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**SAE J409 DEC88**

**Product Analysis —  
Permissible  
Variations from  
Specified Chemical  
Analysis of a Heat or  
Cast of Steel**

SAE Standard  
Reaffirmed December 1988

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Submitted for Recognition as  
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**PRODUCT ANALYSIS - PERMISSIBLE VARIATIONS FROM SPECIFIED CHEMICAL ANALYSIS  
OF A HEAT OR CAST OF STEEL**

Supplementary to the heat or cast analysis, a product analysis may be made on steel in the semi-finished or finished form. For definitions and methods of sampling steel for product chemical analysis, refer to SAE J408.

A product analysis is a chemical analysis on the semi-finished or finished steel to determine conformance to the specification requirements. The range of the specified chemical composition is normally expanded to take into account deviations associated with analytical reproducibility and the heterogeneity of the steel. Individual determinations may vary from the specified heat or cast analysis ranges or limits to the extent shown in Tables 1 through 5; but, the several determinations of any element in a heat or cast may not vary both above and below the specified range except for lead, which may vary both above and below the specified range.

Rimmed or capped steels are not subject to product analysis limits because they are characterized by an inherently large variation in chemical composition. Also, for rephosphorized and resulfurized steels, the product analysis tolerance limits are not applicable for phosphorus and sulfur because of the degree to which these elements segregate.

Boron is not subject to product analysis tolerances.

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TABLE 1 – Permissible Variations from Specified Chemical Ranges and Limits for Carbon Steel in Hot Rolled and Cold Finished Bars and Semifinished for Forging, Wire Rod, and Seamless Tubing

Element	Limit or Max of Specified Range, %	Variation, %, Over Max Limit or Under Min Limit			
		Bars, Wire Rod, Seamless Tubing and Semifinished for Forging to 100 in <sup>2</sup> (0.065 m <sup>2</sup> ) incl	Semifinished Products for Forging		
			Over 100 to 200 in <sup>2</sup> (0.065 to 0.129 m <sup>2</sup> ) incl	Over 200 to 400 in <sup>2</sup> (0.129 to 0.258 m <sup>2</sup> ) incl	Over 400 to 800 in <sup>2</sup> (0.258 to 0.516 m <sup>2</sup> ) incl
Carbon	To 0.25 incl Over 0.25 to 0.55 incl Over 0.55	0.02 0.03 0.04	0.03 0.04 0.05	0.04 0.05 0.06	0.05 0.06 0.07
Manganese	To 0.90 incl Over 0.90 to 1.65 incl	0.03 0.06	0.04 0.06	0.06 0.07	0.07 0.08
Phosphorus	Over max only to 0.040 incl	0.008	0.008	0.010	0.015
Sulfur	Over max only to 0.050 incl	0.008	0.010	0.010	0.015
Silicon	To 0.35 incl Over 0.35 to 0.60	0.02 0.05	0.02 --	0.03 --	0.04 --
Copper	Under min only for copper bearing steels	0.02	0.03	--	--
Lead <sup>a</sup>	0.15 to 0.35 incl	0.03	0.03	--	--

<sup>a</sup>Product analysis tolerance for lead applies, both over and under, to a range of 0.15–0.35% lead.

TABLE 2 - Permissible Variations from Specified Chemical Ranges  
and Limits for Carbon Steel Sheets, Strip, and Welded Tubing

Element	Limit or Max of Specified Range, %	Variation, %, Over Max Limit or Under Min Limit	
		Under Min Limit	Over Max Limit
Carbon	To 0.15 incl	0.02	0.03
	Over 0.15 to 0.40 incl	0.03	0.04
	Over 0.40 to 0.80 incl	0.03	0.05
	Over 0.80	0.03	0.06
Manganese	To 0.60 incl	0.03	0.03
	Over 0.60 to 1.15 incl	0.04	0.04
	Over 1.15 to 1.65 incl	0.05	0.05
Phosphorus	---	---	0.01
Sulfur	---	---	0.01
Silicon	To 0.30 incl	0.02	0.03
	Over 0.30 to 0.60	0.05	0.05
Copper	Under min only for copper bearing steels	0.02	---
Lead <sup>a</sup>	0.15 to 0.35 incl	0.03	0.03

<sup>a</sup>Product analysis tolerance for lead applies both over and under a range of 0.15-0.35% lead.

TABLE 3 - Permissible Variations From Specified Chemical Ranges and Limits for Alloy Steels

Element	Limit or Max of Specified Range, %	Variation, %, Over Max Limit or Under Min Limit				
		Bars, Sheets, Strip and Semifinished Products to 100 in <sup>2</sup> (0.065 m <sup>2</sup> ) incl	Semifinished Products			Plates
			Over 100 to 200 in <sup>2</sup> (0.065 to 0.129 m <sup>2</sup> ) incl	Over 200 to 400 in <sup>2</sup> (0.129 to 0.258 m <sup>2</sup> ) incl	Over 400 to 800 in <sup>2</sup> (0.258 to 0.516 m <sup>2</sup> ) incl	
Carbon	To 0.30 incl Over 0.30 to 0.75 incl Over 0.75	0.01 0.02 0.03	0.02 0.03 0.04	0.03 0.04 0.05	0.04 0.05 0.06	0.02 0.03 0.04
Manganese	To 0.90 incl Over 0.90 to 2.10 incl	0.03 0.04	0.04 0.05	0.05 0.06	0.06 0.07	0.04 0.05
Phosphorus	Over max only	0.005	0.010	0.010	0.010	0.010
Sulfur	To 0.060 incl <sup>a</sup>	0.005	0.010	0.010	0.010	0.010
Silicon	To 0.40 incl Over 0.40 to 2.20 incl	0.02 0.05	0.02 0.06	0.03 0.06	0.04 0.07	0.02 0.06
Nickel	To 1.00 incl Over 1.00 to 2.00 incl Over 2.00 to 5.30 incl Over 5.30 to 10.00 incl	0.03 0.05 0.07 0.10	0.03 0.05 0.07 0.10	0.03 0.05 0.07 0.10	0.03 0.05 0.07 0.10	0.03 0.05 0.07 0.10
Chromium	To 0.90 incl Over 0.90 to 2.10 incl Over 2.10 to 3.99	0.03 0.05 0.10	0.04 0.06 0.10	0.04 0.06 0.12	0.05 0.07 0.14	0.04 0.06 0.10
Molybdenum	To 0.20 incl Over 0.20 to 0.40 incl Over 0.40 to 1.15 incl	0.01 0.02 0.03	0.01 0.03 0.04	0.02 0.03 0.05	0.03 0.04 0.06	0.01 0.03 0.04
Tungsten	To 1.00 incl Over 1.00 to 4.00 incl	0.04 0.08	0.05 0.09	0.05 0.10	0.06 0.12	0.05 0.09
Vanadium	To 0.10 incl Over 0.10 to 0.25 incl Over 0.25 to 0.50 incl Min value specified check under min limit	0.01 0.02 0.03 0.01	0.01 0.02 0.03 0.01	0.01 0.02 0.03 0.01	0.01 0.02 0.03 0.01	0.01 0.02 0.03 0.01
Aluminum <sup>b</sup>	Up to 0.10 incl Over 0.10 to 0.20 incl Over 0.20 to 0.30 incl Over 0.30 to 0.80 incl Over 0.80 to 1.80 incl	0.03 0.04 0.05 0.07 0.10	— — — — —	— — — — —	— — — — —	0.03 0.04 0.05 0.07 0.10
Lead <sup>b</sup>	0.15 to 0.35 incl	0.03 <sup>c</sup>	—	—	—	0.03 <sup>c</sup>
Copper <sup>b</sup>	To 1.00 incl Over 1.00 to 2.00 incl	0.03 0.05	— —	— —	— —	0.03 0.05

<sup>a</sup>Sulfur over 0.060% is not subject to check analysis.<sup>c</sup>Tolerance is over and under.<sup>b</sup>Tolerances shown apply only to 100 in<sup>2</sup> or less and to all plates.

TABLE 4 - Permissible Variations from Specified Chemical Ranges and Limits for Stainless Steels

Element	Limit or Max of Specified Range, %	Variation, %, Over Max Limit or Under Min Limit
Carbon	To 0.030 incl	0.005
	Over 0.030 to 0.20 incl	0.01
	Over 0.20 to 0.60 incl	0.02
	Over 0.60 to 1.20 incl	0.03
Manganese	To 1.00 incl	0.03
	Over 1.00 to 3.00 incl	0.04
	Over 3.00 to 6.00 incl	0.05
	Over 6.00 to 10.00 incl	0.06
Phosphorus	To 0.040 incl	0.005
	Over 0.040 to 0.20 incl	0.010
Sulfur	To 0.040 incl	0.005
	Over 0.040 to 0.20 incl	0.010
	Over 0.20 to 0.50 incl	0.020
Silicon	To 1.00 incl	0.05
	Over 1.00 to 3.00 incl	0.10
Chromium	Over 4.00 to 10.00 incl	0.10
	Over 10.00 to 15.00 incl	0.15
	Over 15.00 to 20.00 incl	0.20
	Over 20.00 to 27.00 incl	0.25
Nickel	To 1.00 incl	0.03
	Over 1.00 to 5.00 incl	0.07
	Over 5.00 to 10.00 incl	0.10
	Over 10.00 to 20.00 incl	0.15
	Over 20.00 to 22.00 incl	0.20
Molybdenum	Over 0.20 to 0.60 incl	0.03
	Over 0.60 to 1.75 incl	0.05
	Over 1.75 to 4.00 incl	0.10
Titanium	All ranges	0.05
Columbium-Tantalum	All ranges	0.05
Tantalum	To 0.10 incl	0.02
Cobalt	0.05 to 0.20 incl	0.01
Aluminum	0.10 to 0.30 incl	0.05
Selenium	All ranges	0.03
Nitrogen	To 0.19 incl	0.01
	Over 0.19 to 0.25 incl	0.02

TABLE 5 - Product Analysis Tolerances - Structural Shapes and Plates (From ASTM A6)

Element	Upper Limit, or Max Specified Value, %	Tolerances, %	
		Under Min Limit	Over Max Limit
Carbon	To 0.15 incl Over 0.15 to 0.40 incl	0.02 0.03	0.03 0.04
Manganese	To 0.60 incl Over 0.60 to 0.90 incl Over 0.90 to 1.20 incl Over 1.20 to 1.35 incl Over 1.35 to 1.65 incl Over 1.65 to 1.95 incl Over 1.95	0.05 0.06 0.08 0.09 0.09 0.11 0.12	0.06 0.08 0.10 0.11 0.12 0.14 0.16
Phosphorus	To 0.04 incl Over 0.04 to 0.15 incl	-- --	0.010 N.A. <sup>a</sup>
Sulfur	To 0.05 incl	--	0.010
Silicon	To 0.30 incl Over 0.30 to 0.40 incl Over 0.40 to 2.20 incl	0.02 0.05 0.06	0.03 0.05 0.06
Nickel	To 1.00 incl Over 1.00 to 2.00 incl	0.03 0.05	0.03 0.05
Chromium	To 0.90 incl Over 0.90 to 2.10 incl	0.04 0.06	0.04 0.06
Molybdenum	To 0.20 incl Over 0.20 to 0.40 incl Over 0.40 to 1.15 incl	0.01 0.03 0.04	0.01 0.03 0.04
Copper	0.20 min only To 1.00 incl Over 1.00 to 2.00 incl	0.02 0.03 0.05	-- 0.03 0.05
Titanium	To 0.10 incl	0.01 <sup>b</sup>	0.01 <sup>b</sup>
Vanadium	To 0.10 incl Over 0.10 to 0.25 incl Min only specified	0.01 <sup>b</sup> 0.02 0.01	0.01 <sup>b</sup> 0.02 --
Boron	Any	N.A. <sup>a</sup>	N.A. <sup>a</sup>
Columbium	To 0.10 incl	0.01 <sup>b</sup>	0.01 <sup>b</sup>
Zirconium	To 0.15 incl	0.03	0.03
Nitrogen	To 0.030 incl	0.005	0.005

<sup>a</sup>N.A. - Product analysis not applicable.

<sup>b</sup>If the minimum of the range is 0.01%, the under tolerance is 0.005%.