



Standard Specification for Packing Material, Graphitic or Carbon Braided Yarn¹

This standard is issued under the fixed designation F2191/F2191M; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This specification covers staple or continuous filament carbon/graphite yarn valve stem compression packing, suitable for use as end-rings on packing systems for valves. Intended services include steam, hydrocarbons, water and non-oxidizing chemicals. Where this specification is invoked as ASTM F2191, Sections 1 – 18 apply. Where this specification is invoked as ASTM/DoD F2191, Sections 1 – 18 and the Supplementary Requirements shall be applicable.

1.2 The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the standard.

1.3 *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 and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 ASTM Standards:²

- C135 Test Method for True Specific Gravity of Refractory Materials by Water Immersion
- C561 Test Method for Ash in a Graphite Sample
- C562 Test Method for Moisture 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)

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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.

- 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 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

2.2 Military Standards:

- MIL-STD-129 Marking for Shipment and Storage⁴
- MIL-P-24583 Packing Material, Graphitic or Carbon Braided Yarn⁴
- MIL-P-24503 Packing Material, Graphitic, Corrugated Ribbon or Textured Tape and Preformed Ring⁴

2.3 Fluid Sealing Association Handbook:

- Guidelines for the Use of Compression Packings, Copyright 1997⁵

3. Terminology

3.1 *base fiber density*—bulk density of the base fiber before being coated or impregnated and braided into packing.

3.2 *braided flexible graphite*—a braid constructed of continuous strands or strips of expanded flexible graphite tape or ribbons, which have been overwrapped or have imbedded reinforcing fibers.

3.3 *carbon fibers*—fibers used in braided packing are produced from viscose rayon, pitch, or polyacrylonitrile (PAN) and are defined as a yarn with a carbon assay of less than 99 %.

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

⁴ Available from Standardization Documents Order Desk, DODSSP, Bldg. 4, Section D, 700 Robbins Ave., Philadelphia, PA 19111-5098, <http://www.dodssp.daps.mil>.

⁵ Available from the Fluid Sealing Association, 994 Old Eagle School Road, Suite 1019, Wayne, PA 19087-1866.

3.4 *carbon yarns*—manufactured from continuous or staple carbon fibers that are twisted or plied into continuous individual strands of between 6 and 18 μm in diameter.

3.5 *carbon/graphite fibers*—carbon/graphite fibers used in braided packing are produced from viscose rayon, pitch, or polyacrylonitrile (PAN).

3.6 *center or corner filler strands*—strands of fiber/yarn that run parallel to the longitudinal axis of the braid in the corners or center to control the internal density and dimensional stability of the braid.

3.7 *continuous*—individual fibers are almost infinite in length.

3.8 *continuous or staple carbon/graphite*—continuous or staple defines the length of the individual fibers in the carbonaceous yarn. Continuous means the fibers are infinite in length and staple means the individual fibers are at least 75 mm [3 in.] long and preferably 150 to 200 mm [6 to 8 in.] long. All of the fibers are between 6 to 18 μm in diameter and are twisted/plied into continuous strands called yarns.

3.9 *corrosion inhibitors*—additives to the yarn or braid to function in a passive or sacrificial manner to reduce galvanic corrosion such as embedded zinc powder, phosphorus, or barium molybdate.

3.10 *detrimental materials*—abrasive or chemically active constituents such as abrasive ash particles (in high ash content foils) or elemental materials as in **Table 2**.

3.11 *diagonal interlocking braid*—these strands criss-cross from the surface of the braid diagonally through the body of the braid and each strand is strongly locked by other strands to form an integral structure (see **Fig. 1**).

3.12 *dispersion*—various coatings or impregnants added to the base fibers or braid to facilitate handling, lubricate the fibers, accelerate break-in, or act as blocking agents during use.

3.13 *graphite fibers*—fibers used in braided packing are produced from viscose rayon, pitch, or polyacrylonitrile (PAN) and are defined as a yarn with a carbon assay of 99 % or higher.

3.14 *graphite yarns*—manufactured from continuous or staple graphite fibers that are twisted or plied into continuous individual strands between 6 to 18 μm in diameter.

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

3.16 *PAN*—polyacrylonitrile fibers used as precursors to manufacture carbon/graphite for braided packing.

TABLE 2 Detrimental Materials (Class 2 only (see 13.8))

Element	Maximum Allowable Total 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

3.17 *PTFE*—polytetrafluoroethylene. (**Warning**—Graphitic valve packing containing PTFE has been associated with accelerated valve stem corrosion.)

3.18 *specific gravity*—the ratio of the mass of a unit volume of a material at a stated temperature to the mass of the same volume of distilled water at the same temperature.

3.19 *square plait braid*—the strands in this type of braid interlock in a single plane and do not interlock through the body of the braid (see **Fig. 1**).

3.20 *staple carbon/graphite*—individual fibers are at least 75 mm [3 in.] long and preferably 150 to 200 mm [6 to 8 in.] long.

3.21 *unraveling*—a loss of the original braiding shape or dimensions of the cut end extending from the cut for a distance greater than that specified along the axis of the packing.

4. Classification

4.1 *Classification*—The material shall be of the following types, classes, and grades, as specified (see 5.1):

4.1.1 *Type I*—Continuous carbon or graphite yarn.

4.1.2 *Type II*—Staple carbon or graphite yarn.

4.1.3 *Type III*—Braided flexible graphite.

4.1.3.1 *Class 1*—For use where detrimental material and lubricant content of the packing need not be controlled beyond normal manufacturing limits.

4.1.3.2 *Class 2*—For use where detrimental materials content must be controlled to limits specified herein.

4.1.3.3 *Class 3*—For use where detrimental materials content need not be controlled beyond normal manufacturing limits, and media temperatures do not exceed 500°F [260°C].

(1) *Grade A*—Treated with corrosion inhibitor.

(2) *Grade B*—No corrosion inhibitor.

5. Ordering Information

5.1 *Acquisition Requirements*—Acquisition documents must specify the following:

5.1.1 Title, number, and date of this specification.

5.1.2 Type, Class and Grade required (see Section 4).

5.1.3 Carbon or graphite.

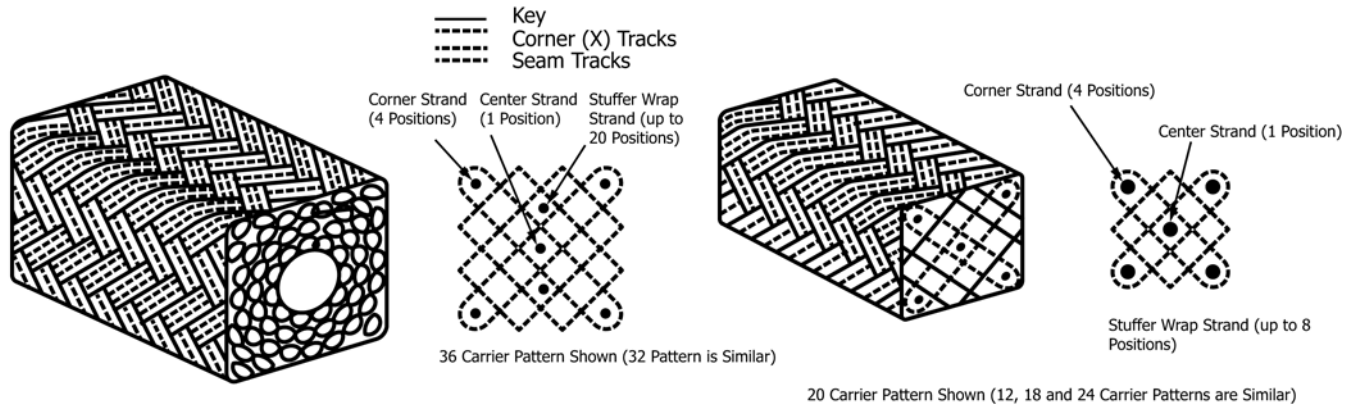
5.1.4 Type of corrosion inhibitor.

5.1.5 Chemical properties (see 7.1).

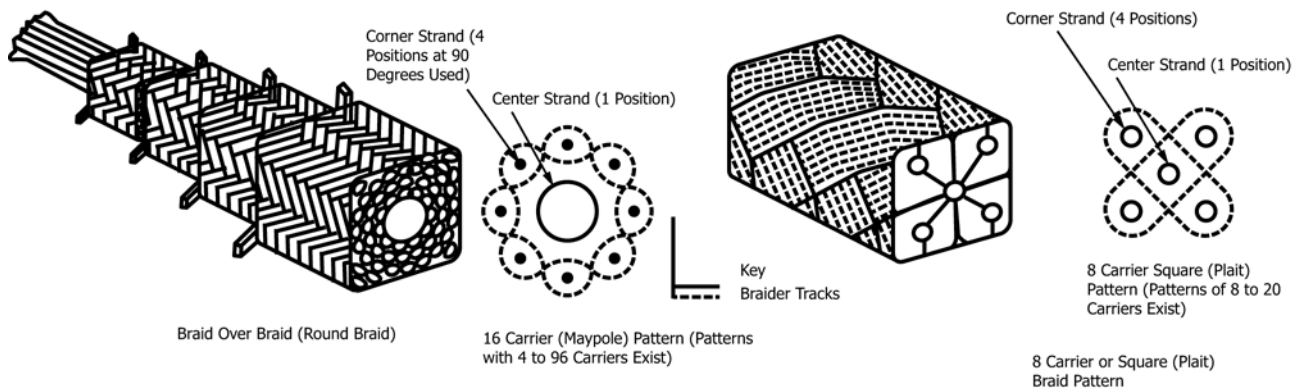
5.1.6 Inspection, testing, and certification of the material shall be agreed upon between the purchaser and the supplier as part of the purchase contract.

TABLE 1 Chemical and Physical Properties

Property	Value	Test
Carbon Assay		
Graphitic	99 % by mass, min.	13.4
Carbon	95 % by mass, min.	13.4
Ash	1 % by mass, max.	13.5
Finished Packing (in as-supplied state):		
Specific gravity	1.38 g/cc, min.	13.6
Moisture content	3 %, max.	13.7
Compression recovery	25 %, min.	13.10



Diagonal Interlocking Through-Body-to-Surface Construction (Sizes ¼ in. (6 mm) and Over)



Interlocking and Square Plait Versus Braid-Over-Braid Patterns
FIG. 1 Packing Construction

5.1.7 Size required (see 9.1). When pre-cut rings are desired, specify the braid cross-section, inside diameter, outside diameter, and number of rings required.

5.1.8 Put-up, if other than required by Table S4.1 (see Supplementary Requirements).

5.1.9 Application data.

5.1.10 Packaging requirements (see Section 18 and Supplementary Requirements).

5.1.11 Marking requirements (see 17.1 and Supplementary Requirements).

6. Materials and Manufacture

6.1 *Materials and Manufacture*—The material shall be as specified in 6.1.1 – 6.1.5.

6.1.1 *Yarn*:

6.1.1.1 Type I packing shall be made of continuous filament carbon or graphite yarn.

6.1.1.2 Type II shall be made of staple carbon or graphite yarn.

6.1.1.3 Type III shall be made of flexible graphite.

6.1.2 *Packing*:

6.1.2.1 Class 1 packing shall be made of Type I or Type II yarn and shall have a pure graphitic dispersion or carbon dispersion.

6.1.2.2 Class 2 packing shall be made of Type I yarn and shall have a pure graphite or carbon dispersion.

6.1.2.3 Class 3 packing shall be made of Type I or Type II yarn and shall have a pure graphite, or carbon dispersion and are permitted to be coated with polytetrafluoroethylene (PTFE) (see 7.2 and 13.9).

6.1.3 *Coating and Corrosion Inhibiting Treatments*:

6.1.3.1 *Grade A*—Grade A packing shall be provided with a powdered zinc (Zn) active corrosion inhibiting treatment or a passive inhibiting treatment such as phosphorus or barium molybdate. If required, both active and passive inhibitors shall be used.

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

6.1.4 *Packing Construction (Type I and Type II)*—Packing shall be square (plait) braided for cross-sectional sizes smaller than 6 mm [¼ in.]. Cross-sectional sizes of 6 mm [¼ in.] or greater shall use a diagonal interlocking type construction. The

diagonal interlocking constructions shall consist of either single or plied yarns braided on 12, 18, 20, 24, 32, or 36 carrier braiding machines. Additional axial center, corner, and (stuffer) warp yarn(s) can be added within the braid as necessary to produce a dense square cross-section packing profile with good dimensional stability.

6.1.5 *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 *PTFE Coating (Class 3 only)*—If PTFE is used, it shall not exceed 10 % by mass of the packing (see **13.9**) unless otherwise agreed to by the purchaser. (**Warning**—Graphitic valve packing containing PTFE has been associated with accelerated valve stem corrosion.)

7.3 *Prohibited Additions*—There shall be no intentional additions of any of the detrimental materials listed in **Table 2** or any antimony (Sb), arsenic (As), bismuth (Bi), cadmium (Cd), gallium (Ga), indium (In), lead (Pb), mercury (Hg), silver (Ag), or tin (Sn), or, in the case of Grade B packing, zinc (Zn).

8. Other Requirements

8.1 *Braid Geometry Retention*—Untaped, cut ends shall not unravel more than 3 mm [$\frac{1}{8}$ in.] with the packing dry or wet (see **13.11**). For example, packing 12 mm [$\frac{1}{2}$ -in.] in cross section shall not unravel more than 3 mm [$\frac{1}{8}$ in.] at either end of the packing.

9. Dimensions, Mass, and Permissible Variations

9.1 *Sizes and Mass*—Packing shall be furnished in the sizes shown in **Table 3**, or other size(s) as is ordered by the customer, (see Section 5 and **6.1.4**). Packing shall be formed approximately square or rectangular in cross-section (either when straight or when placed about a shaft) within the dimensional tolerances of **Table 3**. When specified in the purchase document (see **5.1** and **13.2**), the mass per linear foot (or other measure) shall be in accordance with the sizes listed in **Table 4**. Sizes not listed in **Table 4** shall be as agreed between purchaser and manufacturer and specified in Section 5, Ordering Information. Include minimum mass per linear foot as a part of the bid and purchase documents.

9.1.1 *Tolerance and Measurement Standards*—The generally accepted method of measurements in the packing manufacturing environment is a hand held, direct reading, vernier

caliper. To ensure concentricity, the inside diameter is measured using a ground dimensional plug gauge and the outside diameter is measured by the above (caliper) while the plug is inserted. Information regarding tolerance and measurement is available in the Guidelines for the Use of Compression Packings published by the FSA.

10. Workmanship, Finish, and Appearance

10.1 *Workmanship*—The packing shall be free of defects that have the potential to affect its serviceability as defined in **Table 5**.

10.2 *Construction*—The sample shall be visually examined and confirmed to be of the correct braid construction (square plait braid or diagonal interlocking braid) for the ordered size (see **5.1** and **6.1.4**).

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*—In the event that testing is required as part of the purchasing requirements **5.1**, tests shall be made in accordance with the following or by way of alternate methods of analysis with equal to 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.

13.2 *Size*—Before unbraiding, the size shall be determined by measuring each sample selected for visual examination (see **Table 3**). A steel rule with 1 mm [$\frac{1}{32}$ in.] divisions accurate to 1 mm [$\frac{1}{32}$ in.] or a steel slide caliper with 1 mm [$\frac{1}{32}$ in.] and 0.5 mm [$\frac{1}{64}$ in.] divisions shall be used (see **9.1**).

13.3 *Mass*—The mass shall be determined using a specimen at least 609.6 mm [2 ft] in length for measurement in conjunction with the values of **Table 4**.

13.4 *Carbon Assay*—The sample shall be dried to a constant mass at $149 \pm 3^\circ\text{C}$ [$300 \pm 5^\circ\text{F}$] before testing. For Grade A packing only, the test shall be conducted prior to 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 *Ash Content*—The ash content shall be determined in accordance with Test Method **C561** (see **Table 1**). For Grade A packing only, the test shall be conducted prior to the corrosion inhibiting treatment or the added mass of the corrosion inhibitor shall be determined and subtracted from the base mass of the sample.

TABLE 3 Manufacturing Tolerances by Cross-Sectional Size

Cross Section SI	Cross Section IP	Tolerance SI	Tolerance IP
Up to 6 mm	Up to $\frac{1}{4}$ in.	± 0.4 mm	$\pm \frac{1}{64}$ in.
6 to 25 mm, incl	$\frac{1}{4}$ to 1 in., incl	± 0.8 mm	$\pm \frac{1}{32}$ in.
greater than 25 mm	greater than 1 in.	± 1.6 mm	$\pm \frac{1}{16}$ in.

TABLE 4 Sizes and Mass of Packing

Nominal Size (mm)	Nominal Size (in.)	Types I and II Minimum Mass (g/linear metre)	Types I and II Minimum Mass (lb/linear ft)	Type III Minimum Mass (g/linear m)	Type III Minimum Mass (lb/linear ft)
3	1/8	6.7	.0045	10.4	.007
3.8	5/32	10.4	.007	16.4	.011
4.5	3/16	13.4	.009	25.3	.017
5.3	7/32	19.4	.013	34.3	.023
6	1/4	25.3	.017	44.7	.030
6.8	9/32	31.3	.021	55.1	.037
7.6	5/16	38.7	.026	64.0	.043
8.4	11/32	47.7	.032	76.0	.051
9	3/8	56.6	.038	90.9	.061
9.6	13/32	65.5	.044	107.2	.072
10.2	7/16	77.5	.052	119.2	.080
10.8	15/32	87.9	.059	148.9	.100
12	1/2	99.8	.067	165.3	.111
12.8	17/32	113.2	.076	184.7	.124
13.6	9/16	126.6	.085	195.1	.131
14.2	19/32	141.5	.095	250.2	.168
15	5/8	156.4	.105	238.3	.160
16.5	11/16	189.2	.127	311.3	.209
18	3/4	226.4	.152	312.8	.210
19.5	13/16	265.2	.178	537.7	.361
21	7/8	306.8	.206	558.6	.375
22.5	15/16	353.0	.237	616.6	.414
24	1	402.2	.270	506.4	.340
30	1 1/4	627.1	.421	996.5	.669

TABLE 5 Classification of Visual Defects

Areas of loose weave in braid
Frayed braid surface
Clumps of yarn fibers protruding from surface
Yarn knots excessively sized or extending beyond the braid surface
Uneven or irregular stitch pattern
Particulate or extraneous matter on surface
Lack of corrosion inhibitor (Grade A only)

13.6 *Specific Gravity*—This determination shall be made in accordance with Test Method **C135**, modified as follows: (Alternative methods of analysis with equal or improved accuracy and precision (see Table 1) can be used upon receipt of prior written consent and approval by the purchaser.)

13.6.1 *Preparation for Test Method C135*—A 50 g [1.7637 oz] sample shall be prepared for grinding by unbraiding, cutting, or otherwise reducing the braided packing to pieces not larger than 3 mm [1/8 in.].

NOTE 1—Test Method **C135** uses a water pycnometer test method. Test procedures using a gas pycnometer-based analytical method shall forego the need to reduce of the sample to its fiber state.

13.7 *Moisture Content*—The moisture content shall be determined in accordance with Test Method **C562** (see Table 1).

13.8 *Detrimental Materials 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.

13.9 *Analysis for PTFE Coating (Class 3 only)*—A 5-g specimen of packing shall be placed in a crucible and heated at $104 \pm 1^\circ\text{C}$ [$220 \pm 2^\circ\text{F}$] to constant mass (original dry mass) at room temperature. Then the specimen shall be heated at $316 \pm 5.5^\circ\text{C}$ [$600 \pm 10^\circ\text{F}$] for 24 h, cooled, and the mass determined. The same specimen shall then be heated at $482 + 14 - 0^\circ\text{C}$ [$900 + 25 - 0^\circ\text{F}$] for 3 h, cooled, and the mass determined. After the 482°C [900°F] heating, the crucible mass shall be redetermined without the specimen unless a platinum crucible was used. The new mass of the crucible shall be used to determine the mass of the residue after heating. Heating shall be done in a ventilated hood to avoid exposure to toxic vapors. The percentage of PTFE shall be calculated as follows, based on an average of three determinations (see **7.2**).

TABLE 6 Detrimental Material Tests

Element	Preparation/Analysis Test Methods
Chlorine (Cl), Bromine (Br)	(1) Pyrohydrolysis (ASTM C889)/Ion Chromatographic Analysis (2) ASTM D129 /ASTM D512 (3) ASTM D1246 (for Bromine)
Fluorine (F)	(1) Pyrohydrolysis (ASTM C889)/ Selective Ion Electrode or Ion Chromatographic Analysis (2) ASTM D129 /ASTM D1179 (3) ASTM D3761 (sample preparation and analysis)
Sulfur (S)	(1) High temperature combustion in 100 % Oxygen/Non-Dispersive Infrared Analysis or Ion Chromatographic Analysis (2) ASTM C816 (sample preparation and analysis) (3) ASTM 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 ASTM D3684

$$\text{Percent PTFE} = \frac{100(F - N)}{W}$$

where:

- W = average original dry mass of specimens after extraction,
 F = average mass of residue in crucibles after heating at 316°C [600°F], and
 N = average mass of residue in crucibles after heating at 482°C [900°F].

13.10 *Compression Recovery*—Three specimens, each 44 ± 3 mm [1.750 ± 0.125 in.] long, shall be prepared from the sample and the results of the following test of each specimen averaged for comparison with the compression recovery limit of [Table 1](#).

13.10.1 Center the specimen on a flat plate which is larger than the specimen and has its upper surface perpendicular ($\pm 2^\circ$) to the load to be applied. Place a flat plate of similar size on top of the specimen so that its lower surface is parallel ($\pm 2^\circ$) to the upper surface of the bottom plate. The upper plate shall weigh 2.27 ± 0.45 kg [5 ± 1 lb]. Both plates shall be rigid and maintained parallel during the testing. After the weight of the upper plate has been applied to the specimen for at least 15 s, measure and record the thickness (P) of the preloaded specimen. Several measurements about the circumference of the test plate shall be taken and averaged for this, and subsequent, measurements.

13.10.2 Apply the major load, by either the top or bottom plate, along an axis passing through the center of the specimen in a slow, uniform manner so that the major load is attained within 20 ± 5 s. The major load is that load which will produce a stress of $316.4 \text{ kg/cm}^2 \pm 10\%$ [$4500 \text{ lb/in.}^2 \pm 10\%$] on the area of the specimen initially in contact with the lower test plate.

13.10.3 Maintain the major load for at least 60 s and measure and record the thickness (M) of the fully loaded specimen.

13.10.4 Immediately remove the major load and after about 60 s measure and record the recovered thickness (R) under the original preload.

13.10.5 Calculate the percent compression recovery (PCR) as follows:

$$\text{PCR} = \frac{(R - M)}{(P - M)} \times 100$$

13.11 *Braid Geometry Retention*—Cut a 50 ± 1.5 mm [$2 \pm \frac{1}{16}$ in.] length packing (the ends shall not be taped prior to or after cutting). Soak the test piece in room temperature water for

15 min, minimum. The packing shall not unravel at the ends more than 3 mm [$\frac{1}{8}$ in.] at either end (see [8.1](#)).

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](#)).

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.

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 (antimony (Sb), arsenic (As), bismuth (Bi), cadmium (Cd), lead (Pb), tin (Sn), gallium (Ga), indium (In), silver (Ag), mercury (Hg) and zinc (Zn) [zinc for Grade B only]) have not been added as intentional constituents. Instead 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 which 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](#)). 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](#)).

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 F2191. This specification is adapted from MIL-P-24583.

S1. DoD Intended Use

S1.1 Type I packings are intended for general shipboard service as anti-extrusion end-rings to be used in conjunction with corrugated ribbon or preformed ring graphitic packing material in valves. Grade A packing is intended for use in valves with non-corrosion resistant (for example, carbon steel, 400 series stainless steel) stem and packing gland parts.

S2. Classification

S2.1 The Type (I and II) and Class classifications of this specification correspond to the Type and Class classifications of MIL-P-24583.

S2.2 The Grade B classification of this specification corresponds to the Grade N classification of MIL-P-24583.

S2.3 The Grade A classification of this specification, utilizing zinc powder corrosion inhibitor only, corresponds to the Grade I classification of MIL-P-24583.

S3. Materials and Manufacture

S3.1 *Coating and Corrosion Inhibiting Treatments:*

S3.1.1 *Grade A*—Grade A packing shall be provided with a powdered zinc (Zn) active corrosion inhibiting treatment only (2 % zinc, by weight, minimum).

S3.1.2 *Grade B*—Grade B packing shall not contain corrosion inhibiting additives.

S4. Dimensions and Tolerances

S4.1 *Put-Up*—Unless otherwise specified (see Section 5), packing shall be uniformly coiled on spools or reels of the size specified (see Section 5) in accordance with Table S4.1. No more than three segments of packing shall be provided on the smallest spool or reel.

S5. Quality Assurance

S5.1 As a minimum, manufacturers shall provide and maintain an inspection system that meets the requirements of ANSI/ASQC Q9003.

S6. Test Methods

S6.1 *Examination for Visual and Dimensional Defects*—Units shall be examined for visual and dimensional defects as follows:

S6.1.1 *Size*—The size of each unit selected shall be measured for conformance with the requirements of Section 9, including Table 3, and 13.2.

S6.1.2 *Visual Examination*—Each unit selected shall be visually examined to determine conformance with the requirements of 10.1, including Table 5.

S6.1.3 *Construction*—Each unit selected shall be visually examined to determine conformance with the requirements of 10.2.

S6.2 *Examination for Preparation for Delivery*—Each unit selected shall be visually examined to determine compliance with packaging requirements (see Sections 5 and 18) and marking requirements (see Sections 5 and 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 $524 \pm 14^\circ\text{C}$ [$975 \pm 25^\circ\text{F}$] and a pressure of $84 \pm 3.5 \text{ kg/cm}^2$ [$1200 \pm 50 \text{ lb/in.}^2$] 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. 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 ± 1 days at temperature $524 \pm 14^\circ\text{C}$ [$975 \pm 25^\circ\text{F}$] and $84 \pm 3.5 \text{ kg/cm}^2$ [$1200 \pm 50 \text{ lb/in.}^2$] pressure
- 35 ± 5 days at ambient temperature and pressure (system shut down; valves need not be cycled)
- 5 ± 1 days at $524 \pm 14^\circ\text{C}$ [$975 \pm 25^\circ\text{F}$] and $84 \pm 3.5 \text{ kg/cm}^2$ [$1200 \pm 50 \text{ lb/in.}^2$] pressure

TABLE S4.1 Put-Up

Packing Size, mm	Packing Size, in.	Package, (net mass in kg)	Package, (net mass in lb)
2.4 through 8.7	$\frac{3}{32}$ through $\frac{11}{32}$	0.45, 0.9 or 1.35 kg spools	1, 2, or 3 lb spools
9.5 through 15.1	$\frac{3}{8}$ through $\frac{19}{32}$	0.9, 1.35, or 2.28 kg spools	2, 3, or 5 lb spools
15.9	$\frac{5}{8}$	1.35, 2.28, 4.54 or 11.4 kg reels	3, 5, 10, or 25 lb reels
17.5	$\frac{11}{16}$	1.35, 2.28, 4.54 or 11.4 kg reels	3, 5, 10, or 25 lb reels
19.0	$\frac{3}{4}$	2.28, 4.54 or 11.4 kg reels	5, 10, or 25 lb reels
20.6	$\frac{13}{16}$	2.28, 4.54 or 11.4 kg reels	5, 10, or 25 lb reels
22.2	$\frac{7}{8}$	2.28, 4.54, 11.4 or 22.7 kg reels	5, 10, 25, or 50 lb reels
23.8	$\frac{15}{16}$	2.28, 4.54, 11.4 or 22.7 kg reels	5, 10, 25, or 50 lb reels
25.4	1	4.54, 11.4 or 22.7 kg reels	10, 25, or 50 lb reels
31.8	$1\frac{1}{4}$	4.54, 11.4 or 22.7 kg reels	10, 25, or 50 lb reels

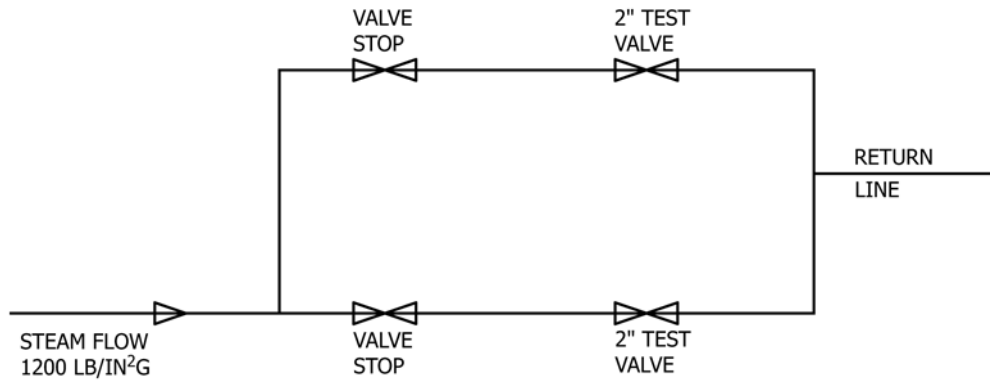


FIG. S6.1 Test Rig

There shall be no steam leakage from the packing gland during the simulated performance test at a temperature of $524 \pm 14^\circ\text{C}$ [$975 \pm 25^\circ\text{F}$] and a pressure of $84 \pm 3.5 \text{ kg/cm}^2$ [$1200 \pm 50 \text{ lb/in.}^2$]. 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-24503MIL-P-24503.

S7. Inspection and Testing

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

S7.2 *First Article Tests*—First article testing shall consist of the examinations and tests of Table S7.1.

S7.3 *Quality Conformance Tests*—Quality conformance testing shall be in accordance with Table S7.1.

S7.4 *Sampling:*

S7.4.1 *Sampling for Visual and Dimensional Examination (S6.1)*—As a minimum, the contractor shall randomly select a quantity of sampling units from each lot of graphitic or carbon braided yarn packing material in accordance with Table S7.2 and subject them to the examinations 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

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

providing a new lot, which shall be selected 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.

S7.4.2 *Sampling for Chemical and Physical Property and Detrimental Material Tests*—A single random sample shall be selected from each lot for the testing of 13.3 – 13.11.

S7.4.3 *Sampling for Examination for Preparation for Delivery (S6.2)*—The lot size shall be the number of shipping containers. Sampling shall be in accordance with Table S7.2.

S7.4.4 *Sampling for Simulated Performance Test (S6.3)*—A sample of sufficient size shall be selected for the simulated performance test.

S8. Certification

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

S9. Product Marking

S9.1 *Minimum Product Marking*—Item description marking shall include, as a minimum, the size, type, class, grade and type of inhibitor (if any) of the packing material. In addition, the item description marking shall include the phrase “ASTM/DoD F2191” to identify the applicability of this specification and any special marking required, such as bar coding (see Section 5). Marking for DoD procurements shall be in accordance with MIL-STD-129.

TABLE S7.1 First Article and Quality Conformance Tests

	Requirements	First Article Tests	Quality Conformance Tests
Examination for visual and dimensional defects	9, 10, 13.2	S6.1	S6.1
Mass	9.1	13.3	13.3
Carbon assay	Table 1	13.4	13.4
Ash	Table 1	13.5	13.5
Specific gravity	Table 1	13.6	13.6
Moisture content	Table 1	13.7	13.7
Detrimental materials (Class 2 only)	Table 1	13.8	13.8
PTFE coating	7.2	13.9	13.9
Compression recovery	Table 1	13.10	13.10
Braid geometry retention	8.1	13.11	13.11
Simulated performance		S6.3	N/A
Examination for preparation for delivery		N/A	S6.2

S9.2 *Spool/Reel Marking*—If packing is to be provided on spools or reels, the required information of S9.1, and the National Stock Number and contract number, shall be marked on the spool or reel.

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 specification. 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 shall 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.

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 is 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)

XI. RATIONALE (COMMENTARY)

This appendix provides general background information for this specification, which is an adaptation of the former MIL-P-24583, “Packing Material, Graphitic or Carbon Yarn.” The intent of this specification is to provide general guidance describing commercial packing requirements in the main body

and military ship requirements in the supplementary requirements section. It is noted that some Grade A military ASTM/DoD packings are restrictive in terms of the corrosion inhibitors.

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