Designation: F2016 – 00 (Reapproved 2018)

An American National Standard

Standard Practice for Establishing Shipbuilding Quality Requirements for Hull Structure, Outfitting, and Coatings[1]

This standard is issued under the fixed designation F2016; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This practice consists of three annexes: hull structure, outfitting, and coating. The subject of these annexes was selected for several reasons. Other commercial shipbuilding nations already have in place widely recognized standards of expectations in these areas. These constitute the most significant areas where workmanship is a critical factor in customer satisfaction. The cost associated with the labor involved in these three areas is a significant factor in construction man-hours and overall schedules.

1.2 The standard criteria provided in this practice are intended to apply to conventional, commercial ship construction. In many cases, specialized, nonconventional vessels using nonstandard materials or built-to-serve sole requirements may require unique acceptance criteria that are beyond those provided in this practice.

1.3 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.4 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D4417 Test Methods for Field Measurement of Surface Profile of Blast Cleaned Steel

E337 Test Method for Measuring Humidity with a Psychrometer (the Measurement of Wet- and Dry-Bulb Temperatures)

2.2 *ISO Standards:*[3]

ISO 8502–3 Assessment of Dust on Steel Surfaces Prepared for Painting (Pressure-Sensitive Tape Method)

ISO 8502–6 Extraction of Soluble Contaminants for Analysis—The Bresle Method

2.3 *NACE Standards:*[4]

NACE No. 5 Surface Preparation and Cleaning of Steel and Other Hard Materials by High-and Ultrahigh-Pressure Water Jetting Prior to Re-coating (SSPC-SP 12)

NACE No. 7 Interim Guide and Visual Reference Photographs for Steel Cleaned by Water Jetting (SSPC-VIS 4(1))

2.4 *SSPC Standards:*[5]

SSPC-AB 1 Mineral and Slag Abrasives

SSPC-AB 2 Specification for Cleanliness of Recycled Ferrous Metallic Abrasives

SSPC-PA 2 Measurement of Dry Coating Thickness With Magnetic Gages

SSPC-SP 1 Solvent Cleaning

SSPC-SP 2 Hand Tool Cleaning

SSPC-SP 3 Power Tool Cleaning

SSPC-SP 7 Brush-Off Blast Cleaning

SSPC-SP 10 Near-White Blast Cleaning

SSPC-SP 11 Power Toll Cleaning to Bare Metal

SSPC-SP 12 Surface Preparation and Cleaning of Steel and Other Hard Materials by High-and Ultrahigh-Pressure Water Jetting Prior to Re-coating (NACE No. 5)

SSPC-VIS 1-89 Visual Standard for Abrasive Blast Cleaned Steel

SSPC-VIS 3 Visual Standard for Power- and Hand-Tool Cleaned Steel

SSPC-VIS 4(1) Interim Guide and Visual Reference Photographs for Steel Cleaned by Water Jetting (NACE No. 7)

[1] This practice is under the jurisdiction of ASTM Committee F25 on Ships and Marine Technology and is the direct responsibility of Subcommittee F25.01 on Structures.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.

[4] Available from NACE International (NACE), 15835 Park Ten Pl., Houston, TX 77084, http://www.nace.org.

[5] Available from Society for Protective Coatings (SSPC), 800 Trumbull Dr., Pittsburgh, PA 15205, http://www.sspc.org.

2.5 *NSRP Documents:*[6]

National Shipbuilding Research Project 6–97–1 "American Shipbuilding Quality Standards," dated May 28, 1999

3. Summary of Practice

3.1 This practice provides workmanship criteria to be applied to commercial shipbuilding or ship repair, or both. The criteria covers three primary phases of ship construction, that is, hull structure, outfitting, and coatings. Specific criteria to be selected from this standard should be as contractually agreed between the ship owner and shipbuilder.

4. Significance and Use

4.1 To achieve success in ship construction, it is necessary for the ship owner and the ship builder to agree on the level of quality in the final product. Classification rules, regulatory requirements, and ship specifications all help to define an acceptable level of construction quality; however, this guidance alone is not sufficient. It is up to the shipbuilder, therefore, to describe the level of workmanship sufficiently that will be reflected in the delivered ship, and for the ship owner to communicate his expectations effectively for the final product.

4.2 It is the intent of this document to contribute to these objectives in the following ways:

4.2.1 To describe a reasonable acceptable level of workmanship for commercial vessels built in the United States.

4.2.2 To provide a baseline from which individual shipyards can begin to develop their own product and process standards in accordance with generally accepted practice in the commercial marine industry.

4.2.3 To provide a foundation for negotiations between the shipbuilder and the ship owner in reaching a common expectation of construction quality.

4.3 The acceptance criteria herein are based on currently practiced levels of quality generally achieved by leading international commercial shipbuilders. These criteria are not intended to be a hard standard with which all U.S. shipyards must comply. Rather, they are intended to provide guidance and recommendations in the key areas that play a major role in customer satisfaction and cost-effective ship construction.

5. Keywords

5.1 coatings; hull structure; outfitting; quality; shipbuilding; workmanship

[6] Available from The Librarian, Documentation Center, Marine Systems Division, University of Michigan Transportation Research Institute, 2901 Baxter Rd., Ann Arbor, MI 48109–2150.

ANNEXES

(Mandatory Information)

A1. HULL STRUCTURE

Ⅰ. HULL **STRUCTURE**					SHIPBUILDING QUALITY STANDARDS
Division		Marking			UNIT: mm
Section	Sub-section	Item	Standard Range	Tolerance Limits	Remarks
Cutting line and fitting line compared with correct ones	General members	Size and shape compared with correct ones.	±2	±3	
			±1.5	±2.5	Especially for the depth of floors and girders of double bottom.
		Corner angle compared with correct ones	±1.5	±2	
		Curvature	±1	±1.5	
		Location of member & mark for fitting compared with correct ones.	±2	±3	
		Block marking (Panel block) compared with correct ones.	±2.5	±3.5	
		Location of member for fitting compared with correct ones.	±2.5	±3.5	

FIG. A1.1 Hull Structure

Ⅰ. HULL **STRUCTURE**							SHIPBUILDING QUALITY STANDARDS
Division		Gas Cutting			UNIT: mm		
Section	Sub-section	Item	Standard Range	Tolerance Limits	Standard Range	Tolerance Limits	Remarks
Roughness	Free edge	Strength Shop member Field	100μ (2nd cl) 150μ (3rd cl)	200μ (3rd cl) 300μ (Out cl)	The class denoted in parentheses is in accordance with following definition. Less Than 50μ 1st calss 50μ ~ 100μ 2nd class 100μ ~ 200μ 3rd class More than 200μ out of class – Special precautions are required in case where grinding or other treatments are requested. – For angle cutting the same as the case in field.		
		Other Shop Field	100μ (2nd cl) 500μ (Out cl)	200μ (3rd cl) 150μ (Out cl)			
	Weld groove	Strength Shop member Field	100μ (2nd cl) 400μ (Out cl)	200μ (3rd cl) 800μ (Out cl)			
		Other Shop Field	100μ (2nd cl) 800μ (Out cl)	1500μ (Out cl) 1500μ (Out cl)			

FIG. A1.2 Hull Structure

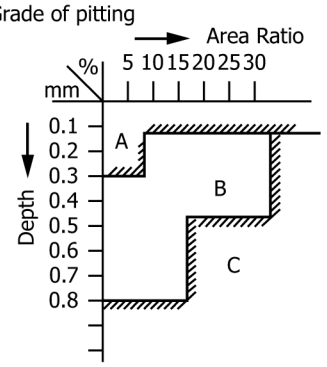
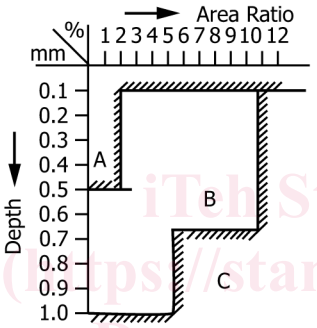
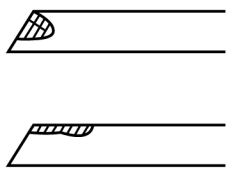
Ⅰ. HULL **STRUCTURE**			SHIPBUILDING QUALITY STANDARDS
Division		Material	
Section	Sub-section	Item	Remarks
Surface flow	Pitting	Grade of pitting  	1. Grade A pitting is minor and no repair is necessary. Grade B pitting is moderate and is to be repaired as necessary. Grade C pitting is severe and requires repair. 2. Pitting that occurs on the boundary line between Grade A and Grade B can be considered minor and treated as Grade A pitting. 3. Repairs shall be made as follows: Depth of pitting : d Plate Thickness : t Where 0.07t>d Grind Smooth (Note: Regardless of plate thickness, at no time should pitting that is 3 mm deep or greater be repaired by grinding only) Where 0.2t≥d0.07t Grind and Weld Note: The area ratio is the estimated percentage of the plate surface that is pitted to the point where the surface appearance is unsatisfactory.
	Flaking	Grade of surface flaking  	1. Grade A pitting is minor and no repair is necessary. Grade B pitting is moderate and is to be repaired as necessary. Grade C pitting is severe and requires repair. 2. Pitting that occurs on the boundary line between Grade A and Grade B can be considered minor and treated as Grade A pitting. 3. Repairs shall be made as follows: Depth of pitting : d Plate Thickness : t Where 0.07t>d Grind Smooth (Note: Regardless of plate thickness, at no time should pitting that is 3 mm deep or greater be repaired by grinding only) Where 0.2t≥d0.07t Grind and Weld Note: The area ratio is the estimated percentage of the plate surface that is pitted to the point where the surface appearance is unsatisfactory.
Casting Steel	Details of Casting Steel	Applicable to cases where defects are over 20% of thickness, or over 25 mm deep and 150 mm long.	When the removal of a surface defect exposes other significant defects such as cavities, cracks or inclusions. The casting is to be checked using dye penetrant inspecion, magnetic particle inspection or ultrasonic inspection and repaired accordingly, using an appropriate method of repair.
Delamination	Local Delamination	 	Where delamination is minor it can be chipped or ground out and built-up with weld metal as shown in Figure (a). Where minor delamination occurs close to the plate surface grinding or chipping and weld metal build-up should be as shown in Figure (b). Repair of moderate delamination should be considered on a case by case basis.
	Severe delamination, requireing a local exchange of plate		Where delamination is fairly extensive, plating should be cropped out locally and replaced. The minimum width of plating to be cropped out is to be as follows: Highly Stressed Primary Longitudinal Strength Members: 1600 mm Moderately Stressed Primary Longitudinal Strength Members: 800 mm All Other Structural Members: 300 mm Where severe delamination that affects the whole plate occurs, the whole plate must be replaced.

FIG. A1.3 Hull Structure

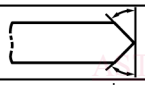
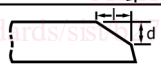
I. HULL **STRUCTURE**				SHIPBUILDING QUALITY STANDARDS	
Division		Gas Cutting		UNIT : mm	
Section	Sub-section	Item	Standard Range	Tolerance Limits	Remarks
Notches & indentations Note: A notch is defined as a highly localized indent that is three times deeper than the tolerance limits for normal roughness.	Free edge	1) Upper edge of sheer strake. 2) Strength deck between 0.6l ⊗ and free edge of opening of shell plate. 3) Main longl strength members.		Notch 0	Notches are to be welded up prior to grinding in areas where a smooth finish is required. Sufficient weld metal should be laid such that after grinding there are no residual voids or cracks between the weld metal and the parent metal.
		Longitudinal & Transverse Strength members		Indentation ≤1	Indentions greater than the stated tolerance limit are to be treated as notches.
		Others		Indentation ≤3	Indentions greater than the stated tolerance limit are to be treated as notches.
	Weld groove	Butt Weld: Shell plate & Upperdeck between 0.6l ⊗		Indentation ≤2	Indentions greater than the stated tolerance limit are to be treated as notches.
		Butt Weld: Others		Indentation ≤3	Indentions greater than the stated tolerance limit are to be treated as notches.
		Fillet Weld		Indentation ≤3	Indentions greater than the stated tolerance limit are to be treated as notches.
Dimension	Straightness of plate edge	Both side submerged arc welding	±0.4	±0.5	
		Manual welding: semi automatic welding	±1.0	±2.5	
	Depth of edge preparation		±1.5	±2.0	
	Angle of edge preparation		±2*	±4*	
	Length of taper	 (l compared with correct sizes)	±0.5d	±1.0d	
	Size of member	Structural members other than double bottom floors and girders.	±3.5	±5.0	
		Depth of double bottom floors and girders.	±2.5	±4.0	
		Breadth of face bar.	±2.0	−3.0 ~ +4.0	
	Edge preparation	Automatic welding	±2*	±4*	
		Semi-automatic & manual welding.	±2*	±4*	

FIG. A1.4 Hull Structure

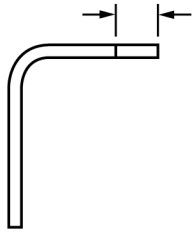
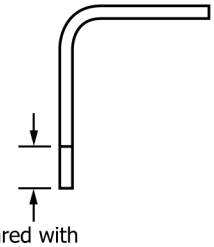
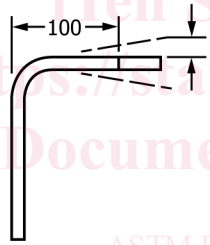
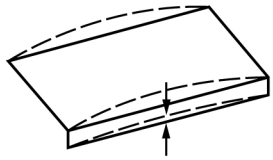
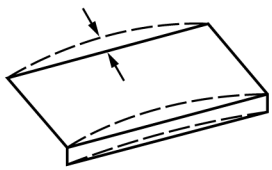
Ⅰ. HULL **STRUCTURE**			SHIPBUILDING QUALITY STANDARDS		
Division		Fabrication		UNIT : mm	
Section	Sub-section	Item	Standard Range	Tolerance Limits	Remarks
Flanged Longitudinal	Breadth of Flange	 Compared with correct size	±3.0	±5.0	
	Depth of web	 Compared with correct size	±3.0	±5.0	Low and moderately stressed members.
			±2.0	±3.0	Highly stressed members.
	Angle between flange and web	 Compared with template per 100 mm in breadth of flange	±2.5	±4.5	
	Curvature or straightness in the plane of flange	 Per 10 m in length	±10	±25	
	Curvature or straightness in the plane of web	 Per 10 m in length	±10	±25	

FIG. A1.5 Hull Structure

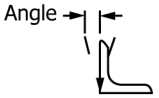
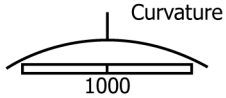
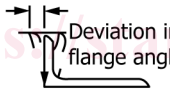
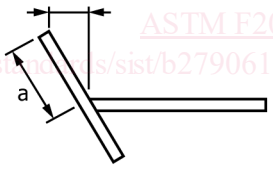
I . HULL **STRUCTURE**			SHIPBUILDING QUALITY STANDARDS		
Division		Fabrication		UNIT : mm	
Section	Sub-section	Item	Standard Range	Tolerance Limits	Remarks
Angle & Built up plate	Stringer angle	Angle  Compared with template	±1.5	±2.0	
		Curvature  1000 Compared with template	±1.0	±1.5	Maximum permitted curvature per 100 mm length of member.
	Frame & Long	Curvature compared with template or check line. Per 10 m in length.	±2.0	±4.0	
		Deviation from.  Inscribed curve Correct from inscribed.	±3.0	±5.0	
		 Deviation in flange angle Compared with template	±1.5	±3.0	
		Deviation of face plate  a	±1.5 per 100 mm	±3.0 per 100 mm	

FIG. A1.6 Hull Structure

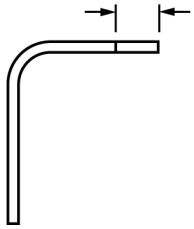
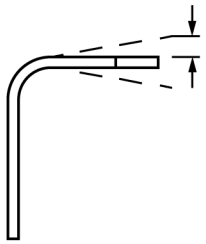
I. HULL **STRUCTURE**			SHIPBUILDING QUALITY STANDARDS		
Division		Fabrication		UNIT: mm	
Section	Sub-section	Item	Standard Range	Tolerance Limits	Remarks
Flanged Bracket	Breadth of flange	 Compared with correct size	±3.0	±5.0	
	Angle between flange and web	 Compared with template per 100 mm in breadth of flange	±3.0	±5.0	
Bending templates (plane or box shape).	Templates for box shapes	Actual line of plate edge, compared with template.	±2.0	±4.0	
		Actual curved surface, compared with template.	±2.0	±4.0	For dimensions greater than IM. ±5.0.
	Section templates	Location of check line for leveling by sight, compared with template. (for transverse)	±1.5	±3.0	
		Location of check line for leveling by sight, compared with template. (for longitudinal)	±1.5	±3.0	
		Shape, compared with template.	±1.5	±3.0	
	Other templates	Shape, compared with template.	±1.5	±3.0	

FIG. A1.7 Hull Structure

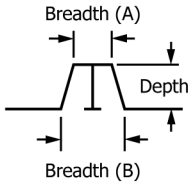
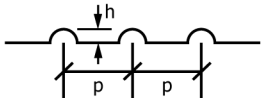
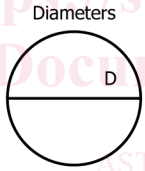
I. HULL **STRUCTURE**					SHIPBUILDING QUALITY STANDARDS
Division		Fabrication			UNIT : mm
Section	Sub-section	Item	Standard Range	Tolerance Limits	Remarks
Plate	Corrugated bulkhead	Depth of corrugation	±3.0	±6.0	
		Breadth of corrugation.  	A ±3.0	±6.0	
			B ±3.0	±6.0	
	Corrugated wall	 Pitch (p)	±6.0	±9.0	
			±2.0	±3.0	
		Depth (h)	±2.5	±5.0	
	Cylindrical structure (most. post etc)	 	$\frac{\pm D}{200}$ But, Max. ±5.0	$\frac{\pm D}{150}$ But, Max. ±7.5	
	Curved shell late	In regard to the check line (for longitudinal)	±2.5	±5.0	
		(for transverse)	±2.5	±5.0	
		Gap between shell plate and section template	±2.5	±5.0	

FIG. A1.8 Hull Structure

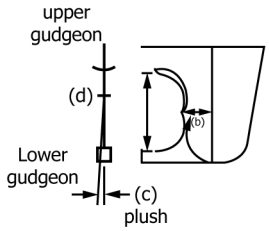
I. HULL **STRUCTURE**					SHIPBUILDING QUALITY STANDARDS		
Division			Sub-assembly		UNIT : mm		
Section	Sub-section		Item		Standard Range	Tolerance Limits	Remarks
Accuracy of Dimensions	Special Sub-assemblies	Block Sub-assembling including Stern frame	Distance between aft edge of boss and aft peak bulkhead	(b)	±5	±10	
			Twist of Sub-assembly	(c)	±5	±10	
			Deviation of rudder from shaft ℄	(d)	±4	±8	
		Rudder	Twist of Rudder plate over its length		±6	±10	Correct or re-assemble partially
		Main engine bed	Flatness of top plate of main engine bed		±5	±10	
			Breadth and length of top plate of main engine bed		±4	±6	
			Others		The same as for flat plate block Sub-assembly		

FIG. A1.9 Hull Structure

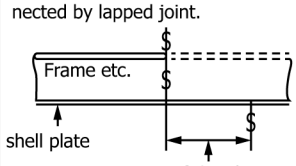
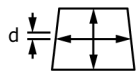
Ⅰ. HULL **STRUCTURE**			SHIPBUILDING QUALITY STANDARDS		
Division		Sub-assembly		UNIT : mm	
Section	Sub-section	Item	Standard Range	Tolerance Limits	Remarks
Accuracy of Dimensions	Flat plate Sub-assembly	Breadth of Sub-assembly	±4.0	±6.0	Cut. when too long
		Length of Sub-assembly	±4.0	±6.0	Cut. when too long
		Squareness of Sub-assembly	±4	±8	Measured difference of diagonal length of final marking lines. When the difference is over the limits, correct the final marking line.
		Distortion of Sub-assembly	±10	±20	Measured on the face of web or girder.
		Deviation of Interior members from shell plating	±5.0	±10.0	Excluding the case when interior members are connected by lapped joint. 
	Curved plate Sub-assembly	Breadth of Sub-assembly	±4.0	±8.0	Measured along the girth. Cut, when too long.
		Length of Sub-assembly	±4.0	±8.0	Cut, when too long.
		Distortion of Sub-assembly	±10	±20	Measured on face of web or girder. Correct the final marking line, when the distortion exceeds the limits.
		Squareness of Sub-assembly	±10	±15	Difference of base line to marking or difference of diagonal lengths along marking  d=1 e1=– e2=1 adjust marking where practicable. 
		Deviation of interior members from shell plating	The same as for the flat plate Sub-assembly above.		
	Plate Block Sub-assembly	Breadth of each panel	The same as for the flat plate Sub-assembly above.		
		Length of each panel			
		Squareness of each panel			
		Distortion of each panel			
		Distortion of interior members from skin plating			

FIG. A1.10 Hull Structure

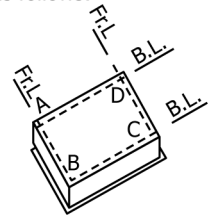
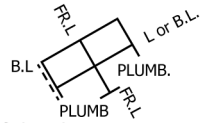
I. HULL **STRUCTURE**			SHIPBUILDING QUALITY STANDARDS		
Division		Sub-assembly		UNIT : mm	
Section	Sub-section	Item	Standard Range	Tolerance Limits	Remarks
Accuracy of Dimensions	Plate Block Sub-assembly	Twist of Sub-assembly B.L. = baseline	±10	±20	Measured as follows:  The points A, B and C are established in the same plane. Measure the deviation of point D from that plane. May re-assemble partially when the deviation exceeds the limits.
		Deviation of upper/lower panel from ℄ or B.L.	±5	±10	 Accuracy of this dimension
		Deviation of upper/lower panel from ℄ or FR.L	±5	±10	
	Plate Block Sub-assembly	Breadth of each panel			The same as for the flat plate Sub-assembly (previous page)
		Length of each panel			
		Distortion of each panel			
		Deviation of interior members from skin plating			
		Twist of Sub-assembly	±15	±25	The same as for the flat plate Sub-assembly (previous page)
		Deviation of upper/lower panel from ℄ or B.L.	±7	±15	Re-assemble partially when the deviation exceeds the limits
		Deviation of upper/lower panel from ℄ or FR.L	±7	±15	
	Block Sub-assembly including stern frame	Distance between upper/lower gudgeon (a)	±5.0	±10.0	

FIG. A1.11 Hull Structure

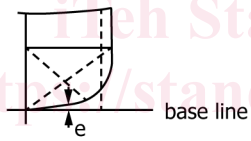
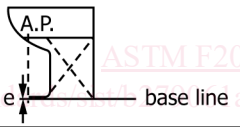
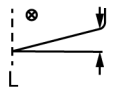
I. HULL **STRUCTURE**			SHIPBUILDING QUALITY STANDARDS		
Division		accuracy		UNIT: mm	
Section	Sub-section	Item	Standard Range	Tolerance Limits	Remarks
Principal Dimensions	Length	Length between Perpendiculars	±50.0 Per 100M	Not defined	Applied to ships of 100 meters length and below. For the convenience of the measurement the point where the keel is connected to the curve of the stem may be substituted for the fore perpendicular in the measurement of the length.
		Length between aft edge of boss and main engine	±25.0	Not defined	
	Breadth	Molded breadth Amldships	±15.0	Not defined	Applied to ships of 15 meters breadth and above. Measured on the upper deck.
	Depth	Molded depth Amidships	±10.0	Not defined	Applied to ships of 10 meters depth and above.
Deformation of hull form	Flatness of Keel	Deformation for the whole length	±25.0	Not defined	Ups (–) and Downs (+) against the check line of keel sighting.
		Deformation for the distance between two adjacent bulkheads	±15.0	Not defined	Sighting by the transit or using slits.
	Forebody Alignment	Alignment of fore-body to baseline. 	±30.0	Not defined	Ups (–) and Downs (+) against the baseline of the keel at the foremost frame on the flat part of the keel.
		Alignment of aft-body to baseline. 	±20.0	Not defined	Ups (–) and Downs (+) against the baseline of the keel at the aft-perpendicular.
	Rise of Floor	Rise of floor amidships 	±15.0	Not defined	The height of the lower turn of the bilge, compared with the palnned height. Measured from the plane passing through the outer surface of the keel plate.

FIG. A1.12 Hull Structure

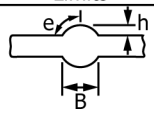
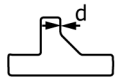
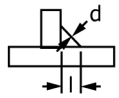
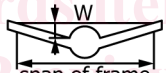
I. HULL **STRUCTURE**			SHIPBUILDING QUALITY STANDARDS	
Division		Welding		UNIT : mm
Section	Sub-section	Item	Tolerance Limits	Remarks
Shape of bead	Height of reinforcement Breadth of bead Flank angle		 h : not defined B : not defined e ≤ 90°	 In case where e is over 90° it is to be repaired by grinding or welding to make e ≤ 90°
	Under cut (butt weld)	Shell plate and face plate between 0.61 ⊗	over 90 mm continuous d ≤ 0.5	Repair using fine electrode. (Avoid short beads for higher tensile steel)
		Other	d ≤ 0.8	
	Under cut (fillet weld)			
	Leg length	Compared with Correct ones (l.d)	 l : Leg length d : Throat depth ≥ 0.9l ≥ 0.9d	When over tolerance limits, weld up. (Avoid short beads for higher tensile steels)
Distorsion of welding joint	Angular distorsion of welding joint	Shell plate between 0.6Lox	 W ≤ 6	When over tolerance limits. repair by line heating or re-weld after cutting and re-fitting.
		Fore and Aft shell plating and Transverse strength member	W ≤ 7	
		Others	W ≤ 8	
Short bead	Tack welding bead Repairing of scar	· 50HT · Cast steel TMPC type 50HT (ceq. > 0.36%)	≥50	In case where short bead is unavoidable, preheat to ±25° C. If short bead is made inadvertently, remove the bead by grinding, and weld over length of visible crack.
		Grade E of mild steel	≥30	
		TMCP type 50HT (ceq. ≤ 0.36%)	≥10	
	Repairing of welding bead	· 50HT · Cast steel TMPC type 50HT (ceq. > 0.36%)	≥50	
		Grade E of mild steel	≥30	
		TMCP type 50HT (ceq. ≤ 0.36%)	≥30	

FIG. A1.13 Hull Structure