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Standard Specification for High Load Rotational Confined Elastomeric Bearings for Bridges and Structures[1]

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[1] This specification is under the jurisdiction of ASTM Committee D-4 D0- on Road and Paving Materials and is the direct responsibility of Subcommittee D04.32 on Bridges and Structues.

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1. Scope

1.1 This specification covers bridge bearings which consist of a confined elastomeric element encased in steel (pot bearings) when the function of the bearing is to transfer loads or accommodate relative movement including rotation between a bridge superstructure and its supporting structure, or both.

1.2 This specification covers the requirements of pot bearings with standard horizontal loads (10 % of vertical).

1.3 The requirements stated in this specification are the minimums necessary for the manufacture of quality bearing devices. It may be necessary to increase these minimum values due to design conditions.

1.4 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are for information only.

1.5 The following safety hazards caveat pertains only to the test method portion, Section 7, of this specification: *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:*

A 36/A 36M Specification for Carbon Structural Steel[2]

A 240/A 240M Specification for Heat-Resisting Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and General Applications[3]

A 572/A 572M Specification for High-Strength Low-Alloy Columbium-Vanadium Steels of Structural Quality Steel [2]

A 588/A 588M Specification for High-Strength Low-Alloy Structural Steel with 50 ksi (345 m MPa) Minimum Yield Point to 4 in. (100 mm) Thick[2]

A 709/A 709M Specification for Carbon and High-Strength Low-Alloy Structural Steel Shapes, Plates and Bars and Quenched and Tempered Alloy Structural Steel Plates for Bridges[2]

B 36/B 36M Specification for Brass Plate, Sheet, Strip, and Rolled Bar[4]

D 395 Test Methods for Rubber Property—Compression Set[5]

D 412 Test Methods for Vulcanized Rubber and Thermoplastic Rubbers and Thermoplastic Elastomers—Tension[5]

D 518 Test Method for Rubber Deterioration—Surface Cracking[5]

D 573 Test Method for Rubber—Deterioration in an Air Oven[5]

D 638 Test Method for Tensile Properties of Plastics[6]

D 746 Test Method for Brittleness Temperature of Plastics and Elastomers by Impact[6]

D 792 Test Methods for Density and Specific Gravity (Relative Density) and Density of Plastics by Displacement[6]

D 1149 Test Method for Rubber Deterioration—Surface Ozone Cracking in a Chamber[5]

[2] *Annual Book of ASTM Standards*, Vol 01.04.
[3] *Annual Book of ASTM Standards*, Vol 01.03.
[4] *Annual Book of ASTM Standards*, Vol 02.01.
[5] *Annual Book of ASTM Standards*, Vol 09.01.
[6] *Annual Book of ASTM Standards*, Vol 08.01.

D ~~14~~895~~7~~ Specification for ~~PTFE Molding and Extrusion Materials~~[6] Polytetrafluoroethylene (PTFE) Resin Produced From Dispersion[7]

D 2240 Test for Rubber Property—Durometer Hardness[5]

2.2 *AWS Standards:*[8]

C.2.2–67 Metalizing with Aluminum and Zinc for Protection of Iron and Steel

D.1.5 Bridge Welding Code—AASHTO/AWS Welding Stainless

2.3 *Military Standard:*[9]

MIL-S-8660

3. Classification

3.1 The bearings are furnished in three types as follows:

3.1.1 *Fixed Pot Bearing*—Rotation only.

3.1.2 *Uni-Directional Sliding Pot Bearing*—Rotation plus movement in one direction.

3.1.3 *Multi-Directional Sliding Pot Bearing*—Rotation plus movement in all directions.

3.2 The elastomer for the manufacture of the confined elastometric element is furnished in one of two materials as follows:

3.2.1 *Type CR*—Polychloroprene (neoprene) rubber.

3.2.2 *Type NR*—Polyisoprene (natural) rubber.

4. Material Specifications

4.1 *Steel*—Steel used for the confining base plates or pot, piston, and top or sole plates shall conform to Specifications A 36/A 36M, A 588/A 588M, A 572/A 572M or A 709/A 709M as required. All exposed surfaces shall be zinc metallized according to AWS C.2.2 (with no chipping) having a minimum thickness of 6 mil (0.152 mm), or treated with other approved coating systems such as coal tar epoxy or organic zinc. Internal surfaces shall not be coated.

4.2 *Stainless Steel*— Stainless steel used as the mating sliding surface to the PTFE in sliding pot bearing shall conform to Specification A 240/A 240M, Type 304, No. 8 mirror finish.

4.3 *Brass*—Flat brass sealing rings shall conform to the requirements of Specification B 36/B 36M half hard, alloy 260.

4.4 *Polytetrafluoroethylene (PTFE)* —The load bearing PTFE shall be resistant to acids, alkalis and petroleum products, and nonabsorbing of water. It shall be stable for temperatures up to 260°C (500°F) and shall be nonflammable. The PTFE shall be manufactured from pure virgin unfilled TFE resin conforming to Specification ~~D 1457.~~ D 4895. The PTFE shall conform to the physical requirements listed in Table 1.

4.5 *Elastomer*—The elastomer portion of the elastomeric compound shall be 100 % virgin natural rubber or 100 % virgin polychloroprene with no reclaim or ground polymers reinforcement allowed. These compounds shall meet the physical property requirements listed in Table 2.

5. Design Requirements

5.1 *Steel Components*:

5.1.1 *Pot*—The pot shall consist of circular ring and a lower base plate. The plate and ring shall be fabricated from one piece of steel.

NOTE 1—Alternative methods of fabrication may be used provided the design is substantiated by calculations and other documentation.

5.1.1.1 Depth of the pot cavity shall be equal to or greater than: pot inside diameter/2 × 1.05 × (design rotation× 2) + piston face width + elastomeric pad thickness.

[7] ~~Available from American Welding Society, P.O. Box 351040, 550 LeJeune Rd., N.W., Miami, FL 33135.~~

[7] *Annual Book of ASTM Standards*, Vol 08.03.

[8] Available from ~~Standardization Documents Order Desk, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111–5094, Attn: NPODS.~~ The American Welding Society (AWS), 550 NW LeJeune Rd., Miami, FL 33126.

[9] Available from Standardization Documents Order Desk, DODSSP, Bldg. 4, Section D, 700 Robbins Ave., Philadelphia, PA 19111-5098

TABLE 1 Physical Property Requirements for PTFE

NOTE 1—15 % glass-filled PTFE may be used for guide bar surfaces (see Specification D 1457).

Physical Property	ASTM Test Method	Requirement Minimum
~~Ultimate tensile strength, psi, (mPa)~~	~~D 638~~	~~2800 (19.3)~~
Ultimate tensile strength, psi, (MPa)	D 638	2800 (19.3)
Ultimate elongation, min, %	D 638	200
~~Specific gravity, min~~	~~D 792~~	~~2.12~~
Specific gravity, min/max	D 792	2.12

TABLE 2 Physical Property Requirements for Pot Bearing Elastomer

NOTE 1—The elastomer meeting these requirements shall be plain, not laminated or fiber reinforced.

Physical Properties	ASTM Test Method	Requirements	
		Polychloroprene	Natural
Hardness, Shore A durometer (IRHD)	D 2240	50 ± 5	50 ± 5
Tensile strength, min, psi (mPa)	D 412	2250 (15.5)	2250 (15.5)
Ultimate elongation, min, %	D 412	400	400
Aged physicals after 70 h at 100°C (212°F)	D 573	. . .	. . .
Hardness change, max		0 to +15	. . .
Tensile strength change, max, %		−15	. . .
Elongation change, max, %		−40	. . .
Aged physicals after 168 h at 70°C (158°F)	D 573	. . .	. . .
Hardness, change, max		. . .	0 to +10
Tensile strength change, max, %		. . .	−25
Elongation change, max, %		. . .	−25
Compression set, 22 h Method B, max, %	D 395	. . .	. . .
at 100°C (212°F)		35	. . .
at 70°C (158°F)		. . .	25
Ozone resistance			
Mounting at 20 % strain	D 518 (Procedure A)	. . .	. . .
Exposure	D 1149	. . .	. . .
40 ±2°C (104°F)		. . .	. . .
100 h at 302 mPa ozone partial pressure		No cracks	. . .
100 h at 500 mPa ozone partial pressure		. . .	No cracks
	(Using 7× magnification lens)		
Low temperature brittleness at −40°C (−40°F)	D 746 (Procedure B)	No failure	. . .
		. . .	No failure

5.1.1.2 The inside diameter of the pot shall be nominally the same as the outside diameter of the elastomeric disc.

5.1.1.3 The thickness of the pot ring shall be designed to withstand the hydrostatic internal pressure caused by the elastomer considered as a fluid, and horizontal applied loads without consideration of the lower (base) plate.

5.1.1.4 The lower base plate shall be of sufficient thickness to ensure distribution of the bearing stress under full dead load applied at an eccentricity of 5 % of the inside diameter of the pot combined with a horizontal load amounting to 10 % of the total vertical load. The thickness of the lower base plate shall be at least 1⁄22 of the pot diameter but in no case less than ¾ in. (19 mm). If the lower base plate of the pot sits directly on concrete, then its thickness should be 0.06 times the pot diameter or ¾ in. (19 mm), whichever is greater.

5.1.1.5 Design calculations shall be submitted with shop drawings.

5.1.2 *Piston*—The piston shall be fully machined from a single piece of steel. Machining shall include profiling the side walls to allow 2 × design rotation and sufficient bearing area against the pot wall to carry maximum lateral loads at a stress not exceeding 0.8 Fy.

5.1.2.1 The piston diameter within the pot shall be 0.03 in. (0.76 mm) to 0.05 in. (1.27 mm) less than the inside diameter of the pot.

5.1.2.2 The piston thickness shall be the greater of the following: (*a*) pot depth — elastomer thickness + (pot diagonal × design rotation) + ⅛ in., or (*b*) ⅝ in. (15.88 mm).

5.1.2.3 The finished piston shall have a smooth finish of 125 μin. (0.31 mm) (RMS), or less, on the surface in contact with the elastomeric disc.

5.2 *Stainless Steel Sliding Surface* :

5.2.1 The thickness of the stainless steel sheet shall be a minimum of 0.059 in. (1.5 mm).

5.2.2 *Fixing of Stainless Steel Sheet* —The stainless steel sheet shall be attached to its backing plate by continuous fillet welding along the edges. It is essential that the stainless steel sheet remains in contact with base metal throughout its service life and interface corrosion cannot occur. The attachment of the stainless steel to its back-up plate shall be capable of resisting the frictional force set up in the bearing in the serviceability limit state. Welding must be in accordance with AWS D.1.5.

5.2.3 The backing plate shall extend beyond the edge of the stainless steel sheet to accommodate the weld and the weld shall not protrude above the stainless steel sheet.

5.2.4 The stainless steel sliding surface shall completely cover the PTFE surface in all operating positions plus one additional inch (2.54 cm) in all directions of movement, except transversely in guided bearings.

5.3 *Brass Sealing Rings*:

5.3.1 Flat brass sealing rings shall have a minimum width of ¼ in. (6.35 mm) for bearings up to 100 kips (444.8 kN), ⅜ in. (9.53 mm) for bearings 100 to 1000 kips (4444.4 kN) capacity and ½ in. (12.7 mm) over 1000 kips (4444.4 kN).

5.3.2 The thickness of each ring shall be 0.08 in. (2 mm) minimum.

5.3.3 The number of rings shall be two for bearings below 1000 kips (4444.4 kN) capacity, 3 for bearings of 1000 kips to 3000 kips (4444.4 kN to 13333.3 kN) capacity, and 4 for bearings over 3000~~0~~ kips (13333.3 kN) capacity.

5.3.4 The flat rings shall have a smooth finish of 63 µin. (0.016 mm) (RMS) or less.

5.3.5 The rings shall be split and shall snugly fit the recess in the elastomeric disc and the inside diameter of the pot. The circumference of the rings shall be truly round without any flat spots. Each ring shall have one vertical cut parallel at 45° to the tangent with a maximum gap of 0.05 in. (1.27 mm) and the splits staggered a minimum of 90° relative to one another when arranged in the pot.

5.4 *PTFE Sliding Surface*:

5.4.1 The PTFE shall be recessed and bonded to the substrate. The shoulders of the recess should be sharp and square. After completion of the bonding operation the PTFE surface shall be smooth and free from blisters and bubbles.

5.4.2 The PTFE shall have a minimum thickness of ⅛ in. (3.17 mm) and shall be recessed at least ½ of its thickness.

5.4.3 Allowable sliding bearing pressures for pure PTFE should be in accordance with the following table:

Design Load Effects	Maximum Average Contact Pressure, psi (N/mm^2) (These figures may vary +2.5 %)
Permanent design load effects	3038 (21)
All design load effects	3500 (24.1)

5.5 *Elastomeric Pad*:

5.5.1 All pads up to 48 in. (1219 mm) diameter shall be one-piece, individually molded or machine-cut from molded slabs. Pads over 48 in. (1219 mm) diameter may be made-up from a maximum of four individually molded or machine cut segments. No layering or stacking of pads is permitted. Cuts, gouges, or nicks from machine cutting or flash trimming will be cause for rejection.

5.5.2 The sealing groove shall be molded integrally or machine-cut. It shall be square to the pad top surface and the same nominal dimensions as the set of rings. No undercutting at the inside corner of the groove is permitted.

5.5.3 Pad thickness shall be designed to limit the strain induced at the perimeter of the pad to 15 % of pad thickness under maximum working rotation.

5.5.4 Areas of elastomeric pad shall be designed for a maximum working stress of 3500 psi (24.1 N/mm^2), +5 % of the total dead, live, and impact loads of the structure.

5.5.5 The elastomeric pad shall be lubricated with a silicone compound conforming to the requirements of MIL-S-8660 or approved equivalent. PTFE shear-reducer discs shall not be used.

5.6 *Guide Bars*:

5.6.1 Each guide bar shall be manufactured from a monolithic piece of steel.

5.6.2 Guided surfaces shall be faced with opposing strips of stainless steel and PTFE. No metal-to-metal contact may be permitted. The PTFE shall be bonded as well as mechanically fastened. The maximum total gap allowed between guiding surfaces shall be ⅛ in. (3.17 mm).

5.6.3 The guide bars and their connections to the sole plate shall be designed for the horizontal forces on the bearing but not less than 10 % of the vertical capacity of the bearing.

5.6.4 Guiding arrangements shall be designed so that the guided member is kept parallel and always within the guides at all points of translation and rotation of the bearing. Where transverse rotation is anticipated, guiding against the fixed base or any extension of it shall be prohibited.

5.7 *Flatness*:

5.7.1 All bearing load carrying surfaces in contact with one another shall be flat within .006 in. (0.13 mm) per any 12 in. (30.5 cm) as determined by a precision straightedge and feeler gages or other approved methods.

6. Sampling

6.1 *Lot Size*:

6.1.1 Sampling, testing, and acceptance consideration will be made on a lot basis. A lot shall be defined as those bearings presented for inspection at a specific time or date.

6.1.2 A lot shall not exceed 25 bearings.

6.1.3 A lot shall consist of those bearings of the same type and may consist of differing vertical load capacities but not to exceed a range of capacity more than 300 kips (1333.3 kN).

6.1.4 The tests and number of samples to perform tests shall be in accordance with the following table:

Test	Samples Required
Proof load and compression strain	One production bearing per lot
Rotation	One production bearing per lot
Coefficient of friction	One production bearing per lot
Physical properties of elastomeric rotational element	One elastomeric element per lot
Physical properties of PTFE sheet	One 10 by 15 in. (40 mm by 60 mm) sheet of PTFE material per project

7. Test Methods

7.1 *Proof Load/Compression Strain* —Applies to fixed and expansion bearings.

7.1.1 Preload the bearing to 10 % of design vertical load, zero the compression measurement gages, then load to 150 % of design load in a minimum of 10 equal increments, recording deflection at each increment. Hold for 1 h. Note any deformations, cracks or extrusion of elastomer or PTFE.

7.2 *Rotation*—Applies to fixed and expansion bearings.

7.2.1 Load the bearing to 75 % of design load while simultaneously placing it in a rotated condition of 0.02 rad or design rotation, whichever is greater. Hold for 1 h. Note any separation (lift-off) of plates from each other or from PTFE or elastomer surfaces.

7.3 *Coefficient of Friction*—Applies to expansion bearings only.

7.3.1 Load the bearing with its design load for a minimum of 12 h, while simultaneously placing it in a rotated condition of 0.02 rad, or design rotation, whichever is greater. Determine the first movement static and dynamic coefficient of friction at a sliding speed of less than 1 in./min (2.54 cm/min). Subject the bearing to 100 sliding cycles of 1 in. (2.54 cm) minimum movement at a speed not exceeding 1 ft/min (30.5 cm/min). Determine the 101st movement static and dynamic coefficient of friction as for the first movement. Note any deformation or cold flow.

7.4 *Physical Properties of Elastomeric Rotational Element*—Applies to fixed and expansion bearings.

7.4.1 Determine physical properties in accordance with the relevant ASTM procedures required in 4.5.

7.5 *Physical Properties of the PTFE Sheet*—Applies to expansion bearings only.

7.5.1 Determine physical properties in accordance with the relevant ASTM test methods required in 4.4.

7.6 *Acceptance Criteria Upon Inspection After Testing*:

7.6.1 Compression deflection shall not exceed 5 % of bearing thickness (not including any masonry or sole plates).

7.6.2 There shall be no lift-off or separation between plates or between plates and PTFE or elastomer under rotation.

7.6.3 Measured static and dynamic coefficient of friction shall not exceed the limits listed in Table 3.

7.6.4 Elastomer properties shall be within limits shown in 4.5.

7.6.5 PTFE properties shall be within the limits shown in 4.4.

7.6.6 There shall be no cracks or permanent deformation of PTFE, stainless steel or other components or welds.

7.6.7 There shall be no extrusion or signs of cold flow of the elastomer or PTFE.

8. Product Marking

8.1 Every bearing shall be marked by stamping and unless otherwise specified in the contract or purchase order, the marking should be on a side face visible after erection of the bridge.

8.2 The marking shall consist of the manufacturer's name or trademark, the bearing identification and the placement details.

8.3 To establish correct setting of expansion bearings, slide plates shall have inscribed on a side visible after erection, a graduated scale showing the limit of design movement on either side of a center-line. A mating center-line shall also be inscribed on the lower part of the bearing.

TABLE 3 Coefficient of Friction for Stainless Steel Sliding on Pure Unfilled PTFE

NOTE 1—Linear interpolation may be used for intermediate values. The values stated below are based on stainless steel sliding on pure PTFE.

Bearing Stress, psi (N/mm^2)	Maximum Allowable Coefficient of Friction
723 (5)	0.08
1447 (10)	0.06
2894 (20)	0.04
3500 (24.1) and over	0.035

9. Precision and Bias

~~9.1 Precision standards~~

9.1 Repeatability tests are currently ~~u~~ being made by producers, howeve~~l~~r, cooperation from users is nonexistent.

10. Keywords

10.1 bearing devices; confined elastomeric bearings; eccentricity; high load rotational bearings; hydrostatic internal pressure; polychloroprene (neoprene) rubber; polyisoprene (natural) rubber; polytetrafluoroethylene (PTFE); pot bearings