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SAE INTERNATIONAL
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SURFACE VEHICLE STANDARD

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PRODUCT ANALYSIS—PERMISSIBLE VARIATIONS FROM SPECIFIED CHEMICAL ANALYSIS OF A HEAT OR CAST OF STEEL

Foreword—This reaffirmed document has been changed only to reflect the new SAE Technical Standards Board format.

1. Scope—Supplementary to the heat or cast analysis, a product analysis may be made on steel in the semifinished 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 of the semifinished 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. The several determinations of any element in a heat or cast may not vary both above and below the specified range except for lead. Tables 1 through 5 provide permissible limits for various steel forms and composition types.

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.

2. References

2.1 Applicable Publications—The following publications form a part of this specification to the extent specified herein. The latest issue of SAE publications shall apply.

2.1.1 SAE PUBLICATION—Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

SAE J408—Methods of Sampling Steel for Chemical Analysis

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2.1.2 ASTM PUBLICATION—Available from ASTM, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.

ASTM A 6—Specification for General Requirements for Rolled Steel Plates, Shapes, Sheet Piling, and Bars for Structural Use
ASTM A 480/A 480M—Specification for General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet, and Strip
ASTM A 513—Specification for Electric-Resistance-Welded Carbon and Alloy Steel Mechanical Tubing
ASTM A 519—Specification for Seamless Carbon and Alloy Steel Mechanical Tubing

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 0.065 m^2 (100 in^2) incl	Variation, %, Over Max Limit or Under Min Limit Semifinished Products for Forging Over 0.065 to 0.129 m^2 (100 to 200 in^2) incl	Variation, %, Over Max Limit or Under Min Limit Semifinished Products for Forging Over 0.129 to 0.258 m^2 (200 to 400 in^2) incl	Variation, %, Over Max Limit or Under Min Limit Semifinished Products for Forging Over 0.258 to 0.516 m^2 (400 to 800 in^2) incl
Carbon	To 0.25 incl	0.02	0.03	0.04	0.05
	Over 0.25 to 0.55 incl	0.03	0.04	0.05	0.06
	Over 0.55	0.04	0.05	0.06	0.07
Manganese	To 0.90 incl	0.03	0.04	0.06	0.07
	Over 0.90 to 1.65 incl	0.06	0.06	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	0.02	0.02	0.03	0.04
	Over 0.35 to 0.60	0.05	—	—	—
Copper	Under min only for copper bearing steels	0.02	0.03	—	—
Lead[1]	0.15 to 0.35 incl	0.03	0.03	—	—

1. Product analysis tolerance for lead applies, both over and under, to a range of 0.15 to 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, %	Limit Variation, % Under Min Limit	Limit Variation, % 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[1]	0.15 to 0.35 incl	0.03	0.03

1. Product analysis tolerance for lead applies both over and under a range of 0.15 to 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, Sheet, Strip, Tubing[1], and Semifinished Products to 0.065 m^2 (100 in^2) incl	Variation, %, Over Max Limit or Under Min Limit Semifinished Products Over 0.065 to 0.129 m^2 (100 to 200 in^2) incl	Variation, %, Over Max Limit or Under Min Limit Semifinished Products Over 0.129 to 0.0258 m^2 (200 to 400 in^2) incl	Variation, %, Over Max Limit or Under Min Limit Semifinished Products Over 0.258 to 0.516 m^2 (400 to 800 in^2) incl
Carbon	To 0.30 incl	0.01	0.02	0.03	0.04
	Over 0.30 to 0.75 incl	0.02	0.03	0.04	0.05
	Over 0.75	0.03	0.04	0.05	0.06
Manganese	To 0.90 incl	0.03	0.04	0.05	0.06
	Over 0.90 to 2.10 incl	0.04	0.05	0.06	0.07
Phosphorus	Over max only	0.005	0.010	0.010	0.010
Sulfur	To 0.060 incl[2]	0.005	0.010	0.010	0.010
Silicon	To 0.40 incl	0.02	0.02	0.03	0.04
	Over 0.40 to 2.20 incl	0.05	0.06	0.06	0.07
Nickel	To 1.00 incl	0.03	0.03	0.03	0.03
	Over 1.00 to 2.00 incl	0.05	0.05	0.05	0.05
	Over 2.00 to 5.30 incl	0.07	0.07	0.07	0.07
	Over 5.30 to 10.00 incl	0.10	0.10	0.10	0.10
Chromium	To 0.90 incl	0.03	0.04	0.04	0.05
	Over 0.90 to 2.10 incl	0.05	0.06	0.06	0.07
	Over 2.10 to 3.99	0.10	0.10	0.12	0.14
Molybdenum	To 0.20 incl	0.01	0.01	0.02	0.03
	Over 0.20 to 0.40 incl	0.02	0.03	0.03	0.04
	Over 0.40 to 1.15 incl	0.03	0.04	0.05	0.06
Tungsten	To 1.00 incl	0.04	0.05	0.05	0.06
	Over 1.00 to 4.00 incl	0.08	0.09	0.10	0.12
Vanadium	To 0.10 incl	0.01	0.01	0.01	0.01
	Over 0.10 to 0.25 incl	0.02	0.02	0.02	0.02
	Over 0.25 to 0.50 incl	0.03	0.03	0.03	0.03
	Min value specified check under min limit	0.01	0.01	0.01	0.01
Aluminum[3]	Up to 0.10 incl	0.03	—	—	—
	Over 0.10 to 0.20 incl	0.04	—	—	—
	Over 0.20 to 0.30 incl	0.05	—	—	—
	Over 0.30 to 0.80 incl	0.07	—	—	—
	Over 0.80 to 1.80 incl	0.10	—	—	—

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, Sheet, Strip, Tubing[1], and Semifinished Products to 0.065 m^2 (100 in^2) incl	Variation, %, Over Max Limit or Under Min Limit Semifinished Products Over 0.065 to 0.129 m^2 (100 to 200 in^2) incl	Variation, %, Over Max Limit or Under Min Limit Semifinished Products Over 0.129 to 0.0258 m^2 (200 to 400 in^2) incl	Variation, %, Over Max Limit or Under Min Limit Semifinished Products Over 0.258 to 0.516 m^2 (400 to 800 in^2) incl
Lead[3]	0.15 to 0.35 incl	0.03[4]	—	—	—
Copper[3]	To 1.00 incl	0.03	—	—	—
	Over 1.00 to 2.00 incl	0.05	—	—	—

1. From ASTM A 513 and A 519.
2. Sulfur over 0.060% is not subject to check analysis.
3. Tolerances shown apply only to 100 in^2 or less.
4. Tolerance is over and under.

TABLE 4—PERMISSIBLE VARIATIONS FROM SPECIFIED CHEMICAL RANGES AND LIMITS FOR STAINLESS STEELS (FROM ASTM A 480/A 480M)

Element	Limit or Max of Specified Range, %	Variation, %, Over Max Limit or Under Min Limit
Carbon	To 0.010 incl	0.002
	Over 0.010 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
	Over 10.00 to 15.00 incl	0.10
	Over 15.00 to 20.00 incl	0.15
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 30.00 incl	0.25

TABLE 4—PERMISSIBLE VARIATIONS FROM SPECIFIED CHEMICAL RANGES AND LIMITS FOR STAINLESS STEELS (FROM ASTM A 480/A 480M)

Element	Limit or Max of Specified Range, %	Variation, %, Over Max Limit or Under Min Limit
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 2.00 incl	0.05
	Over 2.00 to 7.00 incl	0.10
Titanium	To 1.00 incl	0.05
	Over 1.00 to 3.00 incl	0.07
Columbian-Tantalum		
	All ranges	0.05
Tantalum	To 0.10 incl	0.02
Cobalt[1]	Over 0.05 to 0.50 incl	0.01
	Over 0.50 to 2.00 incl	0.02
	Over 2.00 to 5.00 incl	0.05
Aluminum	To 0.15 incl	–0.005, +0.01
	Over 0.15 to 0.50 incl	0.05
	Over 0.50 to 2.00 incl	0.10
Selenium	All ranges	0.03
Nitrogen	To 0.02 incl	0.005
	Over 0.02 to 0.19 incl	0.01
	Over 0.19 to 0.25 incl	0.02
	Over 0.25 to 0.35 incl	0.03
	Over 0.35 to 0.45 incl	0.04
Tungsten	To 1.00 incl	0.03
	Over 1.00 to 2.00 incl	0.05
Vanadium	To 0.50 incl	0.03
	Over 0.50 to 1.50 incl	0.05

1. Product analysis limits for cobalt under 0.05% have not been established, and the manufacturer should be consulted for those limits.

TABLE 5—PRODUCT ANALYSIS TOLERANCES—STRUCTURAL SHAPES AND PLATES (FROM ASTM A 6)

Element	Upper Limit, or Max Specified Value, %	Tolerances, % Under Min Limit	Tolerances, % 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 0.75 incl	0.04	0.05
	Over 0.75	0.04	0.06
Manganese	To 0.60 incl	0.05	0.06
	Over 0.60 to 0.90 incl	0.06	0.08
	Over 0.90 to 1.20 incl	0.08	0.10
	Over 1.20 to 1.35 incl	0.09	0.11
	Over 1.35 to 1.65 incl	0.09	0.12
	Over 1.65 to 1.95 incl	0.11	0.14
	Over 1.95	0.12	0.16
Phosphorus	To 0.04 incl	—	0.010
	Over 0.04 to 0.15 incl		N.A.(1)
Sulfur	To 0.060 incl	—	0.010
	Over 0.060	—	N.A.(1)
Silicon	To 0.30 incl	0.02	0.03
	Over 0.30 to 0.40 incl	0.05	0.05
	Over 0.40 to 2.20 incl	0.06	0.06
Nickel	To 1.00 incl	0.03	0.03
	Over 1.00 to 2.00 incl	0.05	0.05
	Over 2.00 to 3.75 incl	0.07	0.07
	Over 3.75 to 5.30 incl	0.08	0.08
	Over 5.30	0.10	0.10
Chromium	To 0.90 incl	0.04	0.04
	Over 0.90 to 2.00 incl	0.06	0.06
	Over 2.00 to 4.00 incl	0.10	0.10
Molybdenum	To 0.20 incl	0.01	0.01
	Over 0.20 to 0.40 incl	0.03	0.03
	Over 0.40 to 1.15 incl	0.04	0.04
Aluminum	Up to 0.10 incl	0.03	0.03
Copper	0.20 min only	0.02	—
	To 1.00 incl	0.03	0.03
	Over 1.00 to 2.00 incl	0.05	0.05
Titanium	To 0.10 incl	0.01(2)	0.01(2)