

GUIDE FOR

APPLICATION OF HIGHER-STRENGTH THICK HULL STRUCTURAL STEEL PLATES IN CONTAINER CARRIERS FEBRUARY 2009

Guide to Color Coding Used in Online Version of the Guide

The following summarizes the colors corresponding to Rule Changes, Corrigenda items and editorial changes in the Guide files which are available for download.

Rule Changes:

NOTICE NO. 1 – January 2012 (effective 1 February 2012)

NOTICE NO. 2 – February 2014 (effective 1 January 2014)

Corrigenda:

CORRIGENDA/EDITORIALS – 6 April 2010

CORRIGENDA/EDITORIALS – 10 January 2012

CORRIGENDA/EDITORIALS – 1 February 2014

CORRIGENDA/EDITORIALS – 1 January 2017

CORRIGENDA/EDITORIALS – 1 February 2017

Editorials:

Editorial Changes



GUIDE FOR

APPLICATION OF HIGHER-STRENGTH HULL STRUCTURAL THICK STEEL PLATES IN CONTAINER CARRIERS

FEBRUARY 2009 (Updated February 2017 – see next page)

**American Bureau of Shipping
Incorporated by Act of Legislature of
the State of New York 1862**

**© 2009 American Bureau of Shipping. All rights reserved.
ABS Plaza
16855 Northchase Drive
Houston, TX 77060 USA**

Updates

February 2017 consolidation includes:

- January 2017 version plus Corrigenda/Editorials

January 2017 consolidation includes:

- February 2014 version plus Corrigenda/Editorials

February 2014 consolidation includes:

- February 2012 version plus Notice No. 2 and Corrigenda/Editorials

February 2012 consolidation includes:

- January 2012 version plus Notice No. 1

January 2012 consolidation includes:

- April 2010 version plus Corrigenda/Editorials

April 2010 consolidation includes:

- February 2009 version plus Corrigenda/Editorials

Foreword

The drive for efficient sea-borne container transportation has, over the last several decades, led to some significant growth in container carrier size. Application of hull structural thick steel plates in the upper flange of large container carriers becomes a natural choice for the hull structure to meet the required hull girder strength. Steel plates well in excess of 51 mm* are commonly found in large container carriers. More recently, one technical innovation that is having a significant impact on the next generation of container carriers is the application of hull structural thick steel plates with a minimum yield stress of 460 N/mm² (H47).

In addition to the *ABS Rules for Building and Classing Steel Vessels (Steel Vessel Rules)*, this Guide is intended to provide the supplementary requirements for the application of higher-strength hull structural thick steel plates, greater than 51 mm, in large container carriers. For thick steel plates with a minimum yield stress of 390 N/mm² (H40), the requirements reflect a large and successful body of experience with large container carriers in service, taking into consideration the first principles structural analysis methodologies and the experience in material, welding, and construction that is being routinely applied to large container carriers. Also in response to the request from industry for the adoption of H47 steel grade, this Guide is developed to provide guidance on the design, construction and operation, of container carriers built with such high strength steel plates.

After a certain period for trial use, the criteria contained in this Guide will be incorporated and published in the *Steel Vessel Rules*. ABS encourages and welcomes at any time the submission of comments on this Guide. The requirements contained in this Guide became effective on 1 January 2009.

* *Note:* The maximum thickness described in 3-1-2/1.3 of the *Steel Vessel Rules*.



GUIDE FOR

APPLICATION OF HIGHER-STRENGTH HULL STRUCTURAL THICK STEEL PLATES IN CONTAINER CARRIERS

CONTENTS

SECTION 1	Introduction	1
1	General	1
3	Application.....	1
SECTION 2	Hull Structural Design with Higher-Strength Thick Steel Plates	2
1	General	2
3	Selection of Material Grade	2
5	Hull Girder Strength	2
5.1	Hull Girder Section Modulus	2
5.3	Hull Girder Moment of Inertia.....	3
5.5	Hull Girder Shearing Strength.....	3
5.7	Hull Girder Torsional Strength	4
7	Initial Scantling Evaluation	4
9	Total Strength Assessment.....	4
11	Structural Details and Fatigue Strength Assessment	4
TABLE 1	Material Grade	2
TABLE 2	Material Factor Q for Determining Required Hull Girder Section Modulus.....	3
TABLE 3	Material Factor and Strength	3
SECTION 3	Testing and Certification of Thick Steel Plates with Minimum Yield Stress of 460 N/mm².....	5
1	General Requirements.....	5
1.1	Testing and Inspection.....	5
1.3	Defects	5
1.5	Identification of Materials	5
1.7	Manufacturer's Certificates	5
1.9	Identification of Specimens and Retests.....	5
1.11	Standard Test Specimens	5
1.13	Yield Strength and Elongation	5
1.15	Permissible Variations in Dimensions.....	5

1.17	Process of Manufacture.....	5
1.19	Condition of Supply	6
1.21	Marking.....	6
1.23	Surface Finish	6
1.25	Fine Grain Practice.....	6
3	Chemical Composition	6
3.1	Chemical Composition	6
3.3	Carbon Equivalent	6
3.5	Cold Cracking Susceptibility	6
5	Tensile Properties	8
7	Impact Properties.....	8
9	Fracture Toughness Testing	8
TABLE 1	Chemical Properties of H47 Steel.....	7
TABLE 2	Carbon Equivalent for H47 Steel	7
TABLE 3	Cold Cracking Susceptibility for H47 Steel	7
TABLE 4	Tensile Properties of H47 Steel	8
TABLE 5	Impact Properties of H47 Steel	8

SECTION 4 Welding and Fabrication of Thick Steel Plates with Minimum Yield Stress of 460 N/mm²..... 9

1	General	9
1.1	Preparation for Welding.....	9
1.3	Production Welding	9
1.5	Butt Welds	9
1.7	Workmanship Test	9
1.9	Welders	9
1.11	High Heat Input Welding.....	9
3	Requirements of Filler Metals	9
3.1	General.....	9
3.3	Mechanical Properties	9
3.5	Application of Filler Metal	9
5	Approval of Welding Procedures	10
5.1	General.....	10
5.3	Approved Filler Metals.....	10
5.5	Test Requirements	10
7	Weldability Test of Base Metal	10
7.1	General.....	10
7.3	Tensile Properties	10
7.5	Notch Toughness	10
TABLE 1	Applicable Filler Metals	10
TABLE 2	Toughness Requirements of Welds.....	10
TABLE 3	Toughness Requirements of Welds.....	11

SECTION 5	Prevention of Fatigue and Fracture Failure in Thick Steel Plates with Minimum Yield Stress of 460 N/mm²	12
1	General	12
3	Nondestructive Inspection of Welds	12
3.1	General	12
3.3	New Construction	12
3.5	Vessels in Service	12
3.7	Requirements for Nondestructive Test	12
5	Prevention of Fatigue Failure	13
5.1	Fatigue Strength Assessment	13
5.3	Fatigue Strength Improvement of Welds	13
7	Prevention of Fracture Failure	14
7.1	General	14
7.3	Crack Stop Hole	14
7.5	High Toughness Weld	14
7.7	Block Joint Shift	15
7.9	Insert Plate	16
9	Hull Girder Residual Strength	17
FIGURE 1	Grinding of Butt Weld	13
FIGURE 2	Crack Stop Holes	14
FIGURE 3	High Toughness Weld	15
FIGURE 4	Block Joint Shift	16
FIGURE 5	Insert Plate	16

APPENDIX 1	Full Ship Finite Element Based Fatigue Strength Assessment of Upper Flange Structure	18
1	General	18
1.1	Note	18
1.3	Applicability	18
1.5	Loadings	18
1.7	Effects of Corrosion	18
1.9	Format of the Criteria	18
3	Connections to be Considered for the Fatigue Strength Assessment	19
3.1	General	19
3.3	Guidance on Locations	19
3.5	Fatigue Classification	19
5	Fatigue Damage Calculation	30
5.1	Assumptions	30
5.3	Criteria	30
5.5	Long Term Stress Distribution Parameter, γ	30
5.7	Fatigue Damage	31
7	Fatigue Inducing Loads and Load Combination Cases	34
7.1	General	34
7.3	Wave-induced Loads	34
7.5	Combinations of Load Cases for Fatigue Assessment	34

9	Determination of Wave Induced Stress Range	35
9.1	General.....	35
9.3	Hatch Corners	35
11	Hot Spot Stress Approach with Finite Element Analysis	43
11.1	Introduction.....	43
11.3	Calculation of Hot Spot Stress at a Weld Toe	44
11.5	Calculation of Hot Spot Stress at the Edge of Cut-out or Bracket	46
TABLE 1	Fatigue Classification for Structural Details	20
TABLE 2	Welded Joint with Two or More Load Carrying Members.....	23
TABLE 3	Combined Load Cases for Fatigue Strength Formulation	34
FIGURE 1	Basic Design S-N Curves	33
FIGURE 2	Hatch Corners at Decks and Coaming Top	41
FIGURE 3	Circular Shape	42
FIGURE 4	Double Curvature Shape	42
FIGURE 5	Elliptical Shape.....	42
FIGURE 6	Hatch Corner for Longitudinal Deck Girder.....	43
FIGURE 7.....		44
FIGURE 8.....		46
APPENDIX 2	Hull Girder Residual Strength	47
1	General	47
3	Vertical Hull Girder Residual Limit State.....	47
5	Vertical Hull Girder Residual Bending Moment Capacity	47
5.1	General.....	47
5.3	Physical Parameters	48
5.5	Calculation Procedure	50
5.7	Assumptions and Modeling of the Hull Girder Cross-Section	51
5.9	Stress-strain Curves σ - ϵ (or Load-end Shortening Curves)	52
FIGURE 1	Bending Moment – Curvature Curve M - κ	48
FIGURE 2	Dimensions and Properties of Stiffeners	49
FIGURE 3	Example of Defining Structural Elements	52
FIGURE 4	Example of Stress Strain Curves σ - ϵ	53

This Page Intentionally Left Blank

11/11/2017 11:11:11 AM



SECTION 1 Introduction

1 General

This Guide describes the supplementary requirements for application of higher-strength hull structural steel plates, greater than 51 mm and less than or equal to 100 mm thickness, in container carriers with regards to the following: hull structural design, testing and certification of H47 steel material, welding and fabrication of H47 steel material, and prevention of fatigue and fracture failure of H47 steel material. These requirements on the thick steel plates are to be used in conjunction with the following ABS Rules:

- Part 5C, Chapter 5 “Vessels Intended to Carry Containers 130 meters (427 feet) to 450 meters (1476 feet) in Length” of the *ABS Rules for Building and Classing Steel Vessels (Steel Vessel Rules)* for the scantling and strength requirements.
- Chapter 1 “Materials for Hull Construction” of the *ABS Rules for Materials and Welding (Part 2)*
- Chapter 4 “Welding and Fabrication” of the *ABS Rules for Materials and Welding (Part 2)*
- *ABS Rules for Survey After Construction (Part 7)*

For thick steel plates in the upper flange of the hull structure, fatigue and fracture are two most pertinent failure mechanisms. When the hull girder strength is designed to the rule minimum requirements, the accompanying effects of higher-strength thick steel plates are largely associated with higher stress levels and reduced fatigue and fracture strength characteristics. In the upper flange of the hull structure, wave-induced fatigue damages in way of thick plated weld connections are the first and foremost concern. As a countermeasure, the fatigue behavior of these weld connections is to be extensively evaluated to avoid initial crack initiation. Second, the presence of planar flaws in thick plated weld connections can adversely affect the integrity of these connections in the form of accelerated crack growth and fracture. Satisfactory fatigue and fracture characteristics are to be attained from improvements in structural design measures, steel materials, welding consumables, welding procedures and post-weld enhancements. Third, survey after construction is to be enhanced through monitoring critical areas and non-destructive inspection.

3 Application

For H40 steel grade, the supplementary requirements in the Guide are applicable to steel plate thicknesses greater than 51 mm and less than 100 mm used in the upper flange of a container carrier hull structure.

For H47 steel grade, the supplementary requirements in the Guide are applicable to steel plate thicknesses less than 100 mm used in the upper flange of a container carrier hull structure.



SECTION 2 Hull Structural Design with Higher-Strength Thick Steel Plates

1 General

The material factor Q for higher strength steels used in the hull girder strength requirement is an indirect means to minimize potential risks associated with buckling, fatigue and fracture in higher strength steels. For thick plated structural members in the upper flange of a container carrier, buckling can generally be excluded as a critical structural mode. Therefore, prevention of fatigue and fracture in the upper flange should be one of the main focuses for large container carriers. Reference is to be made to Part 5C, Chapter 5 “Vessels Intended to Carry Containers 130 meters (427 feet) to 450 meters (1476 feet) in Length” of the *Steel Vessel Rules* for the scantling and strength requirements. In this Section, specific guidance is provided on the application of higher-strength thick steel plates.

3 Selection of Material Grade

Steel materials for particular locations are not to be of lower grades than those required by Section 2, Table 1 of this Guide. Material class is given in 3-1-2/Table 2 of the *Steel Vessel Rules*.

TABLE 1
Material Grade

Thickness, t mm	Material Class		
	I	II	III
$t \leq 15$	A, AH	A, AH	A, AH
$15 < t \leq 20$	A, AH	A, AH	B, AH
$20 < t \leq 25$	A, AH	B, AH	D, DH
$25 < t \leq 30$	A, AH	D, DH	D, DH
$30 < t \leq 35$	B, AH	D, DH	E, EH
$35 < t \leq 40$	B, AH	D, DH	E, EH
$40 < t \leq 51$	D, DH	E, EH	E, EH
$51 < t \leq 70$	D, DH	E, EH	E, EH
$71 < t \leq 100$	E, EH	E, EH	E, EH

5 Hull Girder Strength

5.1 Hull Girder Section Modulus

The requirement on hull girder section modulus is given in 5C-5-4/3.1 of the *Steel Vessel Rules*. When either the top or bottom flange of the hull girder, or both, is constructed of higher strength material, the section modulus, as obtained from 3-2-1/3.7 the *Steel Vessel Rules* may be reduced by the material factor Q .

$$SM_{hts} = Q(SM)$$

where

SM = section modulus as obtained from 3-2-1/3.7 of the *Steel Vessel Rules*

The material factor Q for steel materials is listed in Section 2, Table 2 of this Guide. For steel plates 51 mm and under in thickness, the material factor Q is defined in 3-2-1/5.5 of the *Steel Vessel Rules* to be 0.78 for H32, 0.72 for H36 and 0.68 for H40. However for steel plates greater than 51 mm in thickness, the material factor Q for the required section modulus is defined in Section 2, Table 2 with reference to Notes 1 and 2.

5.3 Hull Girder Moment of Inertia

The requirement on hull girder moment of inertia is given in 5C-5-4/3.3 of the *Steel Vessel Rules*. The hull girder moment of inertia is to be not less than required 3-2-1/3.7.2 of the *Steel Vessel Rules*.

If the upper flange is constructed of H47 or H40 grade with the reduced material factor Q in Note 1 of Section 2, Table 2 of this Guide, the effects of springing and whipping on fatigue strength of the hull structural strength are to be evaluated in accordance with the requirements in [Subsection 2/11](#) of this Guide.

TABLE 2
Material Factor Q for Determining
Required Hull Girder Section Modulus (2014)

Steel Grade	Material Factor Q ⁽³⁾
Ordinary Strength Steel	1.00
H32	0.78
H36	0.72
H40	0.68 ⁽¹⁾
H47 ⁽²⁾	0.62

Notes:

- 1 The material factor for H40 may be taken as 0.66, provided that the hull structure is additionally verified for compliance with the requirements of:
 - ABS Guide for 'SafeHull-Dynamic Loading Approach' for Vessels
 - ABS [Guide for Spectral-Based Fatigue Analysis for Vessels](#)
 - Appendix 1 of this Guide
- 2 The above requirements are to be applied to hull structures with H47.
- 3 Thickness greater than 100 mm is subject to special consideration.

5.5 Hull Girder Shearing Strength

The requirements of hull girder shearing strength are given in 5C-5-4/5 of the *Steel Vessel Rules*. The material factor Q and strength reduction factor S_m for steel materials to be applied are listed in Section 2, Table 3 of this Guide.

TABLE 3
Material Factor and Strength

Steel Grade	Material Factor, Q	Strength Reduction Factor, S_m
Ordinary Strength Steel	1.00	1.00
H32	0.78	0.95
H36	0.72	0.908
H40	0.68	0.875
H47	0.62	0.824

Note: The above material factor and strength reduction factor are valid for hull girder shearing strength, hull girder torsional strength, initial scantling evaluation (except for hull girder section modulus), and total strength assessment

5.7 Hull Girder Torsional Strength

The requirements of hull girder torsional strength are defined in 5C-5-4/9 of the *Steel Vessel Rules*. The material factor Q and strength reduction factor S_m for steel materials are listed in Section 2, Table 3 of this Guide.

7 Initial Scantling Evaluation

The requirements of initial scantling evaluation are defined in Section 5C-5-4 of the *Steel Vessel Rules*. The material factor Q for the hull girder section modulus requirement is listed in Section 2, Table 2 of this Guide. For all other requirements, the material factor Q and strength reduction factor S_m for steel materials to be applied are listed in Section 2, Table 3 of this Guide.

9 Total Strength Assessment

The requirements for total strength assessment are given in Section 5C-5-5 of the *Steel Vessel Rules*. The strength reduction factor S_m for steel materials to be applied is listed in Section 2, Table 3 of this Guide.

For the hull structure constructed of higher-strength thick steel plates, special attention is to be paid to the effect of bowflare slamming on vertical hull girder bending moment and shear force, see 5C-5-3/11.3.3 of the *Steel Vessel Rules*.

11 Structural Details and Fatigue Strength Assessment

For the hull structure built with higher-strength thick steel plates of H40 or H47, special attention is to be paid to the fatigue strength of the butt welds and hatch corners in the upper flange of the hull structure. Appendix 1 provides specific guidance on the fatigue strength assessment of these structural details.

For other structural details such as longitudinal connections of web frames and transverse bulkheads, Appendix 5C-5-A1 “[Fatigue Strength Assessment of Container Carriers](#)” of the *Steel Vessel Rules* provides the detailed guidance.

For the upper flange of a hull structure constructed of higher-strength thick steel plates of H40 or H47, special attention is to be paid to the effects of whipping on the fatigue strength of the upper flange of the hull structure (A1/5.7 of this Guide).

Furthermore, for the upper flange of a hull structure constructed of higher-strength thick steel plates of H40 or H47, the effects of hull girder springing on the fatigue strength are to be accounted for by direct springing analysis (see A1/5.7 of this Guide).



SECTION 3 Testing and Certification of Thick Steel Plates with Minimum Yield Stress of 460 N/mm²

1 General Requirements

The requirements in this Section are applicable to H47 grade hull structural steel plates up to 100 mm in thickness. The general guideline and requirements defined in the *ABS Rules for Materials and Welding (Part 2)* are to be applied, unless there are specific requirements in this Guide.

1.1 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)*.

1.3 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)*.

1.5 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)*.

1.7 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)*.

1.9 Identification of Specimens and Retests

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

1.11 Standard Test Specimens

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

1.13 Yield Strength and Elongation

The requirements for definition and determination of yield strength and elongation are defined in 2-1-1/13 and 2-1-1/14 of the *ABS Rules for Materials and Welding (Part 2)*.

1.15 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)*.

1.17 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)*.

1.19 Condition of Supply

The condition of supply is to be TMCP. The requirements for supply are defined in 2-1-2/7 of the ABS *Rules for Materials and Welding (Part 2)*.

1.21 Marking

The requirements for marking are defined in 2-1-2/13 of the ABS *Rules for Materials and Welding (Part 2)*.

1.23 Surface Finish

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

1.25 Fine Grain Practice

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

3 Chemical Composition**3.1 Chemical Composition**

The chemical composition is to be determined by the steel manufacturer on samples taken from each ladle of each heat and is to conform to Section 3, Table 1.

3.3 Carbon Equivalent

The carbon equivalent C_{eq} as determined from the ladle analysis in accordance with the following equation is to meet the requirements in Section 3, Table 2.

$$C_{eq} = C + \frac{Mn}{6} + \frac{Cr + Mo + V}{5} + \frac{Ni + Cu}{15} \quad (\%)$$

3.5 Cold Cracking Susceptibility

The cold cracking susceptibility P_{cm} as calculated from the ladle analysis in accordance with the following equation is to meet the requirements in Section 3, Table 3.

$$P_{cm} = C + \frac{Si}{30} + \frac{Mn}{20} + \frac{Cu}{20} + \frac{Ni}{60} + \frac{Cr}{20} + \frac{Mo}{15} + \frac{V}{10} + 5B \quad (\%)$$

TABLE 1
Chemical Properties of H47 Steel

Grade	AH47, DH47, EH47, FH47
Deoxidation	Killed, Fine Grain Practice ⁽¹⁾
Chemical Composition ⁽²⁾	(Ladle Analysis), % max. unless specific in range
C	0.10
Mn	2.00
Si	0.55 ⁽³⁾
P	0.030
S	0.030
Al (acid Soluble) min. ^(4,5)	0.015
Nb ⁽⁵⁾	0.05
V ⁽⁵⁾	0.10
Ti	0.02
Cu	0.35
Cr	0.25
Ni	1.50
Mo	0.08
B	0.002

Notes:

- 1 The steel is to contain at least one of the grain refining elements in sufficient amount to meet the fine grain practice requirement specified in 2-1-3/5 of the *ABS Rules for Materials and Welding (Part 2)*.
- 2 The content of any other element intentionally added is to be determined and reported.
- 3 Where the content of soluble aluminum is not less than 0.015%, the minimum required silicon content does not apply.
- 4 The total aluminum content may be used in lieu of acid soluble content, in accordance with 2-1-3/5 of the *ABS Rules for Materials and Welding (Part 2)*.
- 5 The indicated amount of aluminum, niobium and vanadium applies when any such element is used singly. When used in combination, the minimum content in 2-1-3/5 of the *ABS Rules for Materials and Welding (Part 2)* will apply.

TABLE 2
Carbon Equivalent for H47 Steel

Grade	Carbon Equivalent, Max. (%)	
	$t \leq 51 \text{ mm}$	$51 \text{ mm} < t \leq 100 \text{ mm}$
AH47, DH47, EH47, FH47	0.46	0.49

TABLE 3
Cold Cracking Susceptibility for H47 Steel

Grade	Cold Cracking Susceptibility, Max. (%)
	$t \leq 100 \text{ mm}$
AH47, DH47, EH47, FH47	0.21

5 Tensile Properties

The material is to conform to the requirements of Section 3, Table 4 of this Guide as to tensile properties. The requirements for the preparation and procedure of tensile test are defined in 2-1-2/9 of the *ABS Rules for Materials and Welding (Part 2)*.

TABLE 4
Tensile Properties of H47 Steel

Grade	Tensile Strength N/mm ² (kgf/mm ² , ksi)	Yield Point min. N/mm ² (kgf/mm ² , ksi)	Elongation Min. %
AH47, DH47, EH47, FH47	570–720 (58-71, 83-101)	460 (47, 67)	17

7 Impact Properties

The requirements for the preparation and procedure of Charpy V-notch impact test are defined in 2-1-2/11 of the *ABS Rules for Materials and Welding (Part 2)*. The results of the test are to meet the requirements specified in [Section 3](#), Table 5 of this Guide.

TABLE 5
Impact Properties of H47 Steel

Grade	Temp °C (°F)	Average Absorbed Energy Longitudinal J (kgf-m, ft-lbt)	Average Absorbed Energy Transverse J (kgf-m, ft-lbt)
AH47	0 (32)	64 (6.5, 47)	43 (4.4, 32)
DH47	-20 (-4)	64 (6.5, 47)	43 (4.4, 32)
EH47	-40 (-40)	64 (6.5, 47)	43 (4.4, 32)
FH47	-60 (-76)	64 (6.5, 47)	43 (4.4, 32)

Note: The energy shown is minimum for full size specimen.

9 Fracture Toughness Testing

Fracture toughness of materials and weldments of H47 steel plate is to be verified by CTOD test, ESSO test, or deep notch test by steel manufacturers. CTOD test is to be carried out as per BS 7448 Parts 1 & 2 of ASTM E1820 or any other recognized standard. The requirements for CTOD test are defined in 2-1-1/23 of the *ABS Rules for Materials and Welding (Part 2)*.



SECTION 4 Welding and Fabrication of Thick Steel Plates with Minimum Yield Stress of 460 N/mm²

1 General

The requirements in this Section are applicable to H47 grade hull structural steel plates up to 100 mm in thickness. The general guideline and requirements for the preparation and practice of welding specified in the *ABS Rules for Materials and Welding (Part 2)* is to be applied, unless there are specific requirements in this Guide.

1.1 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)*.

1.3 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)*.

1.5 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)*.

1.7 Workmanship Test

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

1.9 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)*.

1.11 High Heat Input Welding

The requirements for approval of manufactures of H47 steel plates for welding with high heat input are defined in Appendix 5 of the *ABS Rules for Materials and Welding (Part 2)*.

3 Requirements of Filler Metals

3.1 General

Filler metals are to be a type suitable to produce sound welds that have strength 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)*.

3.3 Mechanical Properties

The tensile strength range of filler metals used for H47 steel is to be 570-720 N/mm².

3.5 Application of Filler Metal

The application of filler metal is to meet the requirements in Section 4, Table 1.

TABLE 1
Applicable Filler Metals

<i>Filler Metal Grade</i>	<i>Plate Thickness ≤ 51 mm</i>	<i>Plate Thickness > 51 mm</i>
Grade 3 Y 470	AH47, DH47	AH47
Grade 4 Y 470	AH47, DH47, EH47	AH47, DH47
Grade 5 Y 470	AH47, DH47, EH47, FH47	AH47, DH47, EH47
Grade 6 Y 470	AH47, DH47, EH47, FH47	AH47, DH47, EH47, FH47

5 Approval of Welding Procedures

5.1 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.

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.

5.3 Approved Filler Metals

For butt weld test assembly and fillet weld test assembly, as applicable, one of the grades of steel, or equivalent, as listed in Section 4, Table 1 for the individual grade of filler metals is to be used. The maximum hydrogen content is to be 10 cm³/100 g.

5.5 Test Requirements

Preparation of test specimen and test process is to follow the requirements in the *ABS Rules for Materials and Welding (Part 2)*. Charpy V-notch impact test for the toughness of weldments is to meet the requirements in Section 4, Table 2 of this Guide.

TABLE 2
Toughness Requirements of Welds

<i>Grade</i>	<i>Test Location</i>	<i>Test Temperature</i>	<i>CVN Requirement</i>
AH47, DH47, EH47	WM, FL, FL+1 mm, +3 mm, +5 mm	-20°C	57 J
FH47		-40°C	57 J

7 Weldability Test of Base Metal

7.1 General

The general requirements for weldability test of H47 steel plates are defined in 2-A4-2/5.13 of the *ABS Rules for Materials and Welding (Part 2)*. The mechanical properties of welds are to meet the requirements specified in this Subsection.

7.3 Tensile Properties

Tensile properties are to meet the requirements of the base plate as specified in Section 3.

7.5 Notch Toughness

Charpy V-notch impact test for the toughness of weldments are to meet the requirements specified in Section 4, Table 3.

TABLE 3
Toughness Requirements of Welds

<i>Grade</i>	<i>Test Location</i>	<i>Test Temperature</i>	<i>CVN Requirement</i>
AH47	FL, FL+2 mm, +5 mm, +20 mm	0°C	64 J
DH47		-20°C	64 J
EH47		-40°C	64 J
FH47		-60°C	64 J