



Designation: A 131/A 131M – 01

Standard Specification for Structural Steel for Ships¹

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1. Scope

1.1 This specification covers structural steel plates, shapes, bars, and rivets intended primarily for use in ship construction.

1.2 Material under this specification is available in the following categories:

1.2.1 *Ordinary Strength*—Grades A, B, D, CS, and E with a specified minimum yield point of 34 ksi [235 MPa], and

1.2.2 *Higher Strength*—Grades AH, DH, EH, and FH with specified minimum yield points of either 46 ksi [315 MPa], 51 ksi [350 MPa], or 57 ksi [390 MPa].

1.3 Shapes and bars are normally available as Grades A, AH32, or AH36. Other grades may be furnished by agreement between the purchaser and the manufacturer.

1.4 When the steel is to be welded, it is presupposed that a welding procedure suitable for the grade of steel and intended use or service will be utilized. See Appendix X3 of Specification A 6/A 6M for information on weldability.

1.5 The values stated in either inch-pound units or SI units are to be regarded separately as the standard. Within the text, the SI units are shown in brackets. The values stated in each system are not exact equivalents; therefore, each system must be used independently of the other. Combining values from the two systems may result in nonconformance with this specification.

2. Referenced Documents

2.1 *ASTM Standards*:

A 6/A 6M Specification for General Requirements for Rolled Structural Steel Bars, Plates, Shapes, and Sheet Piling²

A 370 Test Methods and Definitions for Mechanical Testing of Steel Products³

E 112 Test Methods for Determining Average Grain Size⁴

¹ This specification is under the jurisdiction of ASTM Committee A01 on Steel, Stainless Steel, and Related Alloys and is the direct responsibility of Subcommittee A01.02 on Structural Steel for Bridges, Buildings, Rolling Stock, and Ships.

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² *Annual Book of ASTM Standards*, Vol 01.04.

³ *Annual Book of ASTM Standards*, Vol 01.03.

⁴ *Annual Book of ASTM Standards*, Vol 03.01.

3. Terminology

3.1 *Definitions of Terms Specific to This Standard*:

3.1.1 *control rolling, n*—a steel treatment that consists of final rolling within the range used for normalizing heat treatments so that the austenite completely recrystallizes.

3.1.2 *thermo-mechanical controlled processing, n*—a steel treatment that consists of strict control of the steel temperature and the rolling reduction. A high proportion of the rolling reduction is to be carried out close to or below the A_{r3} transformation temperature and may involve rolling towards the lower end of the temperature range of the intercritical duplex phase region thus permitting little if any recrystallization of the austenite. The process may involve accelerated cooling on completion of rolling.

4. Ordering Information

4.1 Specification A 6/A 6M establishes the rules for the ordering information that should be complied with when purchasing material to this specification.

4.2 Additional ordering considerations specific to this specification are:

4.2.1 Cold flanging, if applicable, and

4.2.2 Condition (control rolled or thermo-mechanical controlled processed).

5. Materials and Manufacture

5.1 Except for Grade A steel up to and including ½ in. [12.5 mm] in thickness, rimmed steels shall not be applied.

5.2 Except for Grades A and B steel, semi-killed steels shall not be applied.

5.3 Except as permitted in 5.3.1, Grades D, CS, E, AH32, AH36, AH40, DH32, DH36, DH40, EH32, EH36, EH40, FH32, FH36, and FH40 shall be made using a fine grain practice. For ordinary strength grades, aluminum shall be used to obtain grain refinement. For high strength grades, aluminum, vanadium, or columbium (niobium) may be used for grain refinement.

5.3.1 Grade D material 1.0 in. [25 mm] and under in thickness, at the option of the manufacturer, may be killed and exempt from the fine austenitic grain size requirement of 7.1, but such material shall be subject to the toughness requirement of 8.2.1.

5.4 Plates in all thicknesses ordered to Grade CS shall be normalized. Plates in all thicknesses ordered to Grade E shall be normalized, or thermo-mechanical control processed. Plates over 1 3/8 in. [35 mm] in thickness ordered to Grade D shall be normalized, control rolled, or thermo-mechanical control processed. See Table 1.

5.5 Plates in all thicknesses ordered to Grades EH32 and EH36 shall be normalized, or thermo-mechanical control processed. Plates in all thicknesses ordered to Grade EH40, FH32, FH36, and FH40 shall be normalized, thermo-mechanical control processed, or quenched and tempered. Plates ordered to Grades AH32, AH36, AH40, DH32, DH36, and DH40 shall be normalized, control rolled, or thermo-mechanical control processed when so specified. See Table 2.

5.6 In the case of shapes, the thicknesses referred to are those of the flange. Heat treatment and rolling requirements for shapes and bars are shown in Tables 1 and 2.

6. Chemical Requirements

6.1 The heat analysis shall conform to the requirements for chemical composition prescribed in Tables 3 and 4.

6.1.1 When specified, the steel shall conform on product analysis to the requirements prescribed in Tables 3 and 4, subject to the product analysis tolerances in Specification A 6/A 6M.

6.2 For thermo-mechanical control process steel, the carbon equivalent shall be determined from the heat analysis and shall conform to the requirements in Table 5.

7. Metallurgical Structure

7.1 The steel grades indicated in Section 5 shall be made to fine grain practice, and the requirements for fine austenitic grain size in Specification A 6/A 6M shall be met.

7.2 Where the use of fine grain practice using columbium, vanadium, or combinations is permitted under Section 5, the following limits shall be applied:

7.2.1 Minimum columbium (niobium) content of 0.020 % or minimum vanadium content of 0.050 % for each heat, or

7.2.2 When vanadium and aluminum are used in combination, minimum vanadium content of 0.030 % and minimum acid-soluble aluminum content of 0.010 %, or minimum total aluminum content of 0.015 %.

7.2.3 When columbium (niobium) and aluminum are used in combination, minimum columbium (niobium) content of 0.010 % and minimum acid-soluble aluminum content of 0.010 %, or minimum total aluminum content of 0.015 %.

8. Mechanical Requirements

8.1 *Tension Test:*

8.1.1 Except as specified in the following paragraphs, the material as represented by the test specimens shall conform to the tensile requirements prescribed in Table 6.

8.1.1.1 Shapes less than 1 in.² [645 mm²] in cross section, and bars, other than flats, less than 1/2 in. [12.5 mm] in thickness or diameter need not be subjected to tension tests by the manufacturer, but chemistry consistent with the required tensile properties must be applied.

8.1.1.2 The elongation requirement of Table 6 does not apply to material ordered as floor plates with a raised pattern. However, for floor plates over 1/2 in. [12.5 mm] in thickness, test specimens shall be bent cold with the raised pattern on the inside of the specimen through an angle of 180° without cracking when subjected to a bend test in which the inside diameter is three times plate thickness. Sampling for bend testing shall be as specified for the tension tests in 8.1.2.

8.1.2 One tension test shall be made from each of two different plates, shapes, or bars from each heat of structural steel and steel for cold flanging unless the finished material from a heat is less than 50 tons [45 Mg], when one tension test will be sufficient. If, however, material from one heat differs 3/8 in. [10 mm] or more in thickness or diameter, one tension test

TABLE 1 Condition of Supply and Frequency of Impact Tests Ordinary Strength Hull Structural Steel

Grade	Deoxidation	Products ^A	Condition of Supply ^B (Impact Test Lot Size ^C , in Tons [Mg])				
			Thickness, in inches [mm]				
			exceeding:→ not exceeding:→	0.25 [6.4] 0.5 [12.5]	0.5 [12.5] 1.0 [25]	1.0 [25] 1.375 [35]	1.375 [35] 2.0 [50]
A	Rimmed	All	AR (-)	AR (-)			N (-) ^D TM (-) CR (50 [45]) AR (50 [45])
	Semi-Killed	All		AR (-)			
	Killed	P		AR (-)			
S		AR (-)					
B	Semi-Killed	All		AR (-)		AR (50 [45])	N (50 [45]) TM (50 [45]) CR (25 [23]) AR (25 [23])
	Killed	P		AR (-)		AR (50 [45])	
		S		AR (-)		AR (50 [45])	
D	Killed	P		AR (50) N (50)			
		S		AR (50) N (50)			
D	Killed & Fine Grain	P		AR (50 [45]) N (50 [45])		N (50 [45]) TM (50 [45]) CR (50 [45])	N (50 [45]) TM (50 [45]) CR (25 [23])
		S		AR (50 [45]) N (50 [45])			
E	Killed & Fine Grain	P		N (P) TM (P)			N (P) TM (P)
		S	N (25 [23]) TM (25 [23]) CR (15 [14])				
CS	Killed & Fine Grain	P	N (-)			N (P)	
		S	N (-)				

^AProducts: P = plate S = shapes and bars

^BConditions of Supply: AR = as-rolled N = normalized CR = control rolled TM = thermo-mechanical controlled processing

^CFrequency of Impact Test: (Impact Test Lot Size in Tons from Each Heat) (-) = no impact test required (P) = each plate as-rolled

^DImpact tests for Grade A are not required when material is produced using a fine grain practice and normalized.

TABLE 2 Condition of Supply and Frequency of Impact Tests Higher Strength Hull Structural Steel

Grade	Deoxidation	Grain Refining Element	Products ^C	Condition of Supply ^A (Impact Test Lot Size ^B , in Tons [Mg])						
				Thickness, in inches (mm)						
				Exceeding:→ not exceeding:→	0.25 [6.4] 0.5 [12.5]	0.5 [12.5] 0.80 [20]	0.80 [20] 1.0 [25]	1.0 [25] 1.375 [35]	1.375 [35] 2.0 [50]	2.0 [50] 4.0 [100]
AH36 AH32	Killed & Fine Grain Practice	Nb V	P	AR (50 [45])	N (50 [45]) TM (50 [45]) CR (50 [45])			N (50 [45]) TM (50 [45]) CR (25 [23])		
			S	AR (50 [45])	N (50 [45]) TM (50 [45]) CR (50 [45]) AR (25 [23])					
Al		P	AR (50 [45])	AR (25 [23])	N (50 [45]) TM (50 [45]) CR (50 [45])		N (50 [45]) TM (50 [45]) CR (25 [23])			
		S	AR (50 [45])		N (50 [45]) TM (50 [45]) CR (50 [45]) AR (25 [23])					
Al + Ti		P	AR (50 [45])	N (50 [45]) TM (50 [45]) CR (50 [45])			N (50 [45]) TM (50 [45]) CR (25 [23])			
		S	AR (50 [45])		N (50 [45]) TM (50 [45]) CR (50 [45])					
DH32 DH36		Nb V	P	AR (50 [45])	N (50 [45]) TM (50 [45]) CR (50 [45])			N (50 [45]) TM (50 [45]) CR (25 [23])		
			S	AR (50 [45])		N (50 [45]) TM (50 [45]) CR (50 [45])				
EH32 EH36		Al	P	AR (50 [45])		AR (25 [23])	N (50 [45]) TM (50 [45]) CR (50 [45])	N (50 [45]) TM (50 [45]) CR (25 [23])		
			S	AR (50 [45])		AR (25 [23])	N (50 [45]) TM (50 [45]) CR (50 [45])			
FH32 FH36	Any	P	N (P) TM (P)			N (P) TM (P)				
		S	N (25 [23]) TM (25 [23]) CR (15 [14])							
AH40 DH40	Any	All	AR (50 [45])	N (50 [45]) TM (50 [45]) CR (50 [45])						
		S	N (25 [23]) TM (25 [23]) QT (25 [23])							
EH40 FH40	Any	P	N (50 [45]) TM (50 [45]) CR (50 [45])							
		S	N (P) TM (P) QT (P)							
EH40 FH40	Any	P	N (25 [23]) TM (25 [23]) CR (25 [23])							
		S	N (P) TM (P) QT (P)							
EH40 FH40	Any	P	N (25 [23]) TM (25 [23]) CR (25 [23])							
		S	N (25 [23]) TM (25 [23]) CR (25 [23])							

^AConditions of Supply: AR = as-rolled TM = thermo-mechanical controlled processing CR = controlled QT = quenched and tempered N = normalized

^BFrequency of Impact Test: (Impact Test Lot Size in Tons from Each Heat) (-) = no impact test required (P) = each plate as-rolled

^CProducts: P = plate S = shapes and bars

TABLE 3 Chemical Requirements Ordinary Strength Hull Structural Steel

Grade	A	B	D	E	CS
Deoxidation	Killed or Semi-Killed ^A t ≤ 2.0 in. [50 mm] Killed t > 2.0 in. [50 mm]	Killed or Semi-Killed t ≤ 2.0 in. [50 mm] Killed t > 2.0 in. [50 mm]	Killed t ≤ 1.0 in. [25 mm] Killed and Fine Grain t > 1.0 in. [25 mm] ^B	Killed and Fine Grain ^B	Killed and Fine Grain ^B
Chemical composition (ladle analysis), % max, unless specified otherwise ^C					
C	0.21 ^D	0.21	0.21	0.18	0.16
Mn _{min}	2.5 × C	0.80 ^E	0.60	0.70	1.00
Si	0.50	0.35	0.10–0.35 ^F	0.10–0.35 ^F	0.10–0.35 ^F
P	0.035	0.035	0.035	0.035	0.035
S	0.035	0.035	0.035	0.035	0.035
Ni	See Footnote ^G	See Footnote ^G	See Footnote ^G	See Footnote ^G	See Footnote ^G
Cr	See Footnote ^G	See Footnote ^G	See Footnote ^G	See Footnote ^G	See Footnote ^G
Mo	See Footnote ^G	See Footnote ^G	See Footnote ^G	See Footnote ^G	See Footnote ^G
Cu	See Footnote ^G	See Footnote ^G	See Footnote ^G	See Footnote ^G	See Footnote ^G
C + Mn/6	0.40	0.40	0.40	0.40	0.40

^A For Grade A, rimmed steel shapes and bars may be accepted up to and including 0.5 in. [12.5 mm].

^B Grade D steel over 1.0 in. [25 mm], Grade E steel and Grade CS steel are to contain at least one of the grain refining elements in sufficient amount to meet the fine grain practice requirements (see Section 7).

^C Intentionally added elements are to be determined and reported.

^D A maximum carbon content of 0.23 % is acceptable for Grade A shapes and bars.

^E For Grade B steel of cold flanging quality or where fully killed, the lower limit of manganese may be reduced to 0.60 %.

^F Where the content of soluble aluminum is not less than 0.015 %, the minimum required silicon content does not apply.

^G The contents of nickel, chromium, molybdenum and copper are to be determined and reported. When the amount does not exceed 0.02 %, these elements may be reported as ≤0.02 %.

shall be made from both the thickest and the thinnest material rolled, regardless of the weight represented.

8.1.3 Two tension tests shall be made from each heat of rivet steel.

8.1.4 For quenched and tempered steel, including Grades EH40, FH32, FH36, and FH40, one tension test shall be made on each plate as quenched and tempered.

8.2 Toughness Tests:

8.2.1 Charpy V-notch tests shall be made on Grade A material over 2 in. [50 mm] in thickness, on Grade B material over 1 in. [25 mm] in thickness and on material over ¼ in. [6.4 mm] in thickness of Grades D, E, AH32, AH36, AH40, DH32, DH36, DH40, EH32, EH36, EH40, FH32, FH36, and FH40, as required by Tables 1 and 2. The frequency of Charpy V-notch impact tests shall be as required in Tables 1 and 2. The test results shall conform to the requirements of Table 7.