



財團法人驗船中心

CR CLASSIFICATION SOCIETY

GUIDELINES FOR LNG FUEL READY SHIPS

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CHAPTER 1 General

1.1 General

1.1.1 CR Guidelines for LNG Fuel Ready Ships (hereinafter referred to as the Guidelines) are applied to ships burning conventional fuels but having design features suitable to permit conversion at a future date to a particular gas burning concept based on existing Class requirements for gas fueled ships.

1.1.2 The requirements for the installation of all features of systems proposed are established in the CR Guidelines For Natural Gas-Fuelled Engine Installations.

1.1.3 The Guidelines are for optional application to ship types other than those falling under the scope of the International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk (IGC Code) and the requirements in Part 3, Chapter 4 of the CR Rules for the Construction and Classification of Steel Ships (hereinafter referred to as the Rules for Steel Ships) and burning their cargo. It is applied to ships burning conventional fuels but having design features suitable to permit conversion at a future date to a particular gas burning concept based on existing Class requirements for gas fueled ships.

1.1.4 It is important to note that the international regulations to be followed for gas fueled ships, other than those covered by the IGC Code, are those included in the IMO International Code of Safety for Ships Using Gases or Other Low Flashpoint Fuels (IGF Code), which entered into force on January 2017.

1.1.5 It is recognized that at the time of the conversion of a ship to LNG fueled, the arrangements and installations will still be subject to approval by the flag Administrations and the flag Administration may implement the IMO requirements in effect at the time of conversion. The Guidelines are to be applied to both new construction and existing vessel conversions, regardless of size, utilizing natural gas as fuel.

1.2 Objectives

The objectives of the Guideline are to define a three (3) leveled "Gas Fuel Ready" scheme, to provide the details and preparations needed for each Level, and to describe the type of recognition that CR Classification Society (hereinafter referred to as the Society) will offer subject to compliance of the requirements at each Level. There are three Levels considered as fundamental for defining the readiness of a ship that is requested to be listed under the "Gas Fuel Ready" scheme.

1.2.1 Level 1 : Concept Design Review (refer to Chapter 2)

This is a high level evaluation of the basic suitability of a particular ship design to be able to fit a particular LNG fueled ship concept.

1.2.2 Level 2 : General Design Review (refer to Chapter 3)

This Level is additional to Level 1, and it is categorized in separate groups identifying the different parts of the complete design.

1.2.3 Level 3 : Detail Design Approval and Installation (refer to Chapter 4)

This is the final Level of the "Gas Fuel Ready" scheme and incorporates both the approval of the detailed drawings and the installation of parts of the system and specified equipment onboard the ship including Survey in accordance with the related requirements of the Rules for Steel Ships.

1.3 Class Notation

Upon satisfactory completion of each review level, the class notation **Gas Fuel Ready** and the relevant descriptive letter(s) will be assigned to the ship.

1.3.1 Level 1 : Concept Design Review

Where the concept design for LNG Fuel Ready of the ship is fulfilled the requirements of Chapter 2 and reviewed by the Society, the notation **Gas Fuel Ready-I** will be assigned to the ship.

1.3.2 Level 2 : General Design Review

Where the general design for LNG Fuel Ready of the ship is fulfilled the requirements of Chapter 3 and reviewed by the Society, the notation **Gas Fuel Ready-II** and the relevant descriptive letter(s) will be assigned to the ship.

For example : **Gas Fuel Ready-II(S,TS,TA, ...)**.

1.3.3 Level 3 : Detail Design Approval and Installation

Where the detail design and installation for LNG Fuel Ready of the ship is fulfilled the requirements of Chapter 4 and approved by the Society, the notation **Gas Fuel Ready-III** and the relevant descriptive letter(s) will be assigned to the ship.

For example : **Gas Fuel Ready-III(S,TS,TA,...)**.

CHAPTER 2 Level 1 – Concept Design Review

2.1 Description

This is a high level evaluation of the basic suitability of a particular ship design to be able to fit a particular LNG fueled ship concept design. Basic suitability would mean that the geometry and structural arrangements of the ship can physically encompass the necessary equipment and the safety elements associated with tank location and that the hazardous areas can be accommodated in compliance with the CR Guidelines For Natural Gas-Fuelled Engine Installations at the time of the review.

Upon satisfactory completion of this review level, the notation **Gas Fuel Ready-I** will be assigned to the ship.

2.2 Plans and Data to be Submitted

2.2.1 The following plans and documentation shall be submitted for review:

- (a) Ship general arrangement
- (b) LNG fuel storage tank type, capacity, location, and arrangement
- (c) Preliminary temperature calculation around the LNG storage tank, as deemed necessary depending on LNG tank type and location.
- (d) LNG fuel storage natural boil-off rate
- (e) Fuel gas and gas vapor management plan
- (f) Fuel gas supply and vapor gas handling systems location and arrangement
- (g) LNG fuel bunkering station location and arrangement
- (h) Conceptual arrangement of the fuel gas piping
- (i) Arrangement of machinery space including Gas Valve Unit
- (j) Preliminary hazardous areas classification plan
- (k) Vent mast and venting location and arrangement
- (l) Preliminary trim and stability, longitudinal strength, and visibilityfeasibility study in respect to the effect of the storage tank
- (m) Outline Design Specification of the system and a Ship Safety Concept, as deemed necessary.

CHAPTER 3 Level 2 – General Design Review

3.1 Description

This Level is additional to Level 1 and it is categorized in separate groups identifying the different parts of the complete design. The level of the design details to be reviewed for each system would be general. Detailed information such as particular equipment manufacturers and installations are not required except for the gas consumers. For new construction ships, the drawings and supporting documentation shall be reviewed for compliance with the IGF Code for gas fueled ships having the same applicability date as CR Rules applied for classification of the ship.

Upon satisfactory completion of this review, the notation **Gas Fuel Ready-II** and relevant descriptive letter(s) will be assigned to the ship. The reviewed drawings could then be used as part of the future conversion project pending flag State approval. This level is not necessary for achieving LNG Ready Level 3, but it is an intermediate option for guiding the preparation of documents for the final installation of the relevant part of the system.

The subgroups of Level 2 are:

System/Component	Descriptive Letter(s)
Hull structural reinforcement for LNG storage tank	S
LNG fuel storage tank structure	TS
LNG fuel storage tank arrangements	TA
Fuel gas bunkering system and arrangement	BK
Fuel gas supply system	GS
Gas vapor handling system	BH
Gas Consumers	
Main engines	ME
Auxiliary engines	AE
Gas turbines	GT
Main or Auxiliary boilers	B

The above descriptive letters are to supplement the notation **Gas Fuel Ready-II** when the components or systems indicated have been design reviewed (e.g., **Gas Fuel Ready-II (S, TS, TA)**).

3.2 Plans and Data to be Submitted

The plans and documents to be submitted for each group of Level 2 are listed below.

3.2.1 Hull Structural Reinforcement for LNG Storage Tank

- (a) LNG storage tank type, dimensions, and volume
- (b) Tank supports, collision chocks, and anti-flotation arrangements
- (c) Material specifications for tank supports and steel grade selection for the hull in way of the tank

3.2 Plans and Data to be Submitted

- (d) Fuel gas storage tank thermal insulation with heat transfer calculation, in association with requirements in 6.4.8.1 of PART A-1 of the IGF Code for the thermal insulation, for confirming the steel grade selection for the hull in way of the tank
- (e) Specifications of design loads and structural analyses for the gas storage tank supports and hull reinforcement for accommodating the LNG storage tank together with complete stress analysis, as applicable

3.2.2 LNG Fuel Storage Tank Arrangements

- (a) General arrangement of the gas storage tank(s), and as applicable, hold space/gas fuel storage room
- (b) LNG storage tank supports, collision and anti-floatation arrangements
- (c) Tank pressure accumulation calculation, in association with the regulations for the maintaining of fuel storage condition, as described in 6.9 of Part A-1 of the IGF Code
- (d) Tank relief valves capacity and discharge piping arrangements
- (e) Ventilation and inert gas arrangement for tanks located inside the hull
- (f) Gas fuel piping arrangement in way of the LNG fuel tank

3.2.3 Fuel Gas Bunkering System and Arrangement

- (a) General arrangement of the gas fuel bunkering system
- (b) Bunkering station, manifolds, and valves drawings
- (c) Gas fuel piping systems including piping diagrams and associated components and design pressures and temperatures
- (d) Bunkering station ventilation system capacity and arrangement
- (e) Emergency shutdown (ESD) arrangements and ESD flow chart

3.2.4 Fuel Gas Supply System

- (a) General arrangement of the tank fuel gas supply room
- (b) Ventilation systems capacity and arrangement for the tank fuel gas supply room
- (c) Gas fuel piping systems including piping diagrams and associated components and design pressures and temperatures
- (d) Gas compressors and LNG pumps, with details such as type and size

- (e) Vaporizers/heaters capacity, as applicable
- (f) Pressure vessels specifications, as applicable
- (g) Forced and natural boil-off gas supply system diagram from the tanks to the consumers

3.2.5 Gas Vapor Handling Systems

- (a) Capacity and type of secondary means for handling excess natural boil-off gas
- (b) General arrangement of the re-liquefaction unit compartment or the GCU compartment, as applicable
- (c) Ventilation systems capacity and arrangement for the re-liquefaction unit compartment or the GCU compartment, as applicable
- (d) Gas fuel piping systems including details of piping diagrams and associated components and design pressures and temperatures
- (e) Gas compressors, specifications with type and size
- (f) Gas heaters capacity
- (g) Forced boil-off gas supply system from the tanks to the consumers piping diagrams and arrangements

3.2.6 Gas Consumers (Engines, Gas Turbines and Auxiliaries) Compartments

- (a) General arrangements showing location of the power plant and individual items of machinery, such as the gas turbine units(s), exhaust gas boilers, turbo-generators(s), diesel generators, and other associated equipment (such as the gas combustion units(s), re- liquefaction plant and the gas supply line to the consumers)
- (b) General arrangement of engine compartment(s) or the gas turbine engine enclosure, as applicable
- (c) Ventilation system for engine compartment(s) capacity and arrangement, as applicable
- (d) Gas fuel piping systems including details of piping and associated components and design pressures and temperatures

CHAPTER 4 Level 3 – Detail Design Approval and Installation

4.1 Description

This is the final Level of the “Gas Fuel Ready” scheme and incorporates both the approval of the detailed drawings and the installation of specified equipment onboard the ship. This Level is also categorized in separate groups, identifying the different parts of the complete design. Level 3 includes the complete list of drawings required for approval of each part before installation, and it can be performed straight after Level 1 or in combination with Level 2. Drawings are to be in compliance with the IGF Code. Upon completion of the installation to the Surveyor's satisfaction, the ship will be eligible for the notation **Gas Fuel Ready-III**, including descriptive letters for the component or systems that have been installed in accordance with approved plans. After delivery, the survey intervals and their requirements are covered in 4.3 below.

The subgroups of Level 3 are the same as Level 2, above:

System/Component	Descriptive Letter(s)
Hull structural reinforcement for LNG storage tank	S
LNG fuel storage tank structure	TS
LNG fuel storage tank arrangements	TA
Fuel gas bunkering system and arrangement	BK
Fuel gas supply system	GS
Gas vapor handling system	BH
Gas Consumers	
Main engines	ME
Auxiliary engines	AE
Gas turbines	GT
Main or Auxiliary boilers	B

The above descriptive letters are to supplement the notation **Gas Fuel Ready-III** when the components or systems indicated have been CR approved/surveyed as per the applicable Rules and Guidelines requirements and installed on board to the attending Surveyor's satisfaction (e.g., **Gas Fuel Ready-III (S, GS, ME)**). For those instances when only part of a system is installed or when a gas consumer is able to be converted in the future for burning gas, the applicable descriptive letter with appended brief description to indicate the installed equipment will be included. Some examples are indicated below:

- GS fuel gas piping
- BK manifold
- ME convertible to gas
- AE convertible to dual fuel

4.2 Plans and Data to be Submitted

Plans and specifications covering the entire installation with all of the accessories are to be submitted and are to include, as applicable. The plans and documents to be submitted for each group of Level 3 are listed below.

4.2.1 Hull Structural Reinforcement for LNG Storage Tank

- (a) Detailed drawings of the gas storage tank, supports, collision and anti-floatation arrangements

- (b) Fuel gas storage tank thermal insulation and heat transfer calculation, in association with requirements in 6.4.8 of Part A-1 of the IGF Code for the thermal insulation
- (c) Material specifications for tank supports and steel grade selection for inner hull in way of the tank
- (d) Specifications of design loads and structural analyses for the gas storage tank supports and hull reinforcement for accommodating the LNG storage tank together with complete stress analysis, as applicable
- (e) Weld procedures, stress relieving, and nondestructive testing plans

4.2.2 LNG Fuel Storage Tank Structure

- (a) General arrangement of the gas storage tank(s), and as applicable, hold space/gas fuel storage room, including location of the gas detectors, electrical equipment, and lighting
- (b) Detailed drawings of the gas storage tank supports and stays, secondary barrier (if required), and insulation
- (c) Material specifications for tanks, valves, and associated components
- (d) Weld procedures, stress relieving, and nondestructive testing plans.
- (e) Specifications of design loads and structural analyses for the gas storage tank(s) together with complete stress analysis as applicable
- (f) Sloshing analysis, in association with 6.4.9.4.1.3 in Part A-1 of the IGF Code
- (g) Loading limit curve, in association with regulations on loading limit for liquefied gas fuel tanks in 6.8 of Part A-1 of the IGF Code
- (h) Tank pressure accumulation calculation, where applicable, in association with the regulations for the maintaining of fuel storage condition, as described in 6.9 of Part A-1 of the IGF Code

4.2.3 LNG Fuel Storage Tank Arrangements

- (a) General arrangement of the gas storage tank(s), and as applicable, hold space/gas fuel storage room, including location of the gas detectors, electrical equipment, and lighting
- (b) Detailed drawings of the gas storage tank supports and stays, secondary barrier (if required), and insulation
- (c) Calculation of gas storage tank relief valve capacity including back pressure and relevant supporting documents
- (d) Ventilation or inert gas arrangements for the hold space/gas fuel storage room
- (e) Fixed gas detection and alarm systems, and associated shutoff and shutdown systems

4.2 Plans and Data to be Submitted

- (f) Gas fuel piping systems including details of piping and associated components, design pressures and temperatures, and insulation, where applicable
- (g) Descriptions and schematic diagrams for control and monitoring system including set points for abnormal conditions
- (h) Details of all electrical equipment in the hold space/gas fuel storage room
- (i) Electric bonding (earthing) arrangement
- (j) Operating and maintenance instruction manuals (see 6.8.1, 6.3.12 & 6.7.2.6 in Part A-1 and 18.2.2 to 18.2.4 & 18.4.2.1 in Part C-1 of the IGF Code).
- (k) Forced and natural boil-off gas supply system from the tanks to the consumers
- (l) Testing procedures during sea/gas trials

4.2.4 Fuel Gas Bunkering System and Arrangement

- (a) General arrangement of the gas fuel bunkering system including location of the gas detectors, electrical equipment and lighting
- (b) Detailed drawings of the bunkering station, manifolds, valves, couplings and control stations
- (c) Gas fuel piping systems including details of piping and associated components, design pressures, temperatures and insulation where applicable
- (d) Material specifications for manifolds, valves and associated components
- (e) Weld procedures, stress relieving and non-destructive testing plans
- (f) Ventilation system
- (g) Fixed gas detection and alarm systems, and associated shut-off and shutdown systems
- (h) Descriptions and schematic diagrams for control and monitoring system including set points for abnormal conditions
- (i) Details of all electrical equipment in the bunkering and control stations
- (j) Equipotential bonding and insulating flange arrangement
- (k) Emergency shutdown (ESD) arrangements and ESD flow chart
- (l) Operating and maintenance instruction manuals

- (m) Testing procedures during sea/gas trials (submitted for survey verification only).

4.2.5 Fuel Gas Supply System

- (a) General arrangement of the fuel preparation room including location of the gas detectors, electrical equipment and lighting
- (b) Doors and other openings in fuel preparation rooms
- (c) Ventilation ducts of fuel preparation rooms
- (d) Material specifications for compressors, pumps, evaporators, vaporizers, condensers, coolers, heaters, valves and associated components
- (e) Ventilation systems for the fuel preparation room
- (f) Fixed gas detection and alarm systems, and associated shut-off and shutdown systems
- (g) Gas fuel piping systems including details of piping and associated components, design pressures, temperatures and insulation where applicable
- (h) Weld procedures, stress relieving and non-destructive testing plans
- (i) Gas compressors
- (j) Vaporizers/Heaters
- (k) Pressure vessels
- (l) Descriptions and schematic diagrams for control and monitoring system including set points for abnormal conditions
- (m) Details of all electrical equipment in the fuel gas supply room
- (n) Electric bonding (earthing) arrangement
- (o) Failure Modes and Effects Analysis (FMEA) to determine possible failures and their effects in the safe operation of the fuel gas supply system
- (p) Emergency shutdown arrangements
- (q) Operating and maintenance instruction manuals
- (r) Forced and natural boil-off gas supply system from the tanks to the consumers
- (s) Testing procedures during sea/gas trials (submitted for survey verification only).

4.2.6 Gas Vapor Handling Systems for Reliquefaction Systems

The list of drawings to be submitted depends on the gas vapor handling system that will be selected.

- (a) General arrangement of reliquefaction system compartment, as applicable, including location of the gas detectors, electrical equipment and lighting
- (b) Ventilation systems for reliquefaction system compartment
- (c) Fixed gas detection and alarm systems, and associated shut off and shutdown systems
- (d) Gas fuel piping systems including details of pipes and associated components, design pressures and temperatures
- (e) Gas compressors
- (f) Gas heaters
- (g) Gas storage pressure vessels
- (h) Descriptions and schematic diagrams for control and monitoring system including set points for abnormal conditions
- (i) Details of all electrical equipment in the reliquefaction system compartment
- (j) Electric bonding (earthing) arrangement
- (k) Failure Modes and Effects Analysis (FMEA) to determine possible failures and their effects in the safe operation of the reliquefaction system
- (l) Emergency shutdown arrangements
- (m) Operating and maintenance instruction manuals (see Section 18 in Part C-1 of the IGF Code)
- (n) Forced boil-off gas supply system from the tanks to the consumers
- (o) Testing procedures during sea/gas trials (submitted for survey verification only).

4.2.7 Gas Vapor Handling Systems for Gas Combustion Units

The list of drawings to be submitted depends on the gas vapor handling system that will be selected.

- (a) General arrangement of the GCU compartment, including location of the gas detectors, electrical equipment and lighting
- (b) Ventilation system for the GCU compartment
- (c) Fixed gas detection and alarm systems, and associated shut-off and shutdown systems

- (d) Gas fuel piping systems including details of piping and associated components, design pressures and temperatures
- (e) Burner management system
- (f) Gas compressors
- (g) Gas heaters
- (h) Gas storage pressure vessels
- (i) Descriptions and schematic diagrams for control and monitoring system including set points for abnormal conditions
- (j) Details of all electrical equipment in the GCU compartment
- (k) Electric bonding (earthing) arrangement
- (l) Failure Modes and Effects Analysis (FMEA)
- (m) Emergency shutdown arrangements
- (n) Operating and maintenance instruction manuals (see Section 18 in Part C-1 of the IGC Code)
- (o) Forced boil-off gas supply system from the tanks to the consumers
- (p) Testing procedures during sea/gas trials (submitted for survey verification only).

4.2.8 Gas Consumers (Engines, Gas Turbines and Auxiliaries)

The list of drawings to be submitted depends on the propulsion system that will be selected.

- (a) General arrangement of engine compartment(s), including location of the gas detectors, electrical equipment and lighting
- (b) Ventilation system
- (c) Fixed gas detection and alarm systems, and associated shut-off and shutdown systems
- (d) Gas fuel piping system including details of pipes and associated components, design pressures and temperatures
- (e) Descriptions and schematic diagrams for control and monitoring system including set points for abnormal conditions
- (f) Details of the electrical equipment

4.2 Plans and Data to be Submitted

- (g) Electric bonding (earthing) arrangement
- (h) Arrangement and details of crankcase protection
- (i) Failure Modes and Effects Analysis (FMEA) to determine possible failures and their effects in the safe operation of the engines for each engine type
- (j) Arrangement of explosion protection for air inlet manifolds and for exhaust manifolds including design basis and size calculations
- (k) Emergency shutdown arrangements
- (l) Operating and maintenance instruction manuals
- (m) Testing procedures during sea/gas trials (submitted for survey verification only).
- (n) Engine specific time referenced by 10.3.1.7 in Part A-1 of the IGF Code, after which if the engine has not started then the fuel gas supply is to be shut off and exhaust system is to be purged

4.2.9 Gas Consumers (Dual Fuel Gas Turbine)

The list of drawings to be submitted depends on the propulsion system that will be selected.

- (a) General arrangements showing location of the power plant and individual items of machinery, such as the gas turbine units(s), exhaust gas boilers, turbo generators(s), diesel generators and other associated equipment (such as the gas combustion units(s), reliquefaction plant and the gas supply line to the consumers)
- (b) General arrangement of the gas turbine engine enclosure, including location of the gas detectors, electrical equipment, lighting and ventilation, etc.
- (c) Gas fuel manifold arrangement and details, including design pressure and temperatures, operational schematics, material specifications and bill of materials
- (d) Enclosure, including size and dimensions, gas tightness, entrance and exits and other openings, such as ventilation intakes and outlets
- (e) Ventilation systems details, including inlet cooling air calculations for the enclosure
- (f) Fixed gas detection and alarm systems, and associated shut off and shutdown systems
- (g) Gas fuel piping systems, including details of pipes and associated components, design pressures and temperatures, operational schematics, flange/joints loadings, material specifications and bill of materials
- (h) Gas compressors, with details such as type, size, mechanical components, materials used and details of alarms, indication, shutdown and control system.
- (i) Mist separators

- (j) Vaporizers
- (k) Heat exchangers, including BOG heaters, BOG coolers, etc.
- (l) Pressure vessels, including recovery tanks, etc.
- (m) Descriptions and schematic diagrams for control and monitoring systems, including set points for abnormal conditions together with control logic for the entire power plant and individual items in the systems.
- (n) Details of the electrical equipment in the turbine engine enclosure
- (o) Failure Modes and Effects Analysis (FMEA) to determine possible failures and their effects in the safe operation of the dual fuel gas turbine
- (p) Electric bonding (earthing) arrangement
- (q) Emergency shutdown arrangements
- (r) Operating and maintenance instruction manuals
- (s) Schematic diagram showing gas and fuel supply lines from the source to the consumers for the entire power plant system

4.3 Survey

4.3.1 Material and equipment inspection

The components or systems indicated in this chapter and intended to install on-board are to be inspected in accordance with CR Guidelines for Survey of Products for Marine Use and the applicable requirements in the Rules for Steel Ships.

4.3.2 Installation Survey

During installation of the specified components or systems for the "Gas Fuel Ready" scheme, the installation survey is to be carried out in the presence of the Surveyor.

4.3.3 Survey after installation

The survey after installation of the specified components or systems for the "Gas Fuel Ready" scheme will be included in Annual Survey and Special Survey in accordance with 1.6.4 and 1.6.5 in Part I of the Rules for Steel Ships, as applicable.