



**GUIDE FOR**

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**MATERIAL REQUIREMENTS FOR HIGHER-DUCTILITY  
HULL STRUCTURAL STEEL PLATES AND SECTIONS**

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**American Bureau of Shipping  
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the State of New York 1862**

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## Foreword

Higher-ductility (HD) steel has higher elongation and can absorb more energy without rupturing than conventional steel. HD steel can be used for side structure to improve structural safety and prevent cargo leakage in a collision.

This Guide provides supplementary requirements for the application of HD hull structural steel plates and sections in addition to the requirements specified in the *ABS Rules for Materials and Welding (Part 2)*.

This Guide can be used by steel mills, designers, shipyards and ship owners to support the optional notation **HDS**.

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](http://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](mailto:rsd@eagle.org).*



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## SECTION 1 Introduction

### 1 General

This Guide is to be used in conjunction with the following ABS Rules:

- Part 2, *ABS Rules for Materials and Welding*
- Part 3, “Hull Construction and Equipment” of the *ABS Rules for Building and Classing Steel Vessels (Steel Vessel Rules)*
- Part 7, *ABS Rules for Survey After Construction*

### 3 Higher-Ductility (HD) Steel Designation

This Guide describes the supplementary requirements for higher-ductility (HD) designation for hull structural steel plates and sections with the thicknesses up to 50 mm (2.0 in.).

The regular ship steel grade designation is to be followed by the HD steel designation letters and numbers HDxx, where “xx” is to be either 35 or 50. The minimum elongation for HD35 and HD50 is to be as listed in Section 3, Tables 1 and 2 in this Guide for the applicable type of specimen, which is to have approximately 35% and 50% improved elongation, compared to the same grade steel required by *ABS Rules for Materials and Welding (Part 2)*.

### 5 Application

The application of steel is to follow the steel selection criteria for Hull Construction and Equipment in 3-1-2/3 of the *Steel Vessel Rules*.

The minimum extent of HD steel is to be the side shell plates and frames within the cargo hold region. Frames include longitudinal and transverse stiffeners but exclude web frames, stringers or other deep support members. The cargo hold region is the part of the ship that contains cargo holds, cargo tanks, and slop tanks. The cargo hold region does not include the pump room, if any. The vertical extent is to be from the upper turn of the bilge to the bottom of the sheer strake within the midship. The same vertical extent is to be maintained forward and aft. HDS need not be applied further inboard than 0.025 times the breadth of the vessel at a particular section from the ship side at the level of the summer load line draft, see Section 1, Figure 1.

### 7 Classification Notation

#### 7.1 General

The general requirements in Subsection 1/1 are to be complied with. Additional requirements for higher-ductility steel are given in the following Sections of this Guide.

#### 7.3 HDS

The optional **HDS** notation will be assigned if the requirements in this Guide and minimum extent for application are met.

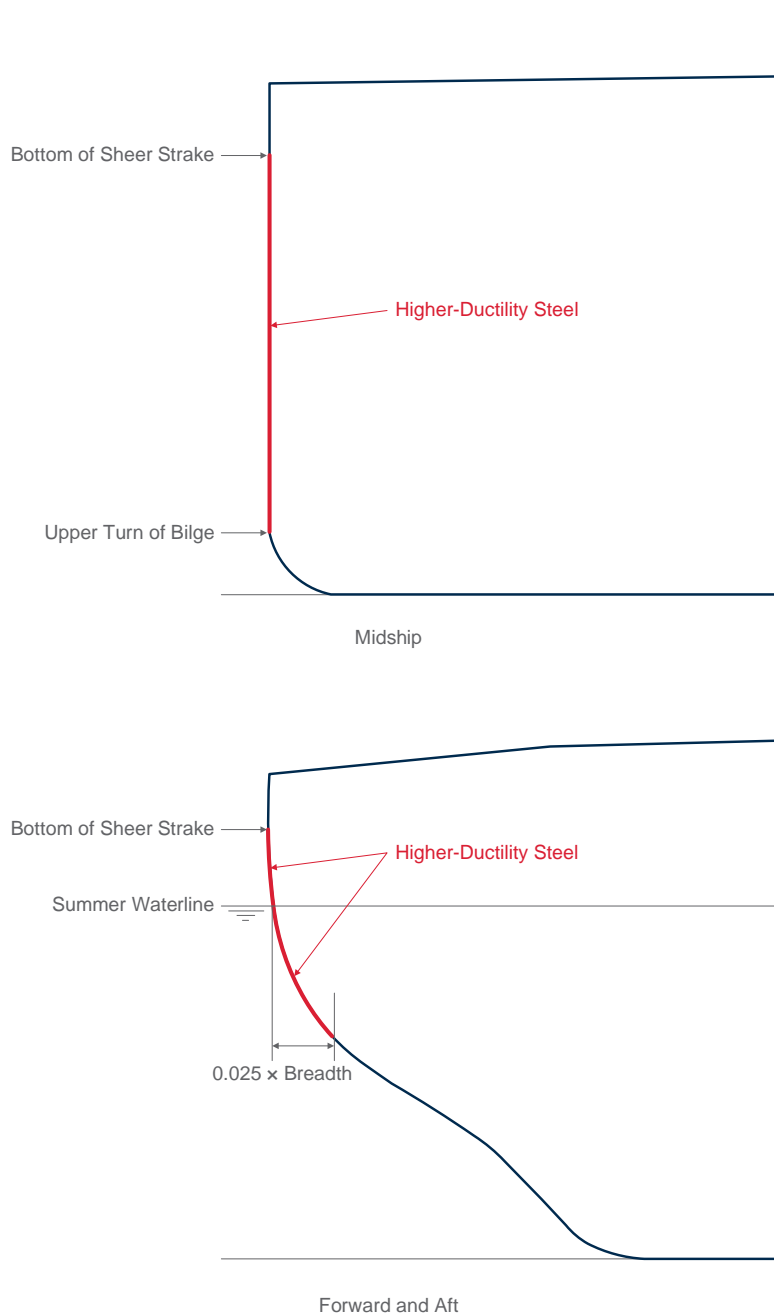
Detailed information on the extent of HD steel can be entered into the *Record* as comments. For example, “HDxx applied to Cargo Tanks and Fuel Oil Tanks”.

## 9 Submittals

The following information is to be submitted:

- Material specification
- Material test report
- Welding procedure
- Location and extent of application
- Vessel drawings with detailed application of HD steel

**FIGURE 1**  
**Minimum Extent of Application of Higher-Ductility Steel**





## SECTION 2 General Requirements

### 1 General

The requirements in this Section are applicable to higher-ductility grade hull structural steel plates up to 50 mm (2.0 in.) in thickness. Unless there are specific requirements in this Guide, the general guidelines and requirements defined in the *ABS Rules for Materials and Welding (Part 2)* are to be applied, which are summarized in Section 2, Table 1 in this Guide.

### 3 Qualification Requirements

Qualification is to be in accordance with Appendix 2-A4-2 of the *ABS Rules for Materials and Welding (Part 2)*.

### 5 Testing and Inspection

The requirements for the testing and inspection are defined in 2-1-1/1 of the *ABS Rules for Materials and Welding (Part 2)*.

### 7 Defects

The requirements for the conditions of defects are defined in 2-1-1/3 of the *ABS Rules for Materials and Welding (Part 2)*.

### 9 Identification of Materials

The requirements for identification of materials are defined in 2-1-1/5 of the *ABS Rules for Materials and Welding (Part 2)*. Refer to 1/1.3 of this Guide for HD designation.

### 11 Manufacturer's Certificates

The requirements for manufacturer's certificates are defined in 2-1-1/7 of the *ABS Rules for Materials and Welding (Part 2)*.

### 13 Identification of Specimens and Retests

The requirements for the identification of specimens and retests are defined in 2-1-1/9 of the *ABS Rules for Materials and Welding (Part 2)*.

### 15 Standard Test Specimens

The requirements for the preparation of specimens for tension test, bending test, and impact test are defined in 2-1-1/11 of the *ABS Rules for Materials and Welding (Part 2)*.

### 17 Yield Strength and Ultimate Tensile Strength (UTS)

The requirements for defining and determining yield strength and UTS are defined in 2-1-1/13 of the *ABS Rules for Materials and Welding (Part 2)*.

## 19 Permissible Variations in Dimensions

The requirements for permissible variations in dimensions are defined in 2-1-1/15 of the *ABS Rules for Materials and Welding (Part 2)*.

## 21 Process of Manufacture

The requirements for process of manufacture are defined in 2-1-2/3 of the *ABS Rules for Materials and Welding (Part 2)* for ordinary-strength steel and 2-1-3/3 of the *ABS Rules for Materials and Welding (Part 2)* for higher-strength steel.

## 23 Condition of Supply

The condition of supply is referred to 2-1-2/7 and 2-1-2/Table 5 for ordinary-strength steel of the *ABS Rules for Materials and Welding (Part 2)*, 2-1-3/3 and 2-1-3/Table 5 of the *ABS Rules for Materials and Welding (Part 2)* for higher-strength steel.

The condition of supply may need TMCP (Thermo-Mechanical Controlled Processing) to meet minimum strength, Charpy and elongation requirements for higher-ductility steel.

## 25 Marking

The requirements for marking are defined in 2-1-2/13 of the *ABS Rules for Materials and Welding (Part 2)* for ordinary-strength steel and 2-1-3/3 of the *ABS Rules for Materials and Welding (Part 2)* for higher-strength steel. Refer to 1/1.3 of this Guide for HD designation (e.g., HD35 or HD50).

## 27 Surface Finish

The requirements for surface finish are defined in 2-1-2/15 of the *ABS Rules for Materials and Welding (Part 2)* for ordinary-strength steel and 2-1-3/3 of the *ABS Rules for Materials and Welding (Part 2)* for higher-strength steel.

## 29 Fine Grain Practice

The requirements for fine grain practice are defined in 2-1-2/5.7 of the *ABS Rules for Materials and Welding (Part 2)* for ordinary-strength steel and 2-1-3/5 of the *ABS Rules for Materials and Welding (Part 2)* for higher-strength steel.

## 31 Ultrasonic Examination of Plate Materials

Ultrasonic examination of plate materials is defined in 2-1-1/21 of the *ABS Rules for Materials and Welding (Part 2)*.



**TABLE 1**  
**General Requirements of Higher-Ductility Steel**

| <i>General Requirements</i>                        | <i>ABS Rules for Materials and Welding (Part 2)</i>  |
|--|--|
| Qualification Requirements                         | 2-A4-2   |
| Testing and Inspection                             | 2-1-1/1  |
| Defects  | 2-1-1/3  |
| Identification of Materials                        | 2-1-1/5<br>Refer to 1/1.3 of this Guide for HD designation   |
| Manufacturer's Certificates                        | 2-1-1/7  |
| Identification of Specimens and Retests            | 2-1-1/9  |
| Standard Test Specimens                            | 2 1-1/11   |
| Yield Strength and Ultimate Tensile Strength (UTS) | 2 1 1/13   |
| Permissible Variations in Dimensions               | 2-1-1/15   |
| Process of Manufacture                             | 2-1-2/3 for ordinary-strength steel<br>2-1-3/3 for higher-strength steel   |
| Condition of Supply                                | 2-1-2/7 and 2-1-2/Table 5 for ordinary-strength steel<br>2-1-3/3 and 2-1-3/Table 5 for higher-strength steel<br>Refer to Subsection 1/23 of this Guide for Condition of Supply |
| Marking  | 2-1-2/13 for ordinary-strength steel<br>2-1-3/3 for higher-strength steel<br>Refer to 1/1.3 of this Guide for HD35 or HD50   |
| Surface Finish                                     | 2-1-2/15 for ordinary-strength steel<br>2-1-3/3 for higher-strength steel  |
| Fine Grain Practice                                | 2-1-2/5.7 for ordinary-strength steel<br>2-1-3/5 for higher-strength steel   |
| Ultrasonic Examination of Plate Materials          | 2-1-1/21   |



## SECTION 3 Additional Requirements for Higher-Ductility Steels

### 1 Qualification

Qualification is to be in accordance with Appendix 4 of the *ABS Rules for Materials and Welding (Part 2)*. In addition, qualification tests are to demonstrate that the steel can be produced consistently with higher elongation, and the supporting data is to be submitted for review (such as through-thickness hardness distribution measurements, and phase fraction and distribution, etc.).

### 3 Chemistry

In general, the chemistry is to be within the limits specified for regular ordinary-strength steel in 2-1-2/Table 1 of the *ABS Rules for Materials and Welding (Part 2)* and higher-strength hull steel in 2-1-3/Table 1 of the *ABS Rules for Materials and Welding (Part 2)*, with the necessary additional restrictions on limit ranges for improved elongation and to obtain the optimized microstructure. The carbon equivalent,  $C_{eq}$ , is to be calculated in accordance with 2-1-3/7 of the *ABS Rules for Materials and Welding (Part 2)* from the ladle analysis. The upper limit of the allowed carbon equivalent is 0.40%, unless otherwise agreed.

### 5 Microstructure

The following practices may be used to improve elongation.

- i) The volume fraction of soft ferrite phase and hard second phase is to be optimized by the chemical composition and manufacturing process such as TMCP.
- ii) The grain size is to be refined and the second phases are to be uniformly distributed by the optimized microstructure.
- iii) The through thickness hardness is to be uniform, such as the hardness value at  $1/8$ -inch below surface, one-quarter and mid thickness for reference.
- iv) The morphology of the inclusions is to be controlled to eliminate the coarse inclusions to originate ductile fracture void and reduce the variation of the ductility.

If these practices are used, items *i)*, *ii)* and *iii)* above are required during approval of manufacturer. Item *iv)* can be reported in accordance with ASTM E45 during production with the same frequency for tensile test, refer to 2-1-2/Table 5 of the *ABS Rules for Materials and Welding (Part 2)* for ordinary-strength-steel and 2-1-3/Table 5 of the *ABS Rules for Materials and Welding (Part 2)* for higher-strength steel.

### 7 Mechanical Properties

#### 7.1 Tensile Properties

The dimensions of tensile specimens are to be in accordance with 2-1-1/Figures 2 and 3 of the *ABS Rules for Materials and Welding (Part 2)*.

Tensile specimen orientation is to be in accordance with 2-1-1/11.3 of the *ABS Rules for Materials and Welding (Part 2)*. The tensile test specimen should represent the cross sectional properties.

Sample frequency for tensile test is to be in accordance with 2-1-2/Table 5 of the *ABS Rules for Materials and Welding (Part 2)* for ordinary-strength-steel and 2-1-3/Table 5 of the *ABS Rules for Materials and Welding (Part 2)* for higher-strength steel.

The requirements for yield and tensile strength are to be specified in 2-1-2/Table 2 of the *ABS Rules for Materials and Welding (Part 2)* for ordinary-strength steel and 2-1-3/Table 2 of the *ABS Rules for Materials and Welding (Part 2)* for higher-strength steel.

### **7.3 Elongation**

The minimum elongation for HD35 and HD50 is to be specified in Section 3, Tables 1 and 2 depending upon the applicable type of test specimen.

### **7.5 Impact Properties**

The dimension of the Charpy V notch specimen is to be in accordance with 2-1-1/Figure 4 of the *ABS Rules for Materials and Welding (Part 2)*.

Charpy specimen orientation and test location are to be in accordance with 2-1-1/11.11 of the *ABS Rules for Materials and Welding (Part 2)*.

Test frequency for Charpy is to be in accordance with 2-1-2/Table 5 of the *ABS Rules for Materials and Welding (Part 2)* for ordinary-strength steel and 2-1-3/Table 5 of the *ABS Rules for Materials and Welding (Part 2)* for higher-strength steel.

The minimum requirements of impact properties are to be specified in 2-1-2/Table 4 of the *ABS Rules for Materials and Welding (Part 2)* for ordinary-strength steel and 2-1-3/Table 4 of the *ABS Rules for Materials and Welding (Part 2)* for higher-strength steel.

## **9 Weldability Qualification at Steel Mill**

Welds are to be tried at different heat inputs, with reference to Appendix 4 and Appendix 5 of the *ABS Rules for Materials and Welding (Part 2)*.

The test results for weldability are to refer Appendix 2-A9-1 of the *ABS Rules for Materials and Welding (Part 2)*.

At the discretion of ABS, the proved elongation may be requested. The test results for weldability are to demonstrate that the weld metal, heat affected zone, and base metal can be effectively joined and that the higher elongation properties and other minimum mechanical properties are maintained.

**TABLE 1**  
**Minimum Elongation for Higher-Ductility Steel for Specimen Types A and C**

| Grade                             | Elongation, min. % <sup>(1,2)</sup> |
|-----------------------------------|-------------------------------------|
| HD35 with 35% improved elongation |                                     |
| A/B/D/E-HD35                      | 30                                  |
| AH32/DH32/EH32-HD35               | 30                                  |
| AH36/DH36/EH36-HD35               | 28                                  |
| HD50 with 50% improved elongation |                                     |
| A/B/D/E-HD50                      | 33                                  |
| AH32/DH32/EH32-HD50               | 33                                  |
| AH36/DH36/EH/36-HD50              | 32                                  |

Notes:

- 1 Minimum elongation for alternative A flat test specimen or alternative C round specimen in 2-1-1/Figure 2 of the *ABS Rules for Materials and Welding (Part 2)*.
- 2 Minimum elongation for ASTM E8M/E8 or A370 50 mm (2 in.) specimen.

**TABLE 2**  
**Minimum Elongation for Higher-Ductility Steel for Alternative Specimen Type B**

| <i>Thickness in mm (in.)</i>      |   |           |           |           |           |          |          |          |
|-----------------------------------|---|-----------|-----------|-----------|-----------|----------|----------|----------|
| >                                 | 0 (0)                                   | 5 (0.20)  | 10 (0.40) | 15 (0.60) | 20 (0.80) | 25 (1.0) | 30 (1.2) | 40 (1.6) |
| ≤                                 | 5 (0.20)                                | 10 (0.40) | 15 (0.60) | 20 (0.80) | 25 (1.0)  | 30 (1.2) | 40 (1.6) | 50 (2.0) |
| Grade                             | <i>Elongation, min. %<sup>(1)</sup></i> |           |           |           |           |          |          |          |
| HD35 with 35% improved elongation |   |           |           |           |           |          |          |          |
| A/B/D/E-HD35                      | 19                                      | 22        | 23        | 24        | 26        | 27       | 28       | 30       |
| AH32/DH32/EH32-HD35               | 19                                      | 22        | 23        | 24        | 26        | 27       | 28       | 30       |
| AH36/DH36/EH36-HD35               | 18                                      | 20        | 22        | 23        | 24        | 26       | 27       | 28       |
| HD50 with 50% improved elongation |   |           |           |           |           |          |          |          |
| A/B/D/E-HD50                      | 21                                      | 24        | 26        | 27        | 29        | 30       | 32       | 33       |
| AH32/DH32/EH32-HD50               | 21                                      | 24        | 26        | 27        | 29        | 30       | 32       | 33       |
| AH36/DH36/EH/36-HD50              | 20                                      | 23        | 24        | 26        | 27        | 29       | 30       | 32       |

Notes:

- 1 Minimum elongation for alternative B flat specimen in 2-1-1/Figure 2 of the *ABS Rules for Materials and Welding (Part 2)*.



## SECTION 4 Welding and Fabrication of Higher-Ductility Steels

### 1 General

The requirements in this Section are applicable to higher-ductility grade hull structural steel plates up to 50 mm (2.0 in.) in thickness. In the absence of specific requirements, the general guidelines and requirements for the preparation and performance of welding are specified in the *ABS Rules for Materials and Welding (Part 2)*, which are summarized in Section 4, Table 1 in this Guide.

### 3 Preparation for Welding

The requirements for the preparation of welding are defined in 2-4-1/3 of the *ABS Rules for Materials and Welding (Part 2)*.

### 5 Production Welding

The requirements for the production of welding are defined in 2-4-1/5 of the *ABS Rules for Materials and Welding (Part 2)*.

### 7 Butt Welds

The requirements for manual and automatic butt welding are defined in 2-4-1/7 of the *ABS Rules for Materials and Welding (Part 2)*.

### 9 Workmanship Testing

The requirements for workmanship testing are defined in 2-4-3/7 of the *ABS Rules for Materials and Welding (Part 2)*.

### 11 Welders

The requirements for qualification tests for welders are defined in 2-4-3/11 of the *ABS Rules for Materials and Welding (Part 2)*.

### 13 High Heat Input Welding

The requirements for approval of manufacturers of higher-ductility steel for welding with high heat input are defined in Appendix 5 of the *ABS Rules for Materials and Welding (Part 2)*.

**TABLE 1**  
**Welding and Fabrication of Higher-Ductility Steel**

| <i>Welding and Fabrication</i> | <i>ABS Rules for Materials and Welding (Part 2)</i> |
|--------------------------------|---|
| Preparation for Welding        | 2-4-1/3   |
| Production Welding             | 2-4-1/5   |
| Butt Welds                     | 2-4-1/7   |
| Workmanship Testing            | 2-4-3/7   |
| Welders                        | 2-4-3/11  |
| High Heat Input Welding        | 2-A5  |



## SECTION 5 Requirements for Filler Metals

### 1 General

Filler metals are to be a type suitable to produce sound welds that possess strength, elongation, and toughness comparable to the materials being welded. The requirements for the approval of welding filler metals are defined in Appendix 2 of the *ABS Rules for Materials and Welding (Part 2)*.

### 3 Application of Filler Metal

The applicable filler metals are to meet the minimum requirements of Appendix 2 and Appendix 3 of the *ABS Rules for Materials and Welding (Part 2)*.



## SECTION 6 Approval of Welding Procedures

### 1 General

Procedures for the welding of all joints are to be established before construction for the welding processes, types of electrodes, edge preparations, welding techniques, and positions proposed.

The welding procedure qualification test is required to determine the shipyard or fabricator's capability in the application of the proposed filler metal to the base material.

### 3 Test Requirements

Preparation of test specimen and test process is to follow the requirements in the *ABS Rules for Materials and Welding (Part 2)*.

The approval of welding procedures is to refer the requirements of Appendix 2-A9 of the *ABS Rules for Materials and Welding (Part 2)*.





## SECTION 7 Nondestructive Examination

### 1 General

Nondestructive examination is to be carried out and standard acceptance criteria are in accordance with the *ABS Guide for Nondestructive Inspection of Hull Welds*.

### 3 Enhanced Nondestructive Examination (NDE)

If agreed by the ship owner and shipbuilder, enhanced nondestructive examination may be requested for welds of higher-ductility steel located in anticipated collision locations.

The multiple angle probe UT (ultrasonic testing), TOFD (time of flight diffraction) or PAUT (phase array ultrasonic testing) are acceptable enhanced NDE techniques.

The acceptance criteria for enhanced NDE are to be agreed by ABS, depending upon ductile design such as materials designation, application etc.