MATERIAL SPECIFICATION FOR BEARINGS - ROTATIONAL AND SLIDING SURFACE

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1203.01 SCOPE

This specification covers the requirements for Materials, design, and fabrication of rotational and sliding surface bearings for bridges.

1203.02 REFERENCES

This specification refers to the following standards, specifications, or publications:

Ontario Provincial Standard Specifications, Construction

OPSS 906 Structural Steel for Bridges
OPSS 911 Coating Structural Steel Systems

Ontario Provincial Standard Specifications, Material

OPSS 1202 Bearings - Elastomeric Plain and Steel-Laminated

Ontario Ministry of Transportation Publications

Structural Manual:
Division 1, Exceptions to the Canadian Highway Bridge Design Code CAN/CSA S6 for Ontario

CSA Standards

B95-1962 (R2002)	Surface Texture (Roughness, Waviness and Lay)
G40.20-13/40.21-13 (R2018)	General Requirements for Rolled or Welded Structural Quality Steel /Structural Quality Steel
S6-19	Canadian Highway Bridge Design Code
S157-17	Strength Design in Aluminium
W48-18	Filler Metals and Allied Materials for Metal Arc Welding
W59-18	Welded Steel Construction (metal Arc Welding)

ASTM International

A240-19	Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet and Strip for Pressure Vessels and for General Applications
B36-18	Standard Specification for Brass Plate, Sheet, Strip, and Roller Bar
B137-95(2014)	Standard Test Method for Measurement of Coating Mass Per Unit Area on Anodically Coated Aluminium
B487-85(2013)	Standard Test Method for Measurement of Metal and Oxide Coating Thickness by Microscopical Examination of a Cross Section
D395-18	Standard Test Method for Rubber Property - Compression Set
D412-16	Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers - Tension
D429-14	Standard Test Methods for Rubber Property - Adhesion to Rigid Substrates
D638-14	Standard Test Method for Tensile Properties of Plastics
D792-13	Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement
D2240-15e1	Standard Test Method for Rubber Property - Durometer Hardness
D4894-19	Standard Specification for Polytetrafluoroethylene (PTFE) Granular Molding and Ram Extrusion Materials
F2329-15	Standard Specification for Zinc Coating, Hot-Dip, Requirements for Application to Carbon and Alloy Steel Bolts, Screws, Washers, Nuts, and Special Threaded Fasteners
F3125-19	Standard Specification for High Strength Structural Bolts and Assemblies, Steel and Alloy Steel, Heat Treated, Inch Dimensions 120 ksi and 150 ksi Minimum Tensile Strength, and Metric Dimensions 830 MPa and 1040 MPa Minimum Tensile Strength

American National Standards Institute (ANSI)

B4.1-1967 (R2009)	Preferred Limits and Fits for Cylindrical Parts

U.S. Military Specifications

SAE AS 8660	Silicone Compound Nato Code Number S-736

1203.03 DEFINITIONS

For the purpose of this specification, the following definitions apply:

Disc Bearing means a bearing consisting of a single moulded disc of unreinforced elastomer confined by upper and lower steel bearing plates and restricted from horizontal movement by limiting rings and a centrally located shear restriction mechanism.

Elastomer means a compound containing virgin natural polyisoprene (natural rubber) for confined elastomeric bearings or polyether urethane polymer for disc bearings.

Plan Dimension means the dimensions of an object, when viewed perpendicular to the top of the object.

Pot Bearing means a bearing consisting of a metal piston supported by a single moulded disc of unreinforced elastomer that is confined within a metal cylinder.

Product Drawings means drawings prepared by the manufacturer that have been approved by the Owner for use with the product.

PTFE means polytetrafluoroethylene polymer.

Spherical Bearing means a bearing consisting of a curved spherical metal surface in contact with and sliding on a matching curved sliding surface.

Substructure means the abutments, piers, columns, and other components of a bridge below the bearings.

Superstructure means all parts of a bridge above the bearings.

1203.04 DESIGN AND SUBMISSION REQUIREMENTS

1203.04.01 Design Requirements

1203.04.01.01 Design

All components of the bearings, including fasteners and sliding materials, shall be designed according to the requirements of CSA S6 and Structural Manual, Division 1.

Bearings subject to uplift shall limit the separation of the bearing components to the value specified in the Contract Documents.

1203.04.01.02 Translations and Rotation

Provision for rotation about any horizontal axis shall be by means of a single disc of confined elastomer for pot bearings, a single disc of polyether urethane polymer compound for disc bearings, and a spherical sliding surface of stainless steel or anodized aluminium alloy against a sliding surface for spherical bearings.

The rotational capacity about any horizontal axis shall be the rotation caused by ultimate limit states loads plus 0.02 radians.

The rotational capacity about the vertical axis through the centre of the bearing shall be a minimum of 0.02 radians, unless specified elsewhere in the Contract Documents.

For bearings that are not restrained in the longitudinal direction, the bearings shall accommodate the design movements at Serviceability Limit States (SLS) plus 25 mm in each direction, but no less than 50 mm in each direction. For bearings that are not restrained in the transverse direction, the bearings shall accommodate the design movements at SLS plus 5 mm in each direction, but not less than 10 mm in each direction.

Brass sealing rings shall have a rectangular cross-section.

The depth of the pot wall shall be such that a minimum vertical distance of 2.5 mm remains between the top of the pot wall and the closest point of contact of the sealing rings with the pot wall upon rotating the piston about any horizontal axis to the maximum rotation at ultimate limit states (ULS) plus 0.02 radians.

The pot and piston surfaces in contact with the confined elastomer shall be lubricated with silicone grease. The bearing shall be sealed by a one-piece continuous preformed closed-cell compressible ring against entry of dirt, dust, and moisture between the elastomer and the pot and piston contact surfaces. Any joint in the ring shall be bonded and the strength shall be at least equal to the strength of the ring.

For disc bearings, the upper and lower plates in contact with the elastomer shall be provided with outer limiting rings to restrict the horizontal movement of the elastomer and a centrally located shear restriction mechanism.

1203.04.01.03 Sliding Surfaces

1203.04.01.03.01 Geometric Requirements

The metal surface shall overlap the sliding material by at least 5 mm at extremes of movement. The metal surface shall be positioned above the sliding material element except for guides for lateral restraint.

1203.04.01.03.02 Polytetrafluoroethylene Polymer Layer

Except when used as mating surfaces for guides for lateral restraint, PTFE resin shall be virgin material and shall be used as unfilled sheets and shall contain spherical reservoirs for lubricant pressed into its surface.

Material used as mating surface for guides for lateral restraint shall not be dimpled or lubricated.

1203.04.01.03.03 Lubrication

All PTFE surfaces except those that act as mating surfaces for guides for lateral restraint or that are subject to a contact pressure of less than 5 MPa shall be permanently lubricated with silicone grease.

1203.04.01.03.04 Contact Pressure

The average contact pressure at serviceability limit state loads for filled PTFE elements used to face mating surfaces for guides for lateral restraint shall not exceed the following:

a) PTFE filled with up to 15% by mass of glass fibres, 45 MPa.

b) Lead filled PTFE in a bronze matrix, 140 MPa.

1203.04.01.04 Guides for Lateral Restraint

Unless the guide bars are machined to form an integral part of the top plate, they shall be recessed greater than 5 mm into the plate to which they are attached and fastened with bolts.

The translational elements of guides for lateral restraint shall be faced with stainless steel and shall provide lateral restraint by sliding against mating surfaces faced with either PTFE or another Approved sliding material. Lead filled PTFE shall be at least 2 mm thick and shall be mechanically fastened and bonded to the substrate. Glass filled or virgin PTFE shall be recessed and bonded to the substrate.

1203.04.01.05 Top and Base Plates

The top and base plates that are permanently attached to the structure shall be provided with the bearings.

1203.04.01.06 Fasteners and Anchorage

Fasteners used to attach the bearing to the top and base plates and the anchorage devices shall be capable of resisting lateral loads as specified in the Contract Documents.

The beneficial effect of friction shall be neglected in proportioning the fasteners and anchors.

1203.04.01.07 Bearing Assembly Replacement

The entire bearing assembly, except for the top plate used to attach it to the superstructure and the base plate used to anchor it to the substructure but including both contact surfaces of the sliding interface, shall be replaceable without damage to the structure and without removal of any concrete, welds, or anchorages permanently attached to the structure and without lifting the superstructure more than 5 mm. Bearings shall not be recessed into plates that are permanently attached to the structure.

1203.04.01.08 Durability

Bearings shall be designed to prevent moisture and dirt from entering the internal surfaces.

Contact between dissimilar metals that could have corrosion potential and between the aluminium alloy and concrete shall be prevented by use of suitable insulation.

1203.04.01.09 Concrete Bearing Pressure

For bearings subject to compressive loading, the top plate and the base plate shall be designed to ensure the average concrete bearing pressure does not exceed 24 MPa at the ultimate limit states providing the following:

a) Concrete on which the plate is supported has a specified nominal 28-Day compressive strength of at least 30 MPa.

b) Edges of the plates are located a minimum of 100 mm from the edge of the concrete.

c) The largest dimension of plate does not exceed 1,000 mm.

Alternatively, the top plate and the base plate of the bearing shall be designed to ensure the factored bearing resistance of concrete specified in CSA S6 and the Structural Manual, Division 1, is not exceeded.

1203.04.02 Submission Requirements

1203.04.02.01 General

Within 30 Days of the Contract award, the name and address of the supplier of the bearings shall be submitted in writing to the Contract Administrator.

Proposals shall bear the seal and signature of the design and checking Engineers.

When another authority is involved, all submissions shall be made a minimum of 35 Days prior to the commencement of work.

1203.04.02.02 Working Drawings

At least seven Days prior to commencement of bearing fabrication, one hardcopy and one electronic PDF copy of Working Drawings for the bearings shall be submitted to the Contract Administrator for information purposes only. An Engineer shall affix his or her seal and signature on the Working Drawings verifying that the drawings are consistent with the Contract Documents.

The Working Drawings shall be according to the Contract Documents and Product Drawings.

The Working Drawings shall clearly indicate all material properties, dimensions, connection attachments, fasteners and accessories, the bearing alphanumeric identification, and the load capacity at the serviceability and ultimate limit states as follows:

a) Maximum vertical permanent and total load.

b) Maximum lateral load and corresponding vertical load.

c) Maximum rotational capacity about any horizontal axis and about the vertical axis at the centre of the bearing.

The bearing supplier shall have a copy of the Working Drawings at the manufacturing plant prior to and during the bearing fabrication.

1203.04.02.03 Mill Test Certificates

Mill test certificates shall be submitted and shall be according OPSS 906 Mill Test Certificates clause.

1203.04.02.04 Test Reports for Fasteners

Test reports for fasteners shall be submitted and shall be according OPSS 906 Test Reports for Fasteners clause.

1203.04.02.05 Manufacturer's Certification

Upon completion of fabrication and prior to installation of the bearings, a certificate of compliance signed by the manufacturer shall be submitted to the Contract Administrator. The certificate of compliance shall state that the fabricated bearings are according to the Working Drawings, Product Drawings, and Contract Documents.

1203.05 MATERIALS

1203.05.01 Steel

Steel components shall be according to OPSS 906, Grades 300W or 350W, except for components permanently attached to steel superstructures, which shall be Grade 350A.

Stainless steel for sliding surfaces shall have a minimum corrosion resistance according to ASTM A240, Type 304.

Steel fasteners shall be Grade A325M according to ASTM F3125 and hot-dipped galvanized according to ASTM F2329. For guide bars, alternative steel fasteners and corrosion protection systems shall be as specified in the Contract Documents.

Stud shear connectors shall be according to CSA W59 Annex H, Type B.

1203.05.02 Aluminium Alloy

Aluminium alloy shall be according to CSA S157.

1203.05.03 Brass

Brass sealing rings for confined elastomer bearings shall be according to ASTM B36, half-hard.

1203.05.04 Elastomers

Polyisoprene shall be according to OPSS 1202 Table 1 except the shear modulus shall be between 0.65 and 0.80 MPa.

Polyether urethane polymer shall be according to Table 1.

1203.05.05 Sliding Materials

PTFE used in sliding surfaces shall be virgin, according to ASTM D4894. The PTFE shall be unfilled and according to Table 2.

Material used as the mating surface for guides for lateral restraint may be one of the following:

a) Unfilled PTFE.

b) PTFE filled with up to 25% by mass of glass fibres.

c) Lead filled PTFE in a bronze matrix.

Sliding materials other than PTFE shall be from the same material supplier and shall be the same material composition as specified on the product drawings.

1203.05.06 Lubricant

Lubricant for PTFE shall be silicone grease according to SAE AS8660.

Lubricant for other sliding materials shall be as specified by the manufacturer and shall be the same lubricant used during the testing of the sliding material.

1203.05.07 Adhesives

Adhesives for bonding sliding materials to metal shall produce a bond with a minimum peel strength of 3.6 N/mm. Adhesives shall not degrade in the service environment and shall be compatible with both the substrate and the sliding material.

1203.07 PRODUCTION

1203.07.01 Welding

Welding of structural quality steels shall be according to CSA W59.

All welding shall be done with electrodes certified by the Canadian Welding Bureau to the requirements of CSA W48.

Stainless steel sheets that come in contact with sliding materials shall be one piece continuously welded around the perimeter to its backing plate to prevent ingress of moisture. The weld shall be clean, uniform, and without overlaps and located outside the area in contact with the sliding material.

1203.07.02 Fasteners

The threaded portion of the bolts shall be coated with silicone grease prior to installation.

1203.07.03 Anchors

The top and base plate anchorage to concrete shall be by studs approved by the Owner that are fusion welded to the plates.

1203.07.04 Machining

Metal to metal contact surfaces shall be machined or fine ground. The pots and pistons for confined elastomer bearings and the upper and lower plates with limiting rings for disc bearings shall be machined from solid metal plate or castings. The concave and convex plates for spherical bearings shall be machined from solid metal plate or castings.

There shall be no openings or discontinuities in the metal surfaces in contact with the elastomer or sliding material.

1203.07.05 Roughness of Metal Surfaces

The roughness of sliding stainless steel metallic surfaces in contact with a sliding material, measured according to CSA B95, shall not be greater than 0.25 µm arithmetic average for plane surfaces and 0.50 µm arithmetic average for spherical surfaces. The roughness of anodized aluminium metallic surfaces shall not be greater than 0.40 µm arithmetic average.

The roughness of metal surfaces in contact with elastomer measured according to CSA B95 shall not be greater than 3.0 µm arithmetic average.

1203.07.06 Attachment of Sliding Surfaces

Virgin or glass filled PTFE elements shall be recessed in a rigid backing material and shall be bonded over the entire area with an adhesive. The rigid backing material shall be grit blasted prior to applying the adhesive.

Lead filled PTFE shall be mechanically fastened and bonded to the backing plates.

The PTFE elements used as mating surfaces for guides for lateral restraint shall extend to within 10 mm from the ends of the backing plates.

Other sliding materials shall be recessed in a rigid backing and shall be bonded over the entire area with an adhesive.

1203.07.07 Anodizing

Aluminium alloy surfaces shall be anodized using the sulphuric acid process and shall meet the requirements in Table 3.

1203.07.08 Corrosion Protection

All exposed metal corners that receive corrosion protection shall have a 3 mm rounding. All exposed metal surfaces of the bearings, except stainless steel and components permanently attached to steel superstructures, shall be protected against corrosion by a low volatile organic compound coating system according to OPSS 911. The continuous weld attaching the stainless steel sheet shall be ground smooth and have the same corrosion protection as the bearing. Steel fasteners shall be galvanized or as specified in the Contract Documents.

For corrosion protection purposes, bearing components permanently attached to steel superstructures shall be considered part of the structural steel.

1203.07.09 Identification

Each bearing shall be marked with the date of manufacture (i.e., yyyy-mm-dd) and an individual alphanumeric identification. The alphanumeric identification shall consist of the designated identification letter of the supplier and source followed by a sequential five digit number. The characters shall be stamped or engraved into two adjacent sides and shall be clearly legible after installation. The characters shall not be less than 10 mm in height with the indentations not less than 1 mm in width and 0.5 mm in depth.

1203.07.10 Tolerances

The deviation from flatness of sliding surfaces shall not exceed:

a) 0.2 mm, when the diameter or diagonal is equal to or less than 800 mm.

b) 0.00025 of the diameter or diagonal, when the diameter or diagonal is greater than 800 mm.

The deviation from flatness of stainless steel or aluminium alloy surfaces in contact with sliding materials for plane surfaces and from the theoretical surface for spherical surfaces shall not exceed:

a) 0.0003 LH mm for a rectangular sliding element.

b) 0.0006 RH mm for a circular sliding element

where:

L = the greater plan dimension for a rectangular bearing,
R = the radius of a circular bearing, and,
H = the free height of sliding element

For confined elastomer bearings, the tolerance of fit between the piston and the pot shall be + 0.75 to + 1.25 mm. The inside diameter of the pot cylinder shall be the same as the nominal diameter of the elastomer and shall be machined to a tolerance of:

a) 0 to + 0.125 mm for diameters up to and including 500 mm.

b) 0 to + 0.175 mm for diameters over 500 mm.

For disc bearings, the gap between the edge of the polyether urethane polymer disc and the inside face of the limiting ring shall be 1.25% ± 0.25% of the diameter of the disc.

The plan dimensions of the recess for the sliding material shall be the same as the nominal plan dimensions of the material and shall be machined to a tolerance of 0 to + 0.2% of the diameter or diagonal.

Overall bearing plan dimension		± 3 mm
Overall bearing height		± 3 mm
Machined surface dimensions		± 0.4 mm
Elastomer:		
Diameter	a) 0.0 to -1.5 mm for diameters ≤ 500 mm b) 0.0 to -2.0 mm for diameters > 500 mm	
Thickness	0.0 to + 1.0 mm	
Brass rings:		
Difference between internal diameter of brass ring and diameter of recess in the moulded elastomer		0 to + 0.5 mm
Difference between sum of thicknesses of brass rings and recess depth in the moulded elastomer		0 to + 0.25 mm
Recessed Guide Bars -	American Standard Clearance Locational Fit Class LC3 according to ANSI B4.1.	
Guides for Lateral Restraint -	Gap between metal restraints surfaces and mating PTFE elements mm	0.50 mm ± 0.25
Sliding material plan dimension	0 to - 0.2% of diameter or diagonal	
Sliding material thickness	0 to + 10.0% of thickness	
Depth of recess for sliding material	0 to + 0.3 mm	

TABLE 1
Physical Requirements for Polyether Urethane Polymer

Physical Property	ASTM Test Methods	Requirements	
		Minimum	Maximum
Hardness, Scale D	D 2240	60	64
Tensile Stress, MPa @ 100% elongation @ 200% elongation	D 412	 14 26	 -- --
Tensile Strength, MPa	D 412	35	--
Ultimate Elongation, %	D 412	220	--
Compression Set, % 22 h @ 70 °C	D 395	--	40

TABLE 2
Physical Requirements for Polytetrafluoroethylene Polymer

Physical Property	ASTM Test Method	Requirement
Tensile Strength, MPa	D 638	minimum 20
Elongation, %	D 638	minimum 200
Relative Density	D 792	2.16 ± 0.03

TABLE 3
Requirements for Anodizing of Aluminium Alloy Surfaces

Physical Property of Sealed Anodic Coating	Units	Test Method	Requirements
Thickness, t	µm	ASTM B 487	25 minimum
Mass, w Apparent density, d	mg/ cm^2 g/ cm^3	ASTM B 137	5.8 minimum 2.32 minimum
The apparent density shall be determined as: $d = \frac{10\ w}{t}$			