GUIDE FOR

LNG BUNKERING

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Foreword

Recently, the marine industry has seen growing interest in the use of alternative fuels such as LNG and alternative technologies such as exhaust emission abatement equipment to meet stricter international, regional, national, and local air emissions legislation. These techniques are primarily aimed at meeting the IMO Annex VI Regulations 13 and 14 requirements for nitrogen oxide emissions from diesel engines and sulfur oxide emissions from all fuel-burning equipment on board.

Most LNG-fueled vessels in operation at the time of issuance of this Guide receive LNG bunkers on a relatively small scale, typically through a shore-to-ship basis by road tankers or dedicated shore side LNG tanks. To support the further growth and development of LNG fueled vessels for short sea and international trade it is recognized that more dedicated LNG infrastructure needs to be developed; particularly small scale LNG storage and distribution centers together with dedicated LNG bunkering vessels enabling ship-to-ship LNG transfer. Furthermore, it is envisaged that greater LNG transfer rates than those typically used for refueling the current gas fueled ship fleet will be required and this will necessitate the deployment of new and additional bunkering equipment and operational practices.

Accordingly, this Guide has been developed in order to outline the requirements for the design, construction and survey of liquefied gas carriers and barges fitted with dedicated LNG transfer arrangements and intended to operate in regular LNG bunkering service. While application of this Guide is optional, the LNG bunkering systems are to be designed, constructed, and tested in accordance with the requirements of this Guide when the optional **LNG Bunkering** notation is requested. Among other safety topics, the Guide addresses bunkering station safety; lifting and hose handling equipment; control, monitoring and ESD safety systems; and emergency release systems.

The optional **LNG Bunkering** notation detailed under 1/7.1 of this Guide may be assigned when such vessels are verified to meet the requirements of this Guide. This Guide is focused on the requirements for bunkering of LNG, the remainder of the vessel is to comply with the applicable edition of the ABS Rules.

A list of relevant documentation, regulations, standards and guides is included as Appendix 1 to this Guide.

This Guide becomes effective on the first day of the month of publication.

Users are advised to check periodically on the ABS website www.eagle.org to verify that this version of this Guide is the most current.

We welcome your feedback. Comments or suggestions can be sent electronically by email to rsd@eagle.org.

GUIDE FOR

LNG BUNKERING

CONTENTS

SECTION 1 General

1 Scope and Application

Application of this Guide is optional. However, compliance with requirements of the Guide is compulsory when seeking the optional **LNG Bunkering** notation, see 1/7.1. This Guide has been developed to outline the requirements for the design, construction, and survey of liquefied gas carriers and barges fitted with dedicated LNG transfer arrangements and intended to operate in regular LNG bunkering service. This Guide is focused on the requirements for bunkering of LNG, the remainder of the vessel is to comply with the applicable edition of the ABS Rules.

Users of this Guide are advised that the process of bunkering LNG involves a number of interested parties, including a vessel's flag Administration, national regulatory bodies and port authorities. Therefore proposals are subject to review and approval by the applicable authorities with respect to installed safety equipment, operational practices, crew training, bunkering safety distances, simultaneous operations, etc. Accordingly ship designers, shipyards, ship owners/operators and other interested stakeholders are encouraged to determine the full applicable requirements and obtain the necessary approvals as early as possible in any LNG bunkering new construction or conversion project.

3 Objectives

The objective of this Guide is to provide criteria for the design, construction, installation, survey and operation of LNG transfer arrangements, associated machinery, equipment and systems in order to minimize risks to the vessel, crew and the environment. Detailed requirements are provided to achieve this objective in accordance with the following key principles and requirements:

- Vessel construction is in accordance with the ABS *Rules for Building and Classing Steel Vessels (Steel Vessel Rules)*, ABS *Rules for Building and Classing Steel Vessels Under 90 Meters (295 feet) in Length (Under 90m Rules)*, ABS *Rules for Building and Classing Steel Barges (Barge Rules)* or the ABS *Rules for Building and Classing Steel Vessels for Service on Rivers and Intracoastal Waterways (River Rules)*, as applicable.
- LNG containment systems are designed in accordance with Chapter 4 of the IGC Code, as incorporated by Section 5C-8-4 of the *Steel Vessel Rules*.
- LNG tank pressure, temperature and loading/filling limits are maintained within the design limits of the tank at all times.
- Means are provided to evacuate, purge and gas free the LNG tanks.
- LNG tanks are in a protected location.
- LNG containment spaces, bunkering stations and machinery spaces containing LNG or gas processing equipment are located and arranged such that the risk of any release of liquid or vapor will be minimized. Arrangements are provided for safe access during operations and inspections.
- LNG piping, systems and arrangements provide safe handling of liquid and vapor under all operating conditions. Means are provided to inert and gas free piping and systems.
- Bunker stations are arranged to provide compatible LNG transfer.
- Automation, instrumentation, monitoring and control systems are provided to minimize the risks with carriage, distibution and bunkering of LNG.
- Operation and maintenance manuals are provided for all LNG containment and transfer equipment and systems covering operation, maintenance and repair procedures.

5 Definitions

5.1 Breakaway Coupling

Breakaway Coupling means an LNG bunkering line coupling designed to separate at a pre-determined load to prevent damage to installed LNG transfer equipment; typically incorporates a dry-break feature to avoid unwanted LNG release.

5.3 Bunkering

Bunkering means the transfer of fuel to a vessel or facility in the form of LNG or traditional marine fuels such as residual or distillate fuel oils.

5.5 Cargo Machinery Space

Cargo Machinery Space are the spaces where cargo compressors, pumps or processing units are located.

5.7 Dual Fuel Diesel Engine

Dual Fuel Diesel Engine is a diesel engine that can burn natural gas as fuel with liquid (pilot) fuel and also have the capability of running on liquid fuel only.

5.9 Enclosed Space

Enclosed Space means any space within which, in the absence of artificial ventilation, the ventilation will be limited and any explosive atmosphere will not be dispersed naturally. See also 4-8-4/27 of the *Steel Vessel Rules*.

5.11 Emergency Release Coupling (ERC)

ERC means emergency release coupling; typically incorporates a dry-break feature to avoid unwanted LNG release. May be termed *PERC* for powered emergency release coupling.

5.13 Emergency Shutdown (ESD)

ESD means emergency shutdown. ESD (otherwise known as ESD-1) is the emergency shutdown of the LNG transfer in a controlled manner. ESD-2 is the automatic activation of the Emergency Release System. For further information refer to SIGTTO “ESD Arrangements and Linked Ship/Shore Systems for Gas Carriers”.

5.15 Hazardous Area

Hazardous Area means an area in which an explosive gas atmosphere is, or may be expected to be, present in quantities such as to require special precautions for the construction, installation and use of equipment. See also 4-1-1/1.9.4 and 4-8-4/27 of the *Steel Vessel Rules*.

5.17 Non-Hazardous Area

Non-hazardous Area means an area in which an explosive gas atmosphere is not expected to be present in quantities such as to require special precautions for the construction, installation and use of equipment.

5.19 International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk (IGC Code)

IGC Code means the International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk, as amended.

5.21 Lower Explosive Limit (LEL)

LEL means the lowest concentration (percentage) of a gas or a vapor in air capable of producing a flash of fire in presence of an ignition source.

5.23 Liquid Cargo Cooling

A *Liquid Cargo Cooling* system is a system that lowers the LNG temperature by an indirect cooling system, for example, by coolant circulated through coils fitted either inside the cargo tank, onto the external surface of the cargo tank or by a remote system.

5.25 Liquefied Natural Gas (LNG)

LNG means liquefied natural gas.

5.27 LNG Containment System

LNG Containment System is the arrangement for containment of LNG including, as applicable, a primary and secondary barrier, associated insulation and any intervening spaces, and adjacent structure if necessary for the support of those elements. The spaces around the LNG containment system are defined as:

5.27.1 Hold Space

Hold Space is the space enclosed by the vessel's structure in which a LNG containment system is located.

5.27.2 Interbarrier Space

Interbarrier Space is the space between a primary and secondary barrier, whether or not completely or partially occupied by insulation or other material.

5.27.3 Insulation Space

Insulation Space is the space, which may or may not be an interbarrier space, occupied wholly or in part by insulation.

5.29 LNG Spraying

LNG Spraying means the process whereby LNG liquid is sprayed into the top of a LNG tank to cool the vapor phase and the tank and thereby reduce pressure in the tank.

5.31 Maximum Allowable Relief Valve Setting (MARVS)

MARVS means Maximum Allowable Relief Valve setting.

5.33 Natural Gas

Natural Gas (dry) is defined as gas without condensation at common operating pressures and temperatures where the predominant component is methane with some ethane and small amounts of heavier hydrocarbons (mainly propane and butane). The gas composition can vary depending on the source of natural gas and the processing of the gas.

5.35 Primary Barrier

Primary Barrier is the inner element designed to contain the LNG when the LNG containment system includes two boundaries.

5.37 Purging

Purging is the process of introducing an inert gas, such as nitrogen, into a LNG tank, hose or piping system already in the inert condition with the objective of further reducing the existing oxygen content and/or reducing the existing hydrocarbon gas content to a level below which combustion cannot be supported if air is subsequently introduced into the system.

5.39 Recognized Standard

A *Recognized Standard* is an international or national specification or criteria acceptable to ABS.

5.41 Re-Liquefaction Unit

A *Re-liquefaction Unit* is a system used for taking the boil-off gas from LNG tanks and condensing it in a refrigeration system. LNG is then returned to the tanks.

5.43 Rules

Rules means the applicable edition of the ABS *Steel Vessel Rules*, *Barge Rules*, *River Rules*, *Under 90m Rules*, etc.

5.45 Secondary Barrier

Secondary Barrier is the liquid-resisting outer element of a LNG containment system designed to afford temporary containment of any envisaged leakage of LNG through the primary barrier and to prevent the lowering of the temperature of the vessel's structure to an unsafe level.

7 Classification Notations

7.1 LNG Bunkering

When a liquefied gas carrier or barge is arranged for regular LNG bunkering service, the optional **LNG Bunkering** notation may be assigned. For application of the notation the arrangements and LNG bunkering systems are to be designed, constructed, and tested in accordance with the requirements of this Guide.

Example – ✠ A1, **Liquefied Gas Carrier, LNG Bunkering,** Ⓔ, ✠ AMS….

7.3 Vapor Return System

Where a vessel assigned the **LNG Bunkering** notation incorporates an optional Vapor Return System, the **VRS** notation may be assigned. The Vapor Return System is to be designed, constructed and tested in accordance with 2/5.5.2 of this Guide.

7.5 Associated Notations

Where a vessel assigned the **LNG Bunkering** notation incorporates additional equipment such as a Re-Liquefaction Unit, Gas Combustion Unit or Dual Fuel Diesel Engine designed, constructed and tested in accordance with the applicable requirements of the applicable sections of Part 5C, Chapter 8 of the *Steel Vessel Rules*, the additional notations **RELIQ**, **GCU** or **DFD** may be assigned.

9 Materials of Construction

Materials in general are to comply with the requirements of the ABS *Rules for Materials and Welding (Part 2).*

Materials used for piping and other components in contact with cryogenic liquids or gases, including materials used in potential leakage locations such as gratings, spray shields, drip trays, etc., are to be in compliance with Section 5C-8-6 of the *Steel Vessel Rules*.

11 Operating and Maintenance Instruction Manuals

Detailed instruction manuals are to be provided onboard covering the operations, safety and emergency procedures, maintenance requirements, personal protective equipment and occupational health hazards relevant to the containment and distribution of LNG.

The manuals are to include, but not be limited to, the regular test and maintenance procedures for the monitoring systems, gas detection systems, safety shut-off systems and the integrity of backup systems together with identification of the relevant responsible parties.

In addition, there is further guidance regarding the contents of the LNG bunkering operating and maintenance manuals in Subsection 3/5 of this Guide and Section 5C-8-18 of the *Steel Vessel Rules*. Inspection and maintenance of certified safe electrical equipment is to be in accordance with the applicable requirements of Section 9 and 10 of IEC 60092-502.

13 Alternatives

Equipment, components, and systems for which there are specific requirements in this Guide, or its associated references, may incorporate alternative arrangements or comply with the requirements of alternative recognized standards, in lieu of the requirements in this Guide. This, however, is subject to such alternative arrangements or standards being determined by ABS as being not less effective than the overall safety requirements of this Guide or associated references. Where applicable, requirements may be imposed by ABS in addition to those contained in the alternative arrangements or standards so that the intent of this Guide is met. In all cases, the equipment, component or system is subject to design review, survey during construction, tests and trials, as applicable, by ABS for purposes of verification of its compliance with the alternative arrangements or standards. The verification process is to be to the extent as intended by this Guide.

15 Certification

Design review, survey, testing, and the issuance of reports or certificates constitute the certification of machinery, equipment and systems; see also 4-1-1/3 of the *Steel Vessel Rules*. There is guidance on the certification requirements for LNG bunkering machinery, equipment and systems in Section 3 of this Guide. The applicable edition of the ABS *Rules* is to be used in association with this Guide.

SECTION 2 Vessel Arrangements and System Design

1 General

While this Guide is focused on the requirements for bunkering of LNG, the remainder of the vessel is to comply with the applicable edition of the ABS *Rules.* This Section details the general requirements for vessel arrangements and system design of liquefied gas carriers or barges intended to operate in regular LNG bunkering service and applying the **LNG Bunkering** notation.

3 Plans and Data to be Submitted

Plans and specifications covering the vessel arrangements are to be submitted and are, as applicable, to include:

- General arrangement
- LNG containment arrangements
- LNG bunkering station arrangements
- BOG management arrangements
- Cargo machinery space arrangements
- Cargo piping arrangements
- Hazardous area classification plan
- Vent mast and venting arrangements

5 BOG Management/Utilization, LNG Temperature Control, LNG Tank Loading and Vapor Return Management

5.1 Utilization or Management of Boil-off Gas and LNG Temperature Control

Unless the LNG tanks are designed to withstand the full gauge vapor pressure of the gas under conditions of the upper ambient design temperatures, as specified in 5C-8-7/2 of the *Steel Vessel Rules*, means are to be provided to maintain the tank pressure below the MARVS by consuming or managing the natural LNG boil-off at all times, including while in port, maneuvering or standing by. Systems and arrangements that may be used for this purpose include one or a combination of the following methods:

i) Pressure accumulation, whereby the LNG is allowed to warm up and increase the tank pressure. The tank insulation, design pressure or both are to be adequate to provide for a suitable margin for the operating time and agreed cargo loading temperatures involved.

ii) A cargo vapor re-liquefaction system. Re-Liquefaction Units are to be designed, constructed and tested in accordance with Appendix 5C-8-A5 of the *Steel Vessel Rules*. BOG compressors are to be in accordance with 5C-8-A5/3.1 and 5C-8-A5/5.5 of the *Steel Vessel Rules*.

iii) The burning of natural or forced BOG in an approved consumer such as a Gas Combustion Unit, dual fuel diesel engine or other approved combustion unit. Gas Combustion Units are to be designed, constructed and tested in accordance with Appendix 5C-8-A6 of the *Steel Vessel Rules*.

Dual fuel diesel engines are to be designed, constructed and tested in accordance with Appendix 5C-8-A7 of the *Steel Vessel Rules*. Dual fuel diesel engines may be considered a primary means of BOG management and utilized as part of the BOG management strategy, when available under all operating conditions.

iv) Liquid cargo cooling. Liquid cargo cooling systems are to be designed, constructed and tested in accordance with the applicable requirements for Re-liquefaction Units in Appendix 5C-8-A5 of the *Steel Vessel Rules*.

5.3 LNG Tank Loading

LNG containment systems are to be designed in accordance with Section 5C-8-4 of the *Steel Vessel Rules.* The sloshing loads requirements detailed under 5C-8-4/14.3 are to be assessed for all partial loading conditions expected in LNG bunkering service such that there are no significant operational limits on partial loading. Such operational limits are to be detailed within the LNG Bunkering Operations Manual referenced under Section 3/5 of this Guide. Any operational limits from partial loading that would affect the vessels ability for unrestricted service will be subject to special consideration.

5.5 Vapor Return System

It is envisaged that a number of different bunkering techniques will be developed that are dependent on the installed LNG tank types, installed equipment, flow rates, receiving facility arrangements, etc. These bunkering operations may use differential pressure or pumped loading combined with LNG spraying for control of LNG tank temperatures and pressures together with the use of re-liquefaction of cargo vapors, cargo cooling, pressure accumulation or consumption of the excess vapor. Therefore, the installed equipment and arrangements will vary on a case-by-case basis. The intent of this Guide is not to exclude any established or novel arrangements.

5.5.1 Vapor Return Connection

LNG bunkering vessels are to be arranged with a vapor return connection on the manifold(s) as per 5C-8-5/6.3 of the *Steel Vessel Rules*.

5.5.2 Optional Vapor Return System

Vessels may also optionally be arranged with a vapor return system designed to manage the maximum vapor return flows without over pressurizing the LNG tanks. Where fitted, the vapor return system is to be designed, constructed and tested in accordance with this Guide; see 1/7.3 of this Guide for the **VRS** notation. See also Subsection 3/5, 3/7.7iii) and 3/7.9 of this Guide for the operational and design requirements for managing vapor return in LNG bunkering operations.

7 Cargo Machinery Space

Cargo machinery spaces are to be arranged in accordance with 5C-8-3/3 of the *Steel Vessel Rules.*

9 LNG Bunker Station

i) The bunkering station(s) and manifold(s) are to be located on the open deck so that sufficient natural ventilation is provided.

ii) The bunker manifold and connections are to be visible from the bunkering control station and cargo control station or bridge, as applicable. Remote video arrangements may be accepted where direct line of sight from the aforementioned locations is not possible.

11 Personnel Protection

Suitable personnel protective equipment in accordance with 5C-8-11/6 and 5C-8-14/1 through 5C-8-14/3 of the *Steel Vessel Rules* is to be provided onboard.

SECTION 3 LNG Bunkering Systems

1 General

The purpose of this Section is to define the on-board requirements for LNG bunkering systems to enable effective transfer of LNG from the LNG bunkering vessel to the receiving vessel or facility and to minimize risks to the vessel, crew and the environment.

The relevant aspects of related standards such as ISO 28460, EN 1473, EN 1474, etc., and the ISO Technical Specification ISO/TS 18683:2015 "Guidelines for systems and installations for supply of LNG as fuel to ships" may be used in addition to the Guide requirements.

3 Plans and Data to be Submitted

Plans and specifications covering the LNG bunkering system with all of the accessories are to be submitted and are, as applicable, to include:

- General arrangement of the LNG bunkering system including location of the gas detectors, electrical equipment and lighting
- Detailed drawings and specifications of the bunkering station(s), manifolds, valves, couplings, transfer arms, hoses, transfer system working envelope, lifting and hose handling cranes, additional hull protection and control stations
- Calculations for the transfer system foundations referenced by 3/9.5v) of this Guide
- LNG piping systems including details of piping and associated components, design pressures, temperatures and insulation
- Purging equipment and arrangements including oxygen concentration calculation as referenced by 3/13vi) of this Guide
- Vapor return system arrangements and procedures including capacity calculations referenced by 3/7.9ii) of this Guide
- Material specifications for LNG manifolds, valves and associated components
- Calculations for the LNG manifold design loads referenced by 3/7.3 of this Guide
- Fabrication procedures, weld procedures, stress relieving and non-destructive testing plans
- Ventilation system
- Fixed gas detection and alarm systems, and associated shut-off and shutdown systems
- Descriptions and schematic diagrams for control and monitoring systems including set points for abnormal conditions
- Details of all electrical equipment in the bunkering and control stations
- Equipotential bonding and insulating flange arrangements
- Failure Modes and Effects Analysis (FMEA) to determine possible failures and their effects in the operation of the LNG bunkering control system
- Emergency shutdown (ESD) arrangements and ESD flow chart together with communication arrangements

- Specifications and details of the emergency release system including emergency release couplings and breakaway couplings
- Operating and maintenance instruction manuals
- Testing procedures during sea/gas trials

5 LNG Bunkering Operation Manuals

In accordance with Subsection 1/11 of this Guide, detailed instruction manuals are to be provided onboard containing the operations, safety and emergency procedures, maintenance requirements and occupational health hazards relevant to LNG bunkering operations.

The manuals are to include, but not be limited to, the instructions for ship-ship compatibility verification, hazardous area evaluation, connecting, leak testing, inerting, gassing up, cooling down, pumping LNG, LNG spraying, vapor return management, draining, purging, disconnecting, emergency shutdown procedures, bunker manifold load limits, any limitation to personnel engaged in bunkering operations, the identification of vessel specific bunkering limitations, appropriate personal protective equipment, flowcharts and ESD valve characteristics.

7 Bunker Station

7.1 General

i) The bunkering system is to be arranged so that no gas is discharged to the environment during normal LNG bunker transfer operations.

ii) Means are to be provided to relieve residual pressure and for draining the liquid from the bunkering lines at bunkering completion.

iii) Bunkering lines are to be arranged for inerting and gas freeing.

iv) Suitable arrangements are to be provided for the collection of any spilled LNG. Accordingly drip trays are to be fitted below LNG bunkering connections and where leakage may occur. The drip trays are to be made of stainless steel or another material suitable for the containment of LNG. Drip trays are to be provided with a means of draining rainwater, seawater, etc., at periodic intervals.

v) The bunker station area, manifold, transfer connections and control station are to be adequately illuminated.

vi) Cargo sampling connections in accordance with 5C-8-5/6.5 of the *Steel Vessel Rules* are to be provided.

7.3 Manifold Design

i) The bunkering manifold(s) is/are to be designed to withstand the external loads during bunkering and to consider the applicable emergency release arrangements.

ii) The maximum permitted external loads are to be detailed in the operation manuals referenced by 3/5 of this Guide and to be clearly displayed in the vicinity of the manifold. .

7.5 Additional Hull Protection

i) A water distribution system, or equivalent, is to be fitted below the bunker manifold(s) connections and associated transfer system to provide a low pressure water curtain for additional protection of the hull and vessel's side structure within the operating envelope of the bunker transfer system.

ii) The water curtain system may be part of the fire main system provided the required fire pump capacity and pressure are sufficient for operation of the required numbers of hydrants, hoses and water spray systems simultaneously and the water curtain system is fitted with isolating valves.

7.7 Manifold Connections

i) All pipelines, hoses or components which may be isolated in a liquid full condition, or where liquid may accumulate, are to be protected by relief valves. The outlet from these pressure relief valves is to be led to the LNG tanks. Alternatively, they may discharge to the vent mast if means are provided to detect and dispose of any liquid cargo which may flow into the vent system.

ii) A manually operated stop valve and a remote operated shutdown valve in series, or a combined manually operated and remote valve, are to be fitted in every bunkering line close to the manifold connecting point. The remote valve is to be operable from the control location for bunkering operations and/or another safe location. The remote valve may also be the ESD valve required by 3/17.5vi) of this Guide.

iii) Provision for LNG vapor return connections are to be provided at the bunker manifold(s). See also 2/5.5.1 of this Guide

iv) Strainers are to be fitted to protect control valves and systems.

v) Manifold connections not being used for bunker transfer operations are to be blanked with blind flanges rated for the design pressure of the pipeline system.

7.9 Vapor Return System, VRS Notation

i) The vapor return system, as applicable, is to be capable of accepting the maximum volumetric vapor flow and excess vapor required to meet the loading rate without over pressurizing the LNG tank(s).

ii) Calculations for the maximum vapor return flow rate, pressure and corresponding tank pressure management details, are to be submitted for verification purposes and summary information detailed in the operation manuals referenced by Subsection 3/5 of this Guide.

iii) The vapor return piping system and equipment are to be adequately separated and protected to avoid over pressurizing the LNG tank(s).

iv) Control and monitoring of the vapor return system is to be integrated into the control and monitoring system required by Subsection 3/17 of this Guide and to be capable of varying LNG delivery rates in consideration of the monitored vapor return system parameters.

v) An ESD valve is to be fitted to the vapor return connection and incorporated within the ESD system required by 3/17.5 of this Guide.

vi) The vapor return system is to be included within the scope of the FMEA required by 3/17.1ii) of this Guide.

7.11 Electrical Bonding/Isolation

i) Electrical isolation of the transfer system is to be achieved by the installation of insulating flanges at one end of the connection hoses for all transfer or vapor return connections.

Insulation flange specifications and arrangements are to be in accordance with recognized industry standards such as ISGOTT “International Safety Guide for Oil Tankers and Terminals” and SIGTTO “LNG Ship to Ship Transfer Guide for Petroleum, Chemicals and Liquefied Gases”.

ii) The bonding connection is to be located away from the manifold area in a non-hazardous area.

7.13 Fire Extinguishing Systems

i) A water spray system in accordance with 5C-8-11/3 of the *Steel Vessel Rules* is to be provided for each bunker manifold area.

ii) A dry chemical powder fire extinguishing system in accordance with 5C-8-11/4 of the *Steel Vessel Rules* is to be provided for each bunker manifold area.

9 LNG Bunker Delivery

9.1 General

It is envisaged that a number of different bunkering techniques will be developed that are dependent on the installed LNG tank types and equipment on both bunkering and receiving vessel. This Subsection details the requirements for the bunkering vessel LNG delivery equipment and systems.

9.3 LNG Pumps

i) Material used in the design of the LNG pumps is to be in accordance with 5C-8-6/2.2 of the *Steel Vessel Rules* except that witnessed material testing is not required.

ii) Each size and type of pump is to be prototype tested in accordance with 5C-8-5/13.1.3(a) of the *Steel Vessel Rules*.

iii) All LNG pumps are to be hydrostatic tested in the presence of the Surveyor in accordance with 5C-8-5/13.1.3(b) of the *Steel Vessel Rules*.

9.5 Hoses, Bunker Transfer Systems, Lifting and Hose Handling Equipment

i) Hoses used in LNG bunker transfer systems are to be in accordance with 5C-8-5/11.7 of the *Steel Vessel Rules*.

ii) Cranes, loose gear, supports, etc., are to be provided for hose handling and bunkering operations and are to be designed, arranged and surveyed in accordance with the applicable requirements of the ABS *Guide for Certification of Lifting Appliances*.

iii) Hose supports or cradles are to be used where necessary to keep hose bends within the design limits, as per manufacturer's recommendations.

iv) Fixed LNG bunker transfer systems are to be designed and tested in accordance with recognized standards such as EN1474-3 (offshore transfer system) and/or EN1474-2 (transfer hoses). LNG bunker transfer systems and hoses are to be arranged to provide sufficient flexibility over the range of expected relative vessel motions.

v) Calculations for the transfer system foundations, as applicable, together with details of any hose support arrangements and working envelope are to be submitted.

9.7 Emergency Release System

i) The LNG bunker delivery system is to be capable of being rapidly disconnected by the use of dry-break emergency release couplings (ERC) or breakaway couplings or similar protective devices. Breakaway couplings are to operate when exceeding design loads in any direction.

ii) This emergency release system is to be designed to prevent damage to the bunkering system components (in particular the risk of surge in the system is to be considered), prevent damage to the ship's structure, transfer arms or hose handling cranes, be operable under ice formation conditions prevalent during LNG bunkering, prevent spark generation and to operate with minimum release of LNG when activated. Refer also to the requirements for the Emergency Shutdown (ESD) System detailed under 3/17.5 of this Guide.

iii) The ERC is to be capable of operation and releasing all bunker transfer lines at all times including immediately following a ship blackout condition.

iv) Where the ERC incorporates powered release capability, the system may be connected to the ESD system but is to be only operable under ESD-2* conditions. However, manual activation of this powered emergency release coupling (PERC) is still to be possible. Manual or automatic activation of the PERC is to be inhibited without prior operation of the ESD system. The release system is to incorporate suitable means to prevent accidental operation. Manual or automatic operation of the PERC is to be indicated by the control and monitoring system referenced by 3/17.3 of this Guide.

* As applicable, reference should be made to the requirements under relevant standards such as SIGTTO "ESD Arrangements and Linked Ship/Shore Systems for Gas Carriers".

9.9 Communication Equipment

i) Effective internal communication equipment is to be provided between the bunker control station and cargo control station or bridge of the LNG bunkering vessel, as applicable.

ii) Two means of voice communication between the LNG bunkering vessel and the receiving ship are to be provided (i.e., main and back up voice communications).

iii) Portable communication equipment is to be of a certified safe type.

11 LNG Piping System

Installed LNG and gas piping is to be in accordance with Section 5C-8-5 of the *Steel Vessel Rules*.

13 Inerting System

i) An arrangement for inerting LNG bunkering lines, supply lines and, as applicable, the receiving vessel, with nitrogen or other suitable inert gas is to be provided. The dewpoint of the gas is to be taken into consideration.

ii) Where the inert gas is produced onboard then the equipment and arrangements are to be in accordance with 5C-8-9/5 of the *Steel Vessel Rules*.

iii) Inert gas pressure vessels are to be in accordance with Section 4-4-1 of the *Steel Vessel Rules*.

iv) Where an inert gas generator or inert gas pressure vessels are located in a dedicated enclosed space then the space is to be equipped with a mechanical forced ventilation system providing a minimum of 6 air changes per hour.

v) Inert gas piping is not to pass through accommodation spaces, service spaces or control stations.

vi) Inert gas generators and storage vessels may be located in machinery spaces provided the space is equipped with oxygen deficiency monitoring equipment and a calculation is submitted to demonstrate that the oxygen concentration will not be below 19% by volume, even if the total quantity of inert gas is accidently released in the space.

15 Gas Detection

Gas detection equipment is to be in accordance with 5C-8-13/6 of the *Steel Vessel Rules* and in addition is to have a permanently installed system of gas detection and audible and visual alarms in the LNG bunkering manifold area. Monitoring and safety shutdowns are to be in accordance with Section 3, Table 1 of this Guide.

17 Control, Monitoring and ESD Safety Systems

17.1 General

i) The bunkering control and monitoring system may be connected to an integrated control system or be a stand-alone system.

ii) A Failure Modes Effects Analysis (FMEA) is to be carried out for the bunkering control system identifying component criticality.

iii) The bunkering control and monitoring system design is to meet the single failure criteria (i.e., no single control system component failure or single fault condition is to lead to loss of control of bunkering operations or result in an unsafe situation). For the purpose of the FMEA, any excessive transient surge pressure is to be treated as a single fault.

For further guidance on implementing FMEA requirements for classification purposes, refer to the ABS *Guidance Notes on Failure Mode and Effects Analysis (FMEA) for Classification*.

iv) Control of bunkering is to be possible from a safe location in regard to bunkering operations.

17.3 Control and Monitoring System

i) Automatic control, alarm and safety functions are to be provided to maintain operations within preset parameters for all LNG bunkering operations. Operation outside the preset parameters or activation of the safety functions is to provide audible and visual alarms in the bunkering control location.

ii) The temperatures, pressures, flow rates and functions of the LNG bunkering system are to be controlled as follows:

a) A control and monitoring system is to be provided in the bunkering control location.

b) The design of the control system is to be such as to identify faults in the equipment, as well as the process system. The control and monitoring systems are to comply with the requirements of 4-9-2/3.1 of the *Steel Vessel Rules*, as applicable.

c) Indications of parameters necessary for the safe and effective operation of the process are to be provided, as per Section 3, Table 1 of this Guide.

d) All computer-based control systems are to comply with the applicable requirements of Section 4-9-3 of the *Steel Vessel Rules.*

iii) At the bunkering control location the tank pressure and tank level are to be monitored. Overfill alarm and automatic shutdown are also to be indicated at this location.

iv) Local reading manifold pressure gauges and transmitters with isolation valves are to be fitted to indicate the pressure between stop valves and hose connections.

17.5 ESD System

i) The LNG bunker transfer system is to be fitted with a linked and compatible emergency shutdown (ESD) system, which is independent from the installed control and monitoring system, to stop bunker flow in the event of an emergency. The ESD system is to be operational during bunker operations and is to be controllable from both the LNG bunker vessel and the receiving ship to enable a safe shut down in the event of an emergency during bunker delivery. The ESD actions are to be coordinated. The bunker transfer ESD system is to be part of the LNG bunkering vessel ESD system.

The ESD function is the controlled cessation of bunker liquid/vapor transfer to or from the vessel upon detection of an unsafe condition. The bunkering process is to be stopped immediately and thereafter LNG will not be transferred. The bunker transfer system of the bunkering vessel as well as that of the receiving vessel will be transferred to a safe static status so that any remedial action can be taken.

The design of the ESD system it to be such as to identify faults in the system and it is to be possible to passively test the ESD system prior to commencing LNG transfer.

Refer also to the requirements for the Emergency Release System detailed under 3/9.7 of this Guide.

ii) The ESD link is to be established as a pre-requisite to the commencement of LNG transfer operations. Arrangements are to be provided such that transfer of LNG is only to be possible after having established this ESD communication link.

This ESD link is to be fail-safe. The purpose of the ship/shore or ship/ship link is to transmit, without delay, a signal from one party to the other.

iii) The design of the ESD system is to consider the potential generation of surge pressures within bunker transfer pipe work.

iv) The ESD system is to be activated by the manual and automatic inputs listed in Section 3, Table 1 of this Guide. Any additional inputs are only to be included in the ESD system if it can be shown their inclusion does not reduce the integrity and reliability of the system overall.

v) A functional flow chart of the ESD system and related systems is to be provided at the LNG bunkering control station and cargo control station or bridge, as applicable.

vi) One ESD valve is to be provided at each manifold connection. The ESD valve may also be the remote operated valve required by 3/7.7ii) of this Guide.

vii) ESD valves are to be arranged in accordance with 5C-8-18/10.2.1 of the *Steel Vessel Rules*.

viii) As a minimum, the ESD system is to be capable of manual operation by a single control at the cargo control station or bridge, the safe control position required by 3/17.1iv) of this Guide and at least two strategic positions around the bunker delivery area.

The monitoring and safety shutdowns for the LNG bunkering system are to be in accordance with Section 3, Table 1 of this Guide.

19 Surveys During Construction

19.1 General

This Subsection pertains to surveys during fabrication at the manufacturer's facility and installation and testing of LNG bunkering components, piping and associated systems onboard the vessel. For surveys at the manufacturer's facility, the scope of the survey will be confined to only those items that are supplied by the manufacturer.

19.3 Surveys at Manufacturer's Facility

Construction and testing of LNG bunkering components and associated piping is to be in accordance with 5C-8-5/8, 5C-8-5/9, 5C-8-5/13 and 5C-8-6/5of the *Steel Vessel Rules*, as applicable.

Certification of the complete LNG bunkering system cannot be accepted based solely on the ABS Type Approval Program, and therefore ABS Surveyor's attendance is required during fabrication for unit certification. However, component parts of the unit can be certified in accordance with the ABS Product Quality Assurance (PQA) Certification system outlined in Appendix 1-1-A3 of the ABS *Rules for Conditions of Classification (Part 1)*.

When Surveyor's attendance at the shop of the manufacturer and at the assembly site is required by the applicable Rules or this Guide, the manufactured/assembled system components will be verified to be satisfactorily in compliance with the aforementioned Rules or Guides. Surveyor's attendance is required typically to:

i) Confirm that the facility to manufacture, fabricate or repair LNG bunkering systems or its components does have and maintains a quality-control program effectively covering design, procurement, manufacturing and testing, as applicable, and meeting the requirements of a recognized standard applicable to their product.

ii) Qualify or verify welder's qualifications, welding procedure specifications and corresponding weld procedure qualification records to the extent deemed necessary by the attending Surveyor.

iii) Verify material certificates/documentations, particularly for materials of piping, main pressure retaining parts of valves, including safety valves that have flanged or threaded ends or other specialty fittings. Witness of material testing where required by the *Steel Vessel Rules*.

iv) Survey final weldments.

v) Witness, as far as deemed necessary and in accordance with the approved fabrication procedures, weld nondestructive examination tests and to review records of nondestructive examinations.

vi) Witness pressure and/or proof-load testing of equipment components and as a unit, as applicable and as called for in the approved fabrication procedures and test plans.

vii) Witness testing of subassemblies and completed units as called for in the fabrication procedures.

viii) Verify all certified safe systems, motor controllers, consoles and instrumentation and control panels are in compliance with approved drawings.

ix) Carry out other inspections and to witness the final Factory Acceptance Test (FAT) as agreed upon during prefabrication meeting.

19.5 Surveys During Installation

The following surveys are to be carried out to the satisfaction of the attending Surveyor on the LNG bunkering components, piping and associated systems during installation and testing:

i) Piping systems are to be visually examined and pressure-tested, as required by 5C-8-5/13.2 of the *Steel Vessel Rules.*

ii) Electrical wiring, connections and bonding arrangements are to be in accordance with Part 4, Chapter 8 of the *Steel Vessel Rules* and checked for continuity and proper workmanship.

iii) Instrumentation is to be tested to confirm proper operation as per its predetermined set points.

iv) Pressure relief and safety valves are to be tested.

v) Control system, alarms, safety functions and shutdowns are to be tested for proper operation, as noted in Section 3, Table 1 of this Guide.

vi) The LNG bunkering systems are to be checked for proper operation.

vii) Availability of operation manuals onboard to be verified.

19.7 Surveys During Trials

During the initial cryogenic/gas trials, the LNG bunkering components and associated systems are to be confirmed for satisfactory operation, including associated controls, alarms and shutdowns. The tests are to be conducted in accordance with the approved testing procedure during gas trials.

TABLE 1
Monitoring and Safety System Functions during LNG Bunkering Operations

Monitored Parameter[1]	*Alarm*	*Activation of ESD System*[3]
Loss of ventilation in LNG cargo machinery space	X	
Gas detection in, LNG cargo machinery space above 30% LEL	X	
Gas detection in LNG cargo machinery space above 60% LEL	X	X
Low oxygen concentration alarm in inert gas storage space	X	
High or low liquid level in LNG tank	X	
High-high liquid level in LNG tank	X	X
High or low pressure in LNG tank	X	
High-high pressure in LNG tank	X	X
High pressure at bunker manifold	X	X
High LNG delivery flow rate	X	
High pressure in vapor return line	X	
High-high pressure in vapor return line	X	X
Gas detection at bunker manifold area above 30% LEL	X	
Gas detection at bunker manifold area above 60% LEL	X	X
High or low temperature at LNG pump inlet	X	
High or low pressure at LNG pump discharge	X	
Transfer arm limit switches out of range	X	
Activation of the Emergency Release System	X	X
Manual ESD shutdowns	X	X
Manual or automatic ESD signal from LNG receiving vessel or facility	X	X
Loss of ESD valve motive power [2]	X	X
Fire detection onboard	X	X

Notes:

1 As applicable to the specific vessel arrangements.

2 ESD valves are to be of fail closed type as referenced by 3/17.5vii) of this Guide.

3 As referenced by 3/17.5iv) of this Guide.

TABLE 2
Certification of LNG Bunkering Systems at Manufacturer's Facility

This Table has been prepared for guidance only and annotated to agree with the *Steel Vessel Rules*, IMO IGC Code and other IMO requirements. The list is not to be considered exhaustive; should additional equipment not listed be fitted onboard, same will be subject to special consideration for compliance with the *Steel Vessel Rules*, the IGC Code and other IMO requirements. This list is not to be considered as substitutive or integrative of the content of the *Steel Vessel Rules* and/or other applicable Regulations. In case of conflict between the content of this list and the applicable *Steel Vessel Rules* and regulations, the latter are to be considered applicable. See also 4-1-1/3 of the *Steel Vessel Rules.*

Code	*Explanation*
DR	*Design Review* – Design review required.
MT	*Material Testing* – Material testing is to be witnessed by the Surveyor.
MS	*Manufacture Survey* – Product is to be surveyed during fabrication stages by the Surveyor.
FS	*Final Survey* – Finished product is to be subject to final hydrostatic, nondestructive, operational testing, or any other required tests, and witnessed by the Surveyor at manufacturer's facility.

Equipment	*DR*	*MT*	*MS*	*FS*
Bunkering manifolds	X	X	X	X
Manifold valves, ESD valves	X	X	X	X
LNG bunker transfer systems	X	X	X	X
Emergency Release Systems	X			X
LNG pumps	X			X
Control and monitoring system	X			
Gas detection system	X			
ESD system	X			

SECTION 4 Surveys After Construction and Maintenance of Class

1 General

This Section pertains to periodical surveys after construction for the equipment described in Sections 1 to 3 of this Guide.

1.1 Definitions

For definitions related to the surveys of equipment covered by this Guide, see Section 1 of this Guide and 7-1-1/3 of the ABS *Rules for Survey After Construction (Part 7).*

1.3 Modifications

When it is intended to carry out any modifications to the LNG containment or distribution systems and associated components, which may affect classification, including substitutions of material differing from that originally installed, the details of such modifications are to be submitted for review. If ABS determines that the modification will affect classification, the affected system or component to be modified will be subject to the review, testing and survey requirements in accordance with this Guide.

3 Survey Intervals

Annual, Intermediate and Special Periodical Survey intervals, or survey under the Continuous Survey Program, are to be in accordance with the applicable parts of Sections 7-2-1 and 7-6-2 of the ABS *Rules for Survey After Construction (Part 7)*. Machinery survey based upon Preventative Maintenance Techniques is to be in accordance with 7-6-1/5 of the ABS *Rules for Survey After Construction (Part 7)*.

5 Surveys

The hull and machinery surveys after construction are to be in accordance with the applicable requirements as contained in 7-3-2/5.11, 7-6-2/1.5, 7-6-2/1.9, 7-6-2/3.3.3, 7-6-2/3.9 and associated references of the ABS *Rules for Survey After Construction (Part 7)*.

7 Alternative Surveys

ABS is at all times amenable to consider alternative survey arrangements which can be shown, through either satisfactory service experience or a systematic analysis based on sound engineering principles, to meet the overall safety, serviceability and standards of the *Steel Vessel Rules* and this Guide. Alternative to requirements particularly contained in Subsection 4/5 of this Guide, an In-Service Inspection Plan (ISIP) may be developed by the Owner and submitted to the Assistant Chief Surveyor's office for review. A stamped copy of the ISIP placed onboard the LNG bunkering vessel is to be referenced during all of the scheduled surveys.

APPENDIX 1 List of Relevant Regulations/Standards/Guides

TABLE 1
List of Relevant Regulations/Standards/Guides

This Table has been prepared for guidance only. The list is not to be considered exhaustive or mandatory; should additional equipment or systems be fitted onboard, or additional requirements determined to be applied by ABS, the LNG bunkering vessels flag administration or authorities responsible for the areas in which the LNG bunkering vessel operates, then the vessel may need to comply with additional standards or guidelines. Equipment or systems determined to be in compliance with alternative standards may be accepted in lieu of the ABS requirements in accordance with the criteria and intent of 1/13 of this Guide.

1	IMO IGC Code	International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk
2	ABS Guide	ABS Guide for Building and Classing Liquefied Gas Carriers with Independent Tanks
3	ABS Guide	ABS Guide for Certification of Lifting Appliances
4	ABS Publication	Bunkering of Liquefied Natural Gas-Fueled Marine Vessels in North America
5	ABS Publication	LNG Bunkering: Technical and Operational Advisory
6	ISO	ISO/TS 18683:2015 Guidelines for systems and installations for supply of LNG as fuel to ships
7	ISO 28460:2010	Petroleum and natural gas industries – Installation and equipment for liquefied natural gas – Ship-to-shore interface and port operations
8	IEC 60079-10-1	Part 10-1: Classification of area – Explosive gas atmospheres
9	IEC 60092-502	Part 502: Tankers – Special Features
10	IEC 60092-502 (1999) Supplement	USCG Supplement to IEC 60092-502
11	EN1474-2	Installation and Equipment for Liquefied Natural Gas. Design and Testing of Marine Transfer Systems. Part 2: Design and testing of transfer hoses
12	EN1474-3	Installation and Equipment for Liquefied Natural Gas. Design and Testing of Marine Transfer Systems. Part 3: Offshore transfer systems
13	SIGTTO	Ship to Ship Transfer Guide for Petroleum, Chemicals and Liquefied Gases, First Edition 2013
14	SIGTTO	Manifold Recommendations for Liquefied Gas Carriers, First Edition 2011
15	SIGTTO	ESD Arrangements and Linked Ship/Shore Systems for Gas Carriers
16	SIGTTO	A justification into the use of insulation flanges (and electrical discontinuous hose) at the ship/shore and ship/ship interface
17	ISGOTT	International Oil Tanker and Terminal Safety Guide, 5th Edition
18	API RP 2003	American Petroleum Institute – Protection Against Ignitions Arising out of Static, Lightning and Stray Currents
19	USCG Policy Letter 02-15	Guidance related to vessels and waterfront facilities conducting liquefied natural gas (LNG) marine fuel transfer (bunkering) operations
20	US Code of Federal Regulations	33CFR Part 127 Waterfront facilities handling liquefied natural gas and liquefied hazardous gas
21	US Code of Federal Regulations	33CFR Part 155 Oil or hazardous material pollution prevention regulations for vessels
22	US Code of Federal Regulations	33CFR Part 156 Oil and hazardous material transfer operations
23	US Code of Federal Regulations	46CFR Part 154 Safety standards for self-propelled vessels carrying liquefied gases
24	US Code of Federal Regulations	46CFR Subchapter D – Tank Vessels
25	US Code of Federal Regulations	46CFR Subchapter O – Certain bulk dangerous cargoes