ITEM 565.640100NI - BASE ISOLATION BEARING SYSTEMS

DESCRIPTION

This work shall consist of furnishing, and installing base isolation bearings of the type required, at the locations indicated on the plans.

MATERIALS

General
Material shall meet the requirements of the Appendix - Base Isolation Bearing Systems Materials. All base isolation bearings shall be sliding isolators. Elastomeric isolators will not be allowed.

Fabrication
The systems shall be complete, factory-produced assemblies. Steel components of bridge bearings shall be fabricated in accordance with the applicable requirements of the NYS Steel Construction Manual (SCM). In addition, where applicable, component parts of the individual bearings shall meet the Fabrication details shown in the contract documents.

Submittals
At the time of the preconstruction conference, the Contractor is required to identify his/her intended isolation system supplier and to provide DCES with a certification of compliance listing all materials in the system. The certificate shall certify that the system conforms to the design and material requirements.

Submittals shall also include:

1. Product literature, including product description, reference standards and performance test data.
2. A list of previous installation dates and locations, with contact names and phone numbers.
3. A detailed description of maintenance requirements, including sources of replacement materials.

DCES will notify Contractor of approval/disapproval within 30 days from date of submittal. Submittals with insufficient test data and supportive certifications will be rejected.

System & Drawing Requirements
Shop drawings will be required for all bearings. They shall be furnished in accordance with the SCM, Section 2. The Contractor shall supply five copies of the approved shop drawings to the Materials Bureau. These will be used to implement the quality assurance process.

The contract plans contain the design requirements and are supplied as a means of specifying the required performance characteristics for the isolation system.

Calculations showing system compliance with all relevant provisions of the AASHTO 2010 Guide Specifications for Seismic Isolation Design shall be submitted to DCES along with the shop drawing submittals for review and approval.
The bearing devices shall be capable of transmitting the maximum vertical and seismic lateral load demand shown on the plans in accordance with the AASHTO 2010 Guide Specifications for Seismic Isolation Design. The longitudinal and transverse force and the transverse displacement demands shown on the plans are the maxima of the lateral service loads to be used for service load design of isolators. Other conditions may control substructure design.

Alternate Isolation Bearing Systems: The bearing details, dimensions and seismic requirements given on the contract documents are based on any sliding isolation bearing system. The use of other types of sliding isolation bearings that provides equivalent or better seismic isolation characteristics to meet the service load and seismicity requirements given on the design plans and Special Provisions are permissible and must conform to the Appendix – Base Isolation Bearing Systems Materials. The beam-seat elevations, as detailed, are computed based on the dimensions given. Any change in the height of the isolators shall be made up in adjustments first to masonry and sole plates (minor changes), and second to the beam seat elevations if absolutely necessary. Changes in the plan dimensions (i.e., width and length) shall take into consideration the physical limits of the beam seats and all isolators shall be centered directly beneath bearing stiffeners and girder webs as detailed on the plans.

Any alternative base isolation bearing system shall not necessitate re-design of the substructure. Full seismic analysis results of the structure with the proposed alternative type of bearing shall be submitted by the Contractor for the DCES review and approval at the time of the preconstruction conference.

SHIPMENT AND STORAGE
Each bearing shall be assembled together with all necessary plates at the place of manufacture. Each bearing shall be shipped in strong protective packaging as an assembled unit. Assembly shall be such that the assembled bearing remains intact when unpackaged and installed. All bearings shall be stored under cover, in their original packaging, above ground, until installation.

CONSTRUCTION DETAILS
The following applicable subsections of Section 565 shall apply: 565-3.02; 565-3.03; 565-3.04; 565-3.06; 565-3.07; 565-3.08.

In addition the following shall apply:

A. The elevation of the concrete bearing surface for all types of bearings is given on the plans. The elevation of the concrete bearing surface may vary from that given on the plans depending on the vertical dimension of the bearing supplied. The Contractor shall notify the Engineer of all required elevation changes. Changes to the roadway profile will not be allowed, and all elevation adjustments necessary to maintain the profile shall be made to the concrete bearing surfaces. All adjustments will be made at no additional cost to the State.
B. The centerline of the bearing shall not be offset from the centerline of bearing stiffeners, or diaphragm connection plates by more than one-half the thickness of the flange at that location, or the thickness of the bearing stiffener, or connection plate, whichever is the lesser distance.

C. Bearings shall be installed only when ambient temperature is within the temperature range of 20°F to 70°F inclusive, unless otherwise shown on the contract plans.

D. Bearings may vary from perfect vertical alignment. The maximum variation from perfect vertical alignment under full dead load shall not exceed 0.125” in any direction. The variation will be measured as the horizontal distance between the centerline of the highest bearing surface and the centerline of the lowest bearing surface.

E. All bearings shall be installed level. All grade corrections shall be accomplished by means of beveled shim plates.

F. After bearing installation has been completed, the contractor shall ensure that each bearing is free to deform horizontally in all directions and is free to rotate about all axes, unless otherwise indicated on the contract plans.

METHOD OF MEASUREMENT
Measurement will be taken as each bearing furnished and installed as required.

BASIS OF PAYMENT
Base Isolation Bearing systems, furnished and installed, as specified, will be paid for at the contract unit price for each Base Isolation Bearing of the type designated. Such price shall include all costs associated with the design of the bearings, shop drawings, testing and all work incidentals to and associated with the furnishing and installation of the bearings as specified herein. The unit bid price for each bearing shall include the cost of all labor, materials and equipment necessary to complete the work.

Progress Payments
The requirements of subsection 565-5.01 shall apply.

NOTE: nnnn denotes serialized pay item. See § 101-02.
APPENDIX - BASE ISOLATION BEARING SYSTEMS MATERIALS

SCOPE. This specification covers the material requirements for base isolation bearing systems. Bearings furnished under this specification shall adequately provide for thermal expansion and contraction, rotation, camber changes, creep, shrinkage and seismic stresses of structural members, where applicable.

GENERAL. All bearings fabricated under the terms of this subsection shall perform the functions for which they have been designed.

Stresses will be computed in accordance with the requirements of the AASHTO GUIDE SPECIFICATION FOR SEISMIC ISOLATION DESIGN dated 2010.

MATERIAL REQUIREMENTS. Bearings fabricated under the requirements of this specification, except as modified by the terms of this subsection, shall meet the applicable requirements of subsections:

716-06; DISC-DESIGN STRUCTURAL BRIDGE BEARINGS,
716-07; POT-DESIGN STRUCTURAL BRIDGE BEARINGS,

Manufacturer shall have supplied isolation bearings for a minimum of 5 projects within New York State and also must be approved to supply bridge bearings according to 716-06 or 716-07.

All materials shall be new. No used or reclaimed material will be permitted.

Elastomeric Material The elastomeric structural/rotational element shall be polyether urethane in accordance with Table 716-06-1 or virgin polyisoprene (natural rubber) meeting or exceeding ASTM D4014, Type NR, Gr. 3 (except as modified below):

(a) Low Temperature Properties
ASTM D2137 Method A (Brittleness Test at -13°F): no failure
ASTM D1229 (Compression Set at 14°F for 7 days at 25% compression) Maximum permissible set: 65%
ASTM D2240 (Low Temperature Stiffness Conditioned for 22 hours at 13°F)
Maximum permissible change in durometer hardness: +10 Shore ‘A’ points

(b) Tensile Strength and Ultimate Elongation of Elastomer:
Minimum tensile strength and ultimate elongation tests will be performed according to ASTM D412. The minimum tensile strength will be 2,250 psi and the minimum ultimate elongation will be 550%.

(c) Hardness of Elastomer: The durometer hardness will be determined by ASTM D2240 and will be 55 ± 5 Shore ‘A’ points.
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( d ) Shear Modulus at 50% Shear Strain of Elastomer: The shear modulus of the elastomer at 50% shear strain will be determined by ASTM D4014. The tangent modulus will be 100 psi ± 10%.

Steel All external plates, regardless of purpose, shall meet the requirements of ASTM A36, A572- Gr. 50, or A588 as noted on the plans. All fabrication shall be done in accordance with the applicable requirements of the SCM.

Fasteners These shall meet the requirements of the SCM unless otherwise noted on the plans.

Protective Coating External load bearing plates shall be cleaned to meet SSPC-SP6, Surface Preparation Specification No. 6 Commercial Blast Cleaning and painted with three coats of paint. The paint, (primer, intermediate and finish coat) shall be selected from NYSDOT’s Approved List, Paints for Structural Steel. All coats of paint used shall be produced by the same manufacturer and applied at a rate sufficient to produce a minimum dry film thickness of 75 μm (3 mils) per coat. Each single paint coat shall be a color different from the others. For bearings used in conjunction with painted steel the color of the finish coat shall be the same color as the finish coat of the structural steel. For bearings used in conjunction with unpainted steel the color of the finish coat shall be a “rusty brown” color which is a reasonable visual match to Federal Color Standard No. 595, Color 20059.

Metal to metal surfaces to be field welded shall be given a coat of clear lacquer or other protective coating approved by the Engineer, or Inspector, if exposure is to exceed three months prior to welding. The coating shall be removed prior to welding. Painting shall be done after the completion of welding.

Fabrication tolerances

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Tolerance</th>
</tr>
</thead>
<tbody>
<tr>
<td>External Plan Dimension</td>
<td>± 0.25 in</td>
</tr>
<tr>
<td>Flatness of Exterior Top Surface of Completed Bearing</td>
<td>± 0.01 in</td>
</tr>
<tr>
<td>Flatness of Exterior Bottom Surface of Completed Bearing</td>
<td>± 0.06 in</td>
</tr>
<tr>
<td>Variation from Plan Parallel to the Theoretical Surface:</td>
<td></td>
</tr>
<tr>
<td>Top</td>
<td>Slope relative to the bottom no more than 0.006 radians</td>
</tr>
<tr>
<td>Sides</td>
<td>± 0.25 in</td>
</tr>
<tr>
<td>Overall Bearing Height</td>
<td>± 0.25 in</td>
</tr>
</tbody>
</table>
Bearings not meeting the above dimensional requirements shall be subject to rejection.

**Testing** The overall objective of this testing is to evaluate the actual performance of the bearing system in accordance with the contract documents. The contractor shall allow a minimum of 30 days for testing and inspection of the bearings.

The Manufacturer shall arrange to test each bearing type with such test witnessed and attested to by a NYSDOT representative designated by the DCES for compliance with specified performance requirements as listed herein. Testing shall be performed at a test facility with the ability to record data and test vertical load, horizontal load, and horizontal displacement simultaneously. Load and displacement measuring equipment shall be calibrated traceable to NIST. The NYSDOT representative shall be notified of the scheduled tests 14 days prior to the testing. NYSDOT shall have free access to the testing area.

Except where otherwise specified, two bearing assemblies shall be tested for each lot. A lot shall be defined as the lot designation stated in the applicable item 716-06 or 716-07. These bearings shall be selected at random, by the NYSDOT representative, from the lot of production bearings. The chosen bearings are to be tested to the applicable design forces and displacements for that bearing. The test values for each bearing are to be taken from the tables in the contract plans.

<table>
<thead>
<tr>
<th>Test</th>
<th>Performed By</th>
<th>Samples Required</th>
</tr>
</thead>
<tbody>
<tr>
<td>Environmental Aging</td>
<td>Manufacturer</td>
<td>Pre-qualified if test has been performed on similar bearing within 10 yr period. (Previous data to be submitted) OTHERWISE 2 production bearings per lot</td>
</tr>
<tr>
<td>Temperature Testing</td>
<td>Manufacturer</td>
<td>Pre-qualified if test has been performed on similar bearing within 10 yr period. (Previous data to be submitted) OTHERWISE 2 production bearings per lot</td>
</tr>
<tr>
<td>Proof Test</td>
<td>Manufacturer</td>
<td>2 production bearings per lot (1)</td>
</tr>
<tr>
<td>Combined Compression plus Shear</td>
<td>Manufacturer</td>
<td>2 production bearings per lot</td>
</tr>
<tr>
<td>Lateral Load Testing</td>
<td>Manufacturer</td>
<td>2 production bearings per lot</td>
</tr>
<tr>
<td>Dynamic Performance Characteristics at Temperature Extremes</td>
<td>Manufacturer</td>
<td>Pre-qualified if test has been performed on similar bearing within 10 yr period. (Previous data to be submitted) OTHERWISE 2 production bearings per lot</td>
</tr>
<tr>
<td>Compression Strain</td>
<td>Manufacturer</td>
<td>3 production bearings per lot</td>
</tr>
</tbody>
</table>
### APPENDIX - BASE ISOLATION BEARING SYSTEMS MATERIALS

<table>
<thead>
<tr>
<th>Test</th>
<th>Performed By</th>
<th>Samples Required</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical Properties Polyether Urethane Rotational Element (except compression set)</td>
<td>Manufacturer</td>
<td>One 10 x 15 inch sheet of polyether urethane material (thickness of 1/16 - 1/8 inch) per lot. (2)</td>
</tr>
<tr>
<td>Compression Set of Polyether Urethane Rotational Element</td>
<td>Manufacturer</td>
<td>One 4 x 4 inch sheet of polyether urethane material, molded or cut to the thickness requirements of ASTM D395, Method B. (3)</td>
</tr>
<tr>
<td>Physical Properties of PTFE Sheet</td>
<td>Manufacturer</td>
<td>One 10 x 15 inch sheet of polytetrafluoroethylene material per lot. (4)</td>
</tr>
</tbody>
</table>

### NOTES:

1. Sample production bearings of such size that cannot be tested by the manufacturer at 150% design capacity for rotation shall be tested at actual design capacity. Bearings which are tested at actual design capacity will be tested at that capacity because it is not possible, or not practical to test them at a higher capacity. Therefore, bearings tested at 150% design capacity which are rejected, will not be retested below 150% design capacity for the purpose of rendering such bearings acceptable. Sample production bearings that cannot be tested by the manufacturer at their actual design capacity for rotation and/or friction shall be tested by an outside laboratory. The Manufacturer shall assume the cost of this testing and submit the certified test results to the Materials Bureau.

2. All submitted sample sheets of polyether urethane material shall be certified by the bearing manufacturer as having been taken from the same batch of polyether urethane material as was used in the actual production bearings.

3. The manufacturer shall have the option of supplying four (4) die cut specimens in accordance with ASTM D-395, Method B. All submitted specimens of polyether urethane material shall be certified by the bearing manufacturer as having been taken from the same batch of polyether urethane material as was used in the actual production bearings.

4. Single sheets of PTFE Material from which the bearing has been fabricated may be submitted to the Materials Bureau for consideration of multiple lot acceptance, provided that the thickness of the material does not vary from lot to lot. All submitted sample sheets shall be certified by the bearing manufacturer as having been taken from the same batch of PTFE material as was used in the actual production bearings.

At the completion of the tests, each bearing shall be inspected by the NYSDOT representative, and all damaged components shall be replaced with new components made from the same batch of material as that used in the production lot. If the bearings meet the test criteria, the tested bearings may be refurbished to their pre-tested condition and used in the completed structure.

Each bearing selected for testing will be performance characteristic tested in accordance with the applicable requirements of the above subsections as well as the following:

1. Environmental Aging

   Purpose: To verify performance of the bearing type in a salt spray environment such as may be encountered over a long period of time under an expansion deck joint which is subject to salting.
Procedure: A bearing assembly shall be exposed in a salt spray chamber for 1000 hours in accordance with the requirements of ASTM B117. The bearing subjected to this test shall then undergo other testing to verify continued satisfactory function.

2. Temperature Testing

Purpose: Establish dependence on temperature.

Sequence: Three fully reversed cycles to peak design displacements ($d_{\text{max}}$) under seismic loading. Tests shall be conducted for temperatures at the start of cyclic loading corresponding to -18°C (0°F) and 32°C (90°F). Tests shall be conducted with a vertical load equal to the total dead load.

Procedure: Place the salt spray bearing in an environmental chamber; maintain the temperature to within $\pm 3^\circ C$ ($\pm 5^\circ F$) of that specified for a period of 24 hours for 32°C (90°F), and 24 hours for -18°C (0°F). After conditioning the bearing for the required time, place the bearing in the test machine and secure it to the supports and loading plate. Apply a vertical load equal to the total dead load to the bearing and allow the load to stabilize. Apply the cyclic lateral load equal to peak design displacements ($d_{\text{max}}$) to the bearing for 3 fully reversed cycles. The test shall be run continuously without pause between cycles.

Criteria: The system, unit or component response is considered to be independent of temperature if:

(a) The average Effective stiffnesses measured at temperature -18°C (0°F) is within 20% of the average effective stiffness measured at a temperature of 32°C (90°F).

(b) The average Energy Dissipation per cycle measured at temperature -18°C (0°F) is within 20% of the average Energy Dissipation per cycle measured at a temperature of 32°C (90°F).

3. Proof Test

Two bearing assemblies from each lot of production bearings shall be proof tested. The sampled bearings shall be axially loaded with simultaneous rotation for one hour in accordance with the Rotation testing specified in 716-06 and/or 716-07. The bearings shall be visually examined during and after the test. The structural/rotational load element shall not exhibit cracks greater than 2 millimeters (0.08 inches) in depth, or width.
APPENDIX - BASE ISOLATION BEARING SYSTEMS MATERIALS

4. Combined Compression Plus Shear

Two bearing assemblies from each lot of production bearings shall be tested in combined compression and shear. The requirements of the AASHTO GUIDE SPECIFICATIONS FOR SEISMIC ISOLATION DESIGN, dated 2010, Section 17.2.2 shall apply. The compressive load shall be the average dead load. Bearings may be tested in pairs.

Each tested bearing will be evaluated for the following performance requirements:

   (a) The effective stiffness \( k_{\text{eff}} \) shall be within the range of \( \pm 10\% \) of the required value (Figure 1).

   (b) The slope of the loading curve \( K_r \) shall be equal to, or greater than, 90% of the required value (Figure 1).

   (c) The average value of energy dissipated per cycle (EDC) shall be equal to or greater than the required value (Figure 1).

Values for the above noted force-deflection characteristics are given in the contract plans.

5. Lateral Load Testing

Two bearing assemblies from each lot of production bearings shall be tested in accordance with the seismic testing requirements of the AASHTO GUIDE SPECIFICATIONS FOR SEISMIC ISOLATION DESIGN, dated 2010, Section 13.2.

The test results shall be within tolerances set forth in Section 13. The vertical load applied to the bearing during this testing shall be the average dead load.

Failure of an isolation bearing device is defined as when:

   (a) The elastomeric material visually tears; or,

   (b) The sliding materials crack; or,

   (c) There is a sudden unexpected increase/decrease in stiffness; or,

   (d) A significant change in performance occurs.

6. Dynamic Performance Characteristics at Temperature Extremes

Purpose: To assess the effects of extreme temperature on the performance characteristics, specifically stiffness, damping, and EDC.
Procedure: With the full dead load applied (for load bearing isolators), three fully reversed cycles of the design displacement are applied at the upper and lower temperature extremes. The temperature range of interest for this project is from -34°C (-30°F) to 49°C (120°F). Further test procedures for handling hot or cold test articles are as follows:

(1) The test article and mounting hardware is placed in the heating/cooling unit for 48 hours.

(2) The test article and mounting hardware is installed in the test rig within 75 minutes after being removed from the thermal chamber; and,

(3) Testing is performed within five minutes after installation is complete.

Criteria: The bearing is considered acceptable if:

(a) The variation in stiffness from ambient temperature (20°C (68°F)) to extremes (-34°C (-30°F) and 49°C (120°F)) shall not exceed 30%.

(b) The variation in EDC from ambient temperature (20°C (68°F)) to extremes (-34°C (-30°F) and 49°C (120°F)) shall not exceed 15%.
The bearing manufacturer shall submit certified test results to the DCES that indicate all tested bearings and/or bearing components meet the following requirements of this specification:

<table>
<thead>
<tr>
<th>Specification Requirement</th>
<th>Material</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polyurethane Properties</td>
<td>Elastomer</td>
</tr>
<tr>
<td>Proof Test</td>
<td>Bearing</td>
</tr>
<tr>
<td>Combined Compression plus Shear Test</td>
<td>Bearing</td>
</tr>
<tr>
<td>Lateral Load Test</td>
<td>Bearing</td>
</tr>
<tr>
<td>Environmental Aging Test</td>
<td>Previous Bearing</td>
</tr>
<tr>
<td>Temperature Tests</td>
<td>Previous Bearing</td>
</tr>
</tbody>
</table>

**Bearing Testing Frequency:**

<table>
<thead>
<tr>
<th>Test</th>
<th>Number of Bearings Tested</th>
</tr>
</thead>
<tbody>
<tr>
<td>Environmental Aging</td>
<td>1 Previous Aged Bearing</td>
</tr>
<tr>
<td>Temperature Testing</td>
<td>1 Previous Aged Bearing</td>
</tr>
<tr>
<td>Proof Test</td>
<td>2 per lot</td>
</tr>
<tr>
<td>Combined Compression plus shear</td>
<td>2 per lot</td>
</tr>
<tr>
<td>Lateral Load Testing</td>
<td>2 per lot</td>
</tr>
<tr>
<td>Dynamic Performance Characteristics at Temperature Extremes</td>
<td>1 Previous Aged Bearing</td>
</tr>
</tbody>
</table>

1- This test is performed on two bearing assemblies from each lot of unaged production bearings, as well as previous testing completed on one Environmentally Aged Bearing.
In addition, certification shall be provided to the DCES for the following:

1. Mill conformance certificate for all steels used.
2. Certificate of compliance for all non-ferrous metals.
3. Certificate of compliance for all bolts and cap screws supplied.
4. A certificate of compliance for the bearings executed by an officer of the manufacturer’s company.

If a bearing manufacturer has not completed Environmental Aging testing on a similar bearing design, or their submitted testing documentation is found to be unacceptable by the Materials Bureau, the bearing manufacturer shall complete the 42 day Environmental Aging tests in addition to all other required bearing testing.

If a bearing manufacturer has not completed Dynamic Performance Characteristics at Temperature Extremes testing on a similar bearing design, or their submitted testing documentation is found to be unacceptable by the Materials Bureau, the bearing manufacturer shall complete the Dynamic Performance Characteristics at Temperature Extremes test in addition to all other required bearing testing.

**BASIS OF ACCEPTANCE.** Bearings will be approved for shipment to the project site at the manufacturing facility, in project lot quantities, or portions thereof, in accordance with the procedural directives of the Materials Bureau. The manufacturer shall be responsible for the final report to be reviewed and accepted by an independent engineer or agency approved by the design engineer or consultant for final acceptance. The independent engineer or agency shall have sufficient experience in seismic analysis of structures and design.
$Q_d = \text{Characteristic strength}$

$F_Y = \text{Yield force}$

$F_{max} = \text{Maximum force}$

$k_e = \text{Post-elastic stiffness}$

$k_u = \text{Elastic unloading stiffness}$

$k_{eff} = \text{Effective stiffness}$

$\Delta_{max} = \text{Maximum bearing displacement}$

$EDC = \text{Energy dissipated per cycle = Area of hysteresis loop}$

$\text{Area enclosed by ABCD}$

**FIGURE 1**

An idealized force - displacement (hysteretic) loop of an isolation bearing.