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TABLE 3 Chemical Requirements Ordinary Strength Hull Structural Steel

Grade	A		B		D		E		CS	
	Killed or Semi-Killed <sup>a</sup> t = 2.0 in. [50 mm] Killed		Killed or Semi-Killed <sup>a</sup> t = 2.0 in. [50 mm] Killed		Killed t = 1.0 in. [25 mm] Killed and Fine Grain <sup>b</sup>		Killed and Fine Grain <sup>b</sup> Killed and Fine Grain <sup>b</sup>		Killed and Fine Grain <sup>b</sup>	
C	Chemical composition (see analysis), % max, unless specified otherwise <sup>c</sup>									
Mn <sub>max</sub>	0.31 <sup>d</sup>	0.31	0.31	0.31	0.18	0.18	0.18	0.18	0.18	0.18
Si	0.50	0.35	0.35	0.35	0.30	0.30	0.30	0.30	0.30	0.30
P	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008
S	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035
Ni	See Footnote <sup>e</sup>	See Footnote <sup>e</sup>	See Footnote <sup>e</sup>	See Footnote <sup>e</sup>	See Footnote <sup>e</sup>	See Footnote <sup>e</sup>	See Footnote <sup>e</sup>	See Footnote <sup>e</sup>	See Footnote <sup>e</sup>	See Footnote <sup>e</sup>
Cr	See Footnote <sup>e</sup>	See Footnote <sup>e</sup>	See Footnote <sup>e</sup>	See Footnote <sup>e</sup>	See Footnote <sup>e</sup>	See Footnote <sup>e</sup>	See Footnote <sup>e</sup>	See Footnote <sup>e</sup>	See Footnote <sup>e</sup>	See Footnote <sup>e</sup>
Mo	See Footnote <sup>e</sup>	See Footnote <sup>e</sup>	See Footnote <sup>e</sup>	See Footnote <sup>e</sup>	See Footnote <sup>e</sup>	See Footnote <sup>e</sup>	See Footnote <sup>e</sup>	See Footnote <sup>e</sup>	See Footnote <sup>e</sup>	See Footnote <sup>e</sup>
Cu	See Footnote <sup>e</sup>	See Footnote <sup>e</sup>	See Footnote <sup>e</sup>	See Footnote <sup>e</sup>	See Footnote <sup>e</sup>	See Footnote <sup>e</sup>	See Footnote <sup>e</sup>	See Footnote <sup>e</sup>	See Footnote <sup>e</sup>	See Footnote <sup>e</sup>
C	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40

<sup>a</sup> For Grade A, annealed steel shapes and bars may be accepted up to and including 0.5 in. (12.5 mm).  
<sup>b</sup> 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).  
<sup>c</sup> Intentionally added elements are to be determined and reported.  
<sup>d</sup> A maximum carbon content of 0.23 % is acceptable for Grade A shapes and bars.  
<sup>e</sup> For Grade B steel of excellent quality or where fully killed, the lower limit of manganese may be reduced to 0.60 %.  
<sup>f</sup> Where the content of soluble aluminum is not less than 0.015 %, the minimum required silicon content does not apply.  
<sup>g</sup> Where the content of soluble aluminum is not less than 0.015 %, the minimum required silicon content does not apply.  
<sup>h</sup> 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 omitted in analysis.

TABLE 4 Chemical Requirements Higher-Strength Hull Structural Steel

Grade	A508EH 32, A508EH 36 and A508EH 40		FH 32/36/40	
	Killed, Fine Grain Practice <sup>a</sup>		Killed, Fine Grain Practice <sup>a</sup>	
C	Chemical composition <sup>b</sup> (see analysis), % max, unless specified in range			
Mn	0.18	0.18	0.18	0.18
Si	0.30-1.60 <sup>c</sup>	0.30-1.60 <sup>c</sup>	0.30-1.60 <sup>c</sup>	0.30-1.60 <sup>c</sup>
P	0.008	0.008	0.008	0.008
S	0.035	0.035	0.035	0.035
Al (acid soluble), min <sup>d</sup>	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05
Ti	0.05-0.10	0.05-0.10	0.05-0.10	0.05-0.10
Ni	0.02	0.02	0.02	0.02
Cu <sup>e</sup>	0.38	0.38	0.38	0.38
Cr <sup>e</sup>	0.20	0.20	0.20	0.20
Ni <sup>e</sup>	0.40	0.40	0.40	0.40
Mn <sup>e</sup>	0.58	0.58	0.58	0.58
N	—	—	0.012 (if present)	—

<sup>a</sup> The steel is to contain at least one of the grain refining elements in sufficient amount to meet the fine grain practice requirement (see Section 7).  
<sup>b</sup> The contents of any other element intentionally added is to be determined and reported.  
<sup>c</sup> Grade A508EH 32, (12.5 mm) and under in thickness may have a minimum manganese content of 0.70 %.  
<sup>d</sup> Where the content of soluble aluminum is not less than 0.015 %, the minimum required silicon content does not apply.  
<sup>e</sup> Where the content of soluble aluminum is not less than 0.015 %, the minimum required silicon content does not apply.  
<sup>f</sup> The total aluminum content may be used instead of acid soluble content, in accordance with 7.1.  
<sup>g</sup> The indicated amount of aluminum, niobium, and vanadium applies when any such element is used singly. When used in combination, the minimum content in 7.2.2 and 7.2.3, as appropriate, still apply.  
<sup>h</sup> These elements need not be reported on the mill sheet unless intentionally added.  
<sup>i</sup> These elements may be reported as <0.02 %, where the amount present does not exceed 0.02 %.

conform to the requirements in Table 5.

TABLE 5 Carbon Equivalent for Higher-Strength Hull Structural Steel Produced by TMCP

Grade	Carbon Equivalent <sup>a</sup> , % max.	
	t = 2.0 in. [50 mm]	t = 2.0 in. [50 mm] t = 4.0 in. [100 mm]
A502, D502, E502	0.38	0.38
F502	0.38	0.40
A508, D508, E508	0.38	0.40
F508	0.38	0.40
A510, D510, E510, F510	0.40	0.40

<sup>a</sup> The following carbon equivalent formula shall be used to calculate the carbon equivalent, C<sub>eq</sub>:  

$$C_{eq} = C + \frac{Mn}{8} + \frac{Cr}{5} + \frac{Mo}{8} + \frac{V}{10} + \frac{Ni}{15} + \frac{Cu}{13} (\%)$$

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 0.030 % for each heat, or
- 7.2.2 When vanadium and aluminum are used in combination, minimum vanadium content of 0.030 % and minimum

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