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Ships and marine technology — Specification of high manganese austenitic steel used for LNG tanks on board ships

Navires et technologie maritime — Spécification des aciers à haute teneur en manganèse utilisés pour les réservoirs de GNL à bord des navires

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Introduction

There have been several requirements regarding metallic materials for cryogenic applications since the adoption of the IGC and IGF Codes. The newly developed, high manganese (Mn) austenitic steel should possess mechanical properties including Charpy impact energy values comparable to those of materials for cryogenic service listed in both the IGC Code[1] and IGF Code[2]. Consequently, high Mn austenitic steel is intended to satisfy the strength requirements of the structure of cargo tanks, fuel tanks and piping systems of LNG carriers and LNG-fuelled ships.

This document provides a standard specification of high manganese austenitic steel for material suppliers, ship owners, ship yards, manufacturers and shipping companies with regard to producing, purchasing and using such materials.

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Ships and marine technology — Specification of high manganese austenitic steel used for LNG tanks on board ships

1 Scope

This document describes the specification of high manganese (Mn) austenitic steel plates to be used for LNG tanks on board ships.

The specification of high manganese austenitic steel can be also considered for design and manufacture of cargo tanks and process pressure vessels of LNG supply/terminal and transportation of fuels and traded gases.

This document is primarily applicable for the specification of LNG tanks below volumetric capacity of approximately 30 000 m^3 using high manganese austenitic steel.

The thickness of plates is limited to between 6 mm to 40 mm.

2 Normative references

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The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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ISO 148-1, *Metallic materials — Charpy pendulum impact test — Part 1: Test method*

ISO 5173, *Destructive tests on welds in metallic materials — Bend tests*

ISO 6892-1,*Metallic materials — Tensile testing — Part 1: Method of test at room temperature*

ASTM A1106/A1106M-17, *Standard specification for pressure vessel plate, alloy steel, austenitic high manganese for cryogenic application*

IACS UR W1, *Material and welding for gas tankers*

IACS UR W13, *Thickness tolerances of steel plates and wide flats*

IACS UR W16, *High strength steels for welded structures*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
high manganese (Mn) austenitic steel
steel with high amount of Mn to retain austenite as its primary phase at atmospheric and service temperature

Note 1 to entry: Refer to Table 1 in 6.1.

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3.2
design temperature
minimum temperature for selection of materials at which cargo or fuel may be loaded or transported in the cargo or fuel tanks[1]

3.3
piece
rolled product from a single slab or billet, or from a single ingot, if this is rolled directly into plates

4 Required specification

The manufacturing, forming and weldability of high manganese austenitic steel shall comply with recognized international, regional or national standards.

Effective quality, process and production controls during manufacturing are the steelmaker's responsibility within the manufacturing specifications. The quality management systems of the steelmaker should be effectively implemented.

The specification of high manganese austenitic steel including chemical composition and mechanical properties as specified in Clause 6 shall be complied with.

Minimum design temperature and the impact test temperature shall be –165 °C and –196 °C, respectively.

5 Manufacture

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5.1 Steel-making practice

Steel shall be manufactured by basic oxygen, electric furnace or open hearth processes or by other processes.

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Steel shall be killed during de-oxidation practice.

5.2 Steel plates

The reduction ratio of slab to finished plate thickness shall be not less than 3:1. Refer to IACS UR W16.

Steel plates shall be produced by hot rolling and shall be controlled cooled after rolling at a rate sufficient to prevent the formation of grain boundary carbides within the temperature range from 800 °C to 500 °C.

A cooling rate faster than 10 °C/s is recommended to prevent carbide precipitation.

The plates shall not be formed at temperatures exceeding 500 °C. Heat treatment following the final rolling process shall not be permitted.

Thickness tolerances of plates shall be in accordance with IACS UR W13.

6 Chemical composition and mechanical properties

6.1 Chemical composition

The chemical composition (%) of samples taken from each ladle of each cast of the steel (see NOTE) shall meet the requirements of Table 1. Refer to ASTM A1106/A1106M-17.

NOTE High manganese austenitic steel is also used as "steel" throughout this document.

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Table 1 — Chemical composition of high manganese austenitic steel

% by mass

C	Mn	P	S	Si[a]	Cr	Cu	B	N
0,35 to 0,55	22,50 to 25,50	0,030 max.	0,010 max.	0,10 to 0,50	3,00 to 4,00	0,30 to 0,70	0,005 0 max.	0,050 max.

[a] Silicon (Si) may be less than 0,10 %, provided total aluminum is 0,03 % or higher, or provided acid soluble aluminum is 0,025 % or higher.

6.2 Mechanical properties

6.2.1 Requirements of tensile strength and yield strength

The tensile strength and yield strength of the steel as represented by tensile test specimens shall meet the requirements specified in Table 2.

6.2.2 Toughness requirements

The toughness of the steel as represented by Charpy V notch test specimens shall meet the requirements specified in Table 2.

Unless otherwise agreed, impact tests shall be conducted at –196 °C. The average absorbed energy for each set of three full size test specimens with their longitudinal axis transverse to the final direction of rolling of the plates, shall be 27 J or more.

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Each impact test specimen shall have a lateral expansion opposite to the notch of not less than 0,38 mm.

In the case of the steel used as a section member, the Charpy V notch test specimens shall be taken in longitudinal direction and its average Charpy impact value shall be 41 J or more.

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Each impact test value shall constitute the average value of three specimens, with not more than one value below the specified minimum value of 27 J but in no case below 20 J for transverse specimens.

For thin plates with plate thickness, t < 12 mm, sub-sized specimens shall be used. Minimum average energy values for sub-sized specimens in accordance with Clause 6.3.2.1 of IGC Code[1] may be accepted.

Table 2 — Mechanical properties for high manganese austenitic steel

Minimum yield strength (0,2 % offset) N/mm^2	Tensile strength N/mm^2	Minimum elongation % at $5,65\sqrt{S_0}$	Charpy impact energy (average)		
			Test temperature °C	Minimum transverse energy J	Minimum longitudinal energy J
400	800 to 970	22,0	–196	27	41

6.2.3 Bend test

The bend test may be omitted as a material acceptance test, but is required for weldability tests. Where a bend test is performed, this shall be carried out in accordance with ISO 5173 or equivalent standards.

The bend tests shall be transverse bend tests, which may be face, root or side bends. However, longitudinal bend tests may be required in lieu of transverse bend tests in cases where the base material and weld metal have different strength levels[1][2].

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