SECTION 13 08 50

VISCOUS DAMPERS

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:

1. Designing, testing, furnishing, and installing viscous dampers, extender braces, clevis plates, flange plates, spherical bearings, pins, spacer plates, mounting bolts, nuts and washers, damper-to-extender-brace assembly equipment, and accessories.

B. Related Sections:

1. Section 01 45 29 – Testing Laboratory Services
2. Section 05 12 00 – Structural Steel

1.02 REFERENCE STANDARDS

A. Standards listed below apply where designation is cited in this Section. Where the applicable year of adoption or revision is not listed below, the latest edition applies.

B. ICBO – International Conference of Building Officials

1. International Building Code (IBC), Latest Edition

C. AISC – American Institute of Steel Construction

1. Specification – Specification for Structural Steel Buildings, Latest Edition.
2. Code – Code of Standard Practice for Steel Buildings and Bridges, Latest Edition. Articles 3.2 and 3.3 and Sections 4 and 9 of AISC Code are superseded by requirements of the General Conditions, Special Conditions and Contract Documents.

D. ASCE – American Society of Civil Engineers

1. Seismic Rehabilitation of Existing Buildings, ASCE 41-06.

E. ASTM – American Society for testing and Materials

1. A36: Standard Specification for Structural Steel.
2. A108: Standard Specification for Steel Bars, Carbon, Cold-Finished Standard Quality.
3. A240: Standard Specification for Heat-Resisting Chromium and Chromium-Nickel Stainless Steel Plate, Sheet and Strip for Pressure Vessels.
4. A312: Standard Specification for Seamless and Welded Austenitic Stainless Steel Pipe.
5. A325: Standard Specification for High-Strength Bolts.
6. A1011: Standard Specification for Structural Steel.

7. A1018: Standard Specification for Structural Steel.
8. A572: Standard Specification for High Strength Low Alloy Columbium-Vanadium Steels of Structural Quality.
9. B505: Standard Specification for Copper-Base Alloy Continuous Castings.
10. B650: Standard Specification for Electrodeposited Engineering Chomium Coatings on Ferrous Substrates.
11. B733: Standard Specification for Autocatalytic (Electroless) Nickel-Phosphorous Coatings on Metal.
12. E4: Standard Practices for Load Verification of Testing Machines.

F. SAE Aerospace Material Specification
1. SAE-AMS-QQ-C-320: Specification for Industrial Chrome Plating.
2. SAE-AMS-STD-2175: Casting, Classification and Inspection

G. SSPC: SSPC: The Society for Protective Coatings
1. SP6: Commercial Blast Cleaning.

H. AWS: American Welding Society
1. D1.1: Structural Welding Code – Steel.

I. U.S. Government, Military Specifications
1. MIL-STD-889: Dissimilar Metals.
2. MIL-HDBK 5: Specification for Metallic Materials.

J. ISO – International Standards Organization
1. ISO-9001: Quality Management Systems.
2. ISO-10012: Measurement Management Systems.
3. ISO-10012-1: Quality Assurance Requirements for Measuring Equipment.

K. ASME – American Society of Mechanical Engineers
1. Boiler and Pressure Vessel Code.

1.03 ENGINEERING DESIGN REQUIREMENTS

A. Constitutive law: The dampers shall conform to the design target force-velocity relationship, as described by Eq. 1.

$F = CV^{0.3}$ (Eq. 1)

Where:

F is the force output of the damper (kips)

C is the damping coefficient (kip-(sec/in.)^0.3)

V is the relative velocity between the ends of the damper (inches/sec.)

B. The BSE-2 design requirements for the dampers follow the requirements of ASCE 41-06 Section and are as follows:

1. 110k Damper
    a. Velocity Exponent = 0.3
    b. Damping Coefficient C = 44 kip-(sec/in.)^0.3
    c. Force
        1) BSE-2 Force = 110 kips
        2) Required Force = $(1.3)^{0.3}$ x 110 = 120 kips
    d. Displacement
        1) BSE-2 Displacement = +/- 2.3 inches
        2) Required Stroke = +/- 1.3 x 2.3 = +/- 3.0 inches
    e. Velocity
        1) BSE-2 Velocity = 21.2 in/sec
        2) Required Velocity = 1.3 x 18.5 = 27.6 in/sec
    f. Dynamic Stiffness = 460 kip/in
    g. Quantity = 14 installed + 2 prototype
2. 220k Damper
    a. Velocity Exponent = 0.3
    b. Damping Coefficient C = 89 kip-(sec/in.)^0.3
    c. Force
        1) BSE-2 Force = 220 kips
        2) Required Force = $(1.3)^{0.3}$ x 220 = 240 kips
    d. Displacement
        1) BSE-2 Displacement = +/- 2.7 inches
        2) Required Stroke = +/- 1.3 x 2.7 = +/- 3.5 inches
    e. Velocity
        1) BSE-2 Velocity = 21.0 in/sec
        2) Required Velocity = 1.3 x 21.0 = 27.3 in/sec
    f. Dynamic Stiffness = 975 kip/in
    g. Quantity = 29 installed + 2 prototype

C. Design Life: 50 years.

1.04 PERFORMANCE CRITERIA

The viscous dampers are intended to satisfy the following performance criteria requirements for the Design Life defined in 1.03.C:

A. Fluid Expansion Compensation: the dampers shall contain provisions to allow for thermal expansion and contraction of the fluid to prevent excessive buildup of internal pressure and also to prevent the formation of a vacuum over the temperature range of +40° F to +120° F. Fluid expansion compensation shall be designed to accommodate changes due to ambient temperature variations and earthquake events.

B. Axial Load: The design axial load (BSE-2) shall be as shown in 1.03.B above, in tension or compression with the rod fully extended, retracted or at any intermediate position. In addition, dampers shall be capable of safely sustaining a maximum axial force 15% greater than the BSE-2 Force, in compression or tension, at any point within the total stroke without failing or binding.

C. Fluid Pressure: The damper shall be designed to withstand the following internal pressures:

1. Proof: 150 percent of the internal pressure present at velocities equal to 1.0V (where V is defined in paragraph 1.03.B at 70° F ± 10° F). When subjected to the proof pressure for five (5) minutes, damper units shall show no signs of external leakage of the operating fluid.
2. Burst: 100 percent of the internal pressure present at velocities equal to 2.5 V (where V is defined in paragraph 1.03.B at 70° F ± 10° F). When subjected to the burst pressure, all structural components of the vessel shall have stresses below the published ultimate (tensile strength) limit.

D. Factors of Safety: Each damper, including end clevises, bearings and pins, shall be designed per the 1992 ASME Boiler and Pressure Vessel Code for minimum factors of safety of 2.0 for material yield stress, 2.0 for critical buckling (ASME – Section NF), and 2.5 for material ultimate stress. Factors of safety shall be applied to the forces listed in paragraph 1.03.B. The total forces and moments introduced into each damper component by the simultaneous acceleration at 1.5g of the damper shall be considered in the design checks for the factors of safety. The allowable stresses (F_a, F_v, F_b, F_t) given in ASME – Article NF – 3322 may be increased by a factor of 1.5 for the design check. The analysis for critical buckling shall assume that the piston rod is in the fully extended position. The buckling analysis shall consider the damper unit to be part of the overall diagonal brace assembly and the buckling length for the damper unit design shall be developed accordingly. Where threaded inserts are to be used for field installation of dampers, calculations shall be prepared and submitted for the design of such inserts, considering such inserts to be part of the entire damper assembly.

E. Force and Velocity Limits: The normal operating force developed over the design range of velocity, including the effects of temperature

variations due to both ambient conditions and an earthquake event, shall be verified by prototype and production testing and shall always fall within the range defined by ±10% of the force computed using the design force-velocity relation of 1.03.A.

F. Leakage: The dampers shall be designed to accommodate a dynamic leakage level that has no effect on the damper's performance. This leakage shall be quantified in a way that is easily measurable. Under non-operating conditions, static seals shall not leak externally. The dampers shall show no visible evidence of external leakage when subject to proof pressure for five (5) minutes.

G. Stroke: Viscous dampers shall be capable of satisfying all performance requirements of this Section when cycled about any point within ± 100% of the BSE-2 Displacement, about the mid-point of the total stroke. The damper shall have as a minimum, a total travel per Section 1.03.B.

H. Adjustment: The dampers shall be designed to provide for a length adjustment of plus or minus 1.0 in. The adjustment required may be met by providing appropriate additional stroke. The Manufacturer shall ensure that it is possible to make static adjustments to the position of the piston rod relative to the main cylinder of the damper.

I. Articulation: The end attachments of the dampers shall allow for free articulation of the unit in any direction up to a maximum horizontal angle of 3 degrees concurrent with a maximum vertical angle of 1 degree. The entire assembly shall be designed to fully operate for specified loads and the articulated condition limits given above. For all dampers, spherical bearings shall be provided per the contract documents.

J. Environmental conditions: The unit shall be capable of operating as specified for an ambient air temperature range of +40° to +120° F. The unit shall be designed to withstand any combination of atmospheric elements, including moisture, wind, ozone and dust.

K. Lateral load resistance: The dampers, including extender rods, end clevises, bearings and pins and connections between the same, shall be designed to withstand a lateral acceleration of 1.5 g of the damper and brace assembly applied in any direction and for any position of rod extension/retraction, in combination with the maximum axial forces specified in Section 1.03.B.

1.05 SUBMITTALS

A. Schedules: The Manufacturer shall submit a detailed manufacturing schedule for the viscous dampers and extender braces for the project at least 30 days prior to the start of any manufacturing work. The Manufacturer shall submit a detailed schedule of submittals, no later than 30 days after award of contract.

B. Proposed Product List:

1. Submit a complete list of major products proposed for use with name of manufacturer, trade name, and model number of each product.
2. For products specified only by reference standards, give manufacturer, trade name, model or catalog designation and reference standard.

C. Certificates of Compliance that all materials and products conform to, or exceed, the specified requirements.

D. Shop Drawings including, but not limited to, fabrication drawings, installation drawings, setting diagrams, bolting templates and schedules. Submit Shop Drawings for:

1. Viscous dampers indicating dimensions, weights, component material types and method of assembly.
2. All steel, mounting and connecting hardware that is integral with the damper, including, but not limited to extender braces, end clevises, bearings, and connection pins.
3. Provide written storage, handling, lifting, and installation instructions for the dampers.
4. Detailed transportation plan showing the route through the facility over which the dampers and all components will be transported from the storage areas to the point of final disposition, including any stocking areas.
5. Splice locations for Damper Extensions. Expect noted on plan as dampers and damper extension that may not have flanged connections, one splice per damper extension is allowed, located approximately in the center of the extension member.

E. System Interface Drawings: Provide detailed drawings titled “System Interface Drawings” for each of the typical damper assemblies. Indicate the vendor or subcontractor responsible for providing each component of the damper-frame system including all connection components, pins, clevis plates, shims, bolts and extender braces.

These drawings shall be produced only after at least one “System Interface Meeting” has occurred. See the requirements for System Interface Meetings in Article 1.06 of this Section.

F. Product Data Requirements: Product data including, but not limited to, manufacturer's product specifications and installation instructions.

G. Technical Data: Technical Data including, but not limited to, the following:

1. Manufacturing procedures and specifications for viscous dampers including identification of applicable codes and standards. Manufacturers shall submit any information which pertains to manufacturing practices and constraints that should be considered in the design of viscous dampers utilizing the Manufacturers' proposed materials.
2. Mounting requirements: installation and mounting requirements, including any need for special techniques, methods, or equipment.
3. Product quality:
    a. Product life.
    b. Fire resistance rating.
    c. Durability of viscous dampers to resist the effects of aging, creep, fatigue, moisture, ozone, chemicals, and other environmental effects.
4. Recommended routine maintenance and periodic inspection requirements: The Manufacturer shall recommend a program for routine maintenance and periodic inspection. At a minimum, the inspection interval, a summary of the inspection tasks to be performed, and any special equipment required as part of the inspection shall be described. The maintenance and inspection program shall include recommendations for periodic testing of the spare dampers to assess the long-term performance of the dampers.
5. Recommended inspection and replacement requirements: The Manufacturer shall recommend a program for inspection and replacement of the dampers and components. This program shall include:
    a. Post-earthquake inspection and replacement requirement.
    b. Method to replace dampers and conceptual details to accommodate replacement.

H. Quality Control Program and Certifications:
   1. Submit a complete description of the Manufacturer's quality control and assurance programs for this project and include all applicable certifications. Manufacturer shall provide a certification that the materials, techniques, methods, and staff proposed for this project will not be altered or modified over the course of this project, unless specifically requested by the Resident Engineer.
   2. Submit a copy of manufacturer’s current ISO 9001 Certificate.

I. The Manufacturer shall provide appropriate specifications and standards for materials and tests that are not covered in this Section to the Resident Engineer for review and comment.

J. Design Calculations and Drawings:
   1. Drawings and design calculations shall be signed and sealed by a registered Professional Engineer (Civil or Mechanical) experienced in the design and fabrication of viscous damping devices, for the material or assembly specified to demonstrate compliance with the Contract Documents.
   2. The calculations shall include, but not necessarily be limited to, the following:
      a. A complete set of design calculations for each type of viscous damper unit and all components including integral end clevis, a complete summary of viscous damper design variables, formulas, and assumptions.
      b. Engineering properties:
         1) Damping coefficient.
         2) Force-velocity characteristics.
         3) Maximum/minimum operating temperature.
         4) Maximum internal fluid pressure under the MCE condition.
         5) Factor-of-safety and buckling calculations (per paragraph 13085.1.04.D and the ASME code).
         6) Maximum lateral load capacity.
         7) Maximum axial load capacity.
         8) Proof pressure.

K. Test Data: Test data from viscous damper tests specified in this Section shall be documented into separate bound reports. The reports shall be entitled "Prototype Damper Test Report" and "Final Production

Damper Test Report", as required by Articles 2.07 and 2.08 of this specification.

L. Dolly and Hoist Plans and Calculations: 5 copies of each, signed and sealed by a registered Professional Engineer (Civil) verifying that proposed loading from point of origin to final installation point will not exceed the dead and live load capacities for elevators, floors, and existing construction. The Dolly and Hoist Plans shall also verify a path of travel that provides adequate space for the dampers, brace extensions, and connection components to be freely transported into and through the building and to their points of installation without clashing with existing structural and non-structural elements.

M. Operating and maintenance data including, but not limited to, the following:
   1. Installation instructions.
   2. Spare parts list.
   3. Copies of guarantees.
   4. Inspection procedures.
   5. Shop Drawings and Product Data.

N. Certification:
   1. Certification that all testing equipment has been checked for accuracy by appropriate standards (ASTM E4) for the purpose of this project.
   2. Certified mill test reports for all steel to be used.

O. Inspection and Test Reports:
   1. Prototype Damper Test Report: Submit Prototype Damper Test Report, as described in paragraph 2.07.C.4 within fourteen (14) calendar days of the completion of testing for review and approval by the Resident Engineer prior to commencement of fabrication of the Production Dampers.
   2. Production Damper Test Report: Submit Production Damper Test Reports, as described in paragraph 2.08.B.1 for each Production Damper within seven (7) calendar days of the completion of testing of the subject damper.
   3. Final Production Damper Test Report: Submit the Final Production Damper Report, as described in paragraph 2.08.B.2, within fourteen (14) calendar days of the completion of all Production Damper testing.

P. Proposed Test Procedures:

1. Submit complete and detailed information, including drawings, describing test equipment capacities and test procedures, and location of test equipment to be used for all tests required in this Section at least thirty (30) days prior to commencement of tests, for review and approval by the Resident Engineer. This applies to all viscous dampers, testing equipment, and apparatus proposed for use in the testing program. Testing shall not proceed until approval is received from the Resident Engineer.

Q. Color Samples:

1. At the Owner’s option, the owner shall select the color of any architecturally exposed dampers. Submit samples of the selected colors and finishes, minimum 6” x 6”, for final approval prior to production.

1.06 SYSTEM INTERFACE

A. System Interface Meetings: The Contractor shall conduct “System Interface Meetings” starting no later than 30 days after “Notice to Proceed” is given to the Manufacturer. The purpose of the System Interface Meetings is to identify and resolve any potential conflicts in the design, manufacture or installation of the damper-frame assembly. A product of these meetings will be the “System Interface Drawings” identified in paragraph 1.05.E. The Contractor, Resident Engineer and all subcontractors and vendors responsible for the manufacture and installation of the damper-frame assemblies and associated components shall attend these meetings.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Deliver products in the Manufacturer's original container, with labels intact and legible.

1. Deliver Production Dampers and Prototype/Spare Dampers in protective packaging to the job site for short-term (3 months maximum) storage. Damaged dampers or components shall not be delivered to the job site. Damaged dampers or components shall be repaired or replaced with new items of the same type. Replacement or repair of any damaged damper or component shall be at the Manufacturer’s expense. Immediately notify the Resident Engineer if damage to a damper is discovered. In the event a damper or its components are damaged, the Resident Engineer shall determine whether the damper may be repaired or shall be replaced.

2. Store dampers and components on pallets, provided by the Manufacturer to allow for transport by forklift to the job site and within the Contractor's designated storage/staging area as shown on the drawings.
3. Care shall be exercised in the handling of the dampers at all times to prevent damage, breaking, denting, or scoring. In the event of damage, notify the Resident Engineer.

B. The Resident Engineer may reject as non-complying such products and equipment that do not bear satisfactory identification as to BSE-2 force, stroke, and other pertinent information as specified.

1.08 WARRANTY

A. Provide written warranty that dampers will be free of defects in material, operation, and installation for a period of 20 years following installation of the dampers.
1. Warranty shall include replacement of defective dampers and associated components.
2. As part of this warranty, vendor shall supply failure reports and attendance by its engineering staff as required in any failure investigation.
3. A certification statement that a maintenance plan does not have to be purchased to activate the warranty shall be submitted with the cost proposal.

PART 2 - PRODUCTS

2.01 VISCOUS DAMPERS

A. Provide production viscous dampers, extender braces, clevis plates, flange plates, spherical bearings, pins, spacer plates, mounting bolts, nuts and washers, damper-to-extender-brace assembly equipment, and accessories.

B. Only manufacturers providing products listed in this Section 13 08 50 will be accepted.

C. Dampers for Prototype Testing (and Spares):
1. Provide three (3) full-size dampers as required for the prototype damper test program.
2. The prototype dampers shall be identical to the production dampers in every way, including all details, parts, components, and methods of manufacture, and shall comply with the project specifications for the production dampers in every respect. No deviations from this requirement will be permitted.

3. After prototype tests are complete and approved by the Resident Engineer, prototype dampers shall be refurbished as necessary, and tested in accordance with Production Damper Tests (2.08). After approval by the Resident Engineer that the dampers have satisfied the acceptance criteria of paragraph 2.08.C they shall be identified as Spares, and shipped to the jobsite and turned over to the Contractor.

2.02 GENERAL REQUIREMENTS

A. Provide viscous dampers of size and materials as specified in the Contract Documents.

1. Dimensions: The overall dimensions of the damper and extender brace assembly, including mounting plates, and except for flange connection plates where allowed per the contractor drawings, shall be held to a minimum consistent with the requirements of this Section, and in no case shall exceed the dimensions shown in the Contract Documents. The dimensional limits specified are:

a. 110k Dampers

1) Diameter $\leq$ 6.625 inches.

b. 220k Dampers

1) Diameter $\leq$ 8.625 inches.

2. External reservoirs shall not be permitted.

B. Provide viscous dampers that comply with the engineering design requirements and performance criteria of this specification. The Manufacturer shall be fully responsible for compliance with these criteria including all production and prototype tests, quality control, and quality assurance measures required by this Section.

2.03 MATERIALS AND FABRICATION

A. General: Dissimilar metal joints shall not be permitted without a non-metallic separator or gasket of at least 0.06 inch thickness. The use of aluminum, aluminum alloys, magnesium, magnesium alloys, beryllium, and beryllium alloys is prohibited. All materials and processes used shall be identified in the Manufacturer's drawings by specifications or standards.

B. Materials: Structural materials shall have allowable stress values taken from ASME Boiler and Pressure Vessel Code, Section II, Part D.

1. Unless suitably protected against electrolytic corrosion, dissimilar metals as defined in MIL-STD-889 shall not be used in contact with each other.

2. Components exposed to the atmosphere or internal pockets of air or gas shall be suitably protected against corrosion.
3. Fungus resistant materials: Only materials that are non-nutrient to fungus shall be used in the dampers.
4. Castings: All castings shall be Class 1A per SAE-AMS-STD-2175 except for parts such as covers, handles, etc., whose failure would not affect the structural integrity or performance characteristics of the damper. Such castings may be Class 2B, subject to the approval of the Resident Engineer.
5. Weldments: All weldments shall conform to AWS D1.1.

C. Parts:

1. Age-sensitive parts and components: All non-metallic packing, seals, wipers, or gaskets shall be of non-age control materials.
2. Plating: All plating shall conform to SAE-AMS-QQ-C-320, ASTM B650 or ASTM B733.
3. Working Fluid: The damper unit shall use the following fluid media: Inert OSHA (or equal) approved non-toxic, non-flammable silicone based fluid, in compliance with U.S. Federal Standard VV-D-l078 or approved equal. The working range of the fluid shall be between minus 40 to plus 400 degrees Fahrenheit. Any working fluid used in the dampers shall be both chemically inert, non-corrosive, non-toxic and non-flammable. Petro-chemical fluids shall not be used.
4. Piston Rods: Base metal shall be wrought or forged steel only and shall be either stainless steel or chrome plated. The piston rod shall be designed with a minimum surface Rockwell-C hardness of Rc=38 and minimum surface finish of 8 RMS for life and wear durability of the bearing and sealing surface. Yield strength shall be greater than 100 ksi.
5. Mounting Pins: 100ksi minimum yield strength, machined and hardened to be compatible with design requirements of the clevis plates and spherical bearings.
6. Exterior Housing: ASTM A36 minimum, or equal. The damper unit shall be fitted with a steel protective cover capable of moving with the device during operation and capable of preventing dusting, scratching, dinging or otherwise marring of the piston rod surface. The steel protective cover shall be fitted with a

removable inspection hatch to allow easy inspection of the Damper Unit seals and piston rod.

7. Spherical Bearings: Spherical bearings shall have an inner ring with a spherical outer surface and an outer ring with a spherical inner surface. Bearings shall be fabricated with stainless or high alloy steel and may be of the lined type with non-metallic liners. Bearings shall be sealed.

D. Fabrication:

1. Protective Treatment: Materials subject to deterioration when exposed to environmental conditions likely to occur during service shall be protected against such deterioration in a manner that will in no way prevent compliance with the requirements of this Section.

2. Maintenance and Service: The dampers shall be designed to be maintenance free. This means that no re-filling or replacement of fluid or any other parts shall be needed. The dampers shall be designed and constructed so that installation, removal, or replacement, if deemed necessary by the Resident Engineer, shall not require any special tools or methods.

E. Identification:

1. General: Each Damper shall have a metal identification tag permanently attached to the exposed damper surface. The manufacturer shall submit the proposed identification for Sate review and approval. At a minimum, all identification shall be engraved in one-half (1/2) inch minimum high characters equally spaced. Identification shall also be included on packaging using bold one (1) inch minimum high characters.

2. Production Dampers: In addition to typical damper rating information, each approved Production Damper shall be identified as illustrated in the following example:

DEPARTMENT OF VETERAN AFFAIRS – VA CARIBBEAN HEALTH SYSTEM – BUILDING 1

1 - Fabrication sequence number

Spare Dampers: In addition to identification markings for production dampers each approved prototype shall be marked "PROTOTYPE”.

3. At the Owner’s Representative’s request, the manufacturer shall omit visible Manufacturer’s logos and identifying information exceeding one inch by six inches in overall dimension.

F. Exterior Finish and Corrosion Protection

1. Paint/Exterior Coating: Exterior visible surfaces of the damper shall have one of the following two finishes:

a. Paint name: Extralife
Manufacturer: Akzo Nobel
Type: epoxy polyurethane paint.

b. Paint name: Tnemec 3-Part Heavy Duty Paint System
Manufacturer: Tnemec
Type: epoxy polyurethane paint system

c. Or equal.

2.04 SOURCE QUALITY CONTROL

A. Inspection and testing will be performed under the provisions of Section 01450 and this Section.

B. Monitor quality control over suppliers, manufacturers, products, services, site conditions, and workmanship to produce work of the specified quality per the requirements established in the Quality Control Program. The Resident Engineer reserves the right to require an external audit.

C. Manufacturers' Instructions: Comply fully with manufacturers' instructions including each step in sequence.

D. Quality:

1. Comply with specified standards as a minimum quality for the work except when more stringent tolerances, code, or specified requirements indicate higher standards or more precise workmanship.

2. Perform work by persons qualified to produce workmanship of specified quality.

E. Resident Engineer’s Inspection: The Resident Engineer or designated testing agency may be present during the manufacturing process as described below:

1. The work of the manufacturer at any stage of the production process may be subject to the periodic observation of the Resident Engineer or designated testing agency.

2. The Resident Engineer shall determine the level of inspection required based upon a review of the Manufacturer’s submittal data.

3. The Resident Engineer’s inspector and Resident Engineer’s consultants shall have unlimited access to any and all of the work at any time, including every phase of the manufacturing process.
4. The Manufacturer shall furnish the Resident Engineer reasonable facilities for obtaining such information as may be necessary to keep the Resident Engineer fully informed respecting the progress and manner of the work and the character of the materials.

F. Product Quality Control: To ensure effective control over product quality, the Manufacturer shall establish and maintain a manufacturing and processing control system, including written process specifications and procedures, to ensure that manufacturing, processing inspection, and testing are accomplished in accordance with one of the following:
1. Control of Quality ISO-9001: The Manufacturer shall provide and maintain a system that complies with requirements of the ISO-9001 model for quality assurance in design, development, production, installation, and servicing of the dampers.

G. Manufacturing Process Control: In addition to compliance with the quality assurance system listed in paragraph 2.05.F, the Manufacturer shall also maintain a system for manufacturing process control for this project which includes as a minimum the following:
1. Specific raw material traceability.
2. Special process certification traceability.
3. Detailed manufacturing instructions that identify by operation and machine the work performed.
4. Inspection instruction.
5. In-process and final detail component inspection instruction with actual dimensions.

H. Part Information: Specific instruction for detail part marking providing for one-way backward traceability to the information listed in paragraph 2.05.G shall be provided by the Manufacturer. This information shall be readily retrievable and shall be combined into one inclusive document that is controlled and approved by quality assurance personnel at the Manufacturer's facility.

I. Calibration System Requirements: All devices used to measure gage, test, inspect, or otherwise examine items to determine compliance with specification and/or contractual requirements shall be calibrated in

compliance with ISO-10012 and ISO-10012-1, to a calibrated measurement standard which has a known valid relationship traceable to NIST.

J. Manufacturer Responsibilities: It is the Manufacturer's responsibility to engineer, fabricate, and deliver the viscous dampers, including end clevises and connecting hardware, to conform to the Contract Documents, and to satisfy all applicable codes.

2.05 TESTING-GENERAL

A. Two (2) types of testing of viscous dampers are required as follows:
   1. Prototype Testing: Full-scale testing of “prototype” dampers to confirm the force-velocity relationship used in the design of the dampers and to validate the design and construction of the units under maximum proof loads and displacements.
   2. Production Testing: Quality control testing of all dampers to be used in the construction (“production dampers”).

B. The Resident Engineer or designated testing agency may be present continuously during the testing process as described below:
   1. Prototype Testing: The Resident Engineer or designated testing agency shall observe all prototype testing.
   2. Prototype Testing: Testing shall occur in one uninterrupted period not to exceed one week in duration without prior approval from the Resident Engineer.
   3. Production Testing: The Resident Engineer or designated testing agency shall observe all production testing.
   4. Production Testing: Testing shall occur in no more than six uninterrupted periods each not to exceed one week in duration without prior approval from the Resident Engineer.
   5. The damper manufacturer shall reimburse the Resident Engineer or designated testing agency for the cost of travel (including coach airfare), lodging, subsistence and per diem living expenses for the Resident Engineer or designated testing agency to observe all production testing during the damper testing.

C. All expenses resulting from test failures, including cost of dampers, repair work, inspection, travel, expenses described in Section 01450 and other personnel costs shall be borne in their entirety by the Contractor.

2.06 PROTOTYPE DAMPER TESTS

A. Prototype damper tests shall be conducted to confirm the force-velocity characteristics of the damper designs to be furnished, to

verify the symmetry of the damper output in both tension and compression, to verify the soundness and leak-proof nature of the construction under proof loading and cyclic testing, and to verify the consistency of performance between the dampers.

B. One (1) full-scale prototype damper of each of the 110k and 220k types shall be tested for conformance to the requirements of this Section. All tests shall be performed at an ambient air temperature of 70° F ± 10° F, unless noted otherwise.

C. The prototype damper tests shall consist of proof load tests, live cycle tests, and dynamic cyclic tests. These tests are described below.

1. Proof load test: An internal pressure equal to 150 percent of the maximum internal pressure present at the development of 1.0V (where V is defined in Equation 1) at 70° F ± 10°F shall be applied to each prototype damper and maintained for a minimum of five (5) minutes. The maximum internal pressure shall be reported.

2. Life Cycle Test:

a. Each prototype damper shall be cycled through the following number of cycles for each of the indicated displacements:

1) 500 cycles at ± 1 inches of displacement.

b. The frequency of the life cycle tests shall be 1.5 cycles per second.

3. Dynamic Cyclic Tests:

a. The prototype dampers shall be subjected to the cyclic loading tests listed in Table 1.

Table 1. Prototype Dynamic Cyclic Tests

(i) 110k Dampers

Test	Velocity (in/sec)	Amplitude (+/- in)	No. of Cycles
1	9	2	10
2	18	2	10
3	28	3	20

(ii) 220k Dampers

Test	Velocity (in/sec)	Amplitude (+/- in)	No. of Cycles
1	9	2.5	10
2	18	2.5	10
3	28	3.5	20

b. The frequency of the prototype tests shall be 1.5 cycles per second.

c. Tests 1, 2, and 3 shall be performed at 70° ± 10° F for each damper type. The test specimens shall be temperature-conditioned at the beginning of each different temperature test series.

d. The dampers shall be conditioned at the test temperature for at least six (6) hours immediately prior to the start of testing, or for sufficient time for the entire damper unit to reach the specified temperature.

e. A minimum of two thermocouples shall be attached to the damper casing for each test, one as close as possible to the mid-stroke piston head position, and the other as close as possible to the piston end of stroke position

f. The tests in Table 1 shall consist of continuous fully-reversed, sinusoidal cycles. If test equipment limits do not permit the complete number of cycles for any test to be performed in one continuous sequence, that test may be performed in two subsets of cycles. The second subset of cycles shall be performed as soon as possible after completion of the first, but in no case shall the time between each subset of cycles be more than five (5) minutes.

g. Where multiple sets of cycles must be used for each test, three substantially different piston head positions shall be used for each set. The approximate position of the piston head at the start of each test shall be recorded.

h. The force, displacement, velocity and damper casing temperature histories shall be digitally recorded for all tests and force-displacement loops and damper force,

displacement and velocity time-history plots included in the test report. The damper force-velocity relation shall be established from the data for each test. The method used to determine the damper force-velocity relation shall be clearly described in the test report. Temperature readings on the casing shall be recorded at 30 second intervals for five minutes following the completion of each test.

4. Test Reports: The report on the prototype damper tests, to be entitled "Prototype Damper Test Report", shall include all raw digital data (electronic and hard copy), a list of all data channels, and all plots and other data as described in 2.07.C.3.g above. Details of any failures shall be described in the report.

D. Acceptance Criteria:

1. No visible leakage or signs of physical deterioration or degradation in performance, in the judgment of the Resident Engineer or designated testing agency, shall be observed at any stage during or after the prototype test series. There shall be no signs of yielding or permanent deformation in the judgment of the Resident Engineer or designated testing agency.
2. The prototype damper test results shall be consistent with the design force-velocity relation given in paragraph 1.03.A for all cycles and all tests. At a given velocity, in no case shall the force output fall outside the range defined by ±10% of the force computed using the design force-velocity relation of 1.03.A.

2.07 PRODUCTION DAMPER TESTS

A. Production damper tests shall be conducted to verify the quality and manufacturing consistency of each production damper and to determine whether each unit conforms to this specification. All tests in this section shall be performed at an ambient air and damper starting temperature of 70° F ± 10° F. Production dampers shall be subjected to the following sequence of quality assurance tests:

1. Proof Load Test: Each production damper shall be subjected to the proof load test described in paragraph 2.07.C.1.
2. Dynamic Performance Verification Test:
   a. The dampers shall be conditioned for sufficient time to ensure that all components are within the specified temperature range immediately prior to the start of testing.

b. Each production damper shall be subjected to the cyclic loading tests listed in Table 2.

Table 2. Production Dynamic Performance Verification Tests

Damper	Test	Velocity (in/sec)	Amplitude (+/- in)	No. of Cycles
110k	1	20	2.5	5
220k	1	20	2.5	5

3. The test shall consist of continuous fully-reversed, sinusoidal cycles starting and ending at the damper mid-stroke position. If test equipment limitations do not permit the complete number of cycles for any test to be performed in one continuous sequence, that test may be performed in two subsets of cycles. The second subset of cycles shall be performed as soon as possible after completion of the first, but in no case shall the time between each subset of cycles be greater than five (5) minutes.
   a. The force, displacement, velocity and damper casing temperature histories shall be digitally recorded for all tests and force-displacement loops and damper force, displacement and velocity time-history plots included in the test report. The damper force-velocity relation shall be established from the data for each test. The method used to determine the damper force-velocity relation shall be clearly described in the test report.

B. Test Reports:
   1. The Production Damper Test Report shall include all raw digital data (electronic and hard copy), a list of the data channels, and calculation of damper force-velocity relationships. Details of any failures shall be described in the report.
   2. The Final Production Damper Test Report shall describe completely all production damper tests. This report shall include all raw digital data (electronic and hard copy), a list of the data channels, and calculation of force velocity relationships for each production damper. Details of any failures shall be described in the report.

C. Acceptance Criteria:

1. Acceptance criteria shall be the same as those given in paragraph 2.07.D. for prototype dampers.
2. Should any production damper fail to satisfy the acceptance criteria, as judged by the Resident Engineer or designated testing agency, unit shall be either rejected, repaired, or replaced at the Resident Engineer’s option and re-tested.
3. Dampers not meeting the acceptance criteria specified above shall not be shipped to the job site.
4. All expenses resulting from test failures, including cost of dampers, repair work, inspection, retesting, travel, expenses described in Section 01450 and other personnel costs shall be borne in their entirety by the Contractor.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine the condition in which the Work is to be installed. Verify alignment of items with adjacent construction. Coordinate with related work. Do not proceed with the Work until unsatisfactory conditions have been resolved.

3.02 PREPARATION

A. Furnish setting drawings, diagrams, templates, instructions, and directions for installation of dampers. Coordinate delivery of dampers to the project site.

B. Coordinate all cutting, shearing, drilling, and punching for attachment to adjacent work. Do not drill or punch holes or use cutting torch on dampers.

3.03 INSTALLATION

A. Install and erect dampers in conformance with manufacturer’s written instructions and the approved shop drawings.

B. Allow for erection loads, and for sufficient temporary bracing to maintain structure safe, plumb, and true alignment until completion of erection and installation of permanent bracing.

C. Do not cut or alter structural members without prior approval of the Resident Engineer.

D. Place temporary bracing necessary for erecting dampers before bolting in accordance with AISC recommendations. Provide additional or temporary bracing wherever loads may be exceeded during erection or placing of dampers.

E. Welding will be permitted only as indicated on approved shop drawings. Welding shall only be performed by welders that have been pre-qualified.

F. In the event of damage, notify the Resident Engineer. Replacement or repair of dampers delivered to the site will be at the discretion of the Resident Engineer. All such work shall be done at no additional cost to the Owner.

G. Touching Up: After the erection and installation are complete, touch up all painted surfaces damaged during transportation and erection. Where primer has been removed apply the priming paint specified for shop priming prior to final coat touch up.

H. Lubricate bearings and bushings for full life.

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