Thermal Stress Analyses for Piping Systems

Object of Amendment

Rules for the Survey and Construction of Steel Ships Part N
Guidance for the Survey and Construction of Steel Ships Part GF and Part N

Reason for Amendment

Section 7 of the *International Code of Safety for Ship Using Gases or Other Low-flashpoint Fuels* (IGF Code) specifies thermal stress analyses for high pressure fuel piping systems and fuel piping systems for which design temperatures are −110°C or colder. Additionally, Section 5 of the *International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk* (IGC Code) also specifies thermal stress analyses for products and process piping systems.

These requirements have already been incorporated into Part GF and Part N of the Rules for the Survey and Construction of Steel Ships. In addition, calculation conditions and other matters to be considered with respect to thermal stress analysis have been specified in the relevant Guidance for each part.

Based on NK's sufficient experience in reviewing the thermal stress analyses, relevant requirements are amended in order to clarify additional items to be considered with respect to thermal stress analysis.

Outline of the Amendment

Specify items to be considered as calculation conditions and evaluation items for the thermal stress analysis of the piping systems covered by 3.2.2, Annex 16.1.1-2, Part N of the Rules; N5.11.5, Part N of the Guidance; and GF7.3.4, Part GF of the Guidance.

Effective Date and Application

This draft amendment applies to ships for which the date of contract for construction is on or after 1 January 2025.

ID: DD23-09

Amended-Original Requirements Comparison Table (Thermal Stress Analyses for Piping Systems)

Amended	Original	Remarks
RULES FOR THE SURVEY AND CONSTRUCTION OF STEEL SHIPS **Part N SHIPS CARRYING LIQUEFIED GASES IN BULK** **Annex 16.1.1-2 HIGH PRESSURE GAS-FUELLED ENGINES** **Chapter 3 GAS FUEL SUPPLY SYSTEMS** **3.2 Gas Fuel Supply Piping Systems** **3.2.2 Construction and Strength** **1** Gas fuel supply piping systems are to be supported effectively by hull structures or engine frames considering the weight of the piping system, and deflections and vibrations of the hull. **2** Gas fuel supply piping systems are to be ensured to have sufficient construction strength by carrying out stress analysis considering the stresses produced by the weight of the piping system, internal pressure, heat contraction, hull deflections and dynamic loads due to the motion of the ship. The same calculation conditions and evaluation items specified in **5.11.5, Part N of the Rules** are to be considered in the stress analysis.	**RULES FOR THE SURVEY AND CONSTRUCTION OF STEEL SHIPS** **Part N SHIPS CARRYING LIQUEFIED GASES IN BULK** **Annex 16.1.1-2 HIGH PRESSURE GAS-FUELLED ENGINES** **Chapter 3 GAS FUEL SUPPLY SYSTEMS** **3.2 Gas Fuel Supply Piping Systems** **3.2.2 Construction and Strength** **1** Gas fuel supply piping systems are to be supported effectively by hull structures or engine frames considering the weight of the piping system, and deflections and vibrations of the hull. **2** Gas fuel supply piping systems are to be ensured to have sufficient construction strength by carrying out stress analysis considering the stresses produced by the weight of the piping system, internal pressure, heat contraction and hull deflections.	

Amended-Original Requirements Comparison Table (Thermal Stress Analyses for Piping Systems)

Amended	Original	Remarks
(-3 to -6 are omitted.) EFFECTIVE DATE AND APPLICATION **1.** The effective date of the amendments is 1 January 2025. **2.** Notwithstanding the amendments to the Rules, the current requirements apply to ships for which the date of contract for construction is before the effective date.	(-3 to -6 are omitted.)	

Amended-Original Requirements Comparison Table (Thermal Stress Analyses for Piping Systems)

Amended	Original	Remarks
GUIDANCE FOR THE SURVEY AND CONSTRUCTION OF STEEL SHIPS **Part GF SHIPS USING LOW-FLASHPOINT FUELS** **GF7 MATERIAL AND GENERAL PIPE DESIGN** **GF7.3 General Pipe Design** **GF7.3.4 Allowable Stress** **1** For the purpose of 7.3.4-3, Part GF of the Rules, the calculation conditions and evaluation items for the stress analysis are to be standardised in accordance with the following (1) to (5): (1) In cases where temperature and pressure conditions of the piping are different at each stage of operation, stress analysis is to be performed for all cases or is to be performed considering the calculation conditions that encompass all cases. For the temperature condition, a state uniformly cooled down to the design temperature is to be considered, and a reference temperature (where thermal stress = 0) of 15°C is to be regarded as standard. (2) Loading conditions are to be in accordance with the following (a) to (i):	**GUIDANCE FOR THE SURVEY AND CONSTRUCTION OF STEEL SHIPS** **Part GF SHIPS USING LOW-FLASHPOINT FUELS** **GF7 MATERIAL AND GENERAL PIPE DESIGN** **GF7.3 General Pipe Design** **(Newly added)**	Assumed that different pipelines are used for passing fuel at each stage of a fuel transfer operation. This is not intended to assume only the most severe conditions.

Amended-Original Requirements Comparison Table (Thermal Stress Analyses for Piping Systems)

Amended	Original	Remarks
(a) For the internal pressure, the design pressure specified in **7.3.3, Part GF of the Rules** is to be considered. (b) Insulation materials are not to be considered as contributing to pipeline strength in any way. (c) In principle, the self-weight of pipelines and internal media, and the inertia forces due to acceleration of the ship's motion are to be considered. (d) For forced displacement, the forced strains corresponding to the allowable sagging moment and hogging moment for the hull are to be considered. However, this does not apply to cases in which the pipelines are located in a compartment that is not affected by hull deformation. Forced displacement during fuel transfer due to thermal contraction of fuel tanks to which the pipelines are connected and forced displacement through support members for pipelines due to deformation of hull structure (e.g. racking deformation) are also to be considered, if not negligible. (e) For the thermal load, a load which can be determined in accordance with **(1)** above is to be considered. (f) For the external load, the load applied to the manifold from the loading arm or other means is to be considered. In such cases, the loads indicated in the standards or other documents, deemed appropriate by the Society, may be		Example of the documents deemed appropriate by the Society: SGMF-manifold arrangements for gas-fuelled vessels

Amended-Original Requirements Comparison Table (Thermal Stress Analyses for Piping Systems)

Amended	Original	Remarks
referred to for this purpose. In cases where the thrust load due to the blowout of the safety valves installed in the cargo tanks or pipes is not negligible, this load is also to be considered. (g) In cases where expansion bellows are installed, displacement due to internal pressure and thrust loads (if any) are to be considered. (h) In cases where double wall piping is installed, the loads exerted on the inner pipe by gas pressure between the inner pipes and outer pipes are to be considered. (i) In cases where pipelines are divided into multiple models, the boundaries of the models are, in principle, to be completely fixed. (3) Support conditions are to be as deemed appropriate by the Society depending upon the construction, arrangement and the materials used for pipe supports. (4) As part of the integrity evaluation of the pipelines, stresses and reaction forces received from support members are to be evaluated. In cases where support members are installed between the inner pipes and outer pipes in double wall piping, the reaction force received from the support members is also to be evaluated. However, if the effect of the reaction force received from the support members can be evaluated as stresses in the pipelines, such as in cases where the model is created using shell elements, evaluation only for the stresses is acceptable. In addition, it is to be confirmed that the displacement does not cause the inner pipes and outer pipes to come into contact.		Needs to be completely fixed so as not to be affected by adjacent models.

Amended-Original Requirements Comparison Table (Thermal Stress Analyses for Piping Systems)

Amended	Original	Remarks
(5) Allowable stresses and allowances of reaction forces are to be as deemed appropriate by the Society depending upon the calculation method and materials used for pipelines. **2** The standard considerations in the stress analysis specified in **7.3.4-5, Part GF of the Rules** are to be in accordance with **1** above.		

Amended-Original Requirements Comparison Table (Thermal Stress Analyses for Piping Systems)

Amended	Original	Remarks
GUIDANCE FOR THE SURVEY AND CONSTRUCTION OF STEEL SHIPS **Part N SHIPS CARRYING LIQUEFIED GASES IN BULK** **N5 PROCESS PRESSURE VESSELS AND LIQUID, VAPOUR, AND PRESSURE PIPING SYSTEMS** **N5.11 Piping System Component Requirements** **N5.11.5 Stress Analysis** **1** For the purpose of **5.11.5, Part N of the Rules**, the calculation conditions and evaluation items in the stress analysis are to be standardised in accordance with the following requirements **(1)** to **(5)**: (1) In cases where temperature and pressure conditions of the piping are different at each stage of operation, stress analysis is to be performed for all cases or is to be performed considering the calculation conditions that encompass all cases. For the temperature condition, a state uniformly cooled down to the design temperature is to be considered, and a reference temperature (where thermal stress = 0) of 15°C is to be regarded as standard. (2) Loading conditions are to be in accordance with the	**GUIDANCE FOR THE SURVEY AND CONSTRUCTION OF STEEL SHIPS** **Part N SHIPS CARRYING LIQUEFIED GASES IN BULK** **N5 PROCESS PRESSURE VESSELS AND LIQUID, VAPOUR, AND PRESSURE PIPING SYSTEMS** **N5.11 Piping System Component Requirements** **N5.11.5 Stress Analysis** **1** For the purpose of **5.11.5, Part N of the Rules**, the calculation conditions and allowable stress in the stress analysis are to be standardized in accordance with the following requirements **(1)** to **(5)**: (1) As the temperature condition, a state uniformly cooled down to the design temperature is to be considered. As the reference temperature (thermal stress = 0), 15℃ is to be regarded as standard. (2) Loading conditions are to be in accordance with the	Same as Part GF except that "Fuel" is replaced with "Cargo"

Amended-Original Requirements Comparison Table (Thermal Stress Analyses for Piping Systems)

Amended	Original	Remarks
following **(a)** to **(i)**:	following requirements **(a)** to **(d)**:	
(a) As the internal pressure, the design pressure specified in **5.4.2, Part N of the Rules** is to be considered.	(a) As the internal pressure, the design pressure specified in the requirements in **5.4.2, Part N of the Rules** is to be considered.	
(b) Insulation materials are not to be considered as contributing to pipeline strength in any way.	(Newly added)	
(c) In principle, the self-weight of pipelines and internal media, and the inertia forces due to acceleration of the ship's motion are to be considered.	(b) The self-weight of pipelines, when it cannot be neglected, is to be considered including its acceleration.	
(d) As the forced displacement, the forced strains corresponding to the allowable sagging moment and hogging moment for the hull are to be considered. However, this does not apply to cases in which the pipelines are located in a compartment that is not affected by hull deformation. Forced displacement during cargo transfer due to thermal contraction of cargo tanks to which the pipelines are connected and forced displacement through support members for pipelines due to deformation of hull structure (e.g. racking deformation) are also to be considered, if not negligible.	(c) As the forced displacement, the forced strains corresponding to the allowable sagging moment and hogging moment for the hull are to be considered.	
(e) For the thermal load, a load which can be determined in accordance with **(1)** above is to be considered.	(d) As the thermal load, one which can be determined according to the condition indicated in the **(1)** above is to be considered.	
(f) For external load, the load applied to the manifold from the loading arm or other means is to be considered. In such cases, the loads indicated in the standards or other documents, deemed	(Newly added)	

Amended-Original Requirements Comparison Table (Thermal Stress Analyses for Piping Systems)

Amended	Original	Remarks
appropriate by the Society, may be referred to for this purpose. In cases where the thrust load due to the blowout of the safety valves installed in the cargo tanks or pipes is not negligible, this load is also to be considered.		
(g) In cases where expansion bellows are installed, displacement due to internal pressure and thrust loads (if any) are to be considered.	(Newly added)	
(h) In cases where double wall piping is installed, the loads exerted on the inner pipe by gas pressure between the inner pipes and outer pipes are to be considered.	(Newly added)	
(i) In cases where pipelines are divided into multiple models, the boundaries of the models are, in principle, to be completely fixed.	(Newly added)	
(3) Support conditions are to be as deemed appropriate by the Society depending upon the construction, arrangement and the materials used for pipe supports.	(3) Support conditions are to be as deemed appropriate by the Society depending upon the construction, arrangement and the materials used for pipe supports.	
(4) As part of the integrity evaluation of the pipelines, stresses and reaction forces received from support members are to be evaluated. In cases where support members are installed between the inner pipes and outer pipes in double wall piping, the reaction force received from the support members is also to be evaluated. However, if the effect of the reaction force received from the support members can be evaluated as stresses in the pipelines, such as in cases where the model is created using shell elements, evaluation only for the stresses is acceptable. In addition, it is to be confirmed that the displacement does not cause the	(Newly added)	

Amended-Original Requirements Comparison Table (Thermal Stress Analyses for Piping Systems)

Amended	Original	Remarks
inner pipes and outer pipes to come into contact. (5) Allowable stresses and allowances of reaction forces are to be as deemed appropriate by the Society depending upon the calculation method and materials used for pipelines. (Deleted) **2** For the purpose of **5.11.5, Part N of the Rules**, stress analysis may be required for piping with design temperatures higher than −110°C where the following **(1)** to **(3)** are relevant: (1) where suitable supports or means to absorb structural expansion and contraction cannot be arranged due to the location of on-deck piping arrangements; (2) where new supporting method or new means to absorb expansion and contraction are used; and (3) other cases deemed necessary by the Society. EFFECTIVE DATE AND APPLICATION **1.** The effective date of the amendments is 1 January 2025. **2.** Notwithstanding the amendments to the Guidance, the current requirements apply to ships for which the date of contract for construction is before the effective date.	(4) Allowable stresses are to be as deemed appropriate by the Society depending upon the calculation method and materials used for pipelines. (5) Insulation materials are to be considered to give no contribution at all to the strength of the pipeline. **2** For the purpose of **5.11.5, Part N of the Rules**, stress analysis may be required for piping with design temperatures higher than -110℃ where the following **(1)** to **(3)** are relevant: (1) Where suitable supports or means to absorb structural expansion and contraction cannot be arranged due to the location of on-deck piping arrangements; (2) Where new supporting method or new means to absorb expansion and contraction are used; and (3) Other cases deemed necessary by the Society.	Transferred to -1(2)(b)