

# Main Roads Technical Standard

## **MRTS81A**

# **Stainless Steel Bridge Bearings**

**June 09**

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# Stainless Steel Bridge Bearings

## 1 INTRODUCTION

This Standard applies to the supply of bearings for support of bridge superstructures for aggressive installations. For normal installations, steel bearings, in accordance with MRTS81 *Bridge Bearings*, shall be used.

This Technical Standard shall be read in conjunction with MRTS01 *Introduction to Technical Standards*, MRTS50 *Specific Quality System Requirements* and other Technical Standards as appropriate.

This Technical Standard forms part of the Main Roads Specifications and Technical Standards Manual.

## 2 DEFINITION OF TERMS

The terms used in this Standard shall be as defined in Clause 2 of MRTS01 *Introduction to Technical Standards*.

## 3 REFERENCED DOCUMENTS

Table 3 lists documents referenced in this Technical Standard.

**Table 3 – Referenced Documents**

Reference	Title
AS 1214	Hot-dip galvanized coatings on threaded fasteners (ISO metric coarse thread series)
AS/NZS 1252	High strength steel bolts with associated nuts and washers for structural engineering
ASTM A 240M	Standard specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet and Strip for Pressure vessels and for General Applications
ASTM A 480M	Standard Specification for General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, sheet, and Strip
AS 2837	Wrought alloy steels – Stainless steel bars and semi finished products
AS/NZS 3678	Structural steel - Hot-rolled plates, floorplates and slabs
AS/NZS 3679.1	Structural steel - Hot-rolled bars and sections
AS 5100.4	Bridge design - Bearings and deck joints
ISO 13000-1	Plastics - Polytetrafluoroethylene (PTFE) semi-finished products - Part 1: Requirements and designation
ASTM A240M	Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications
ASTM A276	Standard Specification for Stainless Steel Bars and Shapes
ASTM D217	Standard Test Methods for Cone Penetration of Lubricating Grease
ASTM D972	Standard Test Method for Evaporation Loss of Lubricating Greases and Oils
ASTM D3294	Standard Specification for PTFE Resin Molded Sheet and Molded Basic Shapes
ASTM D4745	Standard Specification for Filled Compounds of Polytetrafluoroethylene (PTFE) Molding and Extrusion Materials
BS 2572	Specification for phenolic laminated sheet and epoxy cotton fabric laminated sheet
BS 3953	Specification for synthetic resin bonded woven glass fabric laminated sheet
BS 5350	Methods of test for adhesives
BS 6564-3	Polytetrafluoroethylene (PTFE) materials and products. Specification for E glass fibre filled polytetrafluoroethylene

## 4 QUALITY SYSTEM REQUIREMENTS

### 4.1 Hold Points, Witness Points and Milestones

General requirements for Hold Points, Witness Points and Milestones are specified in Clause 5.2 of MRTS01 *Introduction to Technical Standards*.

The Hold Points applicable to this Standard are summarised in Table 4.1. There are no Witness Points and Milestones defined.

**Table 4.1 – Hold Points**

Clause	Hold Point
5.1	1. Design of Guide slide Pot-type bearings.
5.1	2. Suitability of proposed pot bearings.
5.2.5	3. Alternative seal designs
5.4.1	4. Testing of pot-type bearings.
5.4.2	5. NATA certification of calibration.
5.4.5	6. Load Testing Location and Date.
5.4.5.3	7. Method of Friction Load Test.

## 5 STAINLESS STEEL POT-TYPE BEARINGS

### 5.1 General

The type and dimensions of bearings, including movement, rotation and loads, shall be as shown on the Drawings and/or in Annexure MRTS81A.1.

Bearings shall be supplied by a manufacturer experienced in the design and construction of such bearings. Proprietary bearings shall be fitted with a name plate indicating the manufacturer's name, bearing model or type, year of manufacture, unique number ID and design vertical load.

Guide slide pot-bearings shall be designed with two parallel guide bars located outside the cylinder. Bearings with a single guide bar at the centre of the cylinder shall not be used. **Hold Point 1**

All bearings shall be fitted with transit keep plates to firmly hold components together during transport and erection. Keep plates shall be removed after installation is completed.

Before ordering pot bearings, the Contractor shall submit to the Administrator detailed working drawings of the bearings proposed to be used together with evidence as to the satisfactory performance in service of similar bearings and any other information required by this Standard. Manufacturing tolerances shall be included in the working drawings. The Contractor shall allow 14 days for a direction from the Administrator as to the suitability of the proposed bearings. **Hold Point 2**

### 5.2 Materials

#### 5.2.1 Stainless Steel

Stainless steel shall comply with the requirements of ASTM A 240M or ASTM A 480M, having a surface finish not rougher than 0.4 µm CLA in both directions and a Brinell hardness not less than 125.

Sliding surfaces on the sliding plates and the guide bars shall be made of austenitic stainless steel conforming to ASTM A240M Grade 316L with 2B mill surface finish.

The stainless steel used in the manufacture of dowels shall conform to AS 2837 or ASTM A276 Grade 316L for welded components or Grade 316 otherwise.

Where structural steel attachment plates are used, manufacture such plates from structural steel conforming to AS/NZS 3678 and/or AS/NZS 3679.1.

### 5.2.2 Polytetrafluoroethylene

The resin used in the manufacture of polytetrafluoroethylene (PTFE) sheets shall be 100% virgin PTFE, complying with ISO 13000-1 or AS 5100.4 as appropriate.

The following shall apply for PTFE to be permanently lubricated –

- a) The PTFE shall be dimpled or grooved to form lubrication reservoirs in the PTFE surface;
- b) The lubrication reservoirs shall cover between 10% and 30% of the total plan area of the PTFE;
- c) The volume of the reservoirs shall form between 3% and 20% of the total volume of the PTFE or the unconfined portion if the PTFE is recessed;
- d) The depth of the reservoirs shall not be greater than half the thickness of the PTFE, or the height of the PTFE above the backing plate if the PTFE is recessed; and
- e) With the exception of uplift bearings, the lubrication reservoirs shall be filled with long-life silicone grease, under factory conditions. After filling the lubrication reservoirs, the contact surface of the PTFE and the stainless steel shall not be allowed to separate at any time.

The PTFE pad for sliding bearings shall have a minimum thickness of 6 mm for pads with any dimension larger than 650 mm, and 4 mm for smaller dimensions. The pad shall be restrained by adhesive bonding; and it shall recess into the backing material to a depth of half the thickness of the PTFE, to prevent its extrusion.

The PTFE pad shall be permanently lubricated in accordance with Clause 14.2 of AS 5100.4. The lubricant used shall meet the requirements of Clause 5.2.6 of this Standard.

### 5.2.3 Pot and Piston

The cylinder and base plate of the pot shall be fabricated from a single piece of stainless steel. Welding of a separate base plate to the cylinder shall be approved if supporting design calculations and experimental evidence are submitted showing that the strength of the welded component is equivalent to that made from a single piece of stainless steel.

The piston shall be machine-cut from a single piece of stainless steel.

The piston rim shall have a nominal diameter not less than the internal diameter of the pot minus 1.0 mm. The vertical contact rim of the piston, which bears against the cylinder wall, shall be flat in cross-section only where the serviceability rotation (SLS rotation) angle is less than or equal to 0.025 radians and where its thickness is less than or equal to 15 mm. Where the thickness is greater than 15 mm or if the SLS rotation is greater than 0.025 radians, the vertical contact rim of the piston shall be bevelled or curved.

Internal surfaces of the bearing to flatness shall be finished with not more than 0.005 times the nominal dimension and to a maximum surface roughness RA of 6.3  $\mu\text{m}$ .

The gap between the pot and the piston shall be sealed against dust and moisture using either a small compression seal supplied and installed using a neutral cure silicon sealant with at least 50% movement accommodation factor. The seal shall remain effective and undamaged at the maximum serviceability rotation (SLS rotation).

### 5.2.4 Guide Bars

Each guide bar shall be manufactured from a single piece of steel. Guide bars shall be recessed into the sliding plate and shall be able to withstand the lateral forces shown on the Drawings. The two contact surfaces of the guide bars shall be parallel and flat to within 0.001 of the nominal dimension.

The maximum gap between a guide and its corresponding sliding surface shall not exceed 3 mm when the opposite guide is in full contact with its corresponding sliding surface.

### 5.2.5 Internal Seal

The internal seal shall consist of a number of split rings formed to fit snugly in recesses in the elastomeric disc and within the inside surface of the pot. Each ring shall have one vertical cut at 45 degrees to the tangent, with a maximum gap of 1 mm. These cuts shall be staggered a minimum of 90 degrees relative to one another when the rings are fitted to the elastomeric disc.

The rings shall have a minimum thickness of 1.5 mm, with a minimum width of 6 mm for ring diameters less than or equal to 300 mm and 10 mm for ring diameters greater than 300 mm. Where the outside diameter of the ring is greater than 700 mm or the specified rotational capacity is greater than 0.025 radians the minimum number of rings shall be three. In all other cases, the minimum number of rings shall be two.

Alternate internal seal designs shall be submitted to the Administrator for approval prior to the manufacture of the bearings. **Hold Point 3**

**5.2.6 Lubricant**

Lubricant shall be silicone compounds used for filling the lubrication reservoirs in the dimpled face of the PTFE sliding pad and for lubrication of the top and bottom surfaces of the elastomeric disc. It shall retain its consistency at room temperature over a temperature range of - 40°C to + 200°C. The lubricant shall be compatible with all components in contact with it. It shall also comply with the requirements of Table 5.2.6.

**Table 5.2.6 – Properties of Lubricant**

<b>Properties</b>	<b>Requirements</b>	<b>Method of Test</b>
Penetration worked 60 stroke	< 260	ASTM D217
Evaporation – 24 h at 200°C	< 2%	ASTM D972

**5.2.7 Elastomeric Disc**

Each elastomeric disc shall be made from a single piece of elastomer, individually moulded or machine-cut from the moulded rubber slab. No discs shall be layered or stacked.

The disc shall be lubricated with a silicone compound complying with the requirements of Clause 5.2.6 of this Standard.

In the unloaded condition the lateral clearance between the pot and the elastomeric disc shall not exceed 0.2% of the diameter of the pad or 0.5 mm, whichever is greater.

**5.2.8 Holding-Down Bolts**

Holding-down bolts and sockets for pot-type bearings shall be high strength complying with the requirements of AS/NZS 1252 and shall be hot-dipped galvanised in accordance with AS 1214. Secondary coatings may be applied to achieve the design life.

**5.3 Design Requirements**

**5.3.1 Design Life**

All components of bearings shall be formulated to have a service life of not less than 100 years in Exposure Classification B1 of the Australian Bridge Design Code. For Exposure Classifications B2, C and U of the Australian Bridge Design Code, additional requirements may be stated on the Drawings.

**5.3.2 Design Loads**

The Ultimate Design Load, Tested Axial Load and Combined Axial and Lateral Loads for each type of bearing shall be as stated in Clause 1 of Annexure MRTS81A.1 or shown on the Bridge Design Drawings.

**5.3.3 Rotation**

Bearings shall be capable of a rotation of at least 0.02 radians unless shown otherwise on the Drawings. In the rotated position, no part of a bearing shall be in contact with the holding-down bolts irrespective of the displacement of the sliding plate.

**5.3.4 Movement**

The required movement of sliding bearings is stated in Clause 1 of Annexure MRTS81A.1.

Directions of any presets shall be clearly identified by markings on the Bridge Design Drawings.

**5.3.5 Coefficient of Friction**

The coefficient of friction of sliding surfaces shall not exceed 0.04 and shall be verified during test loading.

### 5.3.6 Centre of Rotation

Shifts in the centre of pressure due to rotation, not considering uplift bearings, shall be limited so as not to exceed  $\frac{D}{6}$  where D is the diameter of the elastomer. Calculations of rotational movement and the value of the centre of pressure shall be in accordance with the AS 5100.4.

### 5.3.7 Compressive Stress on Elastomer

The ultimate compressive stress in the elastomer shall be 50 MPa. The initial compression of bearings under the design loads shall not exceed 1.5 mm and 3 mm at Serviceability Limit State and Ultimate Limit State respectively.

### 5.3.8 Shape of Elastomer

The thickness and formulation of the elastomer shall depend on the required rotational capacity and the smoothness of the inner surface of the pot.

However, in no case shall the total pad thickness be less than one fifteenth of the diameter of the elastomeric pad or 10 mm, whichever is the larger.

### 5.3.9 Internal Seal

The rings shall have a maximum surface roughness Ra of 6.3 µm.

### 5.3.10 Extrusion of Elastomer

The elastomer shall be prevented from extrusion from the pot in accordance with the requirements of AS 5100.4.

### 5.3.11 Sliding Surface

The horizontal sliding surface of sliding bearings shall consist of a confined pad of pure PTFE in contact with a polished stainless steel plate.

The stainless steel plate shall be not less than 1.5 mm thick and shall be secured to a backing plate by continuous edge welding, stainless steel countersunk screws, or similar method.

The stainless steel plate shall be sufficiently large so that, under the ultimate limit state movement range, the PTFE does not extend over the edge of the stainless steel plate.

The minimum thickness of unfilled (pure) PTFE shall be 4 mm, restrained by recessing it into a metal backing plate to a depth of half of the thickness of the PTFE. The PTFE shall normally be bonded under factory controlled conditions to the backing plate. However, provided that the backing plate does not deform under load and the recess satisfactorily resists the shearing forces, recessing only may be permitted.

For guides, filled PTFE to ASTM D4745 or BS6564-3 or other approved low friction material, sliding on polished stainless steel shall be used. Filled PTFE shall consist of pure PTFE filled with no more than 25% glass filler. Test method and requirements shall comply with ASTM D3294.

Filled PTFE may be located by bonding only, provided that the bond to the backing plate is made with a proven adhesive and achieves a minimum peel strength of 4 N/mm width when tested in accordance with BS 5350, Part C9. Alternatively, the filled PTFE may be fixed using countersunk fasteners.

The compressive stress on pure PTFE at the ultimate limit state shall not exceed the values stated in Table 5.3.11. Values for filled PTFE may be 50% greater where this can be verified by test data.

**Table 5.3.11 – Compressive Stress on Pure PTFE**

Load Combination	Ultimate Compressive Stress (MPa)	
	Confined	
	Mean	Peak
Total Loads	50	60

The overall clear dimension between runner bar sliding surfaces shall not be more than 3 mm greater than the overall width of the plate that slides between them.

Sliding bearings shall have the larger of the sliding surfaces positioned above the smaller, so that the sliding surfaces are kept clean. Where shown on the Drawings, sliding bearings shall be fitted with a clearly visible movement scale and pointer.

**5.4 Testing**

**5.4.1 General**

The testing operations shall be performed in an accredited NATA laboratory under the supervision of a competent person provided by the Contractor.

All testing and inspection shall be carried out in the presence of the Administrator. **Hold Point 4** The Contractor shall give the Administrator seven days notice of the testing of bearings.

**5.4.2 Test Machines**

Accuracy of load testing machine grade A is to be calibrated minimum every 24 months **Hold Point 5**. Accuracy of friction load and lateral load shall be within 1% of error.

Resolution of peak load for friction load and lateral load shall be within 2% of error.

**5.4.3 Testing of Pot-type Bearings**

A minimum of one representative bearing selected from every five identical bearings, or part thereof, shall be load tested. Representative bearings shall be tested in accordance with the requirements of Clauses 5.4.4 and 5.4.5. The direction of loads or rotations applied in all tests shall replicate the in-service conditions; and the bearings shall be tested as fabricated, excluding the seal between the pot and the piston.

**5.4.4 Geometrical Testing**

Geometrical parameters to be tested shall be flatness, surface roughness, and clearances. These parameters shall comply with the requirements of Clause 5.2.

Flatness shall be measured in all directions using a precision straight edge sliding on the surface and feeler gauges.

**5.4.5 Load Tests**

The Contractor shall give the Administrator at least seven (7) working days notice for the date and location of the first load test for each pot bearing type **Hold Point 6**

Required Load tests for different type of pot bearings are summarised in Table 5.4.5.

**Table 5.4.5 – Load Tests Requirement**

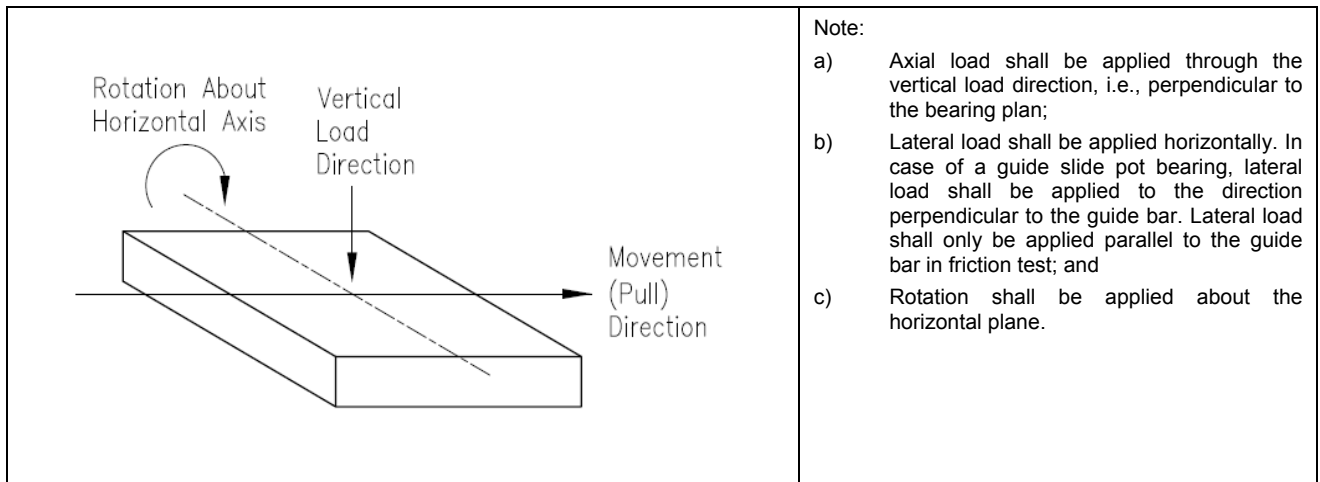
<b>Bearing Type</b>	<b>Vertical</b>	<b>Lateral</b>	<b>Friction</b>	<b>Rotation</b>
Fixed	Required	Required	Not Required	Required
Free Sliding	Required	Not Required	Required	Required
Guided Sliding	Required	Required	Required	Required

Rotation, vertical and horizontal loads shall be applied as the axis defined below in Figure 5.4.5.1.

**5.4.5.1 Vertical Load Test**

Each bearing shall be individually loaded in compression to the value stated in Clause 1 of Annexure MRTS81A.1 given in column "Maximum Ultimate Vertical Load". The Load shall be maintained for one minute, then released, reapplied and maintained for a minimum of three minutes. The test is invalid if the test load is less than 95% of the test load during the 3 minutes of the test. The bearing shall be visually inspected whilst under the second loading.

Figure 5.4.5.1 – Definition of Loads Directions in Bearing Elevation



### 5.4.5.2 Combined Vertical and Lateral Load Test

Bearing shall be loaded in shear and compression to the value stated in Clause 1 of Annexure MRTS81A.1 given in columns "Maximum Ultimate Lateral Load", "Maximum Ultimate Vertical Load" and "Concurrent Minimum Ultimate Vertical Load for Lateral Test". Bearings shall be tested as follows –

- Apply the maximum ultimate lateral load in conjunction with the concurrent minimum ultimate vertical load; and
- Apply the maximum ultimate lateral load in conjunction with the concurrent maximum ultimate vertical load.

In both cases the vertical load shall be applied first, followed by gradual application of the lateral loads. Lateral load shall be applied in the direction perpendicular to the guide bar; and the line of action of the force shall be horizontal. The test loads shall be maintained for a minimum of three minutes during which visual inspection of the bearing shall be carried out.

### 5.4.5.3 Coefficient of Friction Test

The coefficient of friction shall be determined using a vertical load corresponding to the factored down permanent vertical load on the bearing, at an ambient air temperature between 5°C and 35°C. Friction and lateral load shall be applied horizontally. **Hold Point 7**

The test displacement shall be equal to the design displacement value but in no case shall the test displacement be more than 50 mm nor shall it exceed the design movement of the bearing. The vertical load shall be applied and maintained for a duration of three minutes before commencing the test. The test sliding speed shall be in the range of 2.5 to 25 mm per minute as appropriate.

The maximum measured coefficient of friction shall not be greater than the values specified in Table 5.4.5.3 for the relevant stresses on PTFE.

Table 5.4.5.3 – Maximum Allowable Coefficient of Friction for Sliding Surface

Bearing Pressure	5 MPa	15 MPa	20 MPa	≥ 30 MPa
Coefficient of Friction	0.04	0.025	0.02	0.015

Note: Friction values for other bearing pressures shall be linearly interpolated from the above values.

### 5.4.5.4 Rotation Test

The bearing shall be tested at the design rotation specified in Clause 1 of Annexure MRS81A.1 given in column "Design Rotation" to 0.7 times the maximum ultimate vertical load specified in Clause 1 of Annexure MRS81A.1 given in column "Maximum Ultimate Vertical Load".

The applied test load and rotation shall be maintained for minimum duration of three minutes. The direction of rotation is as shown on Figure 5.4.5.1.

### 5.4.6 Failure to Meet Requirements

After load testing, the bearing shall be dismantled and examined for rubber extrusion, PTFE damage, warping, scoring or other effects that may affect the durability of the bearing. Critical bearing dimensions and tolerances shall be measured.

If all the sampled bearings pass the load test, check of rubber extrusion, PTFE damage, warping, scoring or other effects that may affect the durability of the bearing, the bearings shall be accepted.

If any of the sampled bearings fail the load test, check of rubber extrusion, PTFE damage, warping, scoring or other effects that may affect the durability of the bearing, all the bearings shall be subjected to load testing and individual approval or rejection. If any of these defects exist, the individual bearing shall be rejected.

Bearings failing to meet the dimensional requirements of Clause 5.4.4 and the loading requirements of Clause 5.4.5 shall be rejected.

Bearings tested shall be rejected if they exhibit any signs of damage visible to the naked eye such as, but not restricted to –

- a) splitting, extrusion or permanent deformation of the elastomer;
- b) opening, extrusion or permanent deformation of the external seal;
- c) tearing, cracking or permanent deformation of the PTFE sliding surfaces;
- d) cracking, indentation or permanent deformation of the internal seal or other part of the bearing;
- e) abrasive marks indicating abnormal contact between the metal surfaces of the bearing plates or piston, and the pot;
- f) failure or permanent deformations of guide bars; or
- g) flow of elastomers.

If a bearing is rejected, two additional bearings from the batch it represents shall be tested. If both bearings meet the requirements of this Standard, the remaining bearings in the lot shall be accepted. Otherwise each bearing remaining in the lot shall be tested for compliance.

## 6 PROTECTIVE TREATMENT

All parts made of stainless steel shall not receive protective treatment unless otherwise specified. However, the bearings, especially the sliding surfaces, shall be protected from being damaged.

Where the bearing is attached to a steel girder, the top attachment plate shall be welded to the steel girder and the same protective treatment specified for the girder shall be applied. The bearing shall be insulated from the top attachment plate using suitable flat sheets, bushes and washers of at least 3 mm thickness, at the interface between the pot bearing and the top attachment plate and around the attachment bolts to the top attachment plate. These sheets, bushes and washers shall be resin laminated sheets and tubes made from an electrical insulating material complying with the performance requirements of Table 6 below. Drill holes shall be matched through the insulating sheet to accommodate the fixing screws to the top attachment plate.

**Table 6 – Performance for the Insulating Material**

Property	Requirement	Test Method
Insulating resistance after immersion in water	$\geq 5 \times 10^{10}$ Ohms	BS 2572 or BS 3953 as appropriate
Water Absorption	$\leq 50$ mg	BS 2572 or BS 3953 as appropriate
Impact strength, notched Charpy	$\geq 10$ kJ/m <sup>2</sup>	BS 2572 or BS 3953 as appropriate

## 7 BEARING REPORT

At least ten working days prior to delivery of bearings to site, the Contractor shall forward to the Administrator a bearing report with test results demonstrating that all bearings supplied comply with the requirements of this Standard.

## 8 IDENTIFICATION AND DELIVERY

All bearings shall be clearly marked in order to identify their type and location in the bridge.

Mating parts of bearings shall be supplied in sets held together at the correct preset and skew, with metal transit clips or bolts to prevent misalignment or damage of the components during transport and erection. No transit clips or bolts shall be removed until after completion of installation in the bridge. Bearings shall be protected in dust and moisture resistant wrappings until after assembly and during transport to site.

## 9 SUPPLEMENTARY REQUIREMENTS

The requirements of MRTS81A *Stainless Steel Bridge Bearings* are varied by the Supplementary Requirements given in Clause 2 of Annexure MRTS81A.1.