
**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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ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Fax: +41 22 749 09 47
Email: copyright@iso.org
Website: www.iso.org

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

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For an explanation on the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 8, *Ships and marine technology*, Subcommittee SC 8, *Ship design*.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

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 m³ using high manganese austenitic steel.

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

2 Normative references

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.

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](#).

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^[4]

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 $-165\text{ }^{\circ}\text{C}$ and $-196\text{ }^{\circ}\text{C}$, respectively.

5 Manufacture

5.1 Steel-making practice

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

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 $800\text{ }^{\circ}\text{C}$ to $500\text{ }^{\circ}\text{C}$.

A cooling rate faster than $10\text{ }^{\circ}\text{C/s}$ is recommended to prevent carbide precipitation.

The plates shall not be formed at temperatures exceeding $500\text{ }^{\circ}\text{C}$. 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.

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.

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.

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]}.

6.3 Supplementary requirements

Supplementary requirements for steel may not apply unless specified in order. Several supplementary requirements may apply at the option of the purchaser^[1].

The following tests may be performed by agreement between the supplier and the purchaser:

- vacuum treatment;
- product analysis;
- drop weight test (for material of 16 mm and over in thickness);
- ultrasonic examination^[4];
- fracture toughness test^{[5][6]}.

7 Test procedures

7.1 Mechanical test

One tensile test and at least one set of three Charpy V-notch impact test specimens shall be taken from each piece.

The tensile test and Charpy V-notch impact tests shall be made in accordance with ISO 6892-1 and ISO 148-1, respectively.

The longitudinal axis of the test specimens shall be transverse to the final rolling direction of the plates.

7.2 Retest procedures

When the tensile test fails to meet the requirements, two further tests may be made from the same piece.

If both of the additional tests are satisfactory, the piece as applicable is acceptable. If one or both of these tests fail, the piece shall be rejected.

8 Weldability

Weldability of the steel shall be carefully considered in accordance with the relevant requirements prior to manufacture of the tank.

The welding procedure qualification test shall be carried out. A welding procedure specification (WPS) shall be prepared by the shipyard or tank manufacturer which intends to perform the welding procedure qualification test in accordance with Clause 1.4.3 of IACS UR W1 as a minimum requirement.

9 Marking

Each finished piece shall be provided with an easily visible marking with the following information:

- manufacturer's name and address;
- unified identification mark for the grade of steel, for example, "Mn24Cr3";
- year of manufacture;
- delivery condition or transport unit.

10 Documentation

The test certificate copies shall be provided including the following information:

- purchaser's order number and, if known, the hull number for which the material is intended;
- identification of the cast and piece;
- steelwork's identification;
- chemical composition and mechanical properties.

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