



Standard Specification for Packing Material, Graphitic, Corrugated Ribbon or Textured Tape, and Die-Formed Ring¹

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1. Scope

1.1 *Scope*—This specification covers various types, classes, and grades of flexible graphite material in which valve media temperatures are limited to a maximum of 966°C. Where this specification is invoked as ASTM F2168, Sections 1 – 18 apply. Where this specification is invoked as ASTM/DoD F2168, Sections 1 – 18 and the Supplementary Requirements apply.

1.2 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

2. Referenced Documents

2.1 ASTM Standards:²

- C559 Test Method for Bulk Density by Physical Measurements of Manufactured Carbon and Graphite Articles
- C561 Test Method for Ash in a Graphite Sample
- C816 Test Method for Sulfur in Graphite by Combustion-Iodometric Titration Method
- C889 Test Methods for Chemical and Mass Spectrometric Analysis of Nuclear-Grade Gadolinium Oxide (Gd_2O_3) Powder
- D129 Test Method for Sulfur in Petroleum Products (General High Pressure Decomposition Device Method)
- D512 Test Methods for Chloride Ion In Water
- D1179 Test Methods for Fluoride Ion in Water
- D1246 Test Method for Bromide Ion in Water
- D3178 Test Methods for Carbon and Hydrogen in the Analysis Sample of Coal and Coke (Withdrawn 2007)³
- D3684 Test Method for Total Mercury in Coal by the

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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.

³ The last approved version of this historical standard is referenced on www.astm.org.

Oxygen Bomb Combustion/Atomic Absorption Method (Withdrawn 2014)³

D3761 Test Method for Total Fluorine in Coal by the Oxygen Bomb Combustion/Ion Selective Electrode Method

D3951 Practice for Commercial Packaging

D4239 Test Method for Sulfur in the Analysis Sample of Coal and Coke Using High-Temperature Tube Furnace Combustion

3. Terminology

3.1 Definitions:

3.1.1 *accordion crease, n*—because of the method of construction of die-formed rings, an accordion-like linear indication (crease) appear singularly or in multiple locations around the inside and outside diameter surface.

3.1.2 *corrosion inhibitors, n*—additives to the products to function in a passive or sacrificial manner to reduce galvanic corrosion. These additives are typically embedded zinc powder, phosphorus, or barium molybdate.

3.1.3 *corrugated ribbon, n*—graphite ribbon or tape that is subjected to mechanical pressure in a consistent manner to apply surface indentations to the tape or ribbon.

3.1.4 *density, n*—the mass per unit volume at a specified temperature.

3.1.5 *detrimental materials, n*—abrasive or chemically active constituents such as ash particles (in high ash content foils) or elemental materials that cause galvanic action or corrosion in long-term storage or service environments.

3.1.6 *die-formed ring, n*—a packing ring made by mechanically compacting winds of graphite ribbon or braided packing in a die or fixture.

3.1.7 *lot, n*—all finished packing of one size, type, class, and grade produced in a continuous run or at the same time under essentially the same conditions.

3.1.8 *set, n*—the packing components required to pack one valve.

3.1.9 *size, n*—the physical dimensions of the packing material.

4. Classification

4.1 *Classification*—The material shall be of the following types, classes, and grades as specified (see Section 5).

- 4.1.1 *Type I*—Corrugated ribbon or textured tape.
- 4.1.2 *Type II*—Die-formed ring.
- 4.1.3 *Class 1*—For use where detrimental material content of the packing need not be controlled beyond normal manufacturing limit (commercial grade).
- 4.1.4 *Class 2*—For use where detrimental material content shall be controlled to the limits specified herein.
- 4.1.5 *Grade A*—Treated with corrosion inhibitor.
- 4.1.6 *Grade B*—No corrosion inhibitor.

5. Ordering Information

5.1 Contracts or orders for the units under this specification shall include the following information:

- 5.1.1 Title, number, and date of this specification.
- 5.1.2 Type, class, and grade.
- 5.1.3 Type of corrosion inhibitor (see 6.1.3 and Supplementary Requirements).
- 5.1.4 Specify density of die-formed rings.
- 5.1.5 Inspection, testing, and certification of the material shall be agreed upon between the purchaser and the supplier as part of the purchase contract (see Sections 14 and 16).
- 5.1.6 When die-formed (Type II) packing rings are desired, the ring height, inside diameter, outside diameter, number of cuts, and number of packing rings required per set (see 9.2 and 9.3).
- 5.1.7 Marking requirements (see Section 17 and Supplementary Requirements).
- 5.1.8 Packaging requirements (see Section 18 and Supplementary Requirements).
- 5.1.9 Application data (to include operating pressure, operating temperature, and media).
- 5.1.10 Specify thickness of Type I.

6. Materials and Manufacture

6.1 *Material*—Requirements specified herein apply to Class 1 and Class 2 and Grade A and Grade B packing, except where noted.

6.1.1 *Type I*—The packing shall be made entirely of flexible graphitic material having no binders and meeting the requirements of Tables 1 and 2.

6.1.2 *Type II*—Die-formed packing rings shall be manufactured from flexible graphitic material conforming to the requirements of Tables 1 and 2.

6.1.3 *Coating and Corrosion-Inhibiting Treatments:*

6.1.3.1 *Grade A*—Grade A packing shall be provided with a powdered zinc active corrosion-inhibiting treatment or a passive inhibiting treatment such as phosphorous or barium molybdate, as specified (see Section 5). When the use of

TABLE 2 Detrimental Materials (Class 2 Only (See 13.6))

Element	Maximum Total Allowable Impurity Levels in Parts per Million (ppm)
Mercury (Hg)	10
Sulfur (S)	750
Total halogens (chlorine, bromine, and fluorine)	500
Chlorine (Cl)	250
Bromine (Br)	250
Fluorine (F)	250

inhibitors is required, both passive and active inhibitors shall be permitted to be used.

6.1.3.2 *Grade B*—Grade B packing shall not contain corrosion-inhibiting additives.

6.1.4 *Mercury Exclusion*—During manufacturing, fabrication, handling, packaging, and packing, the packing material shall not come in contact with mercury or mercury containing compounds.

7. Properties

7.1 *Chemical and Physical Properties*—Unless otherwise specified, the properties of the finished packing shall conform to the requirements of Table 1. Class 2 also requires compliance with Table 2.

7.2 *Prohibited Additions*—There shall be no intentional additions of any of the detrimental materials of Table 2 or antimony (Sb), arsenic (As), bismuth (Bi), cadmium (Cd), gallium (Ga), indium (In), lead (Pb), mercury (Hg), silver (Ag), or tin (Sn) during the manufacturing, fabrication, handling, packaging, and packing of the product.

8. Other Requirements

8.1 No other requirements noted.

9. Dimensions, Mass, and Permissible Variations

9.1 *Type I Ribbon Packing*—Unless otherwise specified (see Section 5), the packing shall be uniformly coiled, spooled, or reeled in accordance with Table 3.

9.2 *Type II Die-Formed Packing*—Unless otherwise specified (see Section 5), the tolerances for Type II packing shall be in accordance with Table 4. The tolerance applies to finished rings before any cutting operations.

9.3 *Split Rings*—The number of cuts (zero, one, or two) shall be as specified (see Section 5). Cuts shall be made at approximately a 45° angle such that an overlapping joint is formed in the compressed state. When two cuts are required (separating the ring into two parts), the resulting parts shall be

TABLE 1 Chemical and Physical Properties

Property	Value	Unit	Test
Density, bulk	as specified	kg/m ³	13.5
Ash	1 % by mass, max		13.3
Graphite purity	99 %, min		13.4

TABLE 3 Dimensions for Type I

Width	Length, min
6 ± 0.075 mm	7.62 m
12 ± 0.075 mm	7.62 m
18 ± 0.075 mm	15.24 m
25 ± 0.075 mm	15.24 m

TABLE 4 Tolerances for Type II Packing

	Inside Diameter (i.d.)	Outside Diameter (o.d.)	Thickness
to 25 mm o.d.	+0.25 mm -0.000 mm	+0.000 mm -0.25 mm	±0.50 mm
25 mm and above o.d.	+0.38 mm -0.000 mm	+0.000 mm -0.38 mm	±0.75 mm

approximately the same dimension. When the number of cuts is not specified, single-cut rings shall be provided.

10. Workmanship, Finish, and Appearance

10.1 *Workmanship*—The packing shall be free from extraneous material and visual defects that affect its serviceability, as defined in [Table 5](#).

11. Quality Assurance

11.1 *Quality Systems*—Manufacturers shall be prepared to document use of a quality system such as compliance with an ISO 9000 series program or similar program.

12. Specimen Preparation

12.1 *Specimen Preparation*—Buyer and seller shall agree on specimen preparation.

13. Test Methods

13.1 *Tests*—When tests are required as part of the purchasing requirements (see [5.1.5](#)), tests shall be made in accordance with the following methods or by way of alternate methods of analysis with equal or improved accuracy and precision. The use of an alternate analytical method requires the prior written consent of the purchasing party before acceptance will be allowed. Except for the corrosion-inhibiting treatment exceptions of [13.3](#) and [13.4](#), all testing shall be performed on final product after completion of all processing, including application of any binders and, if required, corrosion inhibitors.

13.2 *Size*—The size determined by measuring each sample selected for visual examination (see [Table 4](#)).

13.3 *Ash Content*—The ash content determined in accordance with Test Method [C561](#) (see [Table 1](#)). For Grade A packing only, the test shall be conducted before the corrosion-

inhibiting treatment or the added mass of the corrosion inhibitor shall be determined and subtracted from the base mass of the sample.

13.4 *Graphite Purity*—The sample shall be dried to a constant mass at $149 \pm 3^\circ\text{C}$ before testing. For Grade A packing only, the test shall be conducted before the corrosion-inhibiting treatment or the added mass of the corrosion inhibitor shall be determined and subtracted from the base mass of the sample. The percent carbon shall be based upon mass of the dried sample. This determination shall be made in accordance with Test Methods [D3178](#) or an alternate method of analysis with equal or improved accuracy and precision (see [Table 1](#)).

13.5 *Bulk Density*—The bulk density of the Type I and Type II materials determined in accordance with Test Method [C559](#).

13.6 *Detrimental Material Tests*—For determination of the detrimental materials listed in [Table 2](#) for Class 2 only, the test methods of [Table 6](#) or alternate methods of equal or improved accuracy and precision shall be used.

14. Inspection and Testing

14.1 Inspection and testing of the material shall be agreed upon between the purchaser and the supplier as part of the purchase contract (see [5.1.5](#)).

15. Rejection

15.1 Materials that fail to conform to the requirements of this specification shall be rejected. Rejection shall be reported to the producer or supplier promptly and in writing. In case of dissatisfaction with the results of testing, the producer shall make claim for a rehearing or provide for third party testing.

TABLE 5 Classification of Visual Defects

Item	Category—Major
Type I corrugated ribbon or textured tape	Void. Rip or tear in ribbon. Particulate or extraneous matter on surface that is not easily removed without damaging the packing. Noncontinuous length (no joints). Lack of corrugation or textured surface area. Creasing or crimping.
Type II die-formed rings	Holes or voids. Particulate or extraneous matter on surface that is not easily removed without damaging the packing. Delaminations (laminated rings). Gouges (minor indentations less than 0.12 mm in depth resulting from normal production and handling are acceptable). Split rings not cut cleanly. Lack of corrosion inhibitor (Grade A only). Wrong corrosion inhibitor (Grade A only). Presence of corrosion inhibitor (Grade B only). Cracking (crevices of no appreciable width associated with folds (accordion creases), ply terminations, or plies of die molded ribbon packing rings are acceptable.)

TABLE 6 Detrimental Materials Tests

Element	Preparation/Analysis Test Methods
Chlorine (Cl), bromine (Br)	(1) pyrohydrolysis (C889)/ion chromatographic analysis (2) D129/D512 (3) D1246 (for bromine)
Fluorine (F)	(1) pyrohydrolysis (C889)/selective ion electrode or ion chromatographic analysis (2) D129/D1179 (3) D3761 (sample preparation and analysis)
Sulfur (S)	(1) high temperature combustion in 100 % oxygen/ nondispersive infrared analysis or ion chromatographic analysis (2) C816 (sample preparation and analysis) (3) D4239 Method 3 (sample preparation and analysis)
Mercury (Hg)	(1) direct analysis of volatile elements (Hg) by emission spectrographic method (2) direct analysis of volatile elements by atomic absorption per D3684

16. Certification

16.1 When specified in the purchase order or contract, the purchaser shall be furnished certification that samples representing each lot have been tested and the requirements have been met. When specified in the purchase order or contract, a report of the test results shall be furnished.

16.2 *Detrimental Materials Control*—For Class 2 material only, the vendor shall provide certification that the limits of Table 2 have been met and that low melting metals (Sb, As, Bi, Cd, Pb, Sn, Ga, In, Ag, Hg and Zn [Zn for Grade B only]) have not been added as intentional constituents. In lieu of specific test results for the lot to be delivered, certifications shall be based on tests of both raw materials and production lots of similar finished packing material over an extended time period (not exceeding three years between tests). Any change to manufacturing processing that affects product composition, including changes to raw material, binders, or inhibitors (Grade A) shall require additional testing to form the basis for future certifications.

17. Product Marking

17.1 *Marking*—For commercial shipment, marking shall be in accordance with accepted industry practices or as required in the purchase contract (see 5.1.1). Marking shall include type of corrosion inhibitor, if any.

18. Packaging

18.1 *Commercial Packaging*—Commercial packaging shall be in accordance with Practice D3951 or as required in the purchase contract (see 5.1.1).

19. Keywords

19.1 flexible graphite material; packing material

SUPPLEMENTARY REQUIREMENTS

The following supplementary requirements shall apply only when specified by the purchaser in the contract or order. All of these supplementary requirements, and Sections 1 – 18, are applicable where this specification is invoked as ASTM/DoD F2168. *This specification is adapted from MIL-P-24503.*

S1. Scope

S1.1 *DoD Intended Use*—Packing is intended for general shipboard service in valves with the exception of potable water. Grade A packing is intended for use in valves with noncorrosion-resistant (for example, carbon steel, 400 series stainless steel) stem and packing gland parts.

S1.1.1 *Type I*—Type I packing is in corrugated ribbon or textured tape form for use where packing gland dimensions are not uniform or known. Type I packing is permitted to be used to manufacture Type II packing locally.

S1.1.2 *Type II*—Because Type II packing is die formed, it is designed for applications in new equipment or equipment in which packing gland dimensions are uniform or known and in excellent mechanical condition. The die-molded ribbon packing requires only a drop-in, but not loose, clearance with final gland compression setting the rings for proper operation.

S1.1.3 *Class I*—Class 1 is intended for use where detrimental materials content of the packing need not be controlled beyond normal manufacturing limits.

S1.1.4 *Class 2*—Class 2 is intended for use where detrimental materials content must be kept to a minimum.

S2. Classification

S2.1 The type and class classifications of this specification correspond to the type and class classifications of MIL-P-24503⁴.

S2.2 The Grade B classification of this specification corresponds to the Grade N classification of MIL-P-24503.

S2.3 The Grade A classification of this specification, using zinc powder corrosion inhibitor only, corresponds to the Grade I classification of MIL-P-24503.

S3. Materials and Manufacture

S3.1 Density Requirements:

S3.1.1 *Type I*—Unless otherwise specified (see Section 5), density of corrugated ribbon/textured tape shall be 1040 ± 160 kg/m³.

S3.1.2 *Type II*—Unless otherwise specified (see Section 5), density of finished die-formed rings shall be $1440 + 80/-160$ kg/m³.

⁴ Available from U.S. Government Printing Office Superintendent of Documents, 732 N. Capitol St., NW, Mail Stop: SDE, Washington, DC 20401, <http://www.access.gpo.gov>.

S3.2 *Coating and Corrosion-Inhibiting Treatments:*

S3.2.1 *Grade A*—Grade A packing shall be provided with a powdered zinc active corrosion-inhibiting treatment (2 % Zn by weight, minimum) only.

S3.2.2 *Grade B*—Grade B packing shall not contain corrosion-inhibiting additives.

S4. Dimensions and Tolerances

S4.1 *Type I*—Unless otherwise specified, (see Section 5), thickness of Type I packing shall be nominal 0.38 mm.

S5. Quality Assurance

S5.1 As a minimum, manufacturers shall provide and maintain an inspection system that meets the requirements of ANSI/ASQC Q9003⁵.

S6. Test Methods

S6.1 *Examination for Visual and Dimensional Defects*—Each unit selected for visual and dimensional examination shall be surface examined and measured to determine conformance with the requirements that do not require testing (see Section 10, including Table 5, and 13.2, including Table 6).

S6.2 *Examination for Preparation for Delivery*—Each unit selected shall be visually examined to determine compliance with packaging requirements (see Section 5 and 9.1) and marking requirements (see Section 5 and S.9).

S6.3 *Simulated Performance*—The test shall be conducted in an apparatus designed to simulate conditions in valves in actual service. A schematic of the test rig is shown in Fig. S6.1. The valves used in the simulator shall have glands and stems that are in new condition. The entire piping system and valves shall be insulated so as to minimize heat loss. Thermocouples shall be installed so as to indicate the actual steam temperature. The simulator shall be capable of holding a temperature of 524 ± 14°C and a pressure of 84 ± 3.5 kg/cm² for the duration of the test. The packing shall be installed and the gland initially adjusted so that no leakage occurs with the system at its operating temperature and pressure. While pressurized, the valve shall be fully cycled manually not less than once every half hour (full close to full open). The following schedule shall

be followed for running the test (test need not be conducted over a weekend period, if desired):

- 12 days ± 1 day at temperature 524 ± 14°C and 84 ± 3.5 kg/cm² pressure
- 35 days ± 5 days at ambient temperature and pressure (system shut down; valves need not be cycled)
- 5 days ± 1 day at temperature 524 ± 14°C and 84 ± 3.5 kg/cm² pressure

There shall be no steam leakage from the packing gland during the simulated performance test at a temperature 524 ± 14°C and 84 ± 3.5 kg/cm² pressure. There shall also be no corrosion or degradation of the packing gland at the completion of the test. Any leakage or gland adjustment shall be recorded. This test is equivalent to the simulated performance test of MIL-P-24503.

S7. Inspection and Testing

S7.1 Unless otherwise specified (see Section 5), first-article testing and quality conformance testing shall be required. The inspections and tests making up the first-article and quality conformance testing shall be as follows:

S7.2 *Sampling for First-Article Testing*—A sample shall be subjected to the first-article testing of Table S7.1.

S7.3 *Sampling for Quality Conformance Testing:*

S7.3.1 *Sampling for Visual and Dimensional Examination*—As a minimum, the contractor shall randomly select a quantity of sampling units from each lot in accordance with Table S7.2 and subject them to the examination for visual and dimensional defects of S6.1. The sample size depends on the lot size. If one or more defects are found in any sample, the entire lot shall be rejected. The contractor has the option of screening 100 % of the rejected lot for the defected characteristics or providing a new lot, which shall be inspected in accordance with the sampling plan herein. The contractor shall maintain for a period of three years after contract completion, records of inspections, tests, and any resulting rejections.

S7.3.2 *Sampling for Chemical and Physical Property and Detrimental Materials Tests*—A single random sample shall be selected from each lot for the testing of 13.3 – 13.6.

S7.3.3 *Sampling for Examination for Preparation for Delivery*—The lot size shall be the number of shipping containers. Sampling shall be in accordance with Table S7.2.

⁵ Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.

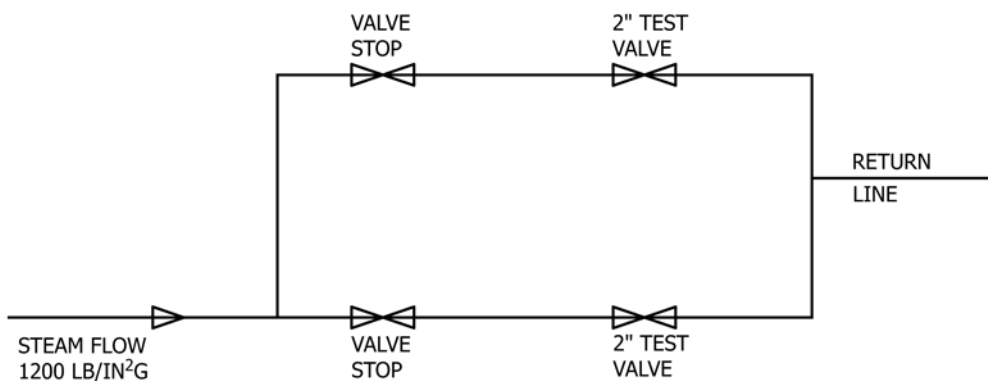


FIG. S6.1 Test Rig

TABLE S7.1 First-Article and Quality Conformance Tests

First Article	Quality Conformance
Examination for visual and dimensional defects (S6.1)	Examination for visual and dimensional defects (S6.1)
Ash content (13.3)	Ash content (13.3)
Graphite purity (13.4)	Graphite purity (13.4)
Bulk density (13.5)	Bulk density (13.5)
Detrimental materials (13.6) (Class 2 only)	Detrimental materials (13.6) (Class 2 only)
Simulated performance (S6.3)	N/A
N/A	Examination for preparation for delivery (S6.2)

TABLE S7.2 Sampling

Lot Size	Sample Size
2 to 50	Lesser of 5 or size of lot
51 to 90	7
91 to 150	11
151 to 280	13
281 to 500	16
501 to 1200	19
1201 to 3200	23
3201 to 10 000	29
10 001 to 35 000	35
35 001 to 500 000 (and above)	40

S8. Certification

S8.1 *Simulated Performance Test*—After the simulated performance test is once performed acceptably, providing product composition or processing has not changed, a certificate of compliance, citing the test report or document accepting compliance with the test requirement, is permitted to be provided thereafter.

S9. Product Marking

S9.1 Item description marking shall include, as a minimum, the size, class, grade, and type of inhibitor (if any) of the graphitic packing material. In addition, the item description marking shall include the phrase “ASTM/DoD F2168” to identify the applicability of this specification and any special marking which shall be required, such as bar coding (see Section 5).

S10. Rejection

S10.1 *Known Defects*—Materials that fail to conform to the requirements of this specification shall not be offered for delivery.

S10.2 *Buyer Testing*—The buyer reserves the right to perform any of the inspections and tests set forth in this document. Materials that fail to conform to the requirements of this specification shall be rejected. Rejection will be reported to the producer or supplier promptly and in writing. In case of dissatisfaction with the results of testing, the producer is entitled to make claim for a rehearing or provide for third party testing.

S10.3 *Replacement of Test Specimens*—A test specimen shall be discarded and a replacement specimen selected from the same lot of material under the following conditions:

S10.3.1 Where the specimen is incorrectly prepared,

S10.3.2 Where the test procedure is incorrect,

S10.3.3 Where there is a malfunction of the testing equipment, and

S10.3.4 Where a flaw that is not indicative of an inferior or defective lot of material develops during the test.

S10.4 *Retests*—Retests are only permitted for ash content, graphite purity, bulk density, and detrimental material tests. Retests shall be performed on twice the number of specimens that were originally nonconforming. Retest specimens shall be taken in the vicinity of the initial location of a failed specimen. If any of the retest specimens fail, the lot shall be rejected with no further retesting permitted.

S10.5 *Resubmittal of Rejected Lots*—A rejected lot is permitted to be resubmitted for acceptance provided that the rejected lot has been reworked, as necessary, to correct the nonconforming condition. Reworking shall consist of any procedure required to correct physical, mechanical, or dimensional deficiencies in nonconforming material to meet specification requirements without adversely affecting its other required characteristics.

APPENDIX

(Nonmandatory Information)

X1. RATIONALE

X1.1 This appendix provides general background information for the specification which is an adaptation of the former MIL-P-24503, “Packing Material, Graphitic, Corrugated Ribbon or Textured Tape and Die-Formed Ring.” The intent of this specification is to provide general guidance describing com-

mercial packing requirements in the main body and military ship requirements in the supplementary requirements section. Note that Grade A military (ASTM/DoD) packing is restrictive in terms of the corrosion inhibitor allowed.

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