18 CFR 380.12(m)(4), 18 CFR 380.12(m)(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), 18 CFR 380.12(o)(13), 18 CFR 380.12(o)(14).*

13.19 FUEL GAS[20]

13.19.1 Fuel Gas Design

PROVIDE a description of the design basis. 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, and Project Specifications in Appendix 13.F, and should describe:

13.19.1.1 Fuel Gas sources
13.19.1.2 Fuel Gas consumers/end users
13.19.1.3 Fuel Gas specifications
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 Basic Process Control Systems
13.19.1.10 Fuel Gas Isolation Valves, Drains, and Vents
13.19.1.11 Fuel Gas Piping, Vessel, and Equipment Design and Specifications
13.19.1.12 Fuel Gas Safety Instrumented Systems
13.19.1.13 Fuel Gas Relief Valves and Discharge
13.19.1.14 Fuel Gas Other Safety Features
13.19.1.14.1 Fuel Gas Odorant System

[20] *18 CFR 380.12(m), 18 CFR 380.12(m)(1), 18 CFR 380.12(m)(3), 18 CFR 380.12(m)(4), 18 CFR 380.12(m)(5), 18 CFR 380.12(o)(3), 18 CFR 380.12(o)(6), 18 CFR 380.12(o)(7), 18 CFR 380.12(o)(8), 18 CFR 380.12(o)(10), 18 CFR 380.12(o)(12), 18 CFR 380.12(o)(13), 18 CFR 380.12(o)(14).*

13.20 NITROGEN AND INERT GAS[21]

13.20.1 Nitrogen Design

PROVIDE a description of the design basis. 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, and Project Specifications in Appendix 13.F, and should describe:

13.20.1.1 Nitrogen Source
13.20.1.2 Nitrogen Consumers/Users, list of continuous and intermittent or usage factors, including leakage
13.20.1.3 Number of Liquid Nitrogen Trucks, No. per year
13.20.1.4 Number of Liquid Nitrogen Storage Tanks, operating and spare
13.20.1.5 Liquid Nitrogen storage capacity, gal
13.20.1.6 Number of Nitrogen Vaporizers, operating and spare
13.20.1.7 Liquid Nitrogen vaporizer type
13.20.1.8 Number of Nitrogen Receivers, operating and spare
13.20.1.9 Liquid Nitrogen vaporizer operating and design flow rate capacities, scfm
13.20.1.10 Nitrogen Receivers operating and design storage capacities, scf
13.20.1.11 Nitrogen receivers operating and design storage pressures (minimum, normal, maximum), psig
13.20.1.12 Nitrogen receivers residence times, minutes
13.20.1.13 Nitrogen System Startup and Operation
13.20.1.14 Liquid Nitrogen Truck Loading
13.20.1.15 Nitrogen System Basic Process Control Systems
13.20.1.16 Nitrogen System Isolation Valves, Drains, and Vents
13.20.1.17 Nitrogen System Piping, Vessel, and Equipment Design and Specifications
13.20.1.18 Nitrogen System Safety Instrumented Systems
13.20.1.19 Nitrogen System Relief Valves and Discharge
13.20.1.20 Nitrogen System Other Safety Features

[21] *18 CFR 380.12(m), 18 CFR 380.12(m)(1), 18 CFR 380.12(m)(3), 18 CFR 380.12(m)(4), 18 CFR 380.12(m)(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), 18 CFR 380.12(o)(13), 18 CFR 380.12(o)(14).*

13.20.2 Inert Gas Design

PROVIDE a description of the design basis. 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, and Project Specifications in Appendix 13.F, and should describe:

- 13.20.2.1 Number of Inert Gas Compressors, operating and spare
- 13.20.2.2 Inert Gas Compressors type
- 13.20.2.3 Number of Inert Gas Receivers, operating and spare
- 13.20.2.4 Inert Gas Source
- 13.20.2.5 Inert Gas Consumers/Users, list of continuous and intermittent or usage factors, including leakage
- 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 Basic Process Control Systems
- 13.20.2.14 Inert Gas Isolation Valves, Drains, and Vents
- 13.20.2.15 Inert Gas Piping, Vessel, and Equipment Design and Specifications
- 13.20.2.16 Inert Gas Safety Instrumented Systems
- 13.20.2.17 Inert Gas Relief Valves and Discharge
- 13.20.2.18 Inert Gas Other Safety Features

13.21 INSTRUMENT AND PLANT/UTILITY AIR[22]

13.21.1 Instrument Air Design

PROVIDE a description of the design basis. 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, and Project Specifications in Appendix 13.F, and should describe:

13.21.1.1 Instrument Air Consumers/Users, list of continuous and intermittent or usage factors, including leakage
13.21.1.2 Instrument Air Specifications, dew point, particulates
13.21.1.3 Number of Filters, operating and spare
13.21.1.4 Number of Instrument Air Compressors, operating and spare
13.21.1.5 Instrument Air Compressors type
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 Number of Instrument Air Dryers, operating and spare
13.21.1.9 Instrument Air Drying System type
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
13.21.1.14 Air Receiver residence times, sec
13.21.1.15 Instrument Air Startup and Operation
13.21.1.16 Instrument Air Basic Process Control Systems
13.21.1.17 Instrument Air Isolation Valves, Drains, and Vents

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[22] *18 CFR 380.12(m), 18 CFR 380.12(m)(1), 18 CFR 380.12(m)(3), 18 CFR 380.12(m)(4), 18 CFR 380.12(m)(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), 18 CFR 380.12(o)(13), 18 CFR 380.12(o)(14).*

13.21.1.18 Instrument Air Piping, Vessel, and Equipment Design and Specifications
13.21.1.19 Instrument Air Safety Instrumented Systems
13.21.1.20 Instrument Air Relief Valves and Discharge
13.21.1.21 Instrument Air Other Safety Features

13.21.2 **Plant/Utility Air Design**

PROVIDE a description of the design basis. 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, and Project Specifications in Appendix 13.F, and should describe:

13.21.2.1 Number of Plant/Utility Air Compressors, operating and spare
13.21.2.2 Plant/Utility Air Compressors type
13.21.2.3 Plant/Utility Air consumers/users, list of continuous and intermittent or usage factors, including leakage
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 Basic Process Control Systems
13.21.2.13 Plant/Utility Air Isolation Valves, Drains, and Vents
13.21.2.14 Plant/Utility Air Piping, Vessel, and Equipment Design and Specifications
13.21.2.15 Plant/Utility Air Safety Instrumented Systems
13.21.2.16 Plant/Utility Air Relief Valves and Discharge
13.21.2.17 Plant/Utility Air Other Safety Features

13.22 UTILITY WATER AND OTHER UTILITIES[23]

13.22.1 Utility Water Design

PROVIDE a description of the design basis. 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 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 Consumers/Users
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 Utilities Startup and Operation
13.22.1.8 Utilities Basic Process Control Systems
13.22.1.9 Utilities Isolation Valves, Drains, and Vents
13.22.1.10 Utilities Piping, Vessel, and Equipment Design and Specifications
13.22.1.11 Utilities Safety Instrumented Systems
13.22.1.12 Utilities Relief Valves and Discharge
13.22.1.13 Utilities Other Safety Features

[23] *18 CFR 380.12(m), 18 CFR 380.12(m)(1), 18 CFR 380.12(m)(3), 18 CFR 380.12(m)(4), 18 CFR 380.12(m)(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), 18 CFR 380.12(o)(13), 18 CFR 380.12(o)(14).*

13.22.2 Other Utilities Design[24]

PROVIDE a description of the design basis. 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 should describe:

13.22.2.1 Other Utilities type (Amine, Water Glycol Solutions, Aqueous Ammonia)
13.22.2.2 Other Utility Consumers/Users
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 Weighing
13.22.2.9 Utilities Startup and Operation
13.22.2.10 Utilities Basic Process Control Systems
13.22.2.11 Utilities Isolation Valves, Drains, and Vents
13.22.2.12 Utilities Piping, Vessel, and Equipment Design and Specifications
13.22.2.13 Utilities Safety Instrumented Systems
13.22.2.14 Utilities Relief Valves and Discharge
13.22.2.15 Utilities Other Safety Features

[24] *18 CFR 380.12(m), 18 CFR 380.12(m)(1), 18 CFR 380.12(m)(3), 18 CFR 380.12(m)(4), 18 CFR 380.12(m)(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), 18 CFR 380.12(o)(13), 18 CFR 380.12(o)(14).*

13.23 PIPING AND VALVES[25]

13.23.1 Piping and Valve Design

PROVIDE a description of the design basis. 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 Piping, Vessel, Equipment, and Building Information in Appendix 13.M, and should describe:

- 13.23.1.1 Piping and Valve List(s)
- 13.23.1.2 Tie-In List(s)
- 13.23.1.3 Piping Layout
- 13.23.1.4 Pipe Supports and Pipe Racks
- 13.23.1.5 Piping, Valve, Flange, and Insulation Design and Specifications
  - 13.23.1.5.1 Conditions and Loads (e.g. pressures, temperatures, vibration, internal and external corrosion, etc.)
  - 13.23.1.5.2 Material of Construction Temperature Limits
  - 13.23.1.5.3 Material of Construction Allowable Stress Limits
  - 13.23.1.5.4 Material of Construction Corrosivity Potential and Corrosion Allowance
  - 13.23.1.5.5 Cathodic Protection
- 13.23.1.6 Non-Destructive Examination (NDE)
  - 13.23.1.6.1 Magnetic Particle or Liquid Penetrant Examination
  - 13.23.1.6.1 Weld Radiographic/Ultrasonic Testing
  - 13.23.1.6.2 Pneumatic/Hydrostatic Leak Testing
  - 13.23.1.6.3 Other
- 13.23.1.7 Piping Preventative Maintenance
  - 13.23.1.7.1 Internal and External Examination
  - 13.23.1.7.2 Corrosion Under Insulation
  - 13.23.1.7.3 Metal Thickness Tests

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[25] *18 CFR 380.12(m), 18 CFR 380.12(m)(1), 18 CFR 380.12(m)(3), 18 CFR 380.12(m)(4), 18 CFR 380.12(m)(5), 18 CFR 380.12(o)(7), 18 CFR 380.12(o)(8), 18 CFR 380.12(o)(14).*

13.24 PROCESS VESSELS[26]

13.24.1 Process Vessel Design

PROVIDE a description of the design basis. 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 Piping, Vessel, Equipment, and Building Information in Appendix 13.M, 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 Preventative 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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[26] *18 CFR 380.12(m), 18 CFR 380.12(m)(1), 18 CFR 380.12(m)(3), 18 CFR 380.12(m)(4), 18 CFR 380.12(m)(5), 18 CFR 380.12(o)(7), 18 CFR 380.12(o)(8), 18 CFR 380.12(o)(14).*

13.25 ROTATING EQUIPMENT[27]

13.25.1 **Rotating Equipment Design**

PROVIDE a description of the design basis. 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 Piping, Vessel, Equipment, and Building Information in Appendix 13.M, and should describe:

- 13.25.1.1 Rotating Equipment and Drivers List
- 13.25.1.2 Equipment Layout
- 13.25.1.3 Equipment Design and Specifications
  - 13.25.1.3.1 Conditions and Loads (e.g. pressures, temperatures, vibration, internal and external corrosion, etc.)
  - 13.25.1.3.2 Material of Construction Allowable Stress Limits
  - 13.25.1.3.3 Material of Construction Temperature Limits
  - 13.25.1.3.4 Material of Construction Corrosivity Potential and Corrosion Allowance
  - 13.25.1.3.5 Cathodic Protection
- 13.25.1.4 Rotating Equipment Preventative Maintenance
  - 13.25.1.4.1 Performance Monitoring and Tests

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[27] *18 CFR 380.12(m), 18 CFR 380.12(m)(1), 18 CFR 380.12(m)(3), 18 CFR 380.12(m)(4), 18 CFR 380.12(m)(5), 18 CFR 380.12(o)(7), 18 CFR 380.12(o)(8), 18 CFR 380.12(o)(14).*

13.26 BUILDINGS AND STRUCTURES[28]

13.26.1 Buildings and Structures Design

PROVIDE a description of the design basis. 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 Piping, Vessel, Equipment, and Building Information in Appendix 13.M, and should describe:

13.26.1.1 Buildings List with Dimensions and Purpose
13.26.1.2 Building and Structure Design and Specifications
13.26.1.3 Building Layout and Siting

[28] *18 CFR 380.12(m), 18 CFR 380.12(m)(1), 18 CFR 380.12(m)(3), 18 CFR 380.12(m)(4), 18 CFR 380.12(m)(5), 18 CFR 380.12(o)(7), 18 CFR 380.12(o)(8), 18 CFR 380.12(o)(14).*

13.27 ELECTRICAL[29]

13.27.1 Electrical System Design

PROVIDE a description of the design basis. 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 Electrical Design Information in Appendix 24.N, and should describe:

13.27.1.1 Power Requirements
13.27.1.2 Main Power Supply, Utility/Generated
13.27.1.3 Number of Main Power Generators
13.27.1.4 Main Power Generators, type
13.27.1.5 Main Power Supply Voltage, kilovolt (kV)
13.27.1.6 Main Power Supply Capacity, kilovolt Ampere (kVA)
13.27.1.7 Emergency Power Supply, Utility/Generated
13.27.1.8 Number of Emergency Power Generator, No.
13.27.1.9 Emergency Power Generators, type
13.27.1.10 Emergency Power Voltage, kV
13.27.1.11 Emergency Power Capacity, kVA
13.27.1.12 UPS services, voltage, size and capacity, V, kVA, h
13.27.1.13 Number of Transformers
13.27.1.14 Transformer type, dry/oil
13.27.1.15 Electrical Distribution System
13.27.1.16 Distribution and Voltage Levels,
13.27.1.17 Uninterruptible Power Supply, Battery Backup System
13.27.1.18 Electrical Cable Design and Specification
13.27.1.19 Cathodic Protection
13.27.1.20 Hazardous Area Classifications
13.27.1.21 Ignition Control Setbacks and Separation
13.27.1.22 Electrical Pass-Through Seals and Vents to the Atmosphere

29 *18 CFR 380.12(m), 18 CFR 380.12(m)(1), 18 CFR 380.12(m)(3), 18 CFR 380.12(m)(4), 18 CFR 380.12(m)(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 OPERATIONS AND MAINTENANCE[30]

13.28.1 Operation and Maintenance Plans

PROVIDE a description of the proposed operation and maintenance Sufficient information should be included to demonstrate that the facility would be operated and maintained to meet the federal regulations and the level of safety is consistent with the design of the facility. At a minimum, the description should reference the Organizational Chart in Appendix 13.A.4 and Operating and Maintenance Procedures in Appendix 13.O, and should describe:

13.28.1.1 Operation Procedure Development
13.28.1.2 Safety Procedures (e.g., hot work and other work permit procedures, etc.)
13.28.1.3 Maintenance Plan and Procedure Development
13.28.1.4 Operations and Maintenance Structure
13.28.1.5 Number of Operation and Maintenance Personnel
13.28.1.6 Location of Operation and Maintenance Personnel
13.28.1.7 Operation and Maintenance Personnel Training
13.28.1.8 Training Plans and Procedures
13.28.1.9 Management Procedures (e.g. alarm management, shift procedures/fatigue management, management of change procedures, etc.)

[30] *18 CFR 380.12(m), 18 CFR 380.12(m)(1), 18 CFR 380.12(m)(3), 18 CFR 380.12(m)(4), 18 CFR 380.12(m)(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).*

13.29 INSTRUMENTATION AND CONTROLS[1]

13.29.1 Basic Process Control System Design

PROVIDE a description of the design basis. 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 Process Instrumentation in Appendix 13.P, and should describe:

13.29.1.1 Instrument List
13.29.1.2 Instrumentation Design and Specifications
13.29.1.3 Number of Servers, operating and backup
13.29.1.4 Number of Historians, operating and backup
13.29.1.5 Distributed Control Systems Block Diagrams
13.29.1.6 Distributed Control Systems Software
13.29.1.7 Number of Lines of Communication to Control Room, operating and backup
13.29.1.8 Control Communication types
13.29.1.9 Control Power Sources, operating and backup
13.29.1.10 Number of Human Machine Interface (HMI) Control Room Displays
13.29.1.11 HMI Control Room Displays type

[1] *18 CFR 380.12(m), 18 CFR 380.12(m)(1), 18 CFR 380.12(m)(3), 18 CFR 380.12(m)(4), 18 CFR 380.12(m)(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 SAFETY INSTRUMENTED SYSTEMS[2]

13.30.1 SIS Design

PROVIDE a description of the design basis. 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 Shutoff Valve Information in Appendix 13.Q, and should describe:

13.30.1.1 Safety Instrumentation System Philosophy
13.30.1.2 Cause and Effect Matrices
13.30.1.3 Safety Instrumentation Design and Specifications
13.30.1.4 Number of Servers, operating and backup
13.30.1.5 Number of Historians, operating and backup
13.30.1.6 Safety Instrumented System Block Diagrams
13.30.1.7 Fire and Gas System Block Diagrams
13.30.1.8 Safety Instrumented System Software
13.30.1.9 Fire and Gas System Software
13.30.1.10 List of Shutdown Valves
13.30.1.11 Shutdown Valve Spacing
13.30.1.12 Shutdown Valve Closure Times
13.30.1.13 Shutdown Valves Design and Specification

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2 *18 CFR 380.12(m), 18 CFR 380.12(m)(1), 18 CFR 380.12(m)(3), 18 CFR 380.12(m)(4), 18 CFR 380.12(m)(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).*

13.31 SECURITY PLANS[3]

13.31.1 **Security Plans**

PROVIDE a general description of the proposed security that addresses the principal concerns for facility security. Identify who would be involved in the development of the security plan during the design phase of the project. Sufficient information should be included to demonstrate that the facility would be designed, installed and operated to meet the federal regulations and that the level of security and safety is consistent with the security threats and vulnerabilities at the facility 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 Assessment and Security Drawings in Appendix 13.G, and should describe:

13.31.1.1 Security Plan Developments
13.31.1.2 Lighting
13.31.1.3 Physical Barriers (e.g. fences, vehicle barriers, etc.)
13.31.1.4 Site and Onsite Access Controls
13.31.1.5 Intrusion Monitoring
13.31.1.6 Intrusion Detection
13.31.1.7 Site Security Service
13.31.1.8 Number of Site Security Personnel
13.31.1.9 Site Security Communication
13.31.1.10 Site Security Use of Force
13.31.1.11 Site Security Training
13.31.1.12 Setbacks, Blast Walls, Hardened Structures, and Blast Resistant Designs

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3 *18 CFR 380.12(m), 18 CFR 380.12(m)(1), 18 CFR 380.12(m)(3), 18 CFR 380.12(m)(4), 18 CFR 380.12(m)(5), 18 CFR 380.12(o)(7), 18 CFR 380.12(o)(8), 18 CFR 380.12(o)(14).*

13.32 RELIEF VALVE AND FLARE/VENT SYSTEMS[4]

13.32.1 Relief Valves and Flare/Vent Systems Design

PROVIDE a description of the design basis. 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 Relief Valve and Flare/Vent System Information in Appendix 13.R, and should describe:

13.32.1.1 List of Relief Valves
13.32.1.2 Relief Valve Studies
13.32.1.3 Number of Vent Stacks
13.32.1.4 Vent Stack type
13.32.1.5 Vent Stack Height and Diameter
13.32.1.6 Vent Stack Studies
13.32.1.7 Number of Flare Stacks
13.32.1.8 Flare Stack type
13.32.1.9 Flare Stack Height and Diameter
13.32.1.10 Flare Stack Studies
13.32.1.11 Vent Stack Sources
13.32.1.12 Vent Stack operating and design flow rate capacities (minimum, normal/rated, maximum), MMscfd
13.32.1.13 Vent Stack operating and design pressures (minimum, normal/rated, maximum), psig
13.32.1.14 Vent Stack operating and design temperatures (minimum, normal, maximum), °F
13.32.1.15 Vent Stack operating and design densities (minimum, normal, maximum), specific gravity
13.32.1.16 Flare Stacks Sources
13.32.1.17 Flare Stacks operating and design flow rate capacities (minimum, normal/rated, maximum), MMscfd
13.32.1.18 Flare Stacks operating and design pressures (minimum, normal/rated, maximum), psig
13.32.1.19 Flare Stacks operating and design temperatures (minimum, normal, maximum), °F

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

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

13.32.1.21 Flare Stacks operating and design radiant heat at base (maximum), Btu/ft^2-hr

13.32.1.22 Flare Stacks operating and design decibel at base (maximum), decibels on the A-weighted scale

13.33 SPILL CONTAINMENT[5]

13.33.1 Spill Containment System Design

PROVIDE a description of the spill containment 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, and Spill, Toxic, Explosion, and Fire Protection Information in Appendix 13.S, and should describe:

13.33.1.1 Spill Locations and Flows
13.33.1.2 Impoundment Volumetric Capacities
13.33.1.3 Trench and Trough Volumetric Flow Capacities
13.33.1.4 Downcomer Volumetric Flow Capacities
13.33.1.5 Impoundment System Water Removal
13.33.1.6 Storm water flow design basis
13.33.1.7 Storm water drainage calculations
13.33.1.8 Impoundment System Snow and Ice Removal
13.33.1.9 Snow and Ice load basis of design and removal
13.33.1.10 Water table depth, ft
13.33.1.11 Frost line depth, ft

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5 *18 CFR 380.12(m), 18 CFR 380.12(m)(1), 18 CFR 380.12(m)(3), 18 CFR 380.12(m)(4), 18 CFR 380.12(m)(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).*

13.34 PASSIVE PROTECTION SYSTEMS[6]

13.34.1 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, and Spill, Toxic, Explosion, and Fire Protection Information in Appendix 13.S, and should describe:

13.34.1.1 Cryogenic Structural Protection
13.34.1.2 Vapor Barriers
13.34.1.3 Equipment Layout Setbacks and Separation
13.34.1.4 Blast Walls, Hardened Structures, and Blast Resistant Design
13.34.1.5 Blast Walls and Hardened Structures
13.34.1.6 Fire Protection
13.34.1.7 Other Passive Protection (e.g. elevated heating, ventilation, and air conditioning (HVAC) intakes, foam glass blocks, etc.)

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6 *18 CFR 380.12(m), 18 CFR 380.12(m)(1), 18 CFR 380.12(m)(3), 18 CFR 380.12(m)(4), 18 CFR 380.12(m)(5), 18 CFR 380.12(o)(7), 18 CFR 380.12(o)(8), 18 CFR 380.12(o)(14).*

13.35 HAZARD DETECTION SYSTEMS[7]

13.35.1 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, and Spill, Toxic, Explosion, and Fire Protection Information in Appendix 13.S, and should describe:

13.35.1.1 Hazard Detection philosophies (selection, layout, alarm, activation, and/or shutdown setpoints, voting logic, voting degradation logic)
13.35.1.2 Hazard Detection Design and Performance Criteria (e.g., Minimum Detector Spacing, Maximum Detection Time, etc.)
13.35.1.3 Low Temperature Detectors
13.35.1.4 Oxygen Deficiency Detectors
13.35.1.5 Toxic Gas Detectors
13.35.1.6 Flammable/combustible Gas Detectors
13.35.1.7 Flame Detectors
13.35.1.8 Heat Detectors
13.35.1.9 Smoke/Products of Combustion Detectors
13.35.1.10 Manual Pull Stations
13.35.1.11 Audible and Visual Notification Systems for field, control room, plant wide, and offsite
13.35.1.12 Other Hazard Detectors (e.g., rate of rise temperature detectors, acoustic leak detectors, closed-circuit television (CCTV) detectors, carbon monoxide, etc.)

[7] *18 CFR 380.12(m), 18 CFR 380.12(m)(1), 18 CFR 380.12(m)(3), 18 CFR 380.12(m)(4), 18 CFR 380.12(m)(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).*

13.36 HAZARD CONTROL SYSTEMS[8]

13.36.1 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, and Spill, Toxic, Explosion, and Fire Protection Information in Appendix 13.S, and should describe:

- 13.36.1.1 Hazard control philosophies (selection, layout, activation)
- 13.36.1.2 Performance Criteria (e.g., minimum flow and capacity, maximum travel distance/spacing, etc.)
- 13.36.1.3 Portable Fire Extinguishers design and layout with reference to Drawings in Appendix 13.S
- 13.36.1.4 Fixed Dry Chemical Systems design and layout with reference to Drawings in Appendix 13.S
- 13.36.1.5 Clean Agent Systems design and layout with reference to Drawings in Appendix 13.S
- 13.36.1.6 Carbon Dioxide Systems design and layout with reference to Drawings in Appendix 13.S
- 13.36.1.7 Other Hazard Control Systems (e.g., nitrogen snuffing, dispersive fans, building ventilation, etc.) design and layout with reference to Drawings in Appendix 13.S

[8] *18 CFR 380.12(m), 18 CFR 380.12(m)(1), 18 CFR 380.12(m)(3), 18 CFR 380.12(m)(4), 18 CFR 380.12(m)(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).*

13.37 FIRE WATER SYSTEM[9]

13.37.1 Fire Water Design

PROVIDE a description of the design basis. 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 Spill, Toxic, Explosion, and Fire Protection Information in Appendix 13.S, and should describe:

- 13.37.1.1 Fire Water philosophy
- 13.37.1.2 Fire Water system design cases, demands, calculations, and basis of sizing
- 13.37.1.3 Main fire water supply and back up supply (e.g., Fire Water tank, pond, ocean, wells, city, etc.)
- 13.37.1.4 Fire water supply pressure, psig
- 13.37.1.5 Fire water storage type and capacity, gal
- 13.37.1.6 Main fire water pumps and driver type
- 13.37.1.7 Number of main fire water pumps, operating and standby
- 13.37.1.8 Main fire water pumps operating and design flow rate capacities (minimum, rated, maximum), gpm
- 13.37.1.9 Main fire water pumps operating and design pressures (minimum, rated, maximum)
- 13.37.1.10 Jockey/make up water source
- 13.37.1.11 Jockey/make up water operating and design flow rate capacities (minimum, rated, maximum), gpm
- 13.37.1.12 Jockey/make up water operating and design pressures (minimum, rated, maximum), psig
- 13.37.1.13 Fire water piping design and layout with reference to Drawings in Appendix 13.S
  - 13.37.1.13.1 Freeze protection (burial depth below frost depth, aboveground heat tracing, etc.)
- 13.37.1.14 Fire water hydrants design and layout with reference to Drawings in Appendix 13.S

[9] *18 CFR 380.12(m), 18 CFR 380.12(m)(1), 18 CFR 380.12(m)(3), 18 CFR 380.12(m)(4), 18 CFR 380.12(m)(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).*

13.37.1.15 Fire water monitors design and layout with reference to Drawings in Appendix 13.S
13.37.1.16 Hose reels design and layout with reference to Drawings in Appendix 13.S
13.37.1.17 Water screens and deluge systems design and layout with reference to Drawings in Appendix 13.S
13.37.1.1 Expansion Foam philosophy
13.37.1.2 Expansion Foam system design cases, demands, calculations, and basis of sizing
13.37.1.3 Expansion Foam Water Supply
13.37.1.4 Expansion Foam Supply
13.37.1.5 Expansion Foam type (e.g. low expansion AFFF, high expansion foam, etc.)
13.37.1.6 Expansion Foam concentration, percent volume
13.37.1.7 Expansion Foam storage type and capacity, gal
13.37.1.8 Expansion Foam pumps and driver type
13.37.1.9 Number of Expansion Foam pumps, operating and standby
13.37.1.10 Expansion Foam pumps operating and design flow rate capacities (minimum, rated, maximum), gpm
13.37.1.11 Expansion Foam pumps operating and design pressures (minimum, rated, maximum)
13.37.1.12 Expansion Foam Piping design and layout with reference to Drawings in Appendix 13.S
13.37.1.12.1 Freeze protection (burial depth below frost depth, aboveground heat tracing, etc.)
13.37.1.13 Expansion Foam Generators design and layout with reference to Drawings in Appendix 13.S
13.37.1.14 Expansion Foam Hose Reels design and layout with reference to Drawings in Appendix 13.S
13.37.1.15 External impact protection (bollards)

13.38 EMERGENCY RESPONSE PLANS[10]

13.38.1 Emergency Response Plans

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

13.38.1.1 Incident Command System organizational chart for emergency response

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

13.38.1.3 Number of emergency response personnel

13.38.1.4 Number and type of emergency response apparatus

13.38.1.5 Response to emergencies and deployment of resources

13.38.1.6 Public and onsite notification and communication

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

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

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

13.38.1.10 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)

13.38.1.11 Contact and communications with the State Fire Marshall

13.38.1.12 Contacts and communications with all other appropriate agencies

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

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[10] *18 CFR 380.12(m), 18 CFR 380.12(m)(1), 18 CFR 380.12(m)(3), 18 CFR 380.12(m)(4), 18 CFR 380.12(m)(5), 18 CFR 380.12(o)(7), 18 CFR 380.12(o)(8), 18 CFR 380.12(o)(14).*

13.38.1.14 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[11]

13.A.1 Site Location Maps and Drawing

PROVIDE area location maps and drawings detailing the surrounding. Plant and surrounding areas 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 the Organizational Chart detailing the structure of the ownership of the facility. The structure should include the owner of the facility, 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 facility. At a minimum, the organizational chart should include the structure and number of all operations, maintenance, engineering, safety, security, health, environment, management, and administrative staff.

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[11] *18 CFR 380.12(m), 18 CFR 380.12(m)(1), 18 CFR 380.12(m)(3), 18 CFR 380.12(m)(4), 18 CFR 380.12(m)(5), 18 CFR 380.12(o)(7), 18 CFR 380.12(o)(8).*

13.A.5 **Feed and Product Destinations Drawings**

PROVIDE drawings of feed and product destinations. The drawings should show feed gas pipeline(s) routes, sendout pipeline routes, and shipping routes:

13.A.5.1 Feed Gas Pipeline Routes
13.A.5.2 Sendout Pipeline Routes
13.A.5.3 Shipping Routes

13.A.6 **Gantt Chart**

PROVIDE a Gantt chart (e.g. level II or III) of the project schedule. The Gantt Chart should include:

13.A.6.1 Front end engineering design and reviews, including milestones for completed Hazard Identification (HAZID) or Preliminary Hazard and Operability (HAZOP), completed Piping and Instramentation Drawings (P&IDs), completed FEED

13.A.6.2 Regulatory Permits and Approvals, including milestones for submittals and authorizations/permits for U.S. Army Corps of Engineers, U.S. Environmental Protection Agency, U.S. Department of Energy, FERC, state agencies

13.A.6.3 Site Preparation, including milestones for starting and completing mobilization, soil stabilization, grading, power, waterlines, underground piping and systems, access roads, laydown areas, and dredging

13.A.6.4 Detailed/Final Engineering, including milestones for starting and completing HAZOP, issued for construction P&IDs, structural design, and fire protection evaluation.

13.A.6.5 Procurement, including milestones for completing procurement of long lead equipment, transit/delivery of major equipment, receipt of bulk materials/fluids

13.A.6.6 Construction, including milestones for starting and completing piling, foundations, fabrication/erection of structural steel, major pieces of equipment, storage tanks, vessels, piping, tie-ins, electrical and instrumentation, insulation, equipment tagging, labeling, and signage.

13.A.6.7 Pre-Commissioning and Commissioning, including milestones for starting and completing cleanout, purging, dryout, leak/pneumatic testing, hydrotests, equipment alignment checks,and Mechanical

Completion, loop checks, alarm/trip checks, commissioning plans and procedures, electrical tests, Facility Acceptance Tests, Site Acceptance Tests and Site Integration Tests (FAT/SAT/SIT), functional tests, introduction of hazardous fluids, and Ready for Startup documentation.

13.A.6.8 Startup, including milestones for starting and completing training of personnel, startup and cooldown procedures.

13.A.6.9 Commencement of operations, including milestones for starting and completing operation procedures, maintenance plans, performance tests, and turnover.

13.B APPENDIX 13.B, DESIGN BASIS, CRITERIA, AND PHILOSOPHIES[12]

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 not be 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. The Design Basis should include:

13.B.1.1 Marine Platform Basis of Design and Criteria
13.B.1.2 Marine Transfer Basis of Design and Criteria
13.B.1.3 FEED Gas System Basis of Design and Criteria
13.B.1.4 Acid Gas Removal Basis of Design and Criteria
13.B.1.5 Mercury Removal Basis of Design and Criteria
13.B.1.6 Water Removal Basis of Design and Criteria
13.B.1.7 Heavies/Condensates Removal, Storage, and Disposition Basis of Design and Criteria
13.B.1.8 NGL Fractionation, Storage, and NGL Disposition Basis of Design and Criteria
13.B.1.9 Refrigerant Basis of Design and Criteria
13.B.1.10 Liquefaction Basis of Design and Criteria
13.B.1.11 Cooling Water Basis of Design and Criteria
13.B.1.12 LNG Transfer Basis of Design and Criteria
13.B.1.13 LNG Storage Tank Basis of Design and Criteria
13.B.1.14 Vapor Handling Basis of Design and Criteria
13.B.1.15 LNG Trucking Basis of Design and Criteria
13.B.1.16 LNG Vaporization Basis of Design and Criteria
13.B.1.17 HTF Storage and Heating Basis of Design and Criteria
13.B.1.18 BTU Adjustment Basis of Design and Criteria
13.B.1.19 Sendout Metering Basis of Design and Criteria
13.B.1.20 Electrical Basis of Design and Criteria
13.B.1.21 Fuel Gas Basis of Design and Criteria
13.B.1.22 Nitrogen Basis of Design and Criteria
13.B.1.23 Inert Gas Basis of Design and Criteria
13.B.1.24 Instrument Air Basis of Design and Criteria
13.B.1.25 Plant/utility Air Basis of Design and Criteria

[12] *18 CFR 380.12(m), 18 CFR 380.12(m)(1), 18 CFR 380.12(m)(3), 18 CFR 380.12(m)(4), 18 CFR 380.12(m)(5), 18 CFR 380.12(o)(7), 18 CFR 380.12(o)(8), 18 CFR 380.12(o)(14).*

13.B.1.26 Piping Basis of Design and Criteria
13.B.1.27 Process Vessel Basis of Design and Criteria
13.B.1.28 Buildings and Structures Basis of Design and Criteria
13.B.1.29 Basic Process Control System Basis of Design and Criteria
13.B.1.30 Safety Instrument System Basis of Design and Criteria
13.B.1.31 Relief Valve and Flare/Vent Systems Basis of Design and Criteria
13.B.1.32 Spill Containment Basis of Design and Criteria
13.B.1.33 Passive Protection Basis of Design and Criteria
13.B.1.34 Hazard Detection Basis of Design and Criteria
13.B.1.35 Hazard Control Basis of Design and Criteria
13.B.1.36 Fire Water Basis of Design and Criteria

13.B.2 **Design 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 Marine Transfer System Philosophies
13.B.2.2 Acid Gas Removal System Philosophies
13.B.2.3 Mercury Removal System Philosophies
13.B.2.4 Dehydration and Regeneration Gas Systems
13.B.2.5 Heavies/Condensates Removal, Storage, and Disposition Systems Philosophies
13.B.2.6 NGL Removal, Storage, and Disposition Systems Philosophies
13.B.2.7 Liquefaction Systems Philosophies
13.B.2.8 Cooling Systems Philosophies
13.B.2.9 LNG Transfer Systems Philosophies
13.B.2.10 LNG Storage Tank Systems Philosophies
13.B.2.11 Vapor Handling Systems Philosophies
13.B.2.12 LNG Vaporization Systems Philosophies
13.B.2.13 Btu Adjustment Systems Philosophies
13.B.2.14 Material Selection Philosophies
13.B.2.15 Basic Plant Control System Philosophies
13.B.2.16 Isolation, Drain, and Vent Philosophies
13.B.2.17 SIS Philosophies
13.B.2.18 Relief Valve and Flare/Vent System Philosophies
13.B.2.19 Spill Containment Philosophies
13.B.2.20 Passive Protection Philosophies
13.B.2.21 Hazard Detection Philosophies
13.B.2.22 Hazard Control Philosophies
13.B.2.23 Fire Water Philosophies

13.C APPENDIX 13.C, REGULATIONS AND PERMITS[13]

13.C.1 Table of Regulatory Agencies, Permits, and Approvals

PROVIDE a table of the federal regulations and permits required for the design, construction, and operation of the facility. 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 any correspondence and submissions relating to all required permits and approvals. Correspondence should resolve any potential safety impacts, including hazards to or from surrounding areas of the facility and shipping route. At a minimum, correspondence should be provided for the following:

13.C.2.1 Coast Guard
13.C.2.2 DOT
13.C.2.3 FAA
13.C.2.4 Other (e.g., DoD, Nuclear Regulatory Commission (NRC), state, etc.) [14]

13.C.3 Regulatory Compliance Matrix

PROVIDE a code compliance matrix that clearly describes how each applicable requirement in 49 CFR 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 193, subpart B, must be given special attention. If applicable, hazards for releases over water should also be presented to ensure compliance with the Coast Guard's LNG regulations in 33 CFR 127.

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[13] *18 CFR 380.12(m), 18 CFR 380.12(m)(1), 18 CFR 380.12(m)(3), 18 CFR 380.12(m)(4), 18 CFR 380.12(m)(5), 18 CFR 380.12(o)(7), 18 CFR 380.12(o)(8), 18 CFR 380.12(13), 18 CFR 380.12(o)(14).*

[14] *DoD should be consulted if the facility, operations, or potential incidents could impact DoD military operations or facilities. NRC should be consulted if the facility, 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[15]

13.D.1 List of Codes and Standards

PROVIDE a list of the codes, standards, and other recognized and general accepted good engineering practices (alphabetical standard bodies and standard numerical order) under which the Project will be designed, constructed, and operated. Codes and Standards should include, but not be limited to the following standard and code bodies/organizations:

13.D.1.1 American Concrete Institute
13.D.1.2 American Gas Association
13.D.1.3 American Institute of Steel Construction
13.D.1.4 American Petroleum Institute (API)
13.38.1.15 American Society of Civil Engineers (ASCE)
13.D.1.5 American Society of Mechanical Engineers
13.D.1.6 American Society for Testing and Materials (ASTM)
13.D.1.7 American Welding Society
13.D.1.8 Gas Processors Association
13.D.1.9 International Code Council
13.D.1.10 International Electrotechnical Commission
13.D.1.11 Institute of Electrical and Electronics Engineers
13.D.1.12 International Society of Automation (ISA)16
13.D.1.13 National Association of Corrosion Engineers
13.D.1.14 National Electrical Manufacturers Association
13.D.1.15 National Fire Protection Association
13.D.1.16 Oil Companies International Marine Forum
13.D.1.17 Society of International Gas Tanker and Terminal Operators
13.D.1.18 Steel Structures Painting Council
13.D.1.19 Tubular Exchanger Manufacturers Association
13.D.1.20 Underwriter Laboratories
13.D.1.21 Other

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15 *18 CFR 380.12(m), 18 CFR 380.12(m)(1), 18 CFR 380.12(m)(3), 18 CFR 380.12(m)(4), 18 CFR 380.12(m)(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).*

16 *Previously, Instrumentation Systems and Automation Society.*

13.E APPENDIX 13.E, ENGINEERING DESIGN INFORMATION[17]

13.E.1 Block Diagram of Facilities

PROVIDE up-to-date overall schematics of the facility. Block Diagrams should show all major systems and should be legible.

13.E.2 Process Flow Diagrams and Utility Flow Diagrams

PROVIDE up-to-date diagrams of the facility. Process Flow Diagrams and Utility 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 and Utility Flow Diagrams should stream designations upstream and downstream of each major piece of process equipment, including:

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 Container
13.E.2.11 Transfer Areas

13.E.3 Heat and Material Balances

PROVIDE up-to-date material and energy balances of the facility. 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. At a minimum, the Heat and Material Balances should include:

13.E.3.1 Design Guarantee Rating Case
13.E.3.2 Average Composition, Average Ambient Conditions
13.E.3.3 Average Composition, Cold Ambient Conditions

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[17] *18 CFR 380.12(m), 18 CFR 380.12(m)(1), 18 CFR 380.12(m)(3), 18 CFR 380.12(m)(4), 18 CFR 380.12(m)(5), 18 CFR 380.12(o)(1), 18 CFR 380.12(o)(6), 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.E.3.4 Average Composition, Warm Ambient Conditions
13.E.3.5 Lean Composition, Average Ambient Conditions
13.E.3.6 Lean Composition, Cold Ambient Conditions
13.E.3.7 Lean Composition, Warm Ambient Conditions
13.E.3.8 Rich Composition, Average Ambient Conditions
13.E.3.9 Rich Composition, Cold Ambient Conditions
13.E.3.10 Rich Composition, Warm Ambient Conditions

13.E.4 Piping and Instrumentation Drawings

PROVIDE up-to-date drawings of the facility. 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 symbology key should be in accordance with accepted practice (e.g., ISA 5.1). At a minimum, the P&IDs should include:

13.E.4.1 Equipment tag number, name, size, duty, capacity and design conditions
13.E.4.2 LNG tank pipe penetration size or nozzle schedule
13.E.4.3 Piping with line number, piping class spec, size and insulation
13.E.4.4 Piping spec breaks and insulation limits
13.E.4.5 Vent, drain, cooldown and recycle piping
13.E.4.6 Isolation flanges, blinds and insulating flanges
13.E.4.7 All valve types, valve operator types, and valve fail position
13.E.4.8 All valves numbered, including control, isolation, check, vent, drain, and car-sealed valves
13.E.4.9 All instrumentation numbered
13.E.4.10 Control loops including software connections
13.E.4.11 Alarm and shutdown set points
13.E.4.12 Shutdown interlocks
13.E.4.13 All relief valves numbered, with set point
13.E.4.14 Relief valve inlet and outlet piping size
13.E.4.15 Car sealed valves and blinds
13.E.4.16 Equipment insulation

13.E.5 Plant and Equipment Layouts

PROVIDE overall plot plans, unit plot plans, and elevation drawings. Overall facility plot plans should show owned/leased property lines, the location of all major components to be installed, including marine facilities, feed gas compression, pretreatment, fractionation, liquefaction, storage, transfer piping, vaporization, truck loading/unloading, vent and/or flare stacks, pumps, auxiliary or appurtenant service facilities, roads, gates, access control and emergency routing, and spill containment systems. 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 with a reasonable degree of accuracy 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 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.5.1 Overall Facility Plot Plans

- 13.E.5.1.1 Feed Gas Pipeline Metering Station
- 13.E.5.1.2 Feed Gas Pretreatment Equipment
- 13.E.5.1.3 Heavies/Condensates Removal Columns, Storage, and Sendout
- 13.E.5.1.4 NGL Fractionation Columns, Storage, and Sendout
- 13.E.5.1.5 Refrigerant Systems and Storage
- 13.E.5.1.6 Liquefaction Equipment
- 13.E.5.1.7 Truck Transfer Areas
- 13.E.5.1.8 LNG Vaporizers
- 13.E.5.1.9 Btu Stabilization Equipment
- 13.E.5.1.10 Compressors and Blowers
- 13.E.5.1.11 Boiloff Recondensation
- 13.E.5.1.12 Vent Stacks and Flare Stacks
- 13.E.5.1.13 Sendout Metering (gas and liquids)
- 13.E.5.1.14 Buildings

13.E.5.1.15 Power Generation
13.E.5.1.16 Major Utility Systems
13.E.5.1.17 Emission Control Equipment
13.E.5.1.18 Spill Impoundments and Dikes
13.E.5.1.19 Fire Water Systems and Storage
13.E.5.1.20 Access and egress roads
13.E.5.1.21 Property and fence lines

13.E.5.2 Unit Plot Plans

13.E.5.3 Section and Elevation Drawings of major equipment, pipe racks, and typical piping support system

13.E.6 **Plant Reliability, Availability, and Maintainability (RAM) Analyses**

PROVIDE copies of any plant RAM analyses that were conducted. At a minimum, the RAM analyses should support the guarantee 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 preventative and routine maintenance, storage/warehousing philosophy, and obsolescence plans for the life of the facility.

13.F APPENDIX 13.F, SPECIFICATIONS[18]

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 should be included to clarify the proposed design and 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 Seismic[19]
  - 13.F.1.2.4 Wind
  - 13.F.1.2.5 Storm Surge
  - 13.F.1.2.6 Tsunami
  - 13.F.1.2.7 Snow and Ice
  - 13.F.1.2.8 Impact
  - 13.F.1.2.9 Blast
  - 13.F.1.2.10 Thermal
  - 13.F.1.2.11 Transport
  - 13.F.1.2.12 Erection/Construction
  - 13.F.1.2.13 Load Combinations and Factors
  - 13.F.1.2.14 Other Design Load Specifications
- 13.F.1.3 Piling Specifications
- 13.F.1.4 Foundation Specifications

[18] *18 CFR 380.12(m), 18 CFR 380.12(m)(1), 18 CFR 380.12(m)(3), 18 CFR 380.12(m)(4), 18 CFR 380.12(m)(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).*

[19] 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.

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 should be included to clarify the proposed design and 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 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 Atmospheric Storage Tanks
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

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 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 should be included to clarify the proposed design and 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 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 should be included to clarify the proposed design and 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[20]

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 include the requirements for siting, equipment layout and spacing, process controls, ignition controls, during all phases of commissioning, startups, shutdowns, operation and maintenance. Recommendations resulting from the HAZID and 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 any Simultaneous Operations (SIMOPS) studies to be used during project construction near operational facilities

13.G.3 **Waterway Safety and Reliability Impact Studies**

PROVIDE an analysis that addresses potential safety and reliability impacts of proposed vessels loaded or unloaded at the facility. 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 addresses: a) potential, effects, and mitigation of collisions and allisions of watercraft with the transiting LNG vessel, moored LNG vessel, and marine facilities; b) potential, effects, and mitigation for groundings, allisions, and collisions of LNG vessel with ground, marine and coastal structures, including marine platform, and other watercraft based on LNG vessel route, shipping channel depths and harbor bottom type, widths, turning basins, and berthing arrangement;

[20] *18 CFR 380.12(m), 18 CFR 380.12(m)(1), 18 CFR 380.12(m)(3), 18 CFR 380.12(m)(4), 18 CFR 380.12(m)(5), 18 CFR 380.12(o)(7), 18 CFR 380.12(o)(8), 18 CFR 380.12(o)(14).*

c) tug requirements, security escorts, and speed limits to safety and securely transport, berth, and unberth LNG vessel; d) LNG vessel berthing and unberthing maneuvers; e) hydrodynamic effect of slips on passing vessels; f) hydrodynamic effect of passive ships on moored LNG ships; and g) 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 of proposed tanker trucks loaded or unloaded at the facility 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 facility should be included that addresses: a) potential, effects, and mitigation of vehicles and proposed tanker trucks on external roadways accidentally colliding with the facilities; b) potential, effects, and mitigation for collisions of vehicle and tanker trucks wither other vehicles and equipment based on entrances, routes, road grades, road widths, turn around areas, and exit ways within the plant; c) vehicle and tanker trucks access control, vehicle barriers, bollards, clearance heights, and speed limits to safety and securely receive, load, and unload tanker trucks; and d) and 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 of proposed rail cars loaded or unloaded at the facility 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, passing rail car direction, and passing rail car contents, sizes, and speeds. An evaluation of external and internal railways at the facility should be provided that addresses: a) potential, effects, and mitigation of rail cars on external roadways accidentally colliding with the facilities; b) potential, effects, and mitigation of derailments and collisions with equipment based on rail car entrances, routes, grades, switchyards, and exit ways within the plant; c) rail car access control, barriers, clearance heights, and speed limits to safety and securely receive, load, and unload rail cars; and d) 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 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: a) potential, effects, and mitigation of aircraft accidentally colliding with the facilities or LNG vessels; and b) potential, effects, and mitigation for intentional acts involving aircraft during flight path to airport.

13.G.7 **Security Drawings**

PROVIDE drawings of the security system. At a minimum, the drawings should include:

13.G.7.1 Security Fencing, Site and Onsite Access Control, Bollard, Vehicle Barrier, and Other Physical Barrier Layout and Drawings

13.G.7.2 Lighting Layout and Drawings

13.G.7.3 Intrusion Monitoring (Camera) and Intrusion Detection Layout and Drawings

13.H APPENDIX 13.H, HAZARD ANALYSES[21]

13.H.1 Safety Data Sheets

PROVIDE safety data sheets for all hazardous materials stored, processed, and handled at the facility and transported to or from the facility.

13.H.2 Design Spill/Release List

PROVIDE a full list of design spills considered and bounding design spills for all hazardous fluids areas. Applicants should provide a piping and equipment inventory table of LNG plant components in hazardous or flammable fluid service. 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 design spill selections. At a minimum, the list should include:

13.H.2.1 Line segment or component number to identify potential design spill

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

[21] *18 CFR 380.12(m), 18 CFR 380.12(m)(1), 18 CFR 380.12(m)(3), 18 CFR 380.12(m)(4), 18 CFR 380.12(m)(5), 18 CFR 380.12(o)(14).*

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

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 (see Attachment 4)

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), composition of mixed refrigerants, NGL/Condensates, acid gas)

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 design spill flow rates

13.H.2.21 Design spills 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 sensitivity tests to determine final design spills/releases, 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 design spills and cascading events.[22] Input and Output files should accompany all modeling runs. The Hazard analysis report should also discuss whether adjacent facilities, operations, or potential hazardous releases could impact the safety or reliability of the proposed LNG facility.

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 provide the source of the weather data.

22 *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, recreational facilities, and other populated areas; 2) transportation infrastructure, including roads and highways, railroads and rail yards, pipelines, electric lines, marinas, airports, and other transportation infrastructure; 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, hospitals, and other public health and safety related facilities; and 5) military facilities, including military bases, test sites, research areas, and other military facilities.*

13.I APPENDIX 13.I, NATURAL HAZARD DESIGN INVESTIGATIONS AND FORCES[23]

13.I.1 Earthquakes

13.I.1.1 Seismic Evaluation

PROVIDE a seismic hazard evaluation for the LNG facility site. Include all supporting information and data for the seismic hazard evaluation of the site and seismic design of the proposed facility as specified in NBSIR 84-2833, 49 CFR 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 local geologic and seismic setting of the site 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 and the OBE. The SSE and OBE should be based on 49 CFR 193 and the incorporated NFPA 59A where the SSE is taken equivalent to the MCE as determined in accordance with the site specific procedures of ASCE 7-05 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. 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, if present, should be addressed in detail with estimated settlements without and with proposed ground improvement. Recommended values to be considered for design after ground improvement should also be included. Seismic Categories should include detailed description, sizes, loads, and relative location and Seismic Category I, II, or III of major structures such as LNG tanks, containment systems, buildings,

[23] *18 CFR 380.12(m), 18 CFR 380.12(m)(1), 18 CFR 380.12(m)(3), 18 CFR 380.12(m)(4), 18 CFR 380.12(m)(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).*

storage tanks, vaporizers, liquefaction trains, power plant structures, and other plant components including unloading and docking facilities. Reference should be made to the Geotechnical Investigation in Appendix 13.J. See Attachment 2 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 Maximum Considered Earthquake site specific MCE Ground Motion Spectral Values for 5% damping

13.I.1.1.4 Design Earthquake site specific DE 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 Safety Shutdown Earthquake site specific SSE Ground Motion Spectral Values for 5% damping

13.I.1.1.6 OBE site specific OBE Ground Motion Spectral Values for 5% damping

13.I.1.1.7 Aftershock Level Earthquake site specific ALE Ground Motion Spectral Values for 5% damping

13.I.1.1.8 Design Surface Fault Offsets (horizontal and vertical) and fault orientations at locations crossing active faults

13.I.1.1.9 Design Offsets for Growth Faults: Provide design fault offsets for growth faults (horizontal and vertical) for the facility design life and fault orientations at locations where crossing growth faults

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 facility. 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 diagrams. An example of a categorized list for an LNG facility is included in Attachment 3.

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, as a minimum, satisfy 49 CFR 193 and the incorporated edition of NFPA 59A. Items to be considered in preparing the seismic design criteria documents are included in Attachment 4. The seismic design criteria should also include the incorporated ASCE 7 Design Earthquake seismic coefficients and seismic design parameters that are to be used in the design of structures, systems and components that are assigned Seismic

Category II and III. 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 (ϕ)-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 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 ϕ-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 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 ϕ-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 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 Sc (i.e. S_{DS})

13.I.1.3.4.2 load combinations, load factors, allowable stress or capacity increases (if any) and ϕ-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 necessary to perform the seismic design of each Seismic Category III structure, component, equipment, and system.

13.I.1.3.5 Seismic criteria for small LNG containers with capacities less than

70,000 gallons should be provided that satisfy the seismic requirements of NFPA 59A-2001. 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 design category assigned to the container

13.I.1.3.5.3 the importance factor assigned to the container

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 ϕ-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 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 LNG facility and the location of both the instrument and the sensors. If instrument already exists at the facility, 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, as 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. The purpose of the instrumentation is to permit a comparison of measured responses of Seismic Category I structures and selected components with predetermined results of analyses that predict when damage might occur. Also, to permit facility operators to understand the possible extent of damage within the facility 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. At a minimum, the 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. For example, see NRC Reg.Guide 1.12, Ref. 31

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 selected components in the event of an earthquake with the results of the seismic system and subsystem analyses

13.I.2 **Tsunami and Seiche**

PROVIDE details on the facilities design that are 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 facility (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 and their size and speed that the facilities will be designed to withstand and 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 basis for both still water and with wind/wave effects considering site specific studies. Include all facility elevations for dikes, storm surge walls, piers, docks, unloading and loading arms and other pier and dock facilities, and other elevated features of the facility, 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 both 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 facility design life 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 for all structures, systems, and components

13.I.2.3 Maximum Considered Tsunami, MCT inundation and run-up elevations for facility site, including the MCE level ground motions at the site if the MCE is the triggering source of the MCT.

13.I.2.4 Tsunami and Seiche Water 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: Provide elevation change to be used in design to account for sea level rise at facility site for the facility design life

13.I.2.7 Design Regional Subsidence: Provide elevation change to be used in design to account for regional subsidence at facility site for the facility design life

13.I.2.8 Discussion of co-seismic subsidence/uplift

13.I.2.9 Discussion of expected settlement over the design life of the facility

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 facility (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 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 facility elevations for dikes, storm surge walls, piers, docks, unloading and loading arms and other pier and dock facilities, and other elevated features of the facility, 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 both 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 facility design life 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), wind importance factors, and storm surge design elevations for all structures, systems, and components

13.I.3.3 Wind speeds (sustained and 3 second gusts) and storm surge (still water, wind/wave run-up effects, crest elevations) 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: Provide elevation change to be used in design to account for sea level rise at facility site for the facility design life

13.I.3.6 Design Regional Subsidence: Provide elevation change to be used in design to account for regional subsidence at facility site for the facility design life

13.I.3.7 Discussion of expected settlement over the design life of the facility

13.I.4 Tornados

PROVIDE details on the facilities design that are being proposed to handle potential tornados. Include information to confirm why and how the overall facility (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 wind of tornados. 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. 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 and their wind speed that would be design against and 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 both 100- and 500-, 1,000-, and 10,000-year return period elevations and wind speeds for EF Category 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 wind importance factors for all structures, systems, and components

13.I.4.3 Wind speeds (sustained and 3 second gusts) 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 Enhanced Fujita Category EF5 (>134 mph sustained, >200 mph 3 second gust),
- 13.I.4.4.2 Tornados Enhanced Fujita Category EF4 (111-134 mph sustained, 166-200 mph 3 second gust),
- 13.I.4.4.3 Tornados Enhanced Fujita Category EF3 (91-111 mph sustained, 136-166 mph 3 second gust),
- 13.I.4.4.4 Tornados Enhanced Fujita Category EF2 (75-91 mph sustained, 111-135 mph 3 second gust),
- 13.I.4.4.5 Tornados Enhanced Fujita Category EF1 (58-74 mph sustained, 86-110 mph 3 second gust),
- 13.I.4.4.6 Tornados Enhanced Fujita Category EF0 (44-57 mph sustained,

65-85 mph 3 second gust).

13.I.5 Floods

PROVIDE details on the facilities design that are 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 facility (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 and their basis considering FEMA flood hazard maps and any conducted site specific studies. Include all facility elevations for dikes, storm surge walls, piers, docks, unloading and loading arms and other pier and dock facilities, and other elevated features of the facility, 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 flooding conditions used as design criteria. Compare with both 100- and 500-, 1,000-, and 10,000-year return period. Include in these elevations the effects of sea level rise and regional subsidence considering the facility design life for time dependent severe natural hazards.

- 13.I.5.1 Flood design basis and criteria
- 13.I.5.2 Identification of stream flows and flood design elevations for all structures, systems, and components
- 13.I.5.3 Floods 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 facility site for the facility design life
- 13.I.5.6 Design Regional Subsidence: Provide elevation change to be used in design to account for regional subsidence at facility site for the facility design life
- 13.I.5.7 Discussion of expected settlement over the design life of the facility

13.I.6 Rain, Ice, and Snow

PROVIDE details on the facilities design that are 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 facility (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 and their basis considering hazard maps and any conducted site specific studies. Include all facility elevations for dikes, storm surge walls, piers, docks, unloading and loading arms and other pier and dock facilities, and other elevated features of the facility, their design basis, and demonstrate how they will conform to industry and Federal standards, including 49 CFR 193 for rainfall removal for impoundments, and 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 for all structures, systems, and components, including snow removal for spill containment systems
- 13.I.6.4 Rain, ice, and snow events 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 that are 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 facility 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 and their basis considering hazard maps and any conducted site specific studies. Include all facility elevations for dikes, storm surge walls, piers, docks, unloading and loading arms and other pier and dock facilities, and other elevated features of the facility, 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 used as design criteria. Compare with both 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 for all structures, systems, and components

13.I.7.3 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[24]

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 with indication of type of harbor bottom.

13.J.3 Climatic Data

PROVIDE the data and analysis a geotechnical investigation and foundation recommendation report. At a minimum, the geotechnical investigation and foundation recommendations should include:

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. Typically a minimum of 5 borings /Cone Penetration Tests (CPT) 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 make recommendations on 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

[24] *18 CFR 380.12(m), 18 CFR 380.12(m)(1), 18 CFR 380.12(m)(3), 18 CFR 380.12(m)(4), 18 CFR 380.12(m)(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).*

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 etc. should be identified and remedial measures including ground improvement methods should be recommended, if such soils are present. See Attachment 1 for more details. At a minimum, the geotechnical investigation should include:

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 special types of cement and corrosion protection of utilities

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, vaporizers, liquefaction trains, containment berms, flood protection walls / berms, power generation equipment, walls including MSE walls, pipe supports, and other foundations and foundation loading. A summary of foundation sizes, preliminary loading, and type of foundations proposed shall be provided for buildings, major liquefaction and power plant equipment, walls, pipe supports, berms, and other significant foundations. The foundation recommendation report should discuss and provide, if needed, 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 and piles designed for down-drag due to settlement; or 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 for loading-unloading facilities, should be provided on the stability of the tanks, storm surge walls and berms, and other safety related structures. At a minimum, the foundation recommendations should address:

13.J.5.1 Shallow Foundations

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 Foundations

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 Pile driving analyzer
13.J.5.2.9 Indicator Pile and Load Test Programs

13.J.5.3 Ground Improvement

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 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. The arrangement of the containment, particularly the relationship and interaction of each storage tank with its surrounding floor, should be provided to establish the effect that the structures could have on the design boundary conditions. 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.6.1 Typical Foundation Drawings
13.J.6.2 Equipment Support Drawings
13.J.6.3 Static Stability Calculations
13.J.6.4 Seismic Stability Calculations
13.J.6.5 Settlement Calculations

13.J.7 Structural Design Basis and Criteria

PROVIDE a structural design basis and criteria document that compiles and summarizes the structural design criteria that is to be used in the design of structures (including non-building structures) and their foundations. The structural design basis and criteria should include the severe natural hazard loading parameters that are to be used, the ASD and strength load combinations, load factors and permitted ASD allowable increases. It 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.K APPENDIX 13.K, MARINE SYSTEMS[25]

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

[25] *18 CFR 380.12(m)(1), 18 CFR 380.12(m)(3), 18 CFR 380.12(m)(4), 18 CFR 380.12(m)(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[26]

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 would be required to be incorporated by the selected tank supplier.

13.L.2 Preliminary LNG Tank Drawings.

PROVIDE 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 Preliminary 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.

[26] *18 CFR 380.12(m)(1), 18 CFR 380.12(m)(3), 18 CFR 380.12(m)(4), 18 CFR 380.12(m)(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[27]

13.M.1 Piping and Valve List

PROVIDE a list of piping and valves with design conditions. Design conditions should include; fluid service, design pressure and temperature conditions, diameter, corrosion allowance.

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 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, motor horsepower and voltage, as applicable.

13.M.4 Equipment Process Data Sheets

PROVIDE equipment process data sheets for each equipment item.

13.M.5 Manufacturer's Data

PROVIDE 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 resistant, or fire resistant.

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

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[27] *18 CFR 380.12(m)(1), 18 CFR 380.12(m)(3), 18 CFR 380.12(m)(4), 18 CFR 380.12(m)(5), 18 CFR 380.12(o)(7), 18 CFR 380.12(o)(8), 18 CFR 380.12(o)(14).*

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[28]

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 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

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[28] *18 CFR 380.12(m)(1), 18 CFR 380.12(m)(3), 18 CFR 380.12(m)(4), 18 CFR 380.12(m)(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, OPERATING AND MAINTENANCE PROCEDURES[29]

13.O.1 Management of Change Procedures and Forms

PROVIDE procedures for the management of change system and review process during final design and construction and sample forms.

[29] *18 CFR 380.12(m)(1), 18 CFR 380.12(m)(3), 18 CFR 380.12(m)(4), 18 CFR 380.12(m)(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.P APPENDIX 13.P, PROCESS CONTROL AND INSTRUMENTATION[30]

13.P.1 Instrument Lists

PROVIDE instrument index for all facilities. At a minimum, the instrument list should include:

13.P.1.1 Instrument tag number
13.P.1.2 Measurement (flow, temperature, pressure, composition, etc.)
13.P.1.3 Instrument Range
13.P.1.4 Calibration
13.P.1.5 Alarm Set Points
13.P.1.6 Shutdown Set Points
13.P.1.7 Voting Logic
13.P.1.8 Voting Degradation Logic
13.P.1.9 Safety Integrity Level (SIL)
13.P.1.10 Notes

[30] *18 CFR 380.12(m)(1), 18 CFR 380.12(m)(3), 18 CFR 380.12(m)(4), 18 CFR 380.12(m)(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[31]

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 distributed control system and safety instrumented system:

13.Q.2.1 DCS block diagrams
13.Q.2.2 SIS 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 Shutoff Valve Manufacturer's Data

PROVIDE manufacturer's specifications, drawings, and literature on the fail-safe shut-off valves and actuators.

[31] *18 CFR 380.12(m)(1), 18 CFR 380.12(m)(3), 18 CFR 380.12(m)(4), 18 CFR 380.12(m)(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[32]

13.R.1 List of Relief Valves

PROVIDE a list of the vacuum and pressure relief valves. At a minimum, the list 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 of the flaring and venting calculations. At a minimum, the calculations 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 stack radiant heats and sound at ground level and nearby structures,
13.R.2.9 Vent stack dispersion at ground level and nearby elevated ignition sources)

[32] *18 CFR 380.12(m)(1), 18 CFR 380.12(m)(3), 18 CFR 380.12(m)(4), 18 CFR 380.12(m)(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[33]

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 types of hazard control systems chosen, general locations, and sizing.

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 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 HTF storage, equipment and piping
13.S.2.8 Refrigerant truck transfer equipment and piping
13.S.2.9 Refrigerant storage, equipment, and piping
13.S.2.10 Liquefaction Process equipment and piping
13.S.2.11 LNG storage, equipment, and piping
13.S.2.12 LNG truck transfer equipment and piping
13.S.2.13 LNG pumps and piping
13.S.2.14 Liquid nitrogen storage, equipment, and piping
13.S.2.15 Diesel storage, equipment and piping
13.S.2.16 Other hazardous fluid storage and piping

[33] *18 CFR 380.12(m)(1), 18 CFR 380.12(m)(3), 18 CFR 380.12(m)(4), 18 CFR 380.12(m)(5), 18 CFR 380.12(o)(2), 18 CFR 380.12(o)(3), 18 CFR 380.12(o)(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 drawings clearly showing the location of each passive structural 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.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 ESD Button Layout Plans
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 conditions, activation, or remote control capabilities and manufacturer/model for all dry chemical equipment, and 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 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

PROVIDE drawings of the fire water system. Drawings should include P&IDs, system and equipment layouts, and coverage plans. 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[34]

13.T.1 Design Studies and Alternatives

PROVIDE copies of company, engineering firm, or consultant studies of a conceptual nature 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:

13.T.1.1 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, cost studies, or other studies that led to the proposed selection

13.T.1.2 Derrick mounted or guy-wired elevated or ground flare designs, including any visual impact analyses, flare radiation analyses, maintainability studies, cost studies, or other studies that led to the proposed selection

13.T.1.3 Ambient air vaporizers, shell and tube, or submerged combustion vaporizer designs, including any emission studies, fog dispersion studies, reliability studies, cost studies, or other studies that led to the proposed selection

13.T.1.4 APCI's propane pre-cooled single mixed refrigerant, ConocoPhillips' Cascade, Chart's single mixed refrigerant, or nitrogen expansion cycle liquefaction systems, including any efficiency studies, cost 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 instead of ethylene in

[34] *18 CFR 380.12(m)(1), 18 CFR 380.12(m)(3), 18 CFR 380.12(m)(4) , 18 CFR 380.12(m)(5), 18 CFR 380.12(o)(7).*

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 transfer fluid, including any hazard analyses, efficiency studies, cost studies, or other studies that led to the proposed selection

13.T.1.6 Dry type transformers versus liquid insulated transformers, including hazard analyses, cost studies, or other studies that led to the proposed selection

13.T.1.7 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, cost studies, or other studies that led to the proposed selection

13.T.1.8 Water storage/supply and use for potable, utility, firefighting water, including reliability studies, cost studies, or other studies that led to the proposed selection

Attachment 1
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 Facility Status

The applicant should document the current status of the site evaluation study. Additional planned investigations should also be described. The applicant should document the current design status of the facility such as conceptual design or final design. The applicant should also 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 utilize both N-values and CPT data for evaluation of liquefaction potential and settlements due to liquefaction. A minimum of three explorations (borings / CPTs) should be performed under each LNG tank and the depth of the exploration should be 20 ft deeper than deepest anticipated foundations and liquefaction potential (at least 100 feet if bedrock is not encountered).

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 2.

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 facility 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 7-05 or IBC 2006.

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 2.

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 prior to pile installation. Downdrag from settlements due to liquefaction should 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 2
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 193 and the incorporated NFPA 59A requirements and 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.

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 as outlined in Attachment 1.

2. Geology

In addition to standard geotechnical information needed to develop foundation recommendations, the additional geological 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 1, 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, which may 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 displacement that could be experienced by the safety-related facilities of the plant. The report of the investigation should be coordinated with the investigation and report under Sections 3.1 and 3.2 of this Appendix 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, 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 should be determined using either ASCE 7-05 or IBC 2006 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 2006 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 3
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 facility 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 vial safety related function such as containment of LNG and fire control. Title 49 CFR 193 incorporates NFPA 59A 2001 edition with the exception of NFPA 59A 2006 edition for seismic design of field fabricated LNG storage tanks. Section 7.2.2.5 of NFPA 59A 2006 and 4.1.3.3 of NFPA 59A-2001 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 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
Fired vaporizers
Fuel gas system for fired equipment Instrumentation
Interconnecting piping systems
Metering system
Odorizing system
Primary LNG pumps
Seawater vaporizers
Secondary LNG 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

As a minimum and in accordance with 49 CFR 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).

As a minimum and in accordance with 49 CFR 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

As a minimum and in accordance with 49 CFR 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 a 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 ASCE 7 would not be so severe as to preclude continued occupancy and function of the facility.

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 4
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 (sketc.hes) 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 utilized 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 5
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 appendix.

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 utilized for such purposes, the general arrangement of the keys should be included. If waterproofing membranes are utilized, 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.

Attachment 6
Failure Rate Table

Type of Failure	Nominal Failure Rate
Cryogenic Storage Tanks (General)	Failures per year of operation
Rupture of Storage Tank Outlet/Withdrawal Line	3E-5 (Failure Rate Criterion)
Single Containment Atmospheric Storage Tanks	Failures per year of operation
Catastrophic Failure of Inner Tank (Rupture)	5E-6 per tank
Catastrophic Failure of Tank Roof	1E-4 per tank
Release from a hole in inner tank with effective diameter of 1m (~3ft)	8E-5 per tank
Release from a hole in inner tank with effective diameter of 0.3m (~1ft)	2E-4 per tank
Release from a hole in inner tank with effective diameter of 0.01m (0.4in)	1E-4 per tank
Double Containment Atmospheric Storage Tanks	Failures per year of operation
Catastrophic Failure of Inner Tank (Rupture)	5E-7 per tank
Catastrophic Failure of Tank Roof	1E-4 per tank
Release from a hole in inner tank with effective diameter of 1m (~3ft)	1E-5 per tank
Release from a hole in inner tank with effective diameter of 0.3m (~1ft)	3E-5 per tank
Release from a hole in inner tank with effective diameter of 0.01m (0.4in)	1E-4 per tank
Full Containment Atmospheric Storage Tanks	Failures per year of operation
Catastrophic Failure of Inner Tank (Rupture)	1E-8 per tank
Catastrophic Failure of Tank Roof	4E-5 per tank
Release from a hole in inner tank with effective diameter of 1m (~3ft)	1E-6 per tank
Release from a hole in inner tank with effective diameter of 0.3m (~1ft)	3E-6 per tank
Release from a hole in inner tank with effective diameter of 0.01m (0.4in)	1E-4 per tank
Process Vessels, Distillation Columns, Heat Exchangers, and Condensers	Failures per year of operation
Catastrophic Failure (Rupture)	5E-6 per vessel
Release from a hole with effective diameter of 0.01m (0.4in)	1E-4 per vessel
Truck Transfer	Failures per year of operation
Rupture of transfer arm	3E-4 per transfer arm
Release from a hole in transfer arm with effective diameter of 10% transfer arm diameter with maximum of 50mm (2-inches)	3E-3 per transfer arm
Rupture of transfer hose	4E-2 per transfer hose
Release from a hole in transfer hose with effective diameter of 10% transfer hose diameter with maximum of 50mm (2-inches)	4E-1 per transfer hose
Ship Transfer	Failures per year of operation
Rupture of transfer arm	2E-5 per transfer arm
Release from a hole in transfer arm with effective diameter of 10% diameter with maximum of 50mm (2-inches)	2E-4per transfer arm

Type of Failure	Nominal Failure Rate
Piping (General)	Failures per year of operation
Rupture at Valve	9E-6 per valve
Rupture at Expansion Joint	4E-3 per expansion joint
Failure of Gasket	3E-2 per gasket
Piping: d< 50mm (2-inch)	Failures per year of operation
Catastrophic rupture	1E-6 per meter of piping
Release from hole with effective diameter of 25mm (1-inch)	5E-6 per meter of piping
Piping: 50mm (2-inch) ≤d< 149mm (6-inch)	Failures per year of operation
Catastrophic rupture	5E-7 per meter of piping
Release from hole with effective diameter of 25mm (1-inch)	2E-6 per meter of piping
Piping: 150mm (6-inch) ≤d< 299mm (12-inch)	Failures per year of operation
Catastrophic rupture	2E-7 per meter of piping
Release from hole with effective diameter of 1/3 diameter	4E-7 per meter of piping
Release from hole with effective diameter of 25mm (1-inch)	7E-7 per meter of piping
Piping: 300mm (12-inch) ≤d< 499mm (20-inch)	Failures per year of operation
Catastrophic rupture	7E-8 per meter of piping
Release from hole with effective diameter of 1/3 diameter	2E-7 per meter of piping
Release from hole with effective diameter of 10% diameter, up to 50mm (2-inches)	4E-7 per meter of piping
Release from hole with effective diameter of 25mm (1-inch)	5E-7 per meter of piping
Piping: 500mm (20-inch) ≤d< 1000mm (40-inch)	Failures per year of operation
Catastrophic rupture	2E-8 per meter of piping
Release from hole with effective diameter of 1/3 diameter	1E-7 per meter of piping
Release from hole with effective diameter of 10% diameter, up to 50mm (2-inches)	2E-7 per meter of piping
Release from hole with effective diameter of 25mm (1-inch)	4E-7 per meter of piping