A Test Plan for the Characterization and Qualification of Highway Bridge Seismic Isolation Bearing Devices

California Department of Transportation

February 8, 2011
Contents

I. Introduction ................................................................. 2
   I.1 Overview .................................................................. 2
   I.2 Test Program Requirements ........................................ 3
       Part 1: Material Test Review ........................................ 3
       Part 2: Device Testing ............................................... 3
   I.3 Manufacturer’s Responsibility .................................... 3
II. Test Plan Details ........................................................... 4
    II.1 Material Characterization ........................................ 4
    II.2 Test Device Requirements ....................................... 4
III. Device Testing Details .................................................. 6
    III.1 Test Procedure Requirements ................................. 6
    III.2 Test Protocols .................................................... 6
    III.3 Test Descriptions and Evaluation ............................ 8
    III.4 Device Test Reporting Requirements ....................... 12
IV. Report Submittal .......................................................... 13
Appendix A Material & Fabrication Requirements ..................... 14
Glossary ..................................................................... 20
I. Introduction

I.1 Overview

A test program is proposed to develop key data on the performance and quality of weight-bearing isolation devices designed for highway bridge applications and to pre-qualify the devices for highway bridge applications.

This test program is to evaluate the properties and performance characteristics of isolation bearings. The test program examines characteristics such as: 1) stability, 2) range, 3) capacity, 4) resilience, 5) resistance to service loads, 6) energy dissipation, 7) survivability in extreme environment, 8) resistance to aging and creep, 9) predictability of response, 10) fatigue and wear. These properties provide bridge designers with critical information on the suitability of these devices for specific design applications, and with insight into the reliability, longevity, and predictability of the product response, and the ability of the vendor or manufacturer to provide a quality product with a claimed predictable performance.

Bearing types can be differentiated in two groups based on their performance characteristics:

1) Weight-Bearing Parallel-Shear Devices. These devices include elastomeric bearings such as Lead Core Rubble Bearings (LRB). The key features are that they are vertical load bearing and contain two horizontal top and bottom mounting surfaces that move laterally in essentially parallel motion with minimal change in vertical spacing.

An elastomeric bearing is a flexible vertical load supporting device with energy dissipating capabilities that lengthens the period of lateral vibration of the system sufficiently to reduce the force response and then tends to return the system to its original position when the load is removed. The elastomer shall be natural rubber and conform to the material requirements specified in Appendix A.

2) Weight-Bearing Spherical Devices. These devices include singular or plate mounted groups of captured, roller-between-surface devices or sliding friction surfaces on uplift contours. The key features are that they are load bearing and contain two horizontal top and bottom mounting surfaces and that lateral motion is accompanied by a change in vertical spacing.

A friction pendulum sliding bearing (FPS) is a vertical load supporting device utilizing rollers or sliding elements that rely on gravity to assist in returning it to its original position when the lateral load is removed. The device lengthens the period of vibration of the system sufficiently to reduce the force response, and has energy dissipating capabilities.
The bearing liner material shall conform to the requirements specified in Appendix A.

1.2 Test Program Requirements

The Program consists of two parts.

Part 1: Materials Test Review

To assess by review the suitability of materials to meet certain minimum requirements. ASTM or equivalent testing of selected materials is required.

The Materials Test Review examines the ability of materials used to fabricate the test devices to satisfy certain requirements for properties such as hardness, tensile strength, shear modulus, heat resistance, compression set, brittleness, ozone resistance, elongation, corrosion, fatigue, creep, temperatures extremes, etc. Test data shall be supplied to assure that materials conform to test requirements outlined in Appendix A.

Part 2: Device Testing

To assess the performance characteristics of the isolators subjected to motion-controlled harmonic loadings.

Device Testing quantifies performance characteristics and properties such as stiffness and energy dissipation, temperature effects, fatigue and wear, and environmental exposure degradation of a complete device. Motion-controlled loads are applied to full-size devices. This information will be used for characterizing and describing the devices for analytical design.

The Devices shall remain stable and show no signs of damage during and after each test. Signs of damage include debonding, cracking, tear, and fracture. Normal wear and scratch marks are not considered damages for the purpose of Device Testing.

Acceptable criteria of each test are specified in Section III.3, Test Descriptions and Evaluation.

1.3 Manufacturer's Responsibility

Manufacturers are responsible for completing all the tests specified in this test plan and submitting a report that includes certification of materials used in fabricating the device, certification of testing facility and equipment, device detail drawings and response prediction, and the test results to the
California Department of Transportation (CALTRANS). Complete details of the reporting requirements are outlined in Section III.4, Device Test Reporting Requirements and Section IV, Report Submittal.

II Test Plan Details

II.1 Material Characterization

The manufacturer shall provide the CALTRANS with a Certification of Compliance listing all materials in the device. The certificate shall certify that the devices conform to the design and material requirements, and were manufactured in accordance with their quality control program. The certification shall be supported by a copy of the results of all tests performed on the devices and device materials. Tests shall be certified correct by the testing laboratory personnel who conducted the test and interpreted the test results. ASTM equivalent testing methods are acceptable if supported by a complete description of the Standard used (such as JIS). The manufacturer shall provide CALTRANS samples of materials as directed.

Test data shall be supplied to assure that materials conform to test requirements outlined in Appendix A.

II.2 Test Device Requirements

The devices shall be designed and fabricated as shown on the working drawings supplied by the manufacturer, and all allowable tolerances shall be shown on the working drawings. Furthermore, a list of names and addresses of companies or subcontractors that manufacturer the test devices shall also accompany the working drawings.

The manufacturer must specify information to define the limits for testing pursuant to requirements provided in Table 1. Considerable thought should be exercised in defining design loads, design displacements, movement ratings, and operational temperature limits since these values reflect on the suitability of these devices for specific applications. The following design parameters shall be specified and used throughout this Test Plan.

**Design Compressive Load (DCL):** The maximum design vertical load (dead load, live load, overturning, etc.) for weight-bearing devices. The DCL should be no less than 500 kips. For sliding friction type bearings, the compressive pressure due to DCL should be no less than 4000 psi.
**Design Lateral Displacement (DD):** The maximum lateral displacement of seismic isolators under seismic loadings. The DD shall be no less than 12 inches.

**Movement Rating (MR):** The small displacement range (lateral) of the device due to temperature and live load fluctuations (excluding earthquakes). The MR should be no less than 3 inches.

**Design Lateral Load (DLL):** The maximum lateral load expected at DD.

<table>
<thead>
<tr>
<th>Table 1 Isolator Requirements$^{(1)}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design Compressive Load (DCL)</td>
</tr>
<tr>
<td>≥500 kips</td>
</tr>
</tbody>
</table>
III Device Testing Details

Two identical devices shall be provided to complete the testing. The test sequence shall follow the order of the test protocols shown on Table 2. One device shall be subjected to Test 1 through Test 6 and Test 8. The other device shall be subjected to Test 7, 8 and 9. Using two identical devices for the testing will limit the maximum number of loading cycles applied to any individual device, and provide information on the repeatability and consistency of performance.

At the manufacturer’s option, a single device may be used to complete the testing following the test order shown in Table 2.

III.1 Test Procedure Requirements

The temperature of the device before each test shall be maintained in the range of 60 degrees Fahrenheit to 90 degrees Fahrenheit.

All tests shall be performed with a continuous sinusoidal displacement input or a constant speed that corresponds to the required frequencies specified in each test. All high speed tests shall be performed with only one frequency, either 0.4 Hz or 0.5 Hz, unless noted otherwise and approved by Caltrans.

The tests shall be performed in the order listed in the table unless noted otherwise and approved by Caltrans.

Circular devices shall be tested in one arbitrarily selected primary direction of operation. Bi-symmetric devices (square or rectangular) shall be tested in the primary direction of operation and at 90 degrees to the primary direction for all tests.

All data shall be recorded continuously during each test. The temperature of the critical components that affect the performance of the device shall be recorded and monitored continuously during the testing.

III.2 Test Protocols

A summary of the test protocols is shown in Table 2. Details of the description and evaluation criteria of each test are specified in III.3, Test Descriptions and Evaluation.
Table 2  A Test Matrix for the Characterization and Qualification of Highway Bridge Seismic Isolation Bearings

<table>
<thead>
<tr>
<th>Test ID</th>
<th>Vertical Load / Pressure</th>
<th>Lateral Displ.</th>
<th>No. of Cycles</th>
<th>Vmax or Frequency(f)</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>DCL</td>
<td>±4 inches</td>
<td>10</td>
<td>0.02 in/sec</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>DCL</td>
<td>DD</td>
<td>5</td>
<td>0.4 Hz (or 0.5 Hz)</td>
<td></td>
</tr>
<tr>
<td>3A (FPS only)</td>
<td>2 ksi 4 ksi 6 ksi</td>
<td>DD</td>
<td>3</td>
<td>0.1 in/sec 1 in/sec 2 in/sec 4 in/sec</td>
<td>Optional: Constant Velocity</td>
</tr>
<tr>
<td>3B (LRB only)</td>
<td>0.6<em>DCL, 1.0</em>DCL 1.4*DCL</td>
<td>DD</td>
<td>3</td>
<td>0.4 Hz (or 0.5 Hz)</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>DCL</td>
<td>0.25<em>DD 0.5</em>DD 0.75<em>DD 1.0</em>DD 1.25*DD</td>
<td>3</td>
<td>0.4 Hz (or 0.5 Hz)</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>DCL</td>
<td>DD</td>
<td>Two series of 5 cycles</td>
<td>0.4 Hz (or 0.5 Hz)</td>
<td>Elapse time between the two series &lt;1 hours</td>
</tr>
<tr>
<td>6</td>
<td>DCL</td>
<td>±2 inches</td>
<td>10,000</td>
<td>f&lt;0.1 Hz and V&gt;0.075 inches/sec</td>
<td>Salt spray chamber for 1000 hours in accordance with the requirements of ASTM B 117 and ASTM D1654-05</td>
</tr>
<tr>
<td>7</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8A</td>
<td>DCL</td>
<td>1.0*DD</td>
<td>5</td>
<td>0.4 Hz (or 0.5 Hz)</td>
<td></td>
</tr>
<tr>
<td>8B</td>
<td>DCL</td>
<td>0.25<em>DD 0.5</em>DD 0.75<em>DD 1.0</em>DD 1.25*DD</td>
<td>3</td>
<td>0.4 Hz (or 0.5 Hz)</td>
<td></td>
</tr>
<tr>
<td>9A (FPS)</td>
<td>2 ksi 4 ksi 6 ksi</td>
<td>DD</td>
<td>3</td>
<td>4 in/sec</td>
<td></td>
</tr>
<tr>
<td>9B (LRB)</td>
<td>0.6<em>DCL, 1.0</em>DCL 1.4*DCL</td>
<td>DD</td>
<td>3</td>
<td>0.4 Hz (or 0.5 Hz)</td>
<td></td>
</tr>
</tbody>
</table>

Notes:
1. Vmax denotes the maximum velocity of the harmonic loading cycles.
2. For Test 2, 3B, 4, 8A, 8B, and 9B, a frequency of 0.5 Hz may be used throughout in lieu of 0.4 Hz.

February 8, 2011
III.3 Test Descriptions and Evaluation

Test 1 Low-frequency Performance Benchmark

**Purpose:** To experimentally verify the elastic stiffness and friction of the device under slow speed moving condition.

**Procedure:** The loads shall be applied as follows:

Ten fully-reversed continuous loading cycles with a lateral displacement of ±4 inches shall be applied to the test device at maximum velocity of 0.02 inches per second. The design compressive load (DCL) shall be applied and maintained during the test.

The lateral force at zero and peak displacements shall be reported for each cycle.

**Evaluation Criteria:** The lateral force at zero lateral displacement for all cycles shall be no larger than 8% of the design compressive load (DCL).

Test 2 High-frequency Performance Benchmark

**Purpose:** To experimentally verify the stiffness, damping, friction, and the response of the device under the dynamic condition.

**Procedure:** The loads shall be applied as follows:

Five fully-reversed continuous loading cycles with the lateral design displacement (DD) shall be applied to the test device at the frequency of 0.4 Hz or 0.5 Hz. The design compressive load (DCL) shall be also applied and maintained during the test.

The lateral force at zero and peak lateral displacements shall be reported for each cycle.

**Evaluation Criteria:** The ratio of the peak force at DD for the second cycle over that for the fifth cycle shall be within the range of 0.7 to 1.3.

Test 3 Vertical Load Characteristics

**Purpose:** To determine the effect of vertical load variation on the device.
Procedure: Three fully-reversed continuous cycles with the design lateral displacement (DD) shall be applied under various vertical loads.

Test 3A - For friction pendulum bearings only, three vertical loads that result in bearing pressures of 2, 4, and 6 ksi shall be tested. For each vertical load, four tests with varying speeds shall be performed. The maximum peak velocities for the four tests shall be 0.1, 1, 2, and 4 inches per second respectively.

Test 3B - For elastomeric bearings only, three vertical loads that result in bearing loads of 60% of DCL, 100% of DCL, and 140% of DCL shall be tested. All tests are performed at a frequency of 0.4 Hz. (Alternatively, all tests may be performed at a frequency of 0.5 Hz.)

The lateral force at zero and peak lateral displacements shall be reported for each cycle.

Evaluation Criteria: For elastomeric bearings only, the ratio of the peak force at 100% of DD for the second cycle over that for the third cycle is within the range of 0.85 to 1.15.

Test 4 Loading Rate Characteristics

Purpose: To determine dynamic performance characteristics in the primary direction of operation at various rates of loading.

Procedure: Three fully-reversed continuous cycles with each of the following lateral displacements shall be tested: 25%, 50%, 75%, 100%, and 125% of the design lateral displacement (DD). All tests shall be performed at the frequency of 0.4 Hz. (Alternatively, all tests may be performed at a frequency of 0.5 Hz.) The design compressive load (DCL) shall be applied and maintained during the test.

The lateral force at zero and peak displacements shall be reported for each cycle.

Evaluation Criteria: The ratio of the peak force at DD for the second cycle over that for the third cycle is within the range of 0.85 to 1.15.

Test 5 Durability Test

Purpose: To assess component durability resulting from a moderate number of full design displacement cycles.

Procedure: Two sets of five(5) fully-reversed continuous cycles of 100% design lateral displacement (DD) shall be applied to the test device at the frequency of 0.4 Hz. (Alternatively, the test may be performed at a frequency of 0.5 Hz.). The design compressive load (DCL) shall be simultaneously applied and maintained during the test. The two sets of 5-
cycle series may be separate by an elapse time of no longer than one hour to allow the device to cool down.

The lateral force at zero and peak lateral displacements shall be reported for each cycle.

**Evaluation Criteria:** The ratio of the peak force at 100% of DD for the second cycle over that for the fifth cycle is within 0.7 and 1.3, and the ratio of the peak force at DD for the seventh cycle over that for the tenth cycle is within the range of 0.7 to 1.3.

**Test 6  Fatigue and Wear (All Categories)**

**Purpose:** To simulate many small displacements due to temperature and live load fluctuations other than earthquake for evaluating possible deterioration in earthquake performance due to resulting wear or fatigue.

**Procedure:** The device is subjected to a minimum of 10,000 cycles of simulated displacement representing the Movement Rating (MR) of the device. The maximum lateral displacement of each cycle may be ±2 inches. The loading shall be applied at a frequency not greater than 0.1 Hz. However, the peak velocity of the loading shall not be less than 4.5 inches/minute. The full design compressive load DCL shall be simultaneously applied and maintained during the test.

**Evaluation Criteria:** There shall be no sign of debonding or damage on the test device. The thickness of PTFE wearing surface after the test shall be at least 90% of that prior to the test.

**Test 7  Environmental Exposure Effect**

**Purpose:** To simulate the condition of the device that is subjected to a salt spray environment over a long period of time such as a device installed under an open bridge deck joint where salting occurs regularly.

**Procedure:** The device shall be exposed in a salt spray chamber for 1000 hours in accordance with the requirements of ASTM B 117 and ASTM D1654-05.

**Evaluation Criteria:** No evaluation is required.

**Test 8  Load-Deflection Characteristics After Environmental Exposure**

**Purpose:** To determine dynamic performance characteristics after environmental exposure.
Procedure: Test 8A - Five fully-reversed continuous loading cycles with the lateral design displacement (DD) shall be applied to the test device at the frequency of 0.4 Hz. The design compressive load (DCL) shall be applied and maintained during the test. Test 8B - Three fully-reversed continuous cycles with 25%, 50%, 75%, 100%, and 125% of design lateral displacement (DD) shall be applied to the test device at 0.4 Hz. The design compressive load (DCL) shall be simultaneously applied and maintained during the test. (Alternatively, all tests may be performed at a frequency of 0.5 Hz.)

The lateral force at zero and peak displacements shall be reported for each cycle.

Evaluation Criteria: (A) The ratio of the peak force at 100% of DD for the second cycle over that for the fifth cycle is within the range of 0.7 to 1.3. (B) The ratio of the peak force at 100% of DD for the second cycle over that for the third cycle is within the range of 0.85 to 1.15.

Test 9 Vertical Load Characteristics After Environmental Exposure Effect

Purpose: To determine the effect on the device due to vertical load variation after environmental exposure.

Procedure: Three fully-reversed continuous cycles with the design lateral displacement (DD) shall be applied under various vertical loads. Test 9A - For friction pendulum bearings only, three vertical loads that result in bearing pressures of 2, 4, and 6 ksi shall be tested. For each vertical load, four tests with varying speeds shall be performed. The maximum peak velocities for the four tests shall be 0.1, 1, 2, and 4 inches per second respectively. Test 9B - For elastomeric bearings only, three vertical loads that result in bearing loads of 60% of DCL, 100% of DCL, and 140% of DCL shall be tested. All tests are performed at a frequency of 0.4 Hz. (Alternatively, all tests may be performed at a frequency of 0.5 Hz.)

The lateral force at zero and peak displacements shall be reported for each cycle.

Evaluation Criteria: The test device shall be stable during the tests and show no sign of damage.
III.4 Device Test Reporting Requirements

The test results shall be reported in a graphical format that includes the key test data listed in Table 3. The numerical values of key data such as those used for acceptance measure in each test shall also be reported on each plot.

<table>
<thead>
<tr>
<th>Test No.</th>
<th>Reported Data</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A  B  C  D  E  F  G  H  I  J  K</td>
</tr>
<tr>
<td>1</td>
<td>X  X  X  X  X  X  X  X  X  X  X</td>
</tr>
<tr>
<td>2</td>
<td>X  X  X  X  X  X  X  X  X  X  X</td>
</tr>
<tr>
<td>3</td>
<td>X  X  X  X  X  X  X  X  X  X  X</td>
</tr>
<tr>
<td>4</td>
<td>X  X  X  X  X  X  X  X  X  X  X</td>
</tr>
<tr>
<td>5</td>
<td>X  X  X  X  X  X  X  X  X  X  X</td>
</tr>
<tr>
<td>6</td>
<td>X  X  X  X  X  X  X  X  X  X  X</td>
</tr>
<tr>
<td>7</td>
<td>No Performance Testing - A brief Report shall be prepared</td>
</tr>
<tr>
<td>8</td>
<td>X  X  X  X  X  X  X  X  X  X  X</td>
</tr>
<tr>
<td>9</td>
<td>X  X  X  X  X  X  X  X  X  X  X</td>
</tr>
</tbody>
</table>

A  Lateral Displacement vs. Time
B  Lateral Force vs. Time
C  Lateral Force vs. Lateral Velocity (calculated)
D  Lateral Force vs. Lateral Displacement for all cycles and each cycle
E  Dissipated Energy (Calculated) for each cycle
F  Restoring Stiffness (Calculated) for each cycle
G  Characteristic strength Temperature vs. Time
H  Vertical Displacement vs. Time
I  Compressive Force vs. Time
J  Compressive Force vs. Lateral Displacement
K  Vertical Displacement vs. Lateral Displacement
IV Report Submittal

The manufacturer shall submit the following information in the report:

1) Material Specifications used to manufacture or purchase the test articles a written summary (<5 pages) of the manufacturer's quality control program to assure that all component materials and fabrication processes comply with the submitted working drawings.

2) ASTM test data for materials. (See Section II.1)

3) Environmental Requirements used to assess harsh environmental effect such as ultraviolet, ozone, salt spray, moisture, sand or dust, etc.

4) Analytical methods used to predict test article response for displacement or velocity load response, stiffness, and damping. The predicted performance shall be placed on the working drawings.

5) Working drawings

6) Testing equipment setup and certification of the calibration of all measuring equipment used in the testing.

7) Testing results of each test protocol specified in the test matrix shown in Table 2. The test results should include the reporting requirements listed in Table 3. For tests which contain multiple cyclic motions, there shall be one plot showing all cycles combined and other plots showing each individual cycle.

8) A summary table showing that the test results comply with evaluation criteria limits or ranges specified in each test.
Appendix A

Material & Fabrication Requirements

HIGHWAY BRIDGE SEISMIC ISOLATOR DEVICES-Devices shall be designed and fabricated as shown on the working drawings supplied by the manufacturer and as provided in the following specifications.

Alternative methods and materials may be supplied by the manufacturer, if supported by complete description and test data.

GENERAL --

Metal parts shall conform to the following:

<table>
<thead>
<tr>
<th>Material</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steel bars, plates and shapes</td>
<td>ASTM Designation: A 709, grade 36, 50, or 50W A 575, A 576 (AISI or M Grades 1016 through 1030 except Grade 1017) A 570, A 572 A 572 Grade 50</td>
</tr>
<tr>
<td>Steel fasteners for general applications:</td>
<td></td>
</tr>
<tr>
<td>Bolts and studs which include threaded rods and non-headed anchor bolts</td>
<td>ASTM Designation: A 307; F 568 Class 4.6 A 108 AASHTO Designation: M 314, Grade 36 or 55</td>
</tr>
<tr>
<td>Nuts</td>
<td>ASTM Designation: A 563 including Appendix X1; A 563M including Appendix X1</td>
</tr>
<tr>
<td>Material</td>
<td>Specification</td>
</tr>
<tr>
<td>-------------------------------------------------------------------------</td>
<td>---------------------------------------------------</td>
</tr>
<tr>
<td>Washers and other parts for general applications</td>
<td>Commercial quality</td>
</tr>
<tr>
<td>High strength steel fasteners:</td>
<td></td>
</tr>
<tr>
<td>Bolts for structural steel joints</td>
<td>ASTM Designation: A 325; A 325M</td>
</tr>
<tr>
<td>Bolts and studs which include threaded rods and non-headed anchor bolts</td>
<td>ASTM Designation: A 449; F 568, Class 9.8 (M1.6-M14), Class 8.8 (M16-M72), Class 8.8.3 (M16-M36)</td>
</tr>
<tr>
<td>Nuts</td>
<td>ASTM Designation: A 563 including Appendix X1; A 563M including Appendix X1</td>
</tr>
<tr>
<td>Washers</td>
<td>ASTM Designation: F 436; F 436M</td>
</tr>
<tr>
<td>Stainless steel bars and plates</td>
<td>ASTM Designation: A 240, Type 304 or 316</td>
</tr>
<tr>
<td>Stainless steel fasteners for general applications:</td>
<td>Alloys 304, 316</td>
</tr>
<tr>
<td>Bolts, screws, nuts, and studs which include threaded rods and non-headed anchor bolts</td>
<td>ASTM Designation: F 593; F 738M</td>
</tr>
<tr>
<td>Washers</td>
<td>ASTM Designation: A 240; ANSI B 18.22M</td>
</tr>
<tr>
<td>Carbon-steel castings</td>
<td>ASTM Designation: A 27/A 27M, Grade 65-35 [450-240], Class 1</td>
</tr>
<tr>
<td>Malleable iron castings</td>
<td>ASTM Designation: A 47, Grade 32510; A 47M, Grade 22010</td>
</tr>
<tr>
<td>Gray iron castings</td>
<td>ASTM Designation: A 48, Class 30B</td>
</tr>
<tr>
<td>Ductile iron castings</td>
<td>ASTM Designation: A 536, Grade 65-45-12</td>
</tr>
<tr>
<td>Cast iron pipe</td>
<td>Commercial quality standard soil</td>
</tr>
</tbody>
</table>
### Metallic Materials - Steel

<table>
<thead>
<tr>
<th>Material</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steel pipe</td>
<td>ASTM A 53 Type E or S</td>
</tr>
<tr>
<td>Steel Sheet Metal</td>
<td>A 570</td>
</tr>
<tr>
<td>Steel Forgings</td>
<td>ASTM designation: A 668 Class C(Carbon), Class G(Alloy)</td>
</tr>
<tr>
<td>H.D. Galvanized Coatings</td>
<td>ASTM A 123, A 153</td>
</tr>
</tbody>
</table>

### Non Ferrous Materials

<table>
<thead>
<tr>
<th>Material</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>PTFE or Equivalent</td>
<td>ASTM D 1457</td>
</tr>
<tr>
<td>Elastomers and Seals</td>
<td>ASTM D 4014</td>
</tr>
<tr>
<td>Bronze Castings</td>
<td>ASTM B 22</td>
</tr>
<tr>
<td>Copper Alloy</td>
<td>ASTM B 100</td>
</tr>
</tbody>
</table>

Non-structural welding shall conform to the requirements in AWS D1.1 or as specified by the manufacturer. Welding of stainless steel parts shall be performed using modern commercial shop practice with stainless steel electrodes. Structural welding, if present, shall conform to the requirements in AWS D1.5.

The external seals or external elastomers in any device shall show no cracks when tested for ozone resistance at 20 percent strain, 100 hrs. at 104° ± 3.6° F. in accordance with ASTM Designation: D 1149 (except 50 ± 5 parts per 100,000,000).

Devices shall be permanently marked on 2 of 4 sides. The markings shall consist of production lot number, date of fabrication, design load, and sample number.
Devices shall be assembled at the factory and suitable temporary assembly ties shall be provided so that the entire assembly is shipped as a unit and remains intact when uncrated and installed. Should it become necessary to disassemble the test device during testing, component pieces shall be match marked to ensure they can be restored to their original place and oriented as manufactured.

The manufacturer shall provide the testing Contractor with a Certificate of Compliance listing all materials in the device. The certificate shall certify that the devices conform to the design and material requirements, and were manufactured in accordance with the approved quality control program. The certification shall be supported by a copy of the results of all tests performed on the devices and device materials.

Tests results shall be certified correct and signed by the testing laboratory personnel who conducted the test and interpreted the test results.

**ELASTOMERIC DESIGNS --**

The devices with alternate layers of rubber and steel plates vulcanized together shall conform to the provisions for steel-laminated elastomeric bearings in ASTM Designation D 4014.

The elastomer in the elastomeric bearing shall be specified by the manufacturer. The elastomer shall be natural rubber only. (High damping rubber is not allowed.) Elastomeric bearings with a lead core shall have a core consisting of a minimum of 99 percent pure lead.

Galvanizing of steel laminates will not be required.

The steel laminates shall be covered at the sides of the bearing with a minimum thickness of 0.5-inch of the same elastomer as specified for the elastomeric bearing.

**SLIDING ELEMENT IN SLIDER AND ROLLER DESIGNS (Category II) AND SLIDER ON CURVED SURFACE DESIGNS --**

The devices with sliding element shall conform to the details shown on the working drawings, and the following:

The bearing material which slides on the metal surfaces may be polytetrafluoroethylene (PTFE) surfacing or other material specified by the manufacturer. All alternative materials shall be identified as to their generic properties, including their physical test properties.

The sliding element shall be protected from exposure to conditions which may affect the friction coefficient of the sliding element.

February 8, 2011
The PTFE bearing surface using a fabric shall be filled or unfilled PTFE fabric made from virgin PTFE oriented multifilament and other fibers. The resin in the filaments shall be virgin PTFE material (not reprocessed) meeting the requirements of ASTM Designation: D 1457.

The PTFE bearing surface using a sheet shall be made from unfilled PTFE resin and shall conform to the following requirements:

The PTFE resin shall be virgin material (not reprocessed) meeting the requirements of ASTM Designation: D 1457. Specific gravity shall be from 2.13 to 2.19. Melting point shall be 623°F (±2°F).

The unfilled PTFE sheets shall be recessed into a steel backing plate a minimum of 1/2 the PTFE thickness.

The PTFE sheet shall be adhesive bonded in the recess of steel plate under controlled factory conditions. The adhesive material shall be an epoxy resin conforming to the requirements of Federal Specification: MMM-A-134.

Contact surfaces of PTFE sheet and steel plate to be bonded shall be uniformly roughened to a minimum roughness height value of 250 micro-inches.

The side of the PTFE sheet to be bonded shall be factory treated by the sodium naphthalene or sodium ammonia process, after the contact surface is roughened.

The bearing liner shall be self-lubricating bonded to the articulated slider and steel block and shall use no added lubricants. The bearing liner material shall be a non-metallic, self-sacrificing solid lubricant type and shall have dynamic and wear characteristics required to meet the specified bearing performance, as verified by the testing. The bearing liner material shall have a compressive strength of at least 40 ksi and a minimum thickness of 0.06 inches.

Stainless steel surfaces shall be a weld overlay on structural steel plate, or at the Contractor's option, solid or sheet stainless steel with a minimum thickness of 0.060 inch.

When a weld overlay is used for stainless steel surfacing, the overlay shall be a minimum of 3/32 inch thick after welding, grinding and polishing and shall be produced using Type 309L electrodes.

When sheets are used for stainless steel surfacing, the sheets shall be attached by perimeter welding. After completion of the weld operation, the stainless steel surface shall be smooth and free from waves.

February 8, 2011
The mating surface of the stainless steel plate in contact with the PTFE surfacing shall have a surface finish determined according to ANSI Standard B46.1. The sliding element of the devices shall have a coefficient of initial static friction as specified by the manufacturer.

Stainless steel surfaces shall not be painted.
Glossary

AASHTO. American Association of State Highway and Transportation Officials
AISI. American Iron and Steel Institute
ASTM. American Society for Testing and Materials
AWS. American Welding Society
Damping. The ability to dissipate energy.
Damping Device. A device that is designed to dissipate energy.
Design Displacement (DD). The maximum lateral displacement of seismic isolators and the maximum displacement of energy dissipators under seismic loading.
Design Compressive Load (DCL). The maximum design vertical load (dead load, live load, overturning, etc.)
Design Lateral Load (DLL). The maximum lateral load expected under seismic loading. (Except Energy Dissipators)
Motion-Controlled. Specified motion that an isolator or energy dissipator is forced to follow.
Movement Rating (MR). The small displacement range (lateral) of the device due to temperature and live load fluctuations (excluding earthquakes).
Spherical Slider Isolator. An device consisting of one surface that either rolls or slides on another spherical surface designed to return to its unloaded position when lateral loads are removed.
Slider Isolator. A device that utilizes rollers or sliding surfaces to isolate a structure from ground motion produced by an earthquake.