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United States Coast Guard

# Marine Safety Center Technical Note

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MARINE SAFETY CENTER TECHNICAL NOTE (MTN) NO. 01-25

Subj: GUIDANCE FOR SUBMITTING DESIGN RISK ASSESSMENTS OF LIQUIFIED NATURAL GAS (LNG) FUELED VESSELS

Ref:
(a) International Maritime Organization (IMO) Resolution MSC.391(95), "International Code of Safety for Ships Using Gases or Other Low-Flashpoint Fuels (IGF Code)"
(b) CG-ENG Policy Letter No. 01-12, CH-1, "Equivalency Determination – Design Criteria for Natural Gas Fuel Systems" dated July 12, 2017
(c) Navigation and Vessel Inspection Circular (NVIC) 02-95, Change 3, The Alternate Compliance Program (ACP)
(d) International Association of Classification Societies (IACS) Recommendation No. 146, Risk Assessment as Required by the IGF Code, August 2016
(e) IMO Resolution MSC.285(86) – Interim Guidelines on Safety for Natural Gas-Fuelled Engine Installations in Ships
(f) IMO MSC.1/Circ. 1558, "Unified Interpretations of the IGF Code"
(g) IMO MSC.1/Circ. 1455, "Guidelines for the Approval of Alternatives and Equivalents as Provided for in Various IMO Instruments"
(h) IMO MSC.1/Circ. 1212/Rev. 2, "Revised Guidelines on Alternative Design and Arrangements for SOLAS Chapters II-1 and III"
(i) IACS Unified Interpretations of the IGF Code GF6 "Protection against cryogenic leakage and control of hazardous zones in fuel preparation rooms on the open deck," December 2017
(j) Marine Safety Center Technical Note (MTN) NO. 04-03, CH-4 "Technical Support and Oversight of Authorized Classification Societies"

1. Purpose: Risk assessments are approved by the Marine Safety Center (MSC) to satisfy the requirement in section 4.2.3 of reference (a), henceforth referred to as the IGF Code, for the Administration to document safety measures imposed on the vessel beyond those prescriptively required. We rely heavily upon the recommendation of the submitter to determine which risk control measures beyond the prescriptive IGF Code requirements are also critical to safety of persons, the environment, or the ship. This document provides information and guidance to streamline submission and approval of liquified natural gas (LNG) design risk assessments.

2. Applicability:

   a. This guidance is intended for LNG fueled vessels designed in accordance with IGF Code Part A-1. While it may be relevant to other alternative fuel types, consult with MSC if you have questions about risk assessments for any other fuels. This document also provides context and clarification where flag state interpretations are needed.

   b. Vessels designed to the Interim Guidelines, reference (e), should apply this guidance when applying the IGF Code to new installations or modifications. Previous approval under the Interim Guidelines is not a guarantee of approval under the IGF Code.

3. Definitions:

   a. Risk assessment – an integrated array of analytical techniques, e.g. reliability, availability and maintainability engineering, statistics, decision theory, systems engineering, human behavior, etc. that can successfully integrate diverse aspects of design and operation in order to assess risk. The term is used in a wide variety of contexts in the maritime industry, but in this document it specifically refers to risk assessments performed to meet the requirements of section 4.2 of the IGF Code.

   b. Risk control measure – a means through an action or strategy to eliminate, reduce, mitigate, or control an element or risk. Risk control measures reduce the consequences and/or likelihood of events, and are either design or operational in nature. Design controls refer to risk control measures regarding the engineering design and integration of marine systems which fall within the scope of plan review. Operational controls refer to risk control measures which involve mariner interface, and which fall under the authority of the cognizant Officer in Charge, Marine Inspection and the RO surveyor.

4. Background:

   a. Reference (e), adopted in 2009, was the precursor to the IGF Code, which was originally adopted in 2015. As noted in section 5.c. of reference (b), IMO incorporated substantive improvements into the IGF Code relative to the Interim Guidelines based on lessons learned, which included a well-defined approach for considering alternatives and clarification on risk assessment requirements.

   b. Part A-1 of the IGF Code specifically relates to ships using natural gas as fuel and provides vessel designers with additional goals and functional requirements. New and expanded sections on drip trays, general pipe design, suitable materials, fuel tank design and storage location, and bunkering have reduced overall design risk through the application of more robust prescriptive requirements.

   c. After the IGF Code was released, the Coast Guard Office of Design and Engineering Standards (CG-ENG) promulgated additional LNG-specific guidance in reference (b), which included the risk assessment process. As the IGF Code identifies risk assessments

as an Administration responsibility, MSC, as the Coast Guard's service delivery center, is the approval authority for risk assessments for both ACP and non-ACP vessels.

5. Risk Assessment Discussion:

**Approach**

a. Risks identified in the risk assessment will be assessed and ranked in the same way noted in section 4.8.7.1 of reference (g) for alternative designs, using acceptable and recognized risk analysis techniques. Risk assessment techniques considered acceptable for any IGF Code risk assessment can be found in Enclosure (1). The list is not comprehensive; other recognized risk assessment techniques may be acceptable and will be reviewed on a case-by-case basis. If implementing a risk assessment technique not listed herein, submitters should contact MSC to request concurrence prior to conducting the risk assessment.

b. The risk assessment should be focused on risks that could negatively affect persons, the environment, or the safety of the ship. While there may be other risks taken into consideration as part of the design process (e.g., crew convenience, economic factors, etc.), such considerations do not need to be submitted to the Coast Guard for approval.

c. If a risk control measure is added to a vessel design in a risk assessment, that does not mean that the Coast Guard considers it to be the only acceptable means of addressing a risk. If a requirement is found to be impracticable to implement, a revised risk assessment may be submitted, and MSC will approve the revisions provided that the new mitigations still adequately address the identified risk.

d. It is recognized that risk assessments may lead to discussions on regulatory interpretations. A list of current notable IGF Code interpretations beyond those in references (f) and (i), is included as Enclosure (3).

**Content**

e. Section 4.2.2 of the IGF Code specifies topics that must be addressed in the risk assessment for ships subject to Part A-1. Section 1.6.1 of reference (d) lays out standard elements of a Risk Assessment Report. No other information is required to be included, but additional risks in excess of this list may be submitted if deemed appropriate by the submitter. MSC's scope of review will include all documentation submitted; therefore, the submitter should carefully consider the risk assessment submittal scope to reduce duplication of risks that are suitably addressed by prescriptive requirements.

f. Any risk control measures submitted to MSC in a risk assessment (e.g., additional gas detectors), should comply with any applicable provisions of reference (b).

g. Additional sections of the IGF Code may call for specific evaluation of the design beyond prescriptive requirements, using terms such as "normally," "probable," "special

consideration," and "evaluated and approved." There may be situations where the risk assessment required by IGF Code 4.2 is the right place to consider such evaluations. However, the IGF Code requires risks identified in the risk assessment to be eliminated where possible, so it cannot be used to request permission to deviate from the Code (e.g., request for approval to not gas free bunker lines per section 8.5.5). Submitters should contact MSC prior to beginning the risk assessment to address any IGF Code evaluations other than those specifically listed in section 4.2.2.

h. When developing individual risk control measures, they should be design-based where possible, with operational controls imposed only where design controls would be impracticable or inapplicable to address the identified risk. Further, operational controls should be incorporated into a management system and properly documented to ensure that the crew is fully informed and familiar with such special measures, as per section 6.3.4.4 of reference (g).

i. The most common issue that MSC finds in risk assessment reports is risk control measures that are worded too vaguely to develop an enforceable requirement. All risk control measures should be unitary, complete, consistent, unambiguous, and verifiable.

j. Risk assessments should be written to clearly identify how each risk control measure relates back to specific identified risks. Organizing risk assessment nodes by location (i.e. bunkering station, tank connection space, fuel preparation room, auxiliary systems, etc.), is preferred, as it simplifies verification of compliance for inspectors and surveyors.

**Alternatives**

k. A risk assessment cannot be used as justification to lessen or omit prescriptive design requirements; such considerations would need to be reviewed as an alternative design, as discussed below. However, the risk assessment process may uncover vessel arrangements where an alternative design approval is necessary. In such cases, it should be clearly notated on the risk assessment report.

l. Section 2.3.3, Enclosure (1) of PL 01-12, CH-1 requires alternative designs to be reviewed and approved by MSC, and to be documented in accordance with SOLAS regulation II-1/55. Additional guidance is provided in MSC Circ. 1212, reference (h). The preliminary qualitative analysis, and specifically the identification, enumeration, and selection of hazards related to the development of alternative design scenarios noted in MSC Circ. 1212 sections 5.3.2 through 5.3.4, may be conducted as part of the risk assessment required by section 4.2 of the IGF Code. However, this information should be documented as part of the preliminary analysis report as detailed in MSC Circ. 1212 section 5.5 and presented to MSC as a separate submission. Generally, risk assessments that are qualitative in nature are not acceptable alone to satisfy the quantitative analysis required by MSC Circ. 1212 section 6.

6. Administrative Process:

**MSC**

a. To ensure design controls are captured in the vessel's approved plans, the risk assessment report should be approved prior to detailed plan review. Due to the complexity and necessity for review by multiple CG offices, MSC will strive to return risk assessments within 45 days of receipt. As noted in section 4.2.3, Enclosure (1) of PL 01-12, CH-1, any plans received prior to risk assessment approval may be held in abeyance by MSC until evaluation of the risk assessment has been completed. It is highly recommended that the risk assessment and all associated plan review should be completed and approved prior to the LNG system's cooldown, gas trials, and commissioning, as often times safety issues are identified through the risk assessment process.

b. Occasionally, risk assessments identify recommendations that require further evaluation to ensure proper risk control measures are identified (e.g., dropped container study, HAZOP analysis, gas dispersion study mooring analysis). Because it is not reasonable to expect all tangential assessments to be conducted simultaneously with the IGF Code risk assessment, MSC will accept risk assessments with these items documented as outstanding. However, risk assessment submittals that are not complete in all other regards will be returned for revision; due to the holistic nature of the process, MSC will not review an incomplete risk assessment report. Any risk assessments which have outstanding recommendations will be marked as being held in abeyance but will still receive a full scope of review. MSC's response will include applicable comments and an enclosure documenting the current additional requirements, but an approval marking will not be noted until an updated version of the risk assessment and/or sufficient supporting documentation is submitted that demonstrates all recommendations have been satisfactorily evaluated.

c. Per paragraph 5.b of NVIC 10-92, CG Recognition of Registered Professional Engineer Certification of Compliance with CG Requirements, the provisions of that NVIC are not applicable for expedited approval of equivalent arrangements. Because PL 01-12, CH-1 establishes design criteria as an equivalency to traditionally fueled vessel regulations, LNG fueled vessels are not eligible for review under NVIC 10-92.

d. While there is no required format for a risk assessment submission, to ensure consistent and effective implementation and tracking by the Coast Guard, MSC will reformat all satisfactory reports into a standard format which will be used to create an enclosure to the approval letter. A small example of some risk assessment content is shown in Enclosure (2) for reference.

**Submitter**

e. Early submittal of a risk assessment enables time for discussion where differing regulatory interpretations arise and design modifications are needed without impacting

vessel operations. While MSC will not review incomplete risk assessments, the submitter is encouraged to seek MSC concurrence on regulatory interpretations as they arise, at any stage of the design.

f. We acknowledge that if a risk assessment is conducted too early in the design process, the design may lacks the level of detail necessary to conduct a thorough risk analysis. Therefore, the risk assessment should be submitted as soon as practical in the judgment of the submitter, and prior to commencing vessel construction or modification.

g. When resubmitting risk assessments that have been held in abeyance as discussed in 6.b. above, any additional resultant risk control measures generated by those evaluations should be noted. This bifurcated approach facilitates the bulk of the review in a timely manner while allowing for additions and/or minor modifications before final approval, so updated submittals will typically be reviewed and responded to within 7 to 14 days of receipt.

**OCMI**

h. The Interim Guidelines required a risk analysis that only evaluated hazards associated with installation, operation, and maintenance that could reasonably affect structural strength and ship integrity. For vessels built to the Interim Guidelines, the cognizant OCMI has the authority to determine which modification plans need to be submitted, reviewed, and approved in accordance with the IGF Code. This includes a risk assessment, the scope of which will be determined and reviewed on a case-by-case basis (in consultation with MSC) depending on the potential impact of modifications.

i. As per PL 01-12, CH-1, design and operational controls from the MSC risk assessment approval letter are to be tracked in the vessel's file for future reference by the OCMI. Risk assessment approval letters will typically include the following recommended Certificate of Inspection endorsement, which will be at the discretion of the OCMI.

> In accordance with section 4.2.3 of the International Code of Safety for Ships Using Gases or Other Low-Flashpoint Fuels, this vessel must comply with the additional requirements identified during the risk assessment process and documented in Enclosure (1) of MSC letter E0-####### dated (Month, Day, Year).

**Recognized Organization**

j. For ACP vessels under reference (c), the Office of Commercial Vessel Compliance (CG-CVC), has delegated the authority to conduct plan review for LNG-fueled vessels. This authority will be documented on each vessel's ACP Enrollment Letter, requiring compliance with IGF Code and PL 01-12, CH-1. The Coast Guard has not delegated the authority to approve alternative designs. The RO should submit any alternative design requests to the CG on behalf of the vessel designer, as they would for equivalencies in accordance with reference (j). The RO should review all alternative design requests,

including associated supporting documentation, and provide an approval recommendation to the Coast Guard.

k. As discussed above, MSC will typically approve the risk assessment report prior to conducting detailed plan review. However, we acknowledge this practice may be impractical considering the timelines and workflow processes previously established by an RO. If an RO approves plans prior to approval of the risk assessment, processes should be established to ensure all design requirements within the risk assessment are captured, with the relevant plans verified and updated as necessary. MSC will target impacted plans for oversight to confirm that the established processes are effective in ensuring the results of the risk assessment are adequately reflected in the vessel design. The RO should complete a review of the risk assessment report to ensure the submittal meets section 5 of this guidance. As surveys of vessels enrolled in ACP are conducted by the RO, it is imperative that the RO internally tracks and verifies any additional requirements that result from the risk assessment.

l. The processes outlined in reference (j) regarding technical support and oversight of technical work are applicable, including notification of all work items in accordance with paragraph 4.b. In addition to the processes of reference (j), to support timely oversight of these systems, a separate notification should be delivered to msc@uscg.mil, identifying any items pertaining specifically to the LNG fuel system that have been “Approved” or “Issued” on the Coast Guard’s behalf. Notifications may be batched to support holistic system reviews as deemed appropriate by the RO as long as the notifications remain timely. Plan review oversight will not be conducted until the risk assessment has been reviewed and approved.

7. Disclaimer: While the guidance contained in this document may assist the industry, the public, the Coast Guard, and other Federal and State agencies in applying statutory and regulatory requirements, this guidance is not a substitute for the applicable legal requirements, nor is it in itself a regulation. It is not intended to, nor does it impose legally binding requirements on any party, including the Coast Guard, other Federal agencies, the States, or the regulated community.

D. H. COST

Encl: (1) Accepted Risk Assessment Techniques
(2) Example Risk Assessment Letter Enclosure
(3) Interpretations of the IGF Code Relevant to Risk Assessments

Copy: Commandant (CG-ENG)
Commandant (CG-CVC)
Commandant (CG-5P-TI)

## Accepted Risk Analysis Techniques

The following is a list of acceptable risk analysis techniques identified through MSC's review of previous risk assessments. This list is provided to ensure transparency and will be updated as needed.

(a) IEC/ISO 31010 – Risk management: Risk assessment techniques

(b) ISO 17776 – Petroleum and natural gas industries, Offshore production installations, Major accident hazard management during the design of new installations

(c) ISO 16901 – Guidance on performing risk assessment in the design of onshore LNG installations including the ship/shore interface

(d) NORSOK Z-013 – Risk and emergency preparedness assessment

(e) CPR 12E – Methods for determining and processing probabilities

(f) Centre for Chemical Process Safety (CCPS), AChE – Guidelines for chemical process quantitative risk analysis

(g) Health & Safety Executive (HSE) – Marine risk assessment

(h) IMO MSC.MEPC.2/Circ.12 – Revised Guidelines for formal safety assessment for use in the IMO rule-making process, dated 8 July 2013

(i) IEC 61882 (2016) – Hazard and Operability Study (HAZOP) – Guidelines

(j) UK IChemE's Book "HAZOP: Guide to Best Practice"

(k) International Association of Drilling Contractors (IADC) – "HSE Case Guidelines for Mobile Offshore Drilling Units – Issue 3.6" – January 2015

**Example Risk Assessment Letter Enclosure**

The following table lists the design and operational requirements identified in the subject vessel's risk assessments (RAs).

| Req # | RA Category | RA ID(s) | Requirement Type | Requirement |
|---|---|---|---|---|
| **Bunkering Station (BS)** | | | | |
| 1 | Design Measure #-- | BS-#.#.# | Design | The bunker station shall be installed with the following:<br>a. Spray shields on all flanged connections,<br>b. A gas detector at the bunker station,<br>c. Low temperature sensors in the drip tray, and<br>d. A water curtain down the side of the vessel for hull protection. |
| 2 | Design Measure #-- | BS-#.## | Design | Fire (heat) detectors shall be installed at the bunker station. |
| 3 | Design Measure #-- | BS-#.# | Design | An ESD shall be installed at the bunker station. |
| 4 | Recommended Action #-- | BS-#.#.# | Design | All bunkering station LNG pipe flanges shall be fitted with stainless steel spray shields. |
| 5 | Recommended Action #-- | BS-#.# | Design | A Vessel Separation Device (VSD) shall be installed at the bunker station. |
| 6 | Recommended Action #-- | BS-#.#.# | Operational | The LNG Bunkering Manual shall include a quick connect/disconnect coupler (QCDC) coupling leakage procedure. |
| 7 | Recommended Action #-- | BS-#.#.# | Operational | The LNG Bunkering Manual shall include QCDC protective covering installation procedures. |
| **Fuel Tank Hold Space (FTHS)** | | | | |
| 8 | Design Measure #- | FTHS-#.## | Design | All LNG tank supply pumps shall have full redundancy, with both the primary and secondary pumps being capable of operating at 100% capacity. |
| **Tank Connection Space (TCS)** | | | | |
| 9 | Design Measure #- | TCS-#.#.# | Design | The TCS shall be protected by a SUCG type approved carbon dioxide fixed fire suppression system. |

*Note: This is a small section of typical content provided as an example, a complete risk assessment would be much more extensive.*

**Interpretations of the IGF Code Relevant to Risk Assessments**

The following is a list of notable regulatory interpretations based on MSC's review of previous risk assessments. It is being provided to promote transparency and consistency in the application of the regulations and will be updated as appropriate.

a. Adequate Natural Ventilation (A/2.2.34)

If an area definition cannot be definitively determined, the RO or submitter should submit an inquiry to MSC including a descriptive qualitative analysis, and justification for the proposed arrangement and area designation. The term "adequate natural ventilation" is not defined in section 2.2 of the IGF Code. However, when determining whether an area is open deck vs. semi-enclosed, especially, but not limited to, tank protective structures, the following should be considered:

(a) Size and location of cutouts
(b) Multi-tiered cutouts
(c) Removal of interior or exterior obstructions (i.e. centerline bulkheads)
(d) Bulkhead limbering
(e) Roof sloping
(f) Addition of cowls/scoops
(g) Location of space relative to other structures
(h) General wind statistics of intended operational areas/routes
(i) Environmental protections for sensitive equipment/tanks
(j) Hazardous areas

b. Valves Downstream of Tank Relief Valves (A-1/6.7.2.7)

It is common to have tank relief valve arrangements that relieve to a common vent header prior to migrating to the vent mast. If one pressure relief valve is taken out of service due to malfunction or leakage, as noted in section 6.7.2.2 of the IGF Code, a stop valve may be fitted on the downstream side to ensure cold vapor does not release into the surrounding area from the vent header in the event of a pressure relief. However, the downstream valves must be fitted with a physical interlock (e.g., keying system) to ensure the other downstream valve remains open to maintain an unimpeded vent line while the relief valve is out of service.

c. Relief Valves in Sections of Liquid Piping (A-1/7.3.1.3)

The IGF Code requirements for relief valves where pipelines may be isolated in a liquid full condition pertains to small sections of pipe (i.e. double isolation on drain lines, instrumentation lines, manually operated isolation valves for maintenance) that could potentially trap LNG, either advertently or inadvertently. A bleed or relief valve must be installed in between the two intervening stop valves or components. As the IGF Code prohibits the use of operational methods or procedures in alternatives when a design requirement cannot be met, use of operational controls, such as lockout-tagout procedures, when feasible design alternatives exist, is not acceptable. If the submitter can demonstrate either through the risk assessment or other analysis that a section of piping cannot be isolated in a liquid full condition via a design control,

such arrangements should receive concurrence from MSC (regardless of ACP enrollment status) to reduce the potential need for design modifications after construction.

d. Bunkering Line (A-1/8.5)

The term “bunkering line” is not defined in section 2.2 of the IGF Code; however, section 2.2.3 of the IGF Code defines “bunkering” as “the transfer of liquid or gaseous fuel from land based or floating facilities into a ships’ permanent tanks or connection of portable tanks to the fuel supply system.” Therefore, MSC interprets the bunkering line to extend from the presentation flange on the outboard side of the vessel to the tank valves where the piping enters the permanent storage tanks or connection to the portable tanks.

e. Single Wall Ventilation Lines in Gas-Safe Machinery Spaces (A-1/9.6)

The term “fuel piping” is not intended to include vent piping within a gas safe machinery space; single wall, fully welded piping is acceptable for such applications.

f. Nitrogen Piping System Fittings (A-1/6.14.4)

Nitrogen pipes in enclosed spaces must be fully welded and have only a minimum of flange connections as needed for fitting valves. However, in keeping with other distribution systems that MSC reviews, such as electrical power distribution systems, MSC acknowledges that elements to which the system is connected (typically provided on self-contained skids) may not be built to comply with the distribution system requirements. For example, nitrogen generation equipment commonly has threaded connection points, and MSC will not require such equipment to be modified after delivery to accept a flanged valve. However, the rest of the piping system beyond the skids will be required to comply with the requirement of the Code, even if a skid manufacturer may provide additional threaded valves for use elsewhere in the distribution system, in much the same way that a non-standard circuit breaker would not be accepted on a one-line diagram even if it was provided along with a motor by the manufacturer.

g. Coffin-style gas valve units (GVUs) in Gas-Safe Machinery Spaces (A-1/7.4.1, 9.8)

While not explicitly discussed in the IGF Code or PL 01-12, CH-1, MSC does not object to the use of enclosed GVUs in the fuel supply to consumers or locating them in gas-safe machinery spaces. However, the GVU must be designed to meet the minimum prescriptive requirements of the outer pipe or duct, as it is an extension of the outer wall.