



GUIDE FOR BUILDING AND CLASSING

FLOATING OFFSHORE LIQUEFIED GAS TERMINALS

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**American Bureau of Shipping
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the State of New York 1862**

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Foreword (1 June 2014)

The industry and ABS share a large and successful body of experience with membrane tank Liquefied Natural Gas (LNG) carriers, independent tank liquefied gas carriers and ship-type FPSOs that have been designed to Part 5C, Chapter 12 of the *ABS Rules for Building and Classing Steel Vessels*, *ABS Guide for Building and Classing Liquefied Gas Carriers with Independent Tanks*, and *ABS Rules for Building and Classing Floating Production Installations (FPI Rules)*, respectively. The development of this *ABS Guide for Building and Classing Floating Offshore Liquefied Gas Terminals* is based on the design and analyses experience with these types of vessels.

This Guide provides criteria that can be applied in the Classification of the hull and tank structure of floating offshore liquefied gas terminals with membrane tanks or independent prismatic tanks. The Guide addresses liquefied gas terminals with ship-shaped or barge-shaped hull forms having a single row of cargo tanks at centerline or a row of two cargo tanks abreast. ABS recognizes that industry participation is a vital factor due to the rapidly progressing use of offshore gas terminals. To understand and apply this new technology and its standards, ABS, the offshore and onshore community and regulatory agencies can benefit from a common understanding of the terms and concepts involved, and an awareness of how these concepts are to be applied to ABS rule-making.

The hull strength criteria contained herein are to be considered as an alternative to those for corresponding aspects of Classification as given in Part 5C, Chapter 8 of the *Steel Vessel Rules* (SVR 5C-8) which includes requirements from the International Code for the Construction and Equipment of Ships carrying Liquefied Gases in Bulk (IGC Code). The Owner may elect to use either this Guide or SVR 5C-8. In the same design, for aspects of the hull structural design that are covered by both this Guide and SVR 5C-8 it is not valid to switch between the criteria in this Guide and SVR 5C-8. This Guide does not cover the design, fabrication and installation of the liquefied gas containment system, except for the structural design of independent tanks.

In June 2014, the definitions of permissible bending stress in Chapter 3, Sections 4 and 6 were revised to cover the strength evaluation of longitudinal members beyond 0.4L amidships.

The effective date of this Guide is 1 January 2018. In general, until the effective date, plan approval for designs will follow prior practice unless review under this Guide is specifically requested by the party signatory to the application for classification.

After a certain period for trial use, the criteria contained in this Guide will be incorporated and published as part of the Offshore Rules. ABS encourages and welcomes at any time the submission of comments on this Guide.

Changes to Conditions of Classification

Chapter 1, Section 1, “Scope and Conditions of Classification” was consolidated into a generic booklet, entitled *Rules for Conditions of Classification – Offshore Units and Structures (Part 1)* for all units, installations, vessels or systems in offshore service. The purpose of this consolidation was to emphasize the common applicability of the classification requirements in “Chapter 1, Section 1” to ABS-classed offshore units, pipelines, risers, and other offshore structures, and thereby make “Conditions of Classification” more readily a common Rule of the various ABS Rules and Guides, as appropriate.

Thus, Chapter 1, Section 1 of this Guide specifies only the unique requirements applicable to floating offshore liquefied gas terminals. These supplemental requirements are always to be used with the aforementioned *Rules for Conditions of Classification – Offshore Units and Structures (Part 1)*.

Reference Note

Reference to a paragraph in the *Steel Vessel Rules*, *MODU Rules* or *FPI Rules* is made in the format ‘P-C-S/ss.p’ where ‘P’ is the Part, ‘C’ is the Chapter, ‘S’ is the Section, ‘ss’ is the Subsection and ‘p’ is the Paragraph.

Reference to a paragraph in this Guide is made in the format ‘C-S/ss.p’, where ‘C’ is the Chapter, ‘S’ is the Section, ‘ss’ is the Subsection and ‘p’ is the Paragraph.

Reference to a Figure or Table in this Guide is made, respectively, in the format ‘C-S/Figure #’, or ‘C-S/Table #’.



GUIDE FOR BUILDING AND CLASSING

FLOATING OFFSHORE LIQUEFIED GAS TERMINALS

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CHAPTER 1 Conditions of Classification

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CHAPTER 1 Conditions of Classification

SECTION 1 Scope and Conditions of Classification (Supplement to the ABS Rules for Conditions of Classification – Offshore Units and Structures)

1 Classification

The requirements for conditions of classification are contained in the separate, generic *ABS Rules for Conditions of Classification – Offshore Units and Structures (Part 1)*.

Additional requirements specific to floating offshore liquefied gas terminals are contained in the following Subsections.

3 Purpose

A *Floating Offshore Liquefied Gas Terminal* provides liquefied gas storage and receives and/or offloads liquefied gas. There are two major variations of offshore liquefied gas terminal: Load Terminals and Discharge Terminals, with various configurations of each.

A *Load Terminal* receives gas directly from one or more wells or from another offshore facility where it may or may not have been processed. The gas is liquefied in an onboard liquefaction facility and stored for offloading as liquefied gas to a trading liquefied gas carrier. Alternatively, a *Load Terminal* may receive liquefied gas from a liquefaction plant via a pipeline.

A *Discharge Terminal* receives liquefied gas from trading liquefied gas carriers and stores it. In such terminals, the stored liquefied gas is normally vaporized in a re-gasification facility and discharged ashore. However, offloading liquefied gas in a lightering operation is also feasible.

5 Classification Symbols and Notations

A listing of Classification Symbols and Notations available to the Owners of vessels, offshore drilling and production units and other marine structures and systems, “List of ABS Notations and Symbols” is available from the ABS website “<http://www.eagle.org>”.

The following notations are specific to floating offshore liquefied gas terminals.

5.1 Class Notations

Floating offshore liquefied gas terminals that have been built, installed and commissioned to the satisfaction of the ABS Surveyors to the full requirements of this Guide, where approved by the Committee for service for the specified design environmental conditions, may be classed and distinguished in the *ABS Record* by the symbol **✱ A1**, followed by **Offshore Liquefied Gas Terminal** and the appropriate notation for the intended service listed below.

Class notations were chosen to provide a clear description of the function of each configuration using the following symbols:

- F** Floating
- L** Liquefaction Facility
- O** Transfer of Liquefied Gas (Offloading/Loading)
- P** Gas Processing Facility
- R** Re-Gasification Facility
- S** Storage Facility
- T** Terminal with processing facilities which are not classed

A complete description of applicable class notations for floating liquefied gas terminals is provided in 2-1/1.1 of this Guide.

5.3 Geographical Limitations

Floating offshore liquefied gas terminals which have been built to the satisfaction of the ABS Surveyors to special modified requirements for a limited service, where approved by the Committee for that particular service, may be classed and distinguished in the *Record* by suitable symbols or notations, but the symbols or notations will either be followed by or have included in them the appropriate service limitation.

5.5 Floating Terminals Not Built Under Survey

The symbol “✕” (Maltese-Cross) signifies that the system was built, installed and commissioned to the satisfaction of the ABS Surveyors. Floating offshore liquefied gas terminals and their equipment that have not been built under ABS survey, but which are submitted for Classification, will be subjected to special consideration. Where found satisfactory and thereafter approved by the Committee, they may be classed and distinguished in the *Record* by the notation described above, but the symbol “✕” signifying survey during construction will be omitted.

7 Rules for Classification

7.1 Application of Rules

This Guide contains provisions for the classification of new build floating offshore liquefied gas terminals. This Guide is intended for use in conjunction with the *ABS Rules for Building and Classing Steel Vessels (Steel Vessel Rules)*, *ABS Rules for Building and Classing Mobile Offshore Drilling Units (MODU Rules)*, *ABS Rules for Building and Classing Offshore Installations*, *ABS Rules for Building and Classing Floating Production Installations (FPI Rules)* or other applicable ABS Rules and Guides.

7.3 Scope of Class

A description of the parts of a floating offshore liquefied gas terminal included in the ABS classification is provided in 2-1/1 of this Guide.

7.5 Alternatives

Any departure from the requirements of this Guide may be considered by ABS on the basis of an additional risk assessment to that required per 2-2/5 of this Guide, or at least a separate, clearly identified part of the risk assessment. In the case of such departures, classification is subject to ABS's approval upon a demonstration of fitness for purpose in line with the principles of ABS Guides and Rules, as well as recognized and generally accepted good engineering practice. Risk acceptance criteria are to be developed in line with the principles of the ABS Rules and are subject to ABS's approval. The *ABS Guidance Notes on Risk Assessment Application for the Marine and Offshore Oil and Gas Industries* contain an overview of risk assessment techniques and additional information.

A risk approach justification of alternatives may be applicable either to the terminal as a whole or to individual systems, subsystems or components. As appropriate, account must be given to remote hazards outside of the bounds of the system under consideration. Such account must include incidents relating to remote hazards directly affecting or being influenced by the system under consideration. ABS will consider the application of risk-based techniques in the design of the terminal, verification surveys during construction and surveys for maintenance of class.

Portions of the terminal not included in the risk assessment are to comply with the applicable parts of the ABS Rules.

The following are the responsibility of the Owner/Operator:

- i) Risk acceptance criteria
- ii) Hazard identification
- iii) Risk assessment
- iv) Risk management
- v) Compliance of the system under consideration with the applicable requirements of Flag and Coastal State

9 Units

This Guide is written in three systems of units, viz., SI units, MKS units and US customary units. Each system is to be used independently of any other system.

Unless indicated otherwise, the format of presentation in this Guide of the three systems of units, is as follows:

SI units (MKS units, US customary units)

11 Abbreviations and References

11.1 Abbreviations

ABS	American Bureau of Shipping
ACI	American Concrete Institute
AISC	American Institute of Steel Construction
ANSI	American National Standards Institute
API	American Petroleum Institute
ASTM	American Society for Testing and Materials
ASME	American Society of Mechanical Engineers
AWS	American Welding Society
CSA	Canadian Standards Association
FIP	Federation Internationale de la Precontrainte
IMO	International Maritime Organization
NACE	National Association of Corrosion Engineers
NFPA	National Fire Protection Association
PCI	Prestressed Concrete Institute
SIGTTO	Society of International Gas Tanker and Terminal Operators Ltd.

11.3 References

- i) *Steel Vessel Rules – ABS Rules for Building and Classing Steel Vessels*
- ii) *MODU Rules – ABS Rules for Building and Classing Mobile Offshore Drilling Units*
- iii) *M/W Rules – ABS Rules for Materials and Welding – Part 2*
- iv) *Offshore Installations Rules – ABS Rules for Building and Classing Offshore Installations*
- v) *SPM Rules – ABS Rules for Building and classing Single Point Moorings*
- vi) *FPI Rules – ABS Rules for Building and Classing Floating Production Installations*
- vii) *Facilities Rules – ABS Rules for Building and Classing Facilities on Offshore Installations*
- viii) *LGC Guide – ABS Guide for Building and Classing Liquefied Gas Carriers with Independent Tanks*
- ix) *ABS Guide for Automatic or Remote Control and Monitoring for Machinery and Systems (other than Propulsion) on Offshore Installations*
- x) *ABS Guide for the Fatigue Assessment of Offshore Structures*
- xi) *ABS Guide for Nondestructive Inspection of Hull Welds*
- xii) *ABS Guidance Notes on Risk Assessment Application for the Marine and Offshore Oil and Gas Industries*
- xiii) *ABS Guide for Risk Evaluations for the Classification of Marine-Related Facilities*
- xiv) *ABS Guidance Notes on Review and Approval of Novel Concepts*
- xv) *ABS Guide for Surveys Using Risk Based Inspection for the Offshore Industry*
- xvi) *ABS Guide for Surveys Based on Reliability-Centered Maintenance*
- xvii) *ACI 213R Guide for Structural Lightweight Aggregate Concrete*
- xviii) *ACI 301 Specifications for Structural Concrete*
- xix) *ACI 311.4R Guide for Concrete Inspection Programs*
- xx) *ACI 318 Building Code Requirements for Structural Concrete*
- xxi) *ACI 357R-84 Guide for the Design and Construction of Fixed Offshore Concrete Structures*
- xxii) *ACI 357.2R-88 State-of-the-Art Report on Barge-Like Concrete Structures*
- xxiii) *AISC Manual of Steel Construction, ASD*
- xxiv) *API RP 2A, RP 2T, RP 14C, RP 500, RP 521, 620, RP 2003*
- xxv) *ASTM 330 Specification for Lightweight Aggregates for Structural Concrete*
- xxvi) *CSA S474-94 Concrete Structures (Offshore Structures)*
- xxvii) *NACE RP0176-94*
- xxviii) *NFPA 59 A Standard for Production, Storage and Handling of Liquefied Natural Gas*

Note: The requirements of the IMO “International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk” are incorporated within requirements in Part 5C, Chapter 8 of the *ABS Steel Vessel Rules*.

ABS is prepared to consider other appropriate alternative methods and recognized codes of practice.



CHAPTER 2 Design Considerations

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CHAPTER 2 Design Considerations

SECTION 1 Classification of Floating Offshore Liquefied Gas Terminals

In addition to all of the requirements contained in the ABS Rules for Conditions of Classification – Offshore Units and Structures (Part 1) and Chapter 1 of this Guide, the following requirements are applicable to floating offshore liquefied gas terminals.

1 ABS Class Symbols and Notations

1.1 Class Notations

Floating offshore liquefied gas terminals (FLGT) that have been built, installed and commissioned to the satisfaction of the ABS Surveyors to the full requirements of this Guide, where approved by the Committee for service for the specified design environmental conditions, may be classed and distinguished in the ABS *Record* by the symbol **✕ A1**, followed by **Offshore Liquefied Gas Terminal** and the appropriate notation for the intended service listed below:

Class notations were chosen to provide a clear description of the function of each configuration using the following symbols:

F	Floating
L	Liquefaction Facility
O	Transfer of Liquefied Gas (Offloading/Loading)
P	Gas Processing Facility
R	Re-Gasification Facility
S	Storage Facility

Where a floating terminal is fitted with processing facilities, but classification of the entire processing facilities is not desired, certain essential safety systems and equipment for the processing facilities as indicated in 2-2/11 of this Guide are to be in compliance with requirements of ABS. The floating terminal will be classed and distinguished in the ABS *Record* by the symbol **✕ A1** followed by **Offshore Liquefied Gas Terminal** and the notation **T**. Compliance with the applicable requirements for the floating terminal, position mooring system and import/export systems is required. Topside structures and modules are to comply with 3-7/11 of this Guide. In addition the shipboard systems, including the electrical system circuit protection for the production facilities and associated fire fighting equipment, are to be reviewed by ABS for the classification of the floating terminal.

For floating terminals designed for LNG, the class notations are:

F(LNG) PLSO – Floating LNG Terminals with Gas Processing and Production, Liquefaction, Storage and Offloading – The floating terminal receives well gas, processes it, liquefies the natural gas and condensate for storage and offloading.

F(LNG) ORS – Floating LNG Storage Terminals with Re-Gasification Facility – The terminal receives LNG from a trading LNG carrier, stores it, re-gasifies and discharges the gas ashore.

F(LNG) SO – Floating LNG Storage and Offloading Terminals – The terminal receives, stores and offloads LNG in a lightering operation.

F(LNG) T – Floating LNG Terminals with Gas Processing and Production, Liquefaction, Storage and Offloading – The terminal receives well gas, processes it, liquefies the natural gas and condensate for storage and offloading. The gas processing, production and liquefaction facilities are not desired to be within the scope of class. However the essential safety features of these facilities are to comply with ABS requirements.

For floating terminals designed for LPG or combined LNG/LPG, the class notations are, respectively:

F(LPG) PLSO, F(LPG) ORS, F(LPG) SO, and F(LPG) T

F(LNG/LPG) PLSO, F(LNG/LPG) ORS, F(LNG/LPG) SO, and F(LNG/LPG) T

For floating terminals designed for liquefied gases other than LNG or LPG, the class notations will indicate in parentheses the specific product.

3 Additional Class Notations

3.1 Disconnectable System (1 September 2012)

A floating terminal that has a propulsion system and a means of disengaging the terminal from its mooring and riser systems to allow the floating terminal to ride out severe weather or seek refuge under its own power for a specified design environmental condition will be classed with the appropriate class notation in 2-1/1.1 above and with the notations **(Disconnectable)**, **✕ AMS** at the end. One example of such class designation is:

✕ A1, Offshore Liquefied Gas Terminal, F(LNG) ORS (Disconnectable), ✕ AMS

If a Disconnectable floating terminal is restricted to a specific service area in proximity to its operating site location, a restricted service notation **Disconnectable-R (from site to designated port) or (from site to geographic area bounded by Lat. X1, Long. Y1; Lat. X2, Long. Y2; Lat. X3, Long. Y3; Lat. X4, Long. Y4)**, may be assigned where permitted by local authorities or regulations.

3.3 Classification of Dynamic Positioning Systems

Dynamic positioning systems installed for station keeping purposes, will be denoted by the notation **✕ DPS** (see Section 2 of the *ABS Guide for Dynamic Positioning Systems*).

3.5 On-site Operation

Floating terminals designed and built to the special modified requirements for on-site operation, where approved by the Committee for that particular service, will be identified in the *Record* by the added notation **(S years)** followed by the approved site of operation, thus **F(LNG) PLSO (S100) Gulf of Mexico**, where “100” signifies that the terminal is reviewed for 100 years design return period.

3.7 Dynamic Loading Approach (1 September 2012)

Where requested, the ABS Dynamic Loading Approach and notation **DLA** may be applied to assess the adequacy of the floating steel structure of liquefied gas terminals. In such cases, the floating terminal will be classed and distinguished in the *Record* by the notation **DLA**. The **DLA** notation will be placed after the appropriate hull classification notation. The application of the dynamic loading approach is optional.

The dynamic load components considered in the evaluation of the hull structure are to include the external hydrodynamic pressure loads, internal dynamic loads (fluids stored onboard, ballast, major equipment items, etc.) and inertial loads of the hull structure. The magnitude of the load components and their combinations are to be determined from appropriate ship motion response calculations for loading conditions that represent the envelope of maximum dynamically-induced stresses in the floating terminal. The adequacy of the hull structure for all combinations of the dynamic loadings is to be evaluated using an acceptable finite element analysis method. In no case are the structural scantlings to be less than those obtained from other requirements in this Guide. In addition, the design of the containment system of independent tanks is to be assessed and analyzed in accordance with Part 5C, Chapter 8 of the *Steel Vessel Rules*.

The basic notation **DLA** is applied when the hydrodynamic loads have been determined using the wave environment of the North Atlantic with a 20-year service life. If the wave environment of the intended site is used during the analysis, the notation will include an **S** qualifier, followed by the design return period at the defined site. For example, if the 100-year return period was used, the following may apply: **DLA (S100)**. Transit conditions to the intended site are also to be included in the DLA evaluation.

3.9 Design Life and Design Fatigue Life (1 September 2012)

3.9.1 Design Life

Floating terminals designed and built to the requirements in this Guide and maintained in accordance with the applicable ABS requirements are intended to have a structural design life of not less than 20 years for a new build hull structure. Where the structural design life is greater than 20 years and the floating terminal is designed for uninterrupted operation on-site without any drydocking, the nominal design corrosion values (NDCV) of the hull structure are to be increased in accordance with 3-2/3.3. When the design life is greater than 20 years (in 5-year increments) the increased life will be identified in the *Record* by the notation **HL (number of years)**. The **(number of years)** refers to the design life greater than 20 years as reflected by the increase in nominal design corrosion values.

3.9.2 Design Fatigue Life

Where a floating terminal's design calls for a minimum design fatigue life of 20 years or in excess of the minimum design life of 20 years, the design fatigue life is to be verified to be in compliance with the fatigue criteria in this Guide. The "design fatigue life" refers to the target value set by the owner or designer, not the value calculated in the analysis.

The required fatigue strength analysis of critical details and welded joints in floating terminals is to be in accordance with 3-5/7.1 and 3-5/7.3, and Chapter 3, Appendix 1.

Only one design fatigue life notation is to be assigned and published in the *Record* for the hull, hull interface structure, position mooring system and components. The hull interface structural requirements are described in Chapter 3, Section 7 of this Guide and the position mooring system requirements in Part 6 of the *FPI Rules*. When only the required fatigue analysis of 3-5/7.1 and 3-5/7.3 is performed, the class notation **FL (number of years)** and the **Year** of maturation of fatigue life in the defined site location is assigned. The fatigue life will be identified in the *Record* by the notation **FL (number of years), Year**; for example, **FL(30), 2041** for a floating terminal built in 2011 if the minimum design fatigue life specified is 30 years.

If in addition, spectral fatigue analysis (see 2-1/3.11 and 3-5/7.5) is requested by the owner or designer, only the design fatigue life notation, **SFA (number of years), Year** will be assigned and published in the *Record* for the hull and hull interface structural system. Although only the **SFA** notation is assigned, and not the **FL** notation, the required fatigue analysis of 3-5/7.1 and 3-5/7.3 and Chapter 3, Appendix 1 is to be performed and the calculated fatigue life is to satisfy the design fatigue life.

The **(number of years)** refers to the design fatigue life equal to 20 years or more (in 5-year increments), as specified by the owner or designer. Where different design fatigue life values are specified for different structural elements within the terminal, such as hull structure components, hull interface structures and position mooring system components, the **(number of years)** refers to the least of the target values. In the case when spectral fatigue analysis is also applied the least of the fatigue life values calculated by the required fatigue strength analysis according to 3-5/7.1 and 3-5/7.3 and spectral fatigue analysis must satisfy the design fatigue life.

For example if the design fatigue life is specified as 25 years, the fatigue calculations of hull structural components must satisfy a fatigue life of 25 years. The fatigue calculations of the position mooring hull interface structures and hull mounted equipment interface structures, and position mooring system must also satisfy fatigue lives of $(25 \times FDF)$ years, where FDF are the fatigue safety factors specified in 3-7/Table 1 for hull interface structures and in 6-1-1/Table 1 of the *FPI Rules* for mooring lines.

3.11 Spectral Fatigue Analysis Notation (1 September 2012)

The fatigue strength criteria require the fatigue strength evaluation of structural details, which might also rely on spectral analysis methods to demonstrate the adequacy of fatigue strength. Where Spectral Fatigue Analysis is performed in accordance with the *ABS Guide for the Fatigue Assessment of Offshore Structures*, the floating terminal will be identified in the *Record* by the notation **SFA (number of years)** followed by the specific site of the terminal. The **(number of years)** refers to the design fatigue life equal to 20 years or more (in 5-year increments), as specified by the applicant (e.g., **SFA (30)**). Only one minimum design fatigue life value is applied to the entire structural system as described in 2-1/3.9. This notation is optional.

3.13 Hull Construction Monitoring Program

Floating Liquefied Gas Terminals designed and reviewed to the *FLGT Guide* are to comply with the requirements of the Offshore Hull Construction Monitoring Program in Chapter 3, Appendix 6 of this Guide and have the notation **OHCM**.

3.15 Additional Corrosion Margin (1 September 2012)

Where the floating terminal incorporates additional plate thicknesses above the required scantlings, the terminal will be identified in the *Record* by the notation **AT**, followed by the description of the major hull girder component(s) that has the additional thickness. This notation will also include a number to indicate the magnitude of the additional thickness (rounded down to the nearest 0.5 mm) that has been applied (i.e., **AT(DK+0.5)**). In order to apply the notation **AT**, the additional thickness must be applied to the complete structural element throughout the tank area of the floating terminal. This notation documents major areas of the structure that have an additional “as-built” margin on thickness to address areas subject to significant corrosion or areas where it may be desirable to increase normal corrosion margins to extend a structural member’s anticipated service life. This notation is optional and is only available to new construction FLGTs.

The major structural components are defined as follows:

DK	Upper deck
ID	Inner deck
SD	Second deck
BS	Bottom shell (including bilge)
IB	Inner-bottom
BG	Watertight bottom girder
SS	Side shell (including shear strake)
ST	Watertight side stringer
IS	Inner skin (including “hopper” sloping plating)
CB	Centerline cofferdam bulkhead
TB	Transverse Bulkhead

3.17 LNG Carriers with Re-gasification Facilities (1 September 2010)

In some cases, an Owner may elect to install a re-gasification facility on a new or existing trading LNG carrier so that the vessel may load and transport LNG and then re-gasify for direct discharge ashore. When such a facility is installed on an ABS-classed LNG carrier, the re-gasification facilities may be eligible for ABS certification which will be denoted with the additional notation **(LNG) R** – Re-gasification Facility, so that the class notation as it appears in the *Record* will be:

✕ A1 Liquefied Gas Carrier, (LNG) R

5 ✕ AMS Notation

Machinery and boilers for self-propulsion that have been constructed and installed to the satisfaction of the ABS Surveyors to ABS's Rule requirements, when found satisfactory after trial and approved by the Committee, will be classed and distinguished in the *Record* by the notation ✕ **AMS**. This notation is mandatory for classification of self-propelled floating terminals built under ABS survey, classed and distinguished in the *Record* by the symbol ✕ **A1**.

7 Notations for Automatic or Remote Control and Monitoring Systems

7.1 ✕ ACC and ✕ ACCU Notations

For automatic or remote control and monitoring systems of the propulsion machinery, ABS will consider additional classifications with symbols ✕ **ACC** or ✕ **ACCU**, as appropriate, provided that the applicable requirements of Part 4, Chapter 9 of the *Steel Vessel Rules* are satisfied.

7.3 ✕ AMCC and ✕ AMCCU Notations

For automatic or remote control and monitoring systems of the machinery other than the propulsion machinery as referenced in Subsection 1/1 of the *ABS Guide for Remote Control and Monitoring for Auxiliary Machinery and Systems (other than Propulsion) on Offshore Installations*, ABS will consider additional classifications with symbols ✕ **AMCC** or ✕ **AMCCU**, as appropriate, provided that the applicable requirements of the *ABS Guide for Remote Control and Monitoring for Auxiliary Machinery and Systems (other than Propulsion) on Offshore Installations* are satisfied.

9 Temporary Mooring Equipment Symbol “ⓔ”

When requested by the Owner, for self-propelled floating terminals, the symbol ⓔ may be placed after the symbols of classification in the *Record*, thus ✕ **A1 ⓔ**, which will signify that the equipment for temporary mooring is in compliance with 3-4-1/3 of the *MODU Rules* or Part 3, Chapter 5 of the *Steel Vessel Rules*.

11 Application of Class Notations (1 June 2013)

Classification boundaries encompass the floating terminal, position mooring system, import/export systems (see 2-2/11.9 and 2-2/11.11 of this Guide) and may include the processing facilities.

The class notations described above cover the following components:

- i) Floating offshore liquefied gas terminal, including the terminal's hull structure, stability, equipment, marine machinery and all electrical systems under one of the notations in 2-1/1 to 2-1/7 of this Guide, subject to the requirements of this Guide
- ii) Position mooring systems according to the requirements of the *FPI Rules*
- iii) Gas processing, production and liquefaction facilities according to the requirements of this Guide and the applicable sections of the *Facilities Rules*
- iv) Liquefied gas storage facilities (Containment Systems) in accordance with the requirements of this Guide and the applicable sections of Part 5C, Chapter 8 of the *Steel Vessel Rules*
- v) Inlet and outlet facilities in accordance with the requirements of this Guide
- vi) LNG and GNG (Gaseous Natural Gas/LNG vapor) handling systems in accordance with the requirements of this Guide and the applicable sections of Part 5C, Chapter 8 of the *Steel Vessel Rules*
- vii) Re-gasification facilities in accordance with the requirements of this Guide
- viii) Safety systems in accordance with the requirements of this Guide
- ix) Helicopter landing area in accordance with the requirements of this Guide and the applicable sections of the *Steel Vessel Rules* and *FPI Rules*

- x) Dynamic positioning systems where installed in accordance with the applicable section of the *Steel Vessel Rules*
- xi) Superstructure and deckhouse structure
- xii) Appurtenant structures, including lifeboat platforms and crane pedestals and foundations

A floating offshore liquefied gas terminal that is classed to the following notations includes the following elements:

TABLE 1
Floating Terminal Configuration (1 June 2013)

	Structure	Storage	Gas Processing	Liquefaction	Gasification	Position Mooring	Import Systems	Export Systems	Risers and Flow Lines	Min. System Compliance Required
F(LNG)PLSO	X	X	X	X	–	X	X	X	Optional	X
F(LNG)ORS	X	X	–	–	X	X	X	X	Optional	X
F(LNG)SO	X	X	–	–	–	X	X	X	Optional	X
F(LNG)T	X	X	–	–	–	X	–	X	–	X

Notes:

- P** = Process
- L** = Liquefaction
- S** = Storage
- O** = Transfer of Liquefied Gas (Offloading/Loading)
- R** = Re-gasification
- T** = Terminal with processing facilities which are not classed

As noted in 2-1/1.1, for **F(LNG)T** notation, the gas processing, production and liquefaction facilities are not within the scope of class. However, the essential safety features of these facilities are to comply with the ABS requirements. The essential safety features to be addressed are outlined in 2-1/Table 2 below.

TABLE 2
F(LNG)T Notation (1 June 2013)

System/Equipment	FLGT Guide ⁽¹⁾
Facilities Layout	2-2/13
Area Classification	2-2/15
Export System (Cargo discharge system including loading arms)	2-2 /11.11
Means to handle leaked LNG cargo in the event of failure of the primary barrier of any one cargo tank for containment systems required to have a secondary barrier.	2-2/9.1, Note 2
Means to inert containment system , insulation systems and offloading systems	2-2/9 and 2-2/11.11
Means for handling natural boil-off from containment system and excess vapor return from the cargo discharge operations	2-2/9 and 2-2/11.11, Note 3
Electrical System Circuit Protection	2-2/19
Electrical power supply, including generators and their prime movers and associated switchgear for all marine, safety systems and cargo discharge operations.	2-2/19
Electrical Installations in Classified Areas	2-2/15, 19
Fire Water Systems	2-2/23.7
Dry Chemical Systems, as applicable	2-2/23.7
Fixed Fire Extinguishing Systems	2-2/23.7
Paint Lockers, Laboratory Spaces, and Flammable Material Store Rooms	2-2/23.7
Emergency Control Station	2-2/23.7, 2-2/23.15

TABLE 2 (continued)
F(LNG)T Notation (1 June 2013)

<i>System/Equipment</i>	<i>FLGT Guide ⁽¹⁾</i>
Operation After Facility Total Shutdown	Note 4
Portable and Semi-portable Extinguishers	2-2/23.7
Gas and Fire Detection Systems	2-2/23.3, 2-2/23.5
Structural Fire Protection	2-2/23.9, 2-2/13.9
Muster Areas	Note 5
Means of Escape	2-2/23.13
Lifesaving Requirements	2-2/23.11
Personnel Safety Equipment and Safety Measures	2-2/23.11
Process System Description	2-1/13.7.1, Note 6

Notes:

- 1 ABS Guide for Building and Classing Floating Offshore Liquefied Gas Terminals (FLGT Guide).
- 2 This may include transfer to other tanks provided required volume is available (reserved) or jettison of cargo overboard which would require that temporary equipment is provided onboard to facilitate same or other arrangements.
- 3 The means of handling boil off gas from hull tanks under normal conditions and also during total process shutdown is to be submitted for ABS Engineering review. This may include the flare system or components of the flare system.
- 4 Operation after Facility Total Shutdown to be in accordance with 3-8/5.13 of the ABS Rules for Building and Classing Facilities on Offshore Installations (Facilities Rules).
- 5 Muster Area to be in accordance with 3-8/11 of the Facilities Rules.
- 6 Process System Description used as reference only.

13 Plans and Data to be Submitted

(2011) Plans and data to be submitted for design review shall generally be submitted electronically to ABS. However, hard copies will also be accepted. Proceeding paragraphs of this Subsection “Plans and Data to be Submitted” cover submittals for the full variety of Class Notations. The actual extent of plans and data to be submitted depend upon the equipment, machinery and systems installed on the terminal and requested for Classification by the Owner.

13.1 Design Plans and Data for Structures (1 September 2010)

Plans showing the scantlings, arrangements and details of the principal parts of the hull structure of each floating terminal to be built under survey are to be submitted and approved before the work of construction has commenced. These plans are to clearly indicate the scantlings, joint details and welding or other methods of connection. In general, plans are to be submitted that include the following, where applicable:

- General arrangement
- Body plan, lines, offsets, curves of form, inboard and outboard profile
- Wind heeling moment curves or equivalent data
- An arrangement plan of watertight compartmentation
- Diagrams showing the extents to which the watertight and weathertight integrity is intended to be maintained, the location, type, and disposition of watertight and weathertight closures
- Capacity plan and tank sounding tables
- Summary of distributions of weights (fixed, variable, ballast, etc.) for various conditions
- Type, location and quantities of permanent ballast, if any
- Loadings for all decks

- Transverse section showing scantlings
- Longitudinal sections showing scantlings
- Decks, including helicopter deck
- Framing, shell plating, watertight bulkheads and flats, structural bulkheads and flats, tank bulkheads and flats with location of overflows and air pipes
- Pillars, girders, diagonals and struts
- Superstructure and deck houses
- Arrangement and details of watertight doors and hatches
- Foundations for anchoring equipment, industrial equipment, process and process support modules, etc., where attached to hull structure, superstructures or deckhouses
- Mooring turrets and yoke arms, including mechanical details
- Corrosion control arrangements
- Methods and locations for nondestructive testing
- Plans and calculations/analyses for the module structures to support process facilities
- Plans and calculations/analyses for module support structures
- Hull Construction Monitoring Plan

13.1.1 Site Condition Reports

The site condition reports, comprised of the environmental and soil data, are to be submitted. For details, refer to Section 3-2-4 of the *FPI Rules*. The principal purpose of these reports is to demonstrate that site conditions have been evaluated in establishing design criteria. Among the items to be discussed are:

- i) Environmental conditions of waves, winds, currents, tides, water depth, air and sea temperature and ice
- ii) Seabed topography for design of anchoring systems, stability and pertinent geotechnical data
- iii) Seismic conditions

Where appropriate, data established for a previous installation in the vicinity of the installation proposed for classification may be utilized if acceptable in the opinion of ABS.

13.1.2 Design Data and Calculations

Information is to be submitted for the terminal which describes the methods of design, and analysis, which were employed to establish its design. The estimated design service life of a terminal is also to be stated. Information for marine systems such as P&IDs, specifications, etc., is also to be submitted. Where model testing is used as a basis for a design, the applicability of the test results will depend on the demonstration of the adequacy of the methods employed, including enumeration of possible sources of error, limits of applicability and methods of extrapolation to full-scale data. Preferably, procedures should be reviewed and agreed upon before model testing is done.

As required in subsequent sections, calculations are to be submitted to demonstrate the sufficiency of the proposed design. Such calculations are to be presented in a logical and well-referenced fashion employing a consistent system of units. Where the calculations are in the form of computer analysis, the submittal is to provide input and output data with computer generated plots for the structural model. A program description (not listings), user manuals and the results of program verification sample problems may be required to be submitted.

13.1.3 Plans and Specifications

Plans or specifications depicting or describing the arrangements and details of the major items of the terminal are to be submitted for review or approval in a timely manner.

Where deemed appropriate, and when requested by the Owner, a schedule for information submittal and plan approval can be jointly established by the Owner and ABS. This schedule, which ABS will adhere to as far as reasonably possible, is to reflect the construction schedule and the complexity of the terminal as it affects the time required for review of the submitted data.

13.1.4 Information Memorandum

An information memorandum on the floating terminal is to be prepared and submitted to ABS. ABS will review the contents of the memorandum to establish consistency with other data submitted for the purpose of obtaining classification. ABS will not review the contents of the memorandum for their accuracy or the features described in the memorandum for their adequacy.

An information memorandum is to contain, as appropriate to the terminal, the following:

- Site plan indicating the general features at the site and the exact location of the terminal
- Environmental design criteria, including the recurrence interval used to assess environmental phenomena (see 2-2/1.1.1)
- Plans showing the general arrangement of the terminal
- Description of the safety and protective systems provided
- The number of personnel to be normally stationed at the terminal
- Listing of governmental authorities having cognizance over the terminal
- Listing of any novel features
- Brief description of any monitoring proposed for use on the terminal
- Description of transportation and installation procedures

13.3 Design Plans and Data for Position Mooring Systems

The design documentation for the mooring system is to include the following, when applicable:

- Mooring arrangement or pattern
- Details of winching equipment
- Details of anchoring system
- Details of mooring line segments
- Connections at anchors and between mooring line segments
- Details of in-line (spring) buoys
- Details of buoy for Catenary Anchor Leg Mooring (CALM) system
- Details of Single Anchor Leg Mooring (SALM) structures, if appropriate
- Details of Turret System to show turret structure, swivel, turntable and disconnecting device
- Details of yoke (hard or soft) connecting the floating terminal and CALM/SALM structure
- Environmental Report
- Mooring Analysis describing method of load calculations and analysis of dynamic system to determine the mooring line design loads
- Model Test report when the design loads are based on model tests in a wave basin
- Thruster specifications and calculations of a system with dynamic positioning system for thruster forces and power to counteract environmental forces (See Sections 3-2-3 and 3-2-4 of the *FPI Rules*.)

13.5 Design Plans for Liquefied Gas Containment System, Liquefied Gas and GNG Handling Systems

The following plans, calculations and information, as appropriate, are to be submitted in addition to those required by Section 1-1-7 of the *ABS Rules for Conditions of Classification – Offshore Units and Structures (Part 1)*:

- Full particulars of the intended cargo and its properties, including flashpoint, maximum vapor pressure, minimum and maximum temperature and loading and storage procedures
- General arrangement plans of the floating terminal showing the position of the following:
 - i) Liquefied gas containment system, fuel oil, water ballast and other tanks and void spaces
 - ii) Manholes and any other opening of the cargo tanks
 - iii) Doors and other openings in cargo pump and compressor rooms and other gas-dangerous rooms
 - iv) Ventilation ducts of cargo compressor rooms and other “gas-dangerous” spaces
 - v) Door, air-locks, manholes, ducts and other openings for “non-gas-dangerous” spaces which are, however, adjacent to the cargo area, including rooms inside and under the forecastle deck
 - vi) Cargo piping, both liquid and gaseous phases, located under and above deck
 - vii) Vent piping and gas-freeing piping and protective devices such as flame screens, etc. fitted at the outlet end of the vents etc.
 - viii) Gas-dangerous spaces
- Plans of the floating terminal structure in way of the cargo tanks, including the installation of attachments, accessories, internal reinforcements, saddles for support and tie-down devices
- Plans of the structure of the cargo containment system, including the installation of attachments, supports and attachment of accessories. For independent pressure cargo tanks, the standard or Code adopted for the construction and design is to be identified. Detailed construction drawings together with design calculations for the pressure boundary, tank support arrangement and analysis for the load distribution. Anti-collision, chocking arrangement and design calculations.
- Distribution of the grades and of the types of steel proposed for the structures of the terminal together with the calculation of the temperatures on all of the structures which can be affected by the low temperatures of the cargo
- Results of direct calculations of the stresses in the floating terminal structure and in the cargo containment system
- A sloshing analysis to demonstrate that the liquefied gas storage tanks, the containment system and the structure can withstand loads under conditions of partially filled tanks to any level consistent with the operations procedures. The description of analysis tools and supporting documents for the validation of the tools are to be provided.
- Specifications and plans of the insulation system and calculation of the heat balance
- Thermal heat analysis determining the liquefied gas boil-off rate from the storage tanks
- Calculations to show the means provided for handling the boil-off gas from storage tanks without causing overpressurization in the tanks
- Procedures and calculations of the cooling down, loading and unloading operations
- Loading and unloading systems, venting systems and gas-freeing systems as well as a schematic diagram of the remote controlled valve system
- Details and installation of the safety valves and relevant calculations of their relieving capacity
- Details and installation of the various monitoring and control systems, including the devices for measuring the level of the cargoes in the tanks and the temperatures in the containment system

- Schematic diagram of the ventilation system indicating the vent pipe sizes and height of the openings above the main deck
- Schematic diagram of the refrigeration system together with the calculations concerning the refrigerating capacity for a re-liquefaction plant, if provided
- Details of the electrical equipment installed in the cargo area and of the electrical bonding of the cargo tanks and piping
- Where fitted, plans and specifications relevant to the use of the cargo as fuel for boilers and internal combustion engines (general installations; schematic diagram of the fuel-gas lines with the indication of all the valves and safety devices; compressors of the fuel gas and relevant engines; fuel-gas heaters and pressure vessels; installation of the burners of the fuel-gas and of the fuel oil; electrical bonding systems).
- Details of testing procedures of cargo tanks and liquid and vapor systems
- Diagram of inert-gas system or hold-space environmental control system
- Diagram of gas-detection system
- Jettison arrangements, if provided
- Details of all cargo and vapor handling equipment
- Welding procedure for cargo tanks, liquefied gas and GNG piping systems
- Emergency shutdown arrangements
- Construction details of cargo and booster pumps and compressors, including material specification
- Hazardous areas drawing showing access, openings, vent outlets
- Bilge and ballast arrangement for the cargo area
- Emergency towing arrangement

13.7 Design Plans for Process Facilities, Support and Safety Systems

13.7.1 Process and Re-Gasification Facilities

- The process system description
- Project specification and overall process concept evaluation
- Process flow sheets
- Heat and mass balance
- Equipment layout drawings
- Area classification and ventilation drawings
- Piping and instrument diagrams (P&IDs)
- Safety analysis function evaluation (SAFE) charts
- Shutdown and emergency shutdown system to include a hazard analysis and Failure Modes and Effects Analysis (FMEA) to identify critical components
- Pressure relief and depressurization systems
- Flare and vent systems
- Spill containment, closed and open drain systems
- Process equipment documentation, including calculation showing suitability of all pressurized components in the system to withstand the maximum design pressure that a specific component is likely to encounter in service
- Process piping systems

- Packaged process units
- The monitoring and control system for the entire system pressure regulation and gas dispersion system (to include calculations for sizing of the venting system and the relief valve) radiant heat analysis to demonstrate that the radiant heat intensity at any deck level or location where normal maintenance or operating activity could take place is not exceeding API RP 521 recommendations

13.7.2 Process Support and Service Systems

- Piping and Instrument Diagrams (P&IDs) for each system
- Equipment documentation
- Process support piping specifications
- Specification data sheets for internal combustion engines and turbines
- Specification data sheets for cranes (Optional)
- Marine support systems, as required by the ABS Rules applicable to the type of floating terminals

13.9 Electrical Installations

- Electrical one-line diagrams
- Short-circuit current calculations
- Coordination study
- Specifications and data sheets for generators and motors
- Specifications and data sheets for distribution transformers
- Details of storage batteries
- Details of emergency power source
- Standard details of wiring cable and conduit installation practices
- Switchboards and distribution panel
- Panel board
- Installations in classified areas

13.11 Instrumentation and Control Systems

- General arrangements
- Data sheet
- Schematic drawings – electrical systems
- Schematic drawings – hydraulic and pneumatic systems
- Programmable electronic systems

13.13 Fire Protection and Personnel Safety

- Firewater system
- Water spray (Deluge) systems for deckhouse, superstructure and manifold areas
- Water spray (Deluge) systems for process equipment
- Dry powder system for liquefied gas storage tank area
- Fixed fire extinguishing systems
- Paint lockers and flammable material storerooms

- Emergency control stations
- Portable and semi-portable extinguishers
- Fire and gas detection and alarm systems
- Fire and gas cause and effect chart
- Structural fire protection (which indicates classification of all bulkheads and decks for quarters section, machinery spaces and processing facilities)
- Heating ventilation and air conditioning (HVAC) plan [including air handling unit (AHU)], location, duct layout, duct construction and bulkhead and deck penetration details
- Joiner detail arrangement and structural fire protection material certification
- Guard rails
- Escape routes (may be included on the fire control plan or separate plan)
- Lifesaving appliances and equipment plan (escape routes must be indicated)
- Insulation of hot surfaces
- Fire and explosion hazard analysis
- Due to the varying configurations of the project, some portions of these requirements may not be applicable

13.15 Procedures

Procedures are to be submitted for the following:

- Installation procedures for loading sections of the terminal structure, deck area, process modules decks and topsides
- Installation procedures for carrying out all installation work offshore including foundation preparation platform installation and completion
- Disconnecting Procedure, if applicable
- Drydocking Procedure
- Hook Up Procedures
- Import/Export System
- Installation Procedures
- Startup and Commissioning Procedures
- Survey and Inspection Planning Document

15 Loading Manual (Operating Manual)

A loading manual is to be prepared and submitted for review pertaining to the safe operation of the floating terminal from a strength point of view. This loading manual is to be prepared for the guidance of and use by the personnel responsible for loading/unloading the floating terminal. The manual is to include means for determining the effects of various loaded, transitional and ballasted conditions upon the hull girder bending moment and shear force and is to be furnished to the master of the floating terminal for guidance. In addition, a loading instrument suitable for the intended service is to be installed on the terminal. The check conditions for the loading instrument and other relevant data are to be submitted for review.

An operating manual is required for the marine operation of all floating liquefied gas terminals, containing the information listed in Section 1-1-5 of the *MODU Rules* [Supplement to the *ABS Rules for Conditions of Classification – Offshore Units and Structures (Part 1)*] and 5B-1-4/11 of the *FPI Rules*, as applicable. The aforementioned loading manual may be included in the overall operating manual or issued as a separate document. The loading manual, if issued as a separate document, is to be referenced in the overall operating manual. Further, where **Disconnectable** is requested as an additional classification notation, the operating manual is to include procedures for disconnection and reconnection of the installation to its mooring and riser system. (See 3-4-1/13 and 3-4-7/3 of the *FPI Rules*.)

17 Trim and Stability Booklet (Operating Manual)

In addition to the loading manual, a floating terminal is to be provided with sufficient information to guide the master and other responsible personnel in the safe loading, transfer and discharge of cargo and ballast with respect to the hull's trim and stability. The information is to include various loaded, transitional and ballasted example conditions over the full range of operating drafts together with stability criteria to enable the responsible personnel to evaluate the intact and damage stability of any other proposed condition of loading.

This information may be prepared as a separate trim and stability booklet or may be included in the overall operating manual. If issued as a separate document, the trim and stability booklet is to be referenced in the overall operating manual. In addition to the booklet or section of the operating manual, the stability guidance information also may be incorporated as part of the loading instrument described in 2-1/15. (See 3-2-1/7 and Part 3, Chapter 3, of the *Steel Vessel Rules*, Regulation 10 of the 1966 Load Line Convention, Regulation 25 of MARPOL 73/78.)

19 Stability (1 August 2017)

The intact and damage stability of the installation are to be evaluated in accordance with the requirements of the flag and coastal States. In addition, the requirements of the 1966 Load Line Convention, IMO Code on Intact Stability, IMO MODU Code, IGC Code, and MARPOL 73/78 are to be considered as applicable. In the absence of flag or coastal State requirements, Section 3-3-1 of the *MODU Rules* is to be complied with. See 2-1/17 of this Guide for general requirements pertaining to the makeup and issuance of loading guidance with respect to stability.

21 Lightweight Data

The lightweight and center of gravity are to be determined for floating terminals. An inclining test will be required for the first floating terminal of a series, when as near to completion as practical, to determine accurately the lightweight and position of center of gravity. An inclining test procedure is to be submitted for review prior to the test, which is to be witnessed by an ABS Surveyor.

23 Load Line

Every floating terminal is to have marks that designate the maximum permissible draft to which the terminal may be loaded. Such markings are to be placed at suitable visible locations on the hull or structure to the satisfaction of ABS.

Except where otherwise permitted by the flag and coastal States, load line marks are to be established under the terms of the International Convention of Load Lines, 1966.

The floating terminal's arrangements are to comply with all applicable regulations of the International Convention on Load Lines.



CHAPTER 2 Design Considerations

SECTION 2 Design of Floating Offshore Liquefied Gas Terminals

1 Environmental Conditions (1 September 2012)

The floating terminal is to be designed for load scenarios encountered during transit and site-specific conditions. Site-specific conditions are to include both the Design Environmental Condition and the Design Operating Condition.

1.1 Position Mooring System

Unless the terminal is classed with the notation **(Disconnectable)**, **✕ AMS**, floating terminals are to be capable of remaining on station under the most adverse environmental conditions specified in 2-2/1.1.1 of this Guide through a position mooring system. The position mooring system may be comprised of a conventional anchor mooring system or Single Point Mooring (SPM) systems such as: Catenary Anchor Leg Mooring (CALM), Single Anchor Leg Mooring (SALM), Turret Mooring, etc. The design, fabrication, installation, deployment and testing is to be in compliance with the requirements of this section of the *FLGT Guide* and Part 6 of the *FPI Rules*.

The position mooring system of a floating terminal is to be designed to survive in the Design Environmental Condition and operate in the Design Operating Condition. For a disconnectable mooring system, the limiting condition at which the mooring system is to be disconnected or reconnected is to be specified.

1.1.1 Design Environmental Condition (DEC)

The *Design Environmental Condition (DEC)* is defined as the extreme condition with a specific combination of wind, waves and current for which the system is to be designed.

The DEC is to be one of the following combinations that results in the most severe loading case:

- 100-year waves with associated wind and current.
- 100-year wind with associated waves and current.
- 100-year current with associated waves and wind.

In areas with high current, additional design environmental load cases may need to be considered.

The 100-year waves are normally characterized by a significant wave height with a spectral shape type and a range of associated peak wave periods.

A minimum return period of 100 years for the DEC is required for floating terminals. A minimum return period of 50 years will be specially considered if it is accepted by the coastal state. Any environmental combinations with return periods shorter than that of the DEC which induce larger mooring load responses are also to be used in the design.

For a floating terminal with a **Disconnectable** notation (see 2-1/3.1 of this Guide), the *DISconnecting Environmental Condition (DISEC)* of the mooring system is the limiting extreme environmental condition at which the terminal is to be disconnected from the mooring system. However, the permanent mooring system, i.e., the mooring system alone (without the terminal), is to be designed to withstand an environmental condition based on a 100-year recurrence period. An acceptable monitoring system is to be provided for tracking environmental conditions or mooring line tensions in order to assist in the decision to disconnect the terminal from the mooring system.

In addition to waves, wind and current, the design of the floating terminal may require investigation of the following environmental factors, as appropriate to the type of terminal structure and the terminal's operating site:

- i) Tides and storm surges
- ii) Air and sea temperatures
- iii) Ice and snow
- iv) Marine growth
- v) Seismicity
- vi) Sea ice

Other phenomena, such as tsunamis, submarine slides, seiche, abnormal composition of air and water, air humidity, salinity, ice drift, icebergs, ice scouring, etc., may require investigation depending upon the specific operating site.

The required investigation of seabed and soil conditions is described in Section 3/6 of the *Offshore Installations Rules*.

1.1.2 Design Operating Condition (DOC)

The *Design Operating Condition (DOC)* is defined as the limiting environmental condition that would require suspension of normal operations. The return period associated with the DOC shall be the larger of: a) the value as specified by the Operator, or b) one year.

1.1.3 Design Installation Condition (DIC)

The *Design Installation Condition (DIC)* is defined as the limiting environmental condition that would require suspension of terminal operations. Specific limits on environmental conditions affecting safe operation during the installation phases described in Part 3, Chapter 4 of the *FPI Rules* are to be established and documented.

1.1.4 Angular Separation of Wind, Current and Waves

For single point mooring systems, which allow the terminal to weathervane, both collinear and non-collinear directions among wind, current and waves are to be considered. Proper angular separation for the DEC of wind, current and waves is to be determined based on the site-specific environmental study. If this information is not available, the following two angular combinations for non-collinear environments can be considered as a minimum:

- i) Wind and current are collinear and both at 30 degrees to waves.
- ii) Wind at 30 degrees to waves and current at 90 degrees to waves.

For spread mooring systems with limited change in the terminal's heading angles (less than 20 degrees) under design environmental loads, the collinear environments of wind, current and waves, which are generally controlling, can be used in design.

For each design sea state, a long-crested sea without spectral energy spreading in direction is normally considered in the mooring analysis.

1.3 Structural Strength and Fatigue Life

1.3.1 On-Site Location

The site-specific environmental conditions, including both 100-year return period environmental events and wave scatter diagram data of wave height/period joint occurrence distribution, are to be considered for the terminal's hull strength and fatigue life assessment. Fatigue life assessment is also to include the effects of on-site operational loading and unloading cycles. A minimum return period of 100 years for the design response should be used for the DEC criteria per API RP 2T. A minimum return period of 50 years for the structural response may be specially considered, provided that it is accepted by the Coastal State. Different environmental conditions may induce different worst responses on various parts of the hull structure. The wave-induced maximum

motion responses and maximum structural load effects may result from different wave periods. Therefore, the following two environmental conditions are to be considered to derive the maximum motion responses and maximum structural load effects. The larger of the two values obtained from *i)* and *ii)* is to be considered the maximum response:

- i)* 100-year return period waves characterized by a significant wave height with a range of associated peak wave periods. Both winter storms and tropical cyclones (hurricanes or typhoons), if any, need to be considered.
- ii)* Wave scatter diagram data of wave height/period joint occurrence distribution. The length of time on which the data base for the wave scatter diagram data is constructed is long enough to be a reliable basis for design (preferably at least five years). The occurrence distribution is to be annualized with equal probability of occurrence for each data point. Each data point is to represent a sea state of approximately three hours in a continuous time duration of the database.

For both of the above environmental conditions the following are also to be considered:

- iii)* Wave directions of head seas and other directions relative to the terminal's heading, including the effects of wind and current, with proper probability distribution are to be considered, irrespective of the type of mooring system utilized.
- iv)* As appropriate, either long-crested seas or short-crested seas with spreading function are to be considered for various design issues.

1.3.2 Transit

The wind and wave conditions representing the environment for the transit route from the building or outfitting site (or the shipyard where the conversion modifications are made) to the project site and the time of the year are to be determined for the design of a floating terminal. Except for floating terminals that qualify for the **Disconnectable** classification notation, any other transit conditions occurring during the operational life of the floating terminal are to be submitted for review. Prior to commencement of such a voyage, an ABS Surveyor is to attend and survey the terminal to assess its condition.

As a minimum, the wind speed and significant wave height of 10-year return period are to be considered, unless a weather routing plan is to be implemented for the voyage. Seasonal effects on the design environments as appropriate for the proposed transit duration can be considered.

In addition to the check on the terminal's hull strength during transit, special attention is to be paid to items such as crane pedestals and process equipment supports that will be subject to motion-induced loading and/or effects of green water. Motion-induced loads during transit are to be calculated and the superstructures and their supports, which are included in the scope of classification, shall be verified against these loads.

If fitted with an internal turret, special consideration is to be given to bottom slamming to preclude damage to the turret supports and bearings.

1.3.3 Disconnectable Terminals

For Disconnectable floating terminals that are disconnected from its mooring and riser systems due to the occurrence of a limiting extreme environmental condition, the structural strength of the terminal shall comply with unrestricted service (North Atlantic) conditions. However, if the Disconnectable floating terminal is restricted to a specific service area in proximity to its operating site location, reduced design load parameters may be applied with an appropriate limited area of disconnected service notation provided that it is accepted by local authorities or regulations. See 2-1/3.1 for class notation

1.3.4 Strength and Fatigue Life

Hull strength and fatigue life assessment are calculated according to 2-2/7 of this Guide for a given on-site location and transit route.

3 Design Basis

The design of the unit and the facilities on the installation for gas processing, liquefaction, storage, re-gasification, including importing of raw gas or liquefied gas and exporting of processed gas or liquefied gas, is to be in accordance with the criteria defined in this Guide, including any additional prevention or mitigation safeguards identified in the risk assessment required in 2-2/5 of this Guide.

In addition to the requirements mentioned above, it is also the responsibility of the designer, Owner and operator to comply with any additional requirements that may be imposed by the flag State or the coastal State or any other jurisdictions in the intended area of deployment and operation. This would include requirements for importing and exporting pipelines.

The complete basis for the design is to be stated in the operations manual and is to include the intended location, the envelope of environmental operating conditions and the storage capacities and throughputs of the production/re-gasification systems.

5 Risk Assessment

A Risk Assessment shall be carried out to identify significant hazards and accident scenarios that may affect the installation or any part thereof, and consider the benefit of existing or potential risk control options.

The objective of the risk assessment is to identify areas of the design that may require the implementation of risk control measures to reduce identified risk(s) to an acceptable level. For this purpose, a systematic process is to be applied to identify situations where a combination or sequence of events could lead to undesirable consequences such as property damage, personnel safety and environmental damage at an acceptable frequency.

The risk assessment shall consider, as a minimum, the following events:

- i) Damage to the primary structure due to extreme weather, impact/collision, dropped objects, helicopter collision, exposure to unsuitably cold temperatures, exposure to high radiant heat
- ii) Fire and explosion
- iii) Loss of primary liquid containment (for a duration to be determined based on an approved contingency plan)
- iv) Liquefied gas leakage
- v) Release of flammable or toxic gas to the atmosphere or inside an enclosed space
- vi) Roll-Over (thermodynamic instability due to liquefied gas stratification)
- vii) Loss of stability
- viii) Loss of any single component in the station keeping/mooring system
- ix) Loss of ability to offload liquefied gas or discharge gas ashore
- x) Loss of any one critical component in the process system
- xi) Loss of electrical power

The identified risk control options (prevention and mitigation measures) deemed necessary to be implemented should be considered part of the design basis of the terminal.

ABS recommends that early in the project a risk assessment plan be developed, documented and submitted to ABS for review prior to conducting the risk assessment. During review of the plan, an agreement will be reached on the extent of ABS participation and/or monitoring of project-related risk studies. ABS's participation in and/or monitoring of key tasks (e.g., Hazard Identification meetings) is necessary in order to establish a minimum level of confidence on the risk assessment results.

7 Structure – Floating Terminal

Chapter 3 of this Guide and the *FPI Rules*, directly and by reference to other standards, present the criteria deemed most applicable to the structural design of Floating Offshore Liquefied Gas Terminals. Major portions of the structural criteria from these ABS standards are excerpted and modified below to reflect envisioned liquefied gas terminal service. This has been done for the convenience of users and to concisely present in this Guide the main structural design and construction features included in the scope of Classification and the criteria to be applied. Reference should be made to the aforementioned Chapter 3 and *FPI Rules* for additional background on the referenced criteria.

7.1 Floating Steel Terminals

7.1.1 General

7.1.1(a) Basic Principle. The design and construction of steel floating liquefied gas and/or liquefied gas vapor terminal structures are to be based on the applicable requirements in Chapter 3 of this Guide and the *Steel Vessel Rules*, with modifications to reflect the service of terminals positioned to a fixed site on a long term basis and cryogenic temperature of the cargo, as indicated in this Guide.

7.1.1(b) Referenced Rules and Guides. Refer to 1-1/11 of this Guide.

7.1.1(c) Proportion. The requirements contained in this Guide are applicable to floating offshore liquefied gas terminals, having lengths of 150 meters (492 feet) or more, but not exceeding 500 m (1640 ft) in length, having breadths not exceeding one-fifth of the length nor 2.5 times the depth to the strength deck. Floating terminals beyond these proportions will be reviewed on a case-by-case basis.

7.1.1(d) Types of Tanks. In this Guide, the following types of tanks are considered:

- Membrane tanks
- Type B (IMO Gas Carrier Code) independent tanks
- Other tanks subject to special consideration

7.1.1(e) Access for Inspection. In the design of the terminal, consideration should be given to providing access for inspection during construction and, to the extent practicable, for survey after construction.

7.1.1(f) Steel-Concrete Hybrid Structures. The steel portions of a steel-concrete hybrid structure are to be designed in accordance with the requirements of 2-2/7.1 of this Guide, and the concrete portions are to be designed as specified in 2-2/7.3. Any effects of the hybrid structure interacting on itself in areas such as corrosion protection should be considered.

7.1.1(g) Steel-Concrete Composite Structures. Steel-concrete composite structures are to be designed in accordance with 2-2/7.1 of this Guide and the AISC, “Allowable Stress Design”.

7.1.2 Materials and Welding

7.1.2(a) Material. This Guide is intended for terminals of welded construction using steels complying with the requirements of Chapter 1 of the *ABS Rules for Materials and Welding (Part 2)* and Section 5C-8-6 of the *Steel Vessel Rules*. Use of materials other than those mentioned and the corresponding scantlings will be specially considered.

7.1.2(b) Selection of Material Grade. The selection of structural steel material grade for hull and tanks is to be in accordance with 3-1-2/3.1 and 5C-8-4/19 of the *Steel Vessel Rules*. The *ABS Rules for Materials and Welding (Part 2)* is one of the “Recognized Standards” in 5C-8-4/19.1.2 of the *Steel Vessel Rules*.

7.1.2(c) Welding. The welding is to be in accordance with Section 2-4-1 of the *ABS Rules for Materials and Welding (Part 2)* and 5C-8-4/20 of the *Steel Vessel Rules*.

7.1.3 Survival Capability and Location of Cargo Tanks

Floating terminals are to comply with the survival capability and cargo tank location requirements in Section 5C-8-2 of the *Steel Vessel Rules*.

7.1.4 Structural Analysis

Scantlings of plating, stiffeners and deep supporting members and hull girder strength are first to be determined in accordance with 2-2/7.1.4(a). A total strength assessment of the structure with the scantlings so determined is to be carried out in accordance with 2-2/7.1.4(b). A hull interface structural analysis is to be carried out in accordance with 2-2/7.1.4(c).

7.1.4(a) Initial Hull Scantlings. The initial thickness of plating, the section modulus of longitudinals/stiffeners, the scantlings of the main supporting structures, and the hull girder strength are to be determined in accordance with the following paragraphs:

- i) **Membrane Tank Terminals.** The initial scantlings are to be in accordance with Chapter 3, Section 4.
- ii) **Type B Independent Tank Terminals.** The initial scantlings are to be in accordance with Chapter 3, Section 4 of this Guide and 5C-8-1/11 (ABS) of the *Steel Vessel Rules*.

7.1.4(b) Total Strength Assessment (1 September 2012). A total strength assessment of the structure, with scantlings initially selected in accordance with 2-2/7.1.4(a), is to be carried out against three modes of failure, i.e., yielding, buckling/ultimate strength and fatigue, to confirm the adequacy of the structural configuration and initially selected scantlings, as follows:

- i) **Membrane Tank Terminals.** The assessment is to be in accordance with Chapter 3, Section 5 of this Guide.
- ii) **Type B Independent Tank Terminals.** The assessment is to be in accordance with Chapter 3, Section 5 of this Guide and 5C-8-1/11 (ABS) of the *Steel Vessel Rules*.

In addition, an assessment in accordance with the Dynamic Loading Approach (DLA) described in 2-1/3.7 or equivalent may be carried out in conjunction with Spectral Fatigue Analysis (SFA).

7.1.4(c) Hull Interface Structural Analysis. The hull design will also need to consider the interface between the position mooring system and the hull structure and the interface between deck-mounted (or above-deck) equipment modules and the hull structure. The interface structure is defined as the attachment zone of load transmission between the main hull structure and hull mounted equipment, including the position mooring system. The analysis of the hull interface structure as defined above is to be performed using direct calculation of local 3-D hull interface finite element models as described in Chapter 3, Section 7.

7.1.5 Fatigue Analysis

7.1.5(a) General. The fatigue strength of welded joints and details at terminations located in highly stressed areas and in fatigue prone locations are to be assessed, especially where higher strength steel is used, as specified in 2-2/5.1.5(d) of this Guide. These fatigue and/or fracture mechanics analyses, based on the combined effect of loading, material properties and flaw characteristics, are performed to predict the service life of the structure and to determine the most effective inspection plan. Special attention is to be given to structural notches, cut-outs, bracket toes and abrupt changes of structural sections. It is envisaged that liquefied gas terminals will be designed for a minimum fatigue life of twenty (20) years.

7.1.5(b) Design Fatigue Life (1 September 2012). The minimum design fatigue life is the service life multiplied by the Fatigue Design Factor (*FDF*) for site-specific service floating terminals using the wave spectrum at that site. Impact on fatigue life as a result of tow from fabrication to operating site is to be included in the fatigue assessment.

The design fatigue life will appear in the *Record* as described in 2-1/3.9 of this Guide.

7.1.5(c) Fatigue Design Factor. *FDF* is a factor, equal or greater than one (1) that is applied to individual structural details and which accounts for: uncertainties in the fatigue assessment process, the consequences of failure (i.e., criticality), and the relative difficulty of inspection and repair. *ABS Guide for the Fatigue Assessment of Offshore Structures* provides specific information on the values of *FDF*.

7.1.5(d) *Process of Fatigue Analysis.* The stress range due to loading and unloading cycles is to be accounted for in the overall fatigue damage assessment, see 3-5/7 and Chapter 3, Appendix 1. The cumulated fatigue damage during the transit voyage from the fabrication site to the operation site is to be included in the overall fatigue damage assessment.

- i) *Membrane Tank Floating Terminals.* The fatigue analysis is to be in accordance with Chapter 3, Appendix 1. In addition, a Spectral Fatigue Analysis may be carried out in accordance with the Spectral Fatigue Procedure for Ship-Shaped FPSOs.
- ii) *Type B Independent Tank Floating Terminals.* The fatigue analysis of the hull structure and tank structure are to be in accordance with Chapter 3, Appendix 1. The fatigue analysis of the tank supports and chocks shall be in accordance with Chapter 3, Appendix 1 using finite element models described in Chapter 3, Appendix 5. In addition, a spectral fatigue analysis may be carried out in accordance with the Spectral Fatigue Procedure for Ship-Shaped FPSOs.

7.1.6 Design Loads for Local Structures

Note: For the purpose of 2-2/7.1.6, “Transit Condition” means that the terminal is either in: a) transit from/to site with own propulsion or with propulsion assistance, or b) on site, but in a disconnectable mode with own propulsion. For the purpose of 2-2/7.1.6, “On-Site Condition” means that the terminal is not in “Transit Condition.”

7.1.6(a) *Sloshing Loads.* The natural periods of liquid motions and sloshing loads are to be determined and an assessment carried out of the strength of boundary structures of liquid tanks.

- i) *Transit Condition.* For membrane tank floating terminals, the sloshing pressure heads given in 3-3/11 and 3-3/13 for membrane tanks and for Type B independent tanks, respectively, may be used for determining the scantlings. Alternatively, sloshing loads may be calculated either by model experiments or numerical simulation using three-dimensional flow analysis for unrestricted service conditions and for sea conditions of the specific site of operation. Methodology and procedures of tests and measurements or analysis methods are to be fully documented and submitted for review.
- ii) *On-site Condition.* Sloshing loads are also to be determined for on-site service. Subsections 3-3/11 and 3-3/13 for membrane tanks and for Type B independent tanks, respectively, may be referred to.

7.1.6(b) *Forebody Strengthening.* Impact loads on the forebody structure are to be determined for transit and on-site conditions. Unless one end is specifically designated as the bow, terminals are to be designed with each end as the bow.

- i) *Bottom Slamming*
 - *Transit Condition.* For terminals with heavy weather ballast draft forward equal to or less than $0.04L$ and greater than $0.025L$, the bottom slamming pressures are to be calculated using 3-3/15.3 and the scantlings determined in accordance with 3-6/7.1. Floating terminals with heavy weather ballast draft forward equal to or less than $0.025L$ will be subject to special consideration.
 - *On-site Condition.* For the determination of loads for the on-site condition, refer to 3-3/15.3.
- ii) *Bowflare Slamming*
 - *Transit Condition.* For floating terminals having a bowflare shape parameter greater than 21 m in the forebody, bowflare slamming loads are to be calculated in accordance with 3-3/15.5 and the scantlings determined in accordance with 3-6/7.3.
 - *On-site Condition.* For the determination of loads for the on-site condition, refer to 3-3/15.5.

iii) *Bow Impact Loads*

- *Transit Condition.* Where experimental data are not available or direct calculation is not carried out, nominal bow pressures above LWL from the forward end to the collision bulkhead may be obtained from 3-3/15.1.
- *On-site Condition.* For the determination of loads for the on-site condition, refer to 3-3/15.1.

iv) *Green Water*

- *Transit Condition.* Where experimental data are not available or direct calculation is not carried out, nominal green water pressure on deck from FP to 0.30L aft, including the extension beyond the FP, may be obtained from 5C-3-3/5.5.4(b) of the *Steel Vessel Rules*. Minimum deck scantlings may then be determined using 5C-3-6/9 of the *Steel Vessel Rules*.
- *On-site Condition.* For the determination of loads for the on-site condition, refer to 3-3/15.7.

7.1.6(c) *Deck Loads.* Deck loads due to on-deck processing facilities for on-site and transit conditions are referenced in 3-3/17.

7.1.6(d) *Terminal Operation.* The expected loads and other demands that will be acting on the floating terminal as a result of the need to berth and moor vessels are to be considered in the design. These may include vessel breasting and mooring loads, the presence of fenders and the additional hydrodynamic and gravity loads that they bring, the need to support bollards and other mooring hardware, etc.

7.1.7 Superstructures, Deckhouses and Helicopter Decks

7.1.7(a) *Superstructures and Deckhouses.* The design of superstructures and deckhouses is to comply with the requirements of 3-2-11 of the *Steel Vessel Rules*. The structural arrangement of forecastle decks in 3-2-11/9 of the *Steel Vessel Rules* is to be satisfied, regardless of speed.

7.1.7(b) *Helicopter Decks.* The design of the helicopter deck structure is to comply with the requirements of 3-2-2/3 of the *MODU Rules*. In addition to the required loadings defined in 3-2-2/3 of the *MODU Rules*, the structural strength of the helicopter deck and its supporting structures are to be evaluated considering the DOC and DEC environments, if applicable.

7.1.8 Other Structures

Appurtenant structures such as lifeboat platform for life saving, crane pedestal and pipe racks, for example, are to comply with the requirements in 3-2-2/11 of the *MODU Rules*. The design criteria for other hull structures where not addressed in this Guide or the referenced Rules and Guides are to conform to recognized practices acceptable to ABS.

7.3 Floating Concrete Terminals

See 2-2/9.7 for prestressed concrete offshore liquefied gas terminals.

9 Containment Systems

The liquefied gas containment system is a mandatory part of ABS classification of the floating terminal's structure. The liquefied gas containment system is to be in accordance with the requirements of Section 5C-8-4 of the *Steel Vessel Rules* or NFPA 59A.

Alternative arrangements for the containment system, such as the use of a properly designed prestressed concrete structure as a secondary cryogenic barrier, application of membrane lining/barrier systems into concrete containment components, etc., may be given special consideration.

9.1 Design Features

Unless considered otherwise, the design of the containment system should incorporate the following features to satisfy the intent of these Rules and Standard:

- i) A secondary containment system such that if there is a failure in the primary system, the secondary system is to be capable of containing the leaked liquid contents for an agreed period of time consistent with the approved scenarios for the safe disposal of same
- ii) There is to be a minimum of two independent means of determining the liquid level in the liquefied gas storage tanks.
- iii) Means to fill the tank from various elevations within the tank to avoid stratification
- iv) Independent high and high-high level alarms
- v) At least one pressure gauge connected to the vapor space
- vi) Two independent overpressure protection devices
- vii) Devices for measuring the liquid temperature at the top, middle and bottom of tank
- viii) A gas detection system which will alarm high gas concentrations in the space between the primary and the secondary barrier

9.3 Design Loads

Tanks, together with their supports and fixtures, are to be designed with consideration of proper combinations of the following loads:

- i) Internal pressure
- ii) External pressure
- iii) Dynamic loads due to motion of the floating terminal
- iv) Thermal loads
- v) Sloshing loads
- vi) Loads corresponding to hull deflections
- vii) Tank and cargo weight with the corresponding reactions in way of the supports
- viii) Insulation weight
- ix) Loads in way of towers and other attachments

The sloshing loads are to consider any level of filling in each tank unless it can be shown that cargo can be shifted in a timely manner, and the level in the tanks can be maintained within the approved design limits.

The loads in way of supports are also to consider the unit inclined up to the worst angle of inclination resulting from flooding consistent with the unit's agreed-to damage stability criteria up to an angle of 30 degrees.

9.5 Steel Terminals

In the case of floating steel offshore liquefied gas terminals, the requirements of Section 5C-8-4 of the *Steel Vessel Rules* are considered applicable.

9.7 Concrete Terminals

On floating concrete offshore liquefied gas terminals constructed of prestressed concrete, the outer containment system may be constructed of concrete in accordance with the requirements of Section 7.4.3 of NFPA 59A.

9.9 Condensate Storage (2015)

Condensate storage tanks integral with the terminal's hull are to be in compliance with the requirements of Section 5C-1-7 of the *Steel Vessel Rules* and 3-5/5.9 of the *Facilities Rules*. Where condensate may contain dangerous or noxious liquid chemical substances with its content ratio exceeding the threshold values as defined in the "International Code for the Construction and Equipment of Ships Carrying Dangerous Chemicals in Bulk" (IBC Code), the requirements of Chapter 9 of Part 5C of the *Steel Vessel Rules* are to be followed as applicable to the particular substances present. Where the threshold values are not specified, ABS is to be consulted for required clarification.

Condensate storage in tanks adjacent to liquefied gas storage tanks will be considered acceptable, provided it can be shown that loss of primary liquefied gas containment would not cause an underpressure situation or the ingress of air into the condensate tank.

11 Process Facilities

Where process facilities are requested to be within the scope of Class, the facilities installed onboard the terminal for processing raw gas from the well(s) or bringing partially processed gas from another installation, liquefied gas production or liquefaction or re-gasification system for converting liquefied gas into vapor for shipment ashore, the entire installation, including the import and export system, are subject to requirements of this Guide.

For Classification purposes, whichever of the process systems are employed, the facilities are to be in place so that the entire operation can be carried out safely. Accordingly, in order to carry out an assessment of the system, the plans and calculations listed in 2-1/13.7 of this Guide are required to be submitted.

ABS may require additional information depending on the systems used and their configuration.

Where processing facilities are not within the scope of Class, requirements contained in this Guide relating to the safety of the terminal will be considered within the scope of Class. For example, the following systems will be subject to approval by ABS:

- i) Interface to the Fire Extinguishing system
- ii) Hazardous areas
- iii) Gas disposal system (venting and relief)

11.1 Process Safety Criteria

The design of the onboard process facilities described above is to include an overall evaluation of the proposed concept with a view toward reducing the likelihood of the occurrence of the undesirable events identified in 2-2/5 of this Guide.

The ABS evaluation will include a systematic consideration of arrangements, layouts, process systems, process support systems, process controls and safety systems as well as a review of all safety critical equipment. The term "safety critical" is meant to include equipment whose reliable performance is considered essential to maintaining a safe facility as well as equipment whose failure in and of itself could lead to an unsafe occurrence.

While the design of the terminal arrangements, safety systems and systems for handling liquefied gas and liquefied gas vapor on a terminal may rely primarily on the proven practices employed on liquefied gas carriers, it must be recognized that on a liquefied gas carrier, except during cargo loading and discharge operations, there is very little hydrocarbon outside of the containment system. Accordingly, additional provisions may be required depending on the process system installed on the terminal. This may include such items as an extension of the hazardous areas, the need for a gas dispersion analysis and the provision of a means to de-energize electrical systems in the event of a major release of high pressure gas.

Due to the varying quantity and means of handling and storage of the hydrocarbon refrigerants, it must also be recognized that the level of risk associated with natural gas liquefaction is dependent on the liquefaction process selected. Accordingly, wherever possible, the location of these systems should be on open deck.

Similarly, while some liquefied gas carriers are arranged for bow or stern loading and unloading in accordance with the provisions of 5C-8-3/8 and 5C-8-5/10.1 of the *Steel Vessel Rules*, it must be recognized that the existing requirements for liquefied gas carriers do not envisage the increased risk of a liquefied gas or liquefied gas vapor release from the systems and equipment that may be employed in the import and export systems covered under 2-2/11.9 and 2-2/11.11 of this Guide. Accordingly, drip trays are to be provided as necessary, and components such as cryogenic hoses and gas swivels that may be susceptible to leakage should be located on the open deck. Furthermore, the means to provide reliable, adequate ventilation in any enclosed spaces containing portions of the gas transfer system and provisions for gas detection are to be considered and included in the overall risk analysis required in 2-2/5 of this Guide.

The safe disposal by flaring of hydrocarbon gas released due to an overpressure or other upset condition should be taken into consideration in the design of the system. However, the process systems are to be closed systems. Accordingly, continuous flaring is not an acceptable design premise.

The process safety overall criterion is that systems and equipment on an offshore liquefied gas terminal be designed to minimize the risk of hazards to personnel, property and environment. Implementation of this criterion to gas processing, liquefaction or re-gasification facilities and the associated support facilities is intended to:

- i) Prevent an abnormal condition from causing an upset condition
- ii) Prevent an upset condition from causing a release of hydrocarbons or cryogenic fluids
- iii) Safely collect and dispose of hydrocarbon or cryogenic fluids released
- iv) Prevent formation of explosive mixtures
- v) Prevent ignition of flammable liquids or gases and vapors released
- vi) Limit exposure of personnel to fire hazards

11.1.1 System Requirements

The design of process systems and process control systems described above, along with process support systems, depressurization and vent systems, flares and drain systems, is to comply with the requirements of Chapter 3, Section 3 of the *Facilities Rules*. In addition, systems that are in direct contact with liquefied gas or liquefied gas vapor are to be designed for compliance with the requirements of Part 5C, Chapter 8 of the *Steel Vessel Rules* and the applicable requirements of NFPA 59A, *Standard for the Production, Storage and Handling of Liquefied Natural Gas (LNG)* 2013. Where there is a conflict between various referenced requirements, ABS is to be consulted for clarification.

The systems and equipment for ship-to-terminal liquefied gas loading or liquefied gas discharge such as special loading arms and/or cryogenic hose, hose cranes, primary emergency release couplings (PERCs), relative motion sensors, emergency shutdown systems and other special arrangements will be considered in each case based on the submitted design justification. The design justification is to include an envelope of limiting operational environments including sea states, wind, current and visibility.

11.1.2 Component Requirements

It is envisaged that a list of major components present on a liquefied gas terminal includes but is not limited to: loading arms, cryogenic hoses, pig receivers, separators, knock-out drums, heat exchangers, packed columns, absorbers, plate fin type heat exchangers, spiral (spool) wound heat exchangers, tube and shell heat exchangers, pumps and compressors with either gas turbine or electric drivers, direct and indirect heaters and vaporizers. These process system components and the associated piping systems that carry hydrocarbon liquids and vapors will be subject to ABS review.

The design, manufacture, testing, certification and installation of process components are to be in compliance with the requirements of 3-3/9 of the *Facilities Rules*. The selection of material of components subject to temperatures below -18°C (0°F) is to comply with the requirements of Section 5C-8-6 of the *Steel Vessel Rules*. Conformance to standards or codes different from those listed therein will be considered, where applicable. Components not covered in the referenced ABS Rules will be considered on the basis of compliance with applicable, acceptable industry standards and the manufacturer's design justification and proof testing. Design justification based on stress analysis should comply with the requirements of the ASME Boiler and Pressure Vessel Code Section VIII Division 2.

11.3 Gas Processing

For the purposes of this Guide, the gas processing facilities are considered to include all systems and components for the reception of raw gas from the well(s) or partially processed gas from another installation on the platform facilities for such processes as acid gas removal, dehydration and mercury removal.

11.5 Liquefaction

For the purpose of this Guide, the Liquefaction Facilities are considered to include all systems and components for pre-cooling, fractionation, main cryogenic refrigeration and storage. There are a number of proven, proprietary liquefaction methodologies available, whichever of these systems is used, and details, as mentioned in 2-2/11.1, are to be submitted.

The subsystems and major items of equipment can vary significantly depending on which liquefaction methodology is employed. Accordingly, a description of the system and an operational philosophy adopted is to be submitted in order to evaluate the safety of the entire system.

However, the following is given as a reference to define the scope of Classification:

- i) It is envisaged that the pre-cooling may be done in a propane, nitrogen or mixed refrigerant heat exchanger with the associated refrigerant refrigeration cycle: compressor, condenser, coolers and accumulators. The pre-cooling heat exchanger may be of the spiral wound or plate fin type.
- ii) It is envisaged that the fractionation includes subsystems or plants called de-ethanizers, de-propanizers and de-butanizers. Each plant is comprised of a vertical column type separator, pumps, heat exchangers and accumulators.
- iii) The main cryogenic refrigeration is normally done in either a multi-stage spiral wound heat exchanger or in an assembly of plate fin type heat exchangers called a cold box. In most liquefied gas liquefaction processes, a mixture of hydrocarbons is used as the primary refrigerant and these processes are called MR Processes. However, in the cascade system, propane, ethane, methane, and ethylene are each used at consecutive stages of refrigeration. In the nitrogen system, nitrogen is used as the refrigerant in a compression and expansion process.
- iv) The storage includes both liquefied gas storage and storage of condensate produced from the liquefaction process.

11.7 Re-gasification

For the purposes of this Guide, Re-gasification Facilities are considered to include all systems and components for removing liquefied gas from the storage tanks, pressurizing, heating and vaporizing liquefied gas and in some cases odorizing the liquefied gas vapor and discharge ashore of vaporized gas through an off-loading system. If there are compressors in the discharge system, they would be considered part of the Re-gasification Facility.

11.9 Import Systems

For the purposes of this Guide, Import Systems on load terminals are considered to include the entire gas swivel on turret-moored units and the first onboard flange for units maintained on station through a spread mooring system, plus all onboard gas flow lines up to the gas processing facility.

In the case of discharge terminals, the Import Systems would include the liquid and vapor loading arms and the cryogenic hoses or the cargo manifold, depending on the liquefied gas ship to terminal transfer configuration employed, plus all on deck valves and piping up to the liquid and vapor inlet flanges on the cargo tank domes.

11.11 Export Systems

For the purpose of this Guide, Export Systems on load terminals are considered to include the cargo pumps, stripping pumps, high duty gas compressors, liquefied gas vaporizers and all valves and piping in the liquid discharge and vapor return systems up to and including the cargo manifold, loading arms or cryogenic hoses, depending on the liquefied gas terminal to ship transfer configuration employed.

In the case of discharge terminals, the Export Systems would include the gas flow lines from the re-gasification facility up to and including the entire gas swivel on turret moored units or the last onboard flange on units maintained on station through a spread mooring system.

11.13 Risers and Flow Lines

Rigid and flexible risers connecting flow lines and submerged jumpers are not considered to be within the scope of classification of the terminal. However, at the Owner's request, the import or export risers starting from, but not including the Pipe Line End Manifold (PLEM), may be included in the scope of classification, provided they are found to be in compliance with the requirements of Part 4, Chapter 2 of the *FPI Rules*.

13 Arrangements

13.1 Referenced Rules, Guides and Documents

Refer to 1-1/11 of this Guide.

13.3 General Arrangement

Machinery and equipment are to be arranged in groups or areas in accordance with API RP14J. Equipment items that could become fuel sources in the event of a fire are to be separated from potential ignition sources by space separation, firewalls or protective walls.

Typical fuel sources may be as listed below:

i) Gas inlet and departing flow lines	xi) Liquefied Gas manifolds or loading arms
ii) Process and Hydrocarbon Refrigerant Piping	xii) Separators and Scrubbers
iii) Risers and Pipelines	xiii) Coalescers
iv) Vents	xiv) Gas Compressors
v) Pig Launchers and Receivers	xv) Liquid Hydrocarbon Pumps
vi) Drains	xvi) Heat Exchangers
vii) Portable Fuel Tanks	xvii) Hydrocarbon Refrigerant Storage Tanks
viii) Chemical Storage Tanks	xviii) Gas Metering Equipment
ix) Laboratory Gas Bottles	xix) Oil Treaters (unfired vessels)
x) Sample Pots	xx) Swivels

Typical ignition sources may be as listed below:

i) Fired Vessels	x) Electrical Equipment
ii) Combustion Engines & Gas Turbines	xi) Waste Heat Recovery Equipment
iii) Living Quarters	xii) Mobile phones
iv) Flares	xiii) Lightning
v) Welding Machines	xiv) Spark Producing Hand Tools
vi) Grinding Machines	xv) Portable Computers
vii) Cutting Machinery or Torches	xvi) Cameras
viii) Static Electricity	xvii) Non-Intrinsically Safe Flashlights
ix) Ships	xviii) Helicopters

In case of a fire, the means of escape is to permit the safe evacuation of all occupants to a safe area, even when the structure they occupy can be considered lost in a conflagration. With safety spacing, protective firewalls and equipment groupings, a possible fire from a classified location is not to impede the safe exit of personnel from the danger source to the lifeboat embarkation zone or any place of refuge.

13.5 Storage Tank Locations

The location of storage tanks with respect to the outer boundaries of the structure is to be consistent with the extent of damage assumed in 2-2/5 and 2-2/7.1.3 of this Guide, unless it can be shown through relative motion studies or traffic studies that other arrangements will be not less effective at protecting the storage tanks.

13.7 Bow or Stern Loading

The requirements of 5C-8-3/8 and 5C-8-5/10.1 of the *Steel Vessel Rules* for bow or stern loading arrangements will be considered applicable to import or export systems that run past accommodations or other sources of vapor ignition.

13.9 Location and Insulation of Accommodation Spaces and Living Quarters

Accommodation spaces or living quarters are to be located outside of hazardous areas and may not be located above or below liquefied gas or condensate storage tanks or process areas. "H-60" bulkhead requirements of 3-8/9 and 4-8/9 of the *Facilities Rules* will be applied. If such bulkhead is more than 33 m (100 ft) from this source, then this can be relaxed to an "H-0" rating. As is explained in Chapter 3, Section 8 of the *Facilities Rules*, "A-60" and "A" rated bulkheads, respectively, may be utilized, provided that a risk or fire load analysis was done and reviewed by ABS, indicating that these bulkheads are acceptable.

15 Hazardous Areas (2015)

The delineation of hazardous areas or gas-dangerous spaces on an offshore liquefied gas terminal is to be consistent with the following general guidelines. Where there is overlapping, in general, the higher (more conservative) delineation should be applied.

The delineation of gas-dangerous spaces in 5C-8-1/2.24 of the *Steel Vessel Rules* and Chapter 7, Section 10.7 of NFPA 59A, as applicable, will be considered applicable to liquefied gas storage and liquefied gas and liquefied gas vapor piping systems associated with liquefied gas storage, loading and discharge.

The delineation of gas-dangerous spaces associated with process facilities is to comply with the requirements of 3-6/15 of the *Facilities Rules*, which are consistent with API RP 500 series.

The delineation of hazardous areas associated with the below deck storage of condensate and other hydrocarbon liquids with a flash point of less than 60°C is to be consistent with the requirements of 5C-1-7/31.5 of the *Steel Vessel Rules*.

Where condensate in the condensate storage tank contains dangerous or noxious liquid chemical substances as defined in the "International Code for the Construction and Equipment of Ships Carrying Dangerous Chemicals in Bulk" (IBC Code), the requirements applicable to the particular substances as specified in Chapter 9 of Part 5C of the *Steel Vessel Rules* are also to be complied with.

17 Process Support and Service Systems

This Subsection presents criteria for the design and installation of process support and service systems on offshore liquefied gas terminals. General arrangement of these systems is to comply with API RP 14J, or other applicable standard. Process support systems are utility and auxiliary systems that complement the process systems covered in 2-2/11 of this Guide.

Process support systems include, but are not limited to, the following:

- i) Utility/Instrument Air System
- ii) Fuel/Instrument Gas System
- iii) Use of Produced Gas as Fuel

- iv) Purging System
- v) Inert Gas System
- vi) Nitrogen System
- vii) Fuel Oil System
- viii) Hydraulic System
- ix) Lubricating Oil System
- x) Chemical Injection System
- xi) Heating and Cooling System

These systems are to be in compliance with the requirements of Chapter 3, Section 4 of the *Facilities Rules* and Part 5C, Chapter 8 of the *Steel Vessel Rules*, as applicable.

Depending on the type of structure support systems and components may include, but are not limited to, the following:

- Boilers and Pressure Vessels
- Turbines and Gears
- Internal Combustion Engines
- Pumps and Piping Systems (i.e., Fuel Oil, Lube Oil, Fresh Water, Bilge, Ballast, Control, Inert Gas, etc.)
- Components of the station keeping system

These systems are to be in compliance with the requirements of Chapter 3, Section 5 of the *Facilities Rules* and the applicable sections of the *Steel Vessel Rules* and the *MODU Rules*.

19 Electrical Systems and Installations

Electrical systems used solely for the process facilities described in 2-2/11 of this Guide are to meet the requirements of Section 5C-8-10 of the *Steel Vessel Rules* and Chapter 3, Section 6 of the *Facilities Rules*. Where electrical systems or equipment are used to supply services other than these process facilities, the equipment is also to comply with the requirements of a recognized code for electrical installations acceptable to ABS.

Electrical installations are to comply with the above-referenced requirements and with API RP 14F. Consideration will be given to the use of other recognized national or international standards such as IEC, provided they are no less effective and the entire system is designed to such standards. For installations classified by class and zone, the requirements of API RP 14FZ (when approved) may be used in lieu of API 14F.

Where sections of API RP 14F are called out in the following text, the intent is solely to help identify relevant clauses. The designer is not relieved from full compliance with all of the recommended practices contained in API RP 14F. The references to IEC standards are intended solely as minimum requirements when standards other than API RP 14F are applied.

Where conflicts exist between various referenced standards, ABS is to be consulted to provide required clarification.

21 Instrumentation and Control Systems

The control and instrumentation systems are to provide an effective means for monitoring and controlling pressures, temperatures, flow rates, liquid levels and other process variables for the safe and continuous operation of the process and storage facilities. Where control over the electrical power generation and distribution is required for the operation of the facilities, then the control system should also be arranged to cover this. Control and instrumentation systems for process, process support, utility and electrical systems are to be suitable for the intended application. All control and safety shutdown systems are to be designed for safe operation of the equipment during start-up, shutdown and normal operational conditions.

Instrumentation and control systems serving the process facilities described in 2-2/11 of this Guide are to be in compliance with Chapter 3, Section 7 of the *Facilities Rules* which is based on API RP 14C and other applicable standards.

Instrumentation and control systems serving the liquefied gas storage and transfer of liquefied gas and liquefied gas vapor on and off the unit are to be in compliance with the requirements of Section 5C-8-13 of the *Steel Vessel Rules*.

Where there is a conflict between overlapping referenced requirements, ABS is to be consulted for required clarification.

23 Safety Systems

23.1 General

23.1.1 Approach

The safety systems referred to in this Subsection are intended to protect life, property and the environment and are applicable to the entire installation, including the loading and off-loading arrangements for gas, liquefied gas and liquefied gas vapor. The overall safety system should be comprised of subsystems providing two levels of protection: the primary system, which is to provide protection against the risk of fire or explosion; and the secondary system, which is intended to reduce the consequence of fire by affording protection to the people and the facility and reducing the risk of fire spread. The primary and secondary safety measures required consist of both active and passive systems as described in this Subsection. However, in all cases, the effectiveness of these systems should be established by conducting a fire and explosion hazard analysis.

Each space considered a fire risk, such as the process equipment, cargo deck area, spaces containing gas processing equipment such as compressors, heaters, etc. and machinery spaces containing any oil fired unit or internal combustion machinery with an aggregate power of not less than 375 kW, is to be fitted with an approved gas detection, fire detection and fire extinguishing system complying with the requirements of this Subsection.

23.1.2 Governmental Authority

In addition to the ABS Class requirements of this Subsection, depending on the flag registry of the terminal and the area of operation, the flag State and the coastal State may have additional requirements or regulations which may need to be complied with. Therefore, the appropriate governmental authorities should be consulted for each installation.

23.1.3 Primary Systems

Many of the products being handled onboard an offshore liquefied gas terminal are highly flammable, and therefore, examples of some of the measures that may be necessary to protect against fire or explosion risk are as follows:

- i) Avoid the possibility of liquid or gas escaping in locations where there is a source of vapor ignition. A typical example of this will be to isolate the vent and relief valve outlets from storage tanks and process systems in relation to the air intakes and openings.
- ii) Provide fixed gas detection systems comprised of two different types of elements which will activate an audible alarm at a manned control station to alert of a gas release before the gas can migrate to an unclassified area.
- iii) A low temperature detection system in and around the liquefied gas storage facility to alarm at a normally manned station to alert in the event of a liquid or vapor leak.
- iv) A multi-tiered Emergency Shutdown system capable of isolating an upset condition with local system or single train shutdowns before the condition requires a complete platform shutdown.

- v) Maintain integrity of the containment boundary at all times to reduce the possibility of an uncontrolled discharge of liquefied gas or liquefied gas vapor. Where it is possible for liquefied gas to leak in the event of a failure, such as at a joint, valve or similar connection, a spill tray immediately underneath these components should be provided.
- vi) Maintain a positive separation between process areas, cargo storage, cargo handling area and areas containing sources of vapor ignition. A typical example of this is electrically driven cargo or process compressors.
- vii) Eliminate direct access from the space containing process equipment to spaces containing machinery such as electrical equipment, fired equipment or other similar equipment which may be considered an ignition source.

23.1.4 Secondary Systems

The secondary systems are systems that are employed to prevent the spread of fire may be categorized as follows:

- i) Fire detection system
- ii) Fire extinguishing systems
- iii) Water deluge system
- iv) Personnel protection and life saving appliances
- v) Structural fire protection

23.3 Gas Detection Systems

23.3.1

The fixed gas detection system is to comply with requirement of Section 5C-8-13 of the *Steel Vessel Rules* and Chapter 3, Section 8 and of the *Facilities Rules*.

23.3.2

The requirements of NFPA 59A Chapter 12 will be considered to be applicable in the liquefied gas processing areas. In such areas, where there is a potential for gas concentrations to accumulate, the gas detection sensors should activate an audible and visual alarm at not more than 25% of the lower flammable limit of the gas or vapor being monitored.

23.3.3

The gas detection system is to be of an approved type and the installation arrangements such that loss of single detector(s) over a specific area will not render the entire system ineffective.

23.3.4

The gas detection system should be provided with an alternative source of power such that in the event of failure of the main power source, the alternative power supply will commence automatically.

23.5 Fire Detection Systems

The fire detection system protecting the liquefied gas storage and liquefied gas and liquefied gas vapor handling systems is to be in accordance with the requirements of Section 5C-8-11 of the *Steel Vessel Rules* and Chapter 3, Section 8 of the *Facilities Rules*, as applicable. The requirements of NFPA 59A Chapter 12 are also considered applicable.

23.7 Fire Extinguishing and Water Spray (Deluge) Systems

NFPA 59A Chapter 12 is considered applicable to offshore liquefied gas terminals, and as is required therein, the extent of fire protection required shall be determined by an evaluation based on sound fire protection engineering principles, analysis of local conditions, hazards within the facility and exposure to or from other sources of fire such as the attending vessels.

Fire water systems, water spray systems, dry powder, foam and carbon dioxide systems are to be provided, as required by Section 5C-8-11 of the *Steel Vessel Rules* and Chapter 3, Section 8 of the *Facilities Rules*.

23.9 Structural Fire Protection

The term “structural fire protection” refers to the passive method of providing fire protection to the spaces/compartments of the unit through the usage of fire divisions and the limitation of combustibles in the construction materials. Maintaining the adequacy of the fire division includes proper protection of penetrations in those divisions which includes electrical, piping or ventilation system penetrations.

The requirements of 3-8/9 of the *Facilities Rules* are to be complied with. In applying these requirements, the gas inlet and liquefied gas vapor outlet system, including the swivel, are to be treated as wellhead areas.

23.11 Personnel Protection and Life Saving Appliances

Compliance with Section 5C-8-14 of the *Steel Vessel Rules* and Chapter 3, Section 8 of the *Facilities Rules* is required.

Personnel involved in emergency activities shall be equipped with the necessary protective clothing and equipment qualified in accordance with 5C-8-11/6 of the *Steel Vessel Rules* and NFPA 600 *Standard on Industrial Fire Brigades*.

Written practices and procedures shall be developed to protect personnel from identified hazards such as entry into confined or hazardous spaces.

23.13 Means of Escape

At least two means of escape are to be provided for all continuously manned areas and areas that are used on a regular working basis. The two means of escape must be through routes that minimize the possibility of having both routes blocked in an emergency situation. Escape routes are to have a minimum width of 0.71 m (28 in.). Dead-end corridors exceeding 7 m (23 ft.) in length are not permitted. Dead-end corridors are defined as a pathway which (when used during an escape) has no exit.

Escape route paths are to be properly identified and provided with adequate lighting. An escape route plan is to be prominently displayed at various points in/of the facility. Alternatively, this information may be included in the Fire Control or Fire/Safety Plan.

23.15 Emergency Shutdown Systems

23.15.1 Process Emergency Shutdown (ESD)

An emergency shutdown (ESD) system with manual stations is to be provided, in accordance with Appendix C of API RP14 and Section 12.3 of NFPA 59A, to shut down the flow of hydrocarbon gas on to the platform and to terminate all gas processing and liquefaction process on the facility.

In addition, for the liquefied gas loading and discharge systems and the liquefied gas storage systems, Emergency Shutdown Valves are to be provided along with means for control, in accordance with 5C-8-5/5 of the *Steel Vessel Rules*.

The emergency shutdown system is to be automatically activated by:

- i) The detection of an abnormal operating condition by pressure sensors in the inlet and outlet systems or in the process systems
- ii) The detection of fire on the floating terminal
- iii) The detection of combustible gas at a 60% level of the lower explosive limit
- iv) The detection of hydrogen sulfide (H₂S) gas at a level of 50 ppm

Emergency shutdown stations are to be provided for manual activation of the Process Safety Shutdown system for shutdown of all pumping and process systems. These manual activation stations are to be protected against accidental activation and are to be conveniently located at the primary evacuation points (i.e., boat landing, helicopter deck, etc.) and the emergency control stations.

For design guidance, the following additional locations may be considered appropriate for emergency shutdown stations:

- i) Exit stairway at each deck level
- ii) Main exits of living quarters
- iii) Main exits of production (process) facility deck

25 Other Systems

For marine systems or electrical systems associated with marine operations and accommodations, the relevant ABS requirements as referenced in the *FPI Rules* and/or *MODU Rules* and/or *Steel Vessel Rules* are to be complied with.



CHAPTER 3 Structural Design Requirements

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