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Standard Specification for Isotropic Pure Molybdenum¹

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1. Scope

1.1 This specification covers monolithic forms of unalloyed molybdenum.

1.2 *Grade 1 (UNS R03610)*—Unalloyed monolithic forms molybdenum.

1.3 *Grade 2 (UNS R03610)*—Unalloyed monolithic forms molybdenum.

1.4 The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system are not necessarily exact equivalents; therefore, to ensure conformance with the standard, each system shall be used independently of the other, and values from the two systems shall not be combined.

1.5 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.6 *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

E8/E8M Test Methods for Tension Testing of Metallic Materials

E29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications

¹ This specification is under the jurisdiction of ASTM Committee B10 on Reactive and Refractory Metals and Alloys and is the direct responsibility of Subcommittee B10.04 on Molybdenum and Tungsten.

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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.

2.2 *ISO Standard:*

ISO 2768 General Tolerances Package³

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *batch, n—for chemical composition*, the ingots obtained from a single blend of powder sintered together under the same conditions.

3.1.2 *batch, n—for mechanical property measurement*, the product manufactured from ingots sintered from a single powder lot in a single sintering run in the same furnace and, when required, in a single post-sintering thermal treatment.

3.1.3 *monolithic form, n*—any form with a cross section up to a maximum of 156 000 mm² [242 in.] and a length of 1000 mm [39 in.].

4. Ordering Information

4.1 Orders for material produced to this specification shall include the following information as applicable:

4.1.1 Product form and grade (Section 5) and metallurgical condition (Section 7),

4.1.2 Mechanical requirements (Section 8) and tolerances (Section 9),

4.1.3 Workmanship and quality level requirements (Section 10),

4.1.4 Disposition of rejected material (Section 13),

4.1.5 Certification and reports (Section 14),

4.1.6 Marking (Section 15), and

4.1.7 Packaging (Section 16).

5. Materials and Manufacture

5.1 The molybdenum product covered by this specification shall be manufactured by conventional powder metallurgical processes such as powder compaction, pressing, sintering, and high-temperature thermal processing.

5.1.1 *Material Grades:*

5.1.2 *Grade 1*—The molybdenum product of Grade 1 shall be manufactured by conventional powder metallurgical processes such as powder compaction, pressing, and sintering.

³ Available from the American National Standards Institute, 25 W. 43rd St., 4th Floor, New York, NY 10036, www.ansi.org.

5.1.3 *Grade 2*—The molybdenum product of Grade 2 shall be manufactured by conventional powder metallurgical processes such as powder compaction, pressing, sintering, and additional post-sintering high-temperature thermal processing.

6. Chemical Composition

6.1 The molybdenum ingots and billets for conversion to finished products covered by this specification shall conform to the requirements of chemical composition prescribed in [Table 1](#).

6.2 Heat Analysis:

6.2.1 Heat analysis is made by the manufacturer of the metal of a representative sample of powder from a single powder blend sintered together under the same conditions.

6.2.2 Heat analysis shall be as specified in [Table 1](#).

6.2.3 The manufacturer shall not ship material that is outside the limits specified in [Table 1](#) for the applicable type with the exception of oxygen and nitrogen whose percentage may vary with the method of fabrication.

6.3 Check Analysis:

6.3.1 Check analysis is an analysis made by the purchaser or the manufacturer of the metal after it has been processed into finished mill forms either for the purpose of verifying the composition of a heat or lot or to determine variations in the composition within a heat or lot.

6.3.2 Check analysis tolerances do not broaden the specified heat analysis requirements but cover variations between laboratories in the measurement of chemical content.

6.3.3 Check analysis limits shall be as specified in [Table 2](#).

7. Metallurgical Condition

7.1 Products shall be delivered in the pressed and sintered condition and, if required, with additional high-temperature thermal processing.

8. Mechanical Properties

8.1 Material supplied under this specification shall conform to the mechanical property requirements given in [Table 3](#) when tested at temperatures between 18.3 °C and 29.4 °C [65 °F and 85 °F] in accordance with the requirements specified in [Section 11](#).

9. Dimensions, Mass, and Permissible Variations

9.1 All surfaces of product supplied under this specification shall be furnished in the rough machined condition with tolerances per ISO 2768.

TABLE 2 Permissible Variations in Check Analysis

	Material Number (R03610)	Check Analysis Limits, Maximum or Range, %	Permissible Variations in Check Analysis, %
C		0.010	+0.002
O		0.0070	+10 % relative
N		0.0020	+0.0005
Fe		0.010	+10 % relative
Ni		0.005	+10 % relative
Si		0.010	+0.002

TABLE 3 Mechanical Requirements

Material Grade	Tensile Strength, min, MPa [ksi]	Yield Strength, 0.2 % Offset, min, MPa [ksi]	Elongation in 20 mm [0.8 in.], min, %	Diamond Pyramid Hardness (DPH), 10 kg, min
Grade 1 UNS (R03610)	370 [54]	260 [38]	10	150
Grade 2 UNS (R03610)	450 [65]	320 [46]	20	150

10. Workmanship, Finish, and Appearance

10.1 Cracks, seams, slivers, blisters, burrs, and other injurious imperfections shall not exceed standards of acceptability agreed upon by the manufacturer and the purchaser.

10.2 Methods of testing for these defects and standards of acceptability shall be as agreed upon between the manufacturer and the purchaser.

10.3 The manufacturer shall be permitted to remove surface imperfections provided such removal does not reduce the dimension below the minimum permitted by the tolerance for the dimension specified.

11. Sampling

11.1 Sampling:

11.1.1 Care shall be exercised to ensure that the analytical sample selected for testing is representative of the material and form and is not contaminated by the sampling procedure.

11.1.2 Samples for mechanical testing shall be prepared from the finished material after all metallurgical processing is completed along X, Y, and Z axes, three probes per axis. Samples may be taken before final inspection and shall be representative of the finished product. Test reports/certifications shall include a minimum of two mechanical test results per axis. In lieu of the above sampling and testing requirement with prior approval of the manufacturer and user, test specimens may be taken from a separate ingot that has simultaneously received the same process conditions.

11.2 *Chemical Analysis*—Analysis may be made using the manufacturer’s standard methods. If there is any question relating to the sampling technique or the analysis of the sample, the methods of sampling and analysis shall be as agreed upon between the purchaser and the manufacturer.

11.3 *Mechanical Testing*—Tension test specimens shall be prepared and tested in accordance with Test Methods [E8/E8M](#).

TABLE 1 Chemical Requirements

Composition, %	
	Material Number (R03610)
C, max	0.010
O, max	0.0070
N, max	0.0020
Fe, max	0.010
Ni, max	0.005
Si, max	0.010
Mo	balance