SECTION 230549 – SEISMIC RESTRAINT FOR PIPING, DUCTWORK, AND EQUIPMENT

PART 1 - GENERAL

1.1 APPLICABLE REQUIREMENTS

A. All work to be furnished and installed under this section shall comply with all the requirements of General Conditions, Supplemental Conditions, Division 01 - General Requirements, and Section 230500 - Basic HVAC Materials and Methods, and other Sections in Division 23 specified herein.

1.2 SUMMARY

A. This Section includes the following:

1. Seismic restraint and support of piping, ductwork and mechanical equipment as required by code and as designed by a registered Professional Structural Engineer for each related nonstructural equipment restraint.
2. Mechanical component supports and the means how they are attached to the mechanical component shall be designed for the forces and displacements determined in ASCE 7 Chapter 13. Such supports include structural members, braces, frames, skirts, legs, saddles, pedestals, cables, guys, stays, snubbers, and tethers, as well as elements forged or cast as a part of the mechanical component.
3. All ductwork designed to carry toxic, highly toxic, flammable gases or used for smoke control shall be seismically braced regardless of size or location.

1.3 DEFINITIONS

A. AHJ: Authority Having Jurisdiction.

B. ASCE: American Society of Civil Engineers.

C. ASHRAE: American Society of Heating, Refrigerating and Air-Conditioning Engineers.

D. IBC: International Building Code with Amendments.

E. ICC-ES: ICC-Evaluation Service.

F. SMACNA: Sheet Metal and Air Conditioning Contractors' National Association.

G. Mechanical Attachments: Means by which components or supports of nonstructural components are secured or connected to the seismic force-resisting system of the structure. Such attachments include anchor bolts, welded connections, and mechanical fasteners.

H. Mechanical Supports: Those members, assemblies of members, or manufactured elements, including braces, frames, legs, lugs, snubbers, hangers, saddles, or struts, and associated fasteners that transmit loads between nonstructural components and their attachments to the structure.

I. Mechanical Components: Elements, including, but not limited to, pumps, air handling units, boilers, chillers, pipes, ductwork, and exhaust fans.

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1.4 RELATED WORK SPECIFIED ELSEWHERE

A. Section 230500: Basic HVAC Materials and Methods.

B. Section 230548: Vibration Isolation for Piping, Ductwork and Equipment.

C. Section 232113: Hydronic Piping, Valves and Specialties.

D. Section 233113: Air Distribution.

E. Other Division 23 Sections.

1.5 QUALITY ASSURANCE

A. Manufacturer's Qualifications: Provide systems that are the standard product of an equipment manufacturer regularly engaged in the production of such units who issues complete catalog information on such products. Units shall not be fabricated by the Contractor.

B. Structural Performance: Restraint devices and systems shall withstand the effects of locally defined gravity loads, seismic loads, dead loads, live loads, winds loads and stresses within limits and under conditions indicated per the local building code and ASCE 7. Coordinate all support structures and restraint systems with project registered professional Structural Engineer.

C. Special Inspections: Provide structural design and Special Inspections as required in Chapter 17 of the local building code and the Authority Having Jurisdiction, and as defined in the manufacturer installation instructions for each anchorage system. All anchors post-installed in hardened concrete members shall have periodic Special Inspections. Special inspection agencies shall be independent of the design and construction companies and shall act as agents for the AHJ, but contracted directly with the Owner or Owner’s Representative.

D. Codes and Standards: Provide components conforming to the seismic load requirements of the latest addition of the local building code and the following where applicable:

2. International Building Code with State Amendments ASCE 7 (Latest Edition) - Minimum Design Loads for Buildings and Other Structures

a. Ductwork and piping requirements defined in Chapter 13 Seismic Design Requirements for nonstructural Components.
b. Seismic Design Categories, B through F, are defined in Chapter 12, Table 12.6-1. Seismic Design Category B and C apply to all structures. While Seismic Design Categories D, E and F may apply to Category I and II buildings not exceeding two stories, light frame construction and/or structures not exceeding 160 in height.
c. Nonstructural components in Seismic Design Category A are exempt from seismic design requirements.

3. SMACNA - Seismic Restraint Manual Guidelines for Mechanical Systems (Latest Edition.

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a. Seismic guidelines for ductwork and piping bracing as adopted by Authority Having Jurisdiction.

4. ASHRAE – Practical Guide to Seismic Restraint (Latest Edition).
5. ANSI/FM 1950: American National Standard for Seismic Sway Braces for Pipe, Tubing and Conduit (Latest Edition).
6. Factory Mutual (FM): Earthquakes Data Sheet 1-2 (Latest Edition).
7. Factory Mutual (FM): Earthquake Protection for Water-Based Fire Protection Systems Data Sheet 2-8 (Latest Edition).
8. Mason Industries/Mason West - Seismic Restraint Guidelines for Suspended Distribution Systems (Latest Edition).

a. For all suspended piping, suspended ductwork and suspended electrical raceways.

1.6 APPLICABILITY

A. Seismic restraints are required for nonstructural mechanical systems, but may not be required for the following conditions related to nonstructural components per ASCE 7 Section 13.1.4:

1. Mechanical components in Seismic Design Category B facilities.
2. Mechanical components in Seismic Design Category C facility if the component Importance Factor, I_p, is equal to 1.0.
3. Mechanical components in Seismic Design Categories D, E, or F facilities where all of the following apply:

a. The component Importance Factor, I_p, is equal to 1.0;
b. The component is positively attached to the structure;
c. Flexible connections are provided between the component and associated ductwork, piping, and conduit; and any of the following applies:

1) The component weighs 400 lbs. (1,780 N) or less and has a center of mass located four feet (1.22 m) or less above the adjacent floor level; or
2) The component weighs 20 lbs. (89 N) or less; or
3) The distributed ductwork or piping system weights 5 lbs./ft. (73 N/m) or less.

B. Provide seismic bracing at the following locations per SMACNA Seismic Restraint Manual Guidelines for Mechanical Systems (Latest Edition) and ASCE 7:

1. Piping:

a. Transverse bracing shall be provided at 40 feet (12.2 m) maximum except where a lesser spacing is indicated in SMACNA tables.
b. Longitudinal bracing shall be provided at 80 feet (24.4 m) maximum except where a lesser spacing is indicated in SMACNA tables. Anchor locations for thermal expansion may be used as longitudinal braces. Longitudinal braces must be capable of resisting the additional force induced by expansion and contraction.

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c. Bracing locations for insulated piping shall use welded lugs that extend through the insulation to allow improved continuity of insulation and vapor barriers. Bracing shall occur at locations other than normal support locations where clevis or trapeze type hangers are used.

2. Ductwork:

a. Transverse bracing shall be provided at 30 feet (9.2 m) maximum except where a lesser spacing is indicated in SMACNA tables.
b. Longitudinal bracing shall be provided at 60 feet (18.4 m) maximum except where a lesser spacing is indicated in SMACNA tables.

3. Equipment:

a. All suspended mechanical components weighing more than 20 lbs. (89 N) shall be seismically braced as required per ASCE 7 Section 13.1.4. However, equipment installed in-line with the duct system, with a weight up to 75 lbs. (334 N), such as fans, heat exchangers and humidifiers, may be considered as supported and laterally braced by the duct system as required per ASCE 7 Section 13.6.7.

C. Seismic restraints may be omitted where the following conditions apply and as allowed by the local Authority Having Jurisdiction (AHJ):

1. Ductwork supported by hangers and each hanger in the duct run is 12" (305 mm) or less in length from the duct support point to the supporting structure.
2. Ductwork cross-sectional area is less than six (6) square feet (0.557 m^2), round ductwork is 32 inches (0.8 m) in diameter, or less, or weighs 17 lbs./ft. (248 N/m) or less.
3. Pipes suspended by hangers 12" (305 mm) or less in length from the top of the pipe to the bottom of the supporting structure for the hanger. Where pipes are supported by trapeze, the trapeze shall be supported by hangers having a length of 12” (305 mm) or less.
4. Pipe bracing is not required where the following conditions apply:

a. For Seismic Design Category C where the Ip value is greater than 1.0 and pipe sizes are 2” (50 mm) in diameter or less, and piping weighs less than 10 lbs./ft. (146 N/m).
b. For Seismic Design Category D, E, or F where the Ip is greater than 1.0 and pipe sizes are 1” (25 mm) in diameter or less, and piping weighs less than 10 lbs./ft. (146 N/m).
c. For Seismic Design Category D, E, or F and where the Ip equals 1.0 and pipe sizes are 3” (80 mm) in diameter or less, and piping weighs less than 10 lbs./ft. (146 N/m).

D. Seismically restrained piping systems shall not move more than 2” during a seismic event and shall not impact the building structure or other nonstructural components during a seismic event. The design force of restraint elements shall be doubled (2 x Fp) to allow for movement up to 2” per ASCE 7 Section 15.7.4.

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1.7 PERFORMANCE REQUIREMENTS

A. Component Importance Factor and Risk Category:

1. Ip=1.0: Standard Occupancies and components associated with Risk Category I, II, and III, including offices and schools.
2. Ip=1.5: Components associated with Risk Category IV Buildings (Essential Services); or for conditions outlined in ASCE 7 Section 13.1.3 regardless of Risk Category, or Hospitals and Correctional Treatment Centers. Components include, but are not limited to, the following:
    a. The component is required to function for life-safety purposes after an earthquake, including fire protection sprinkler systems.
    b. The component conveys, supports, or otherwise contains toxic, highly toxic, or explosive substances where the quantity of the material exceeds a threshold quantity established by the AHJ and is sufficient to pose a threat to the public if released.
3. Additions, alterations, and repairs involving nonstructural mechanical components in structures designed in accordance with pre-1973 building codes may have a Component Importance Factor of Ip=1.0. However, components required to operate for life-safety purposes after an earthquake, including emergency and standby power systems, mechanical smoke removal system, fire alarm panels and egress stairways shall have an Ip=1.5.

B. Building Seismic Design Category:

1. The directions of application of seismic forces used in the design shall be those which will produce the most critical load effects. Seismic Design Categories are classified as B, C, D, E or F. Refer to Architectural and Structural Designs for project specific classification.

C. Mechanical Seismic Coefficients for Mechanical Components:

1. Refer to ASCE 7 Table 13.6-1 for a_p factor (component amplification factor) and R_p factor (component response modification factor) as required for each unique mechanical component.

1.8 SUBMITTALS

A. Product Data:

1. Include rated load, rated deflection, and overload capacity for each device or system.
2. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of seismic-restraint component used.
    a. Tabulate types and sizes of seismic restraints, complete with report numbers and rated strength in tension and shear as evaluated by an evaluation service or agency acceptable to authorities having jurisdiction.
    b. Annotate to indicate application of each product submitted and compliance with requirements.

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3. Submit seismic brace product details from the Mason West Seismic Restraint Guidelines detailing compliance with the specifications.
4. Where products from the Mason West Seismic Restraint Guidelines cannot be used, special details must be submitted for approval.

B. Delegated-Design Submittal: For each vibration isolation and seismic-restraint device.

1. Seismic restraint calculations must be provided for all connections to the structure.
2. Calculations must be stamped by a registered professional Structural or Civil Engineer.
3. Include design calculations and details for selecting vibration isolators, seismic restraints, and vibration isolation bases complying with performance requirements, design criteria, and analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
4. Provide flexible joints, supports and piping joints as required to accommodate movement across seismic expansion joints and vertical building drift between floors.

1.9 MANUFACTURER AND CONTRACTOR RESPONSIBILITIES

A. All seismic restraints shall be designed by a registered professional Structural Engineer.

B. Seismic restraint layouts for piping and ductwork shall be added to the contractor’s shop drawings and shall include:

1. The number, size and location of seismic braces.
2. Maximum support loads and seismic loads at the seismic brace locations.
3. Reference to specific details or pages from the Mason West Seismic Restraint Guidelines.

C. Submit seismic restraint layout drawings and special details for approval of the project registered professional Structural Engineer per the requirements listed in the Mason West Seismic Restraint Guidelines.

D. Seismic restraint layout drawings shall bear the stamp and signature of the registered professional Structural Engineer who designed the layout of the braces.

1.10 LOADS ON STRUCTURE

A. The responsibility of determining allowable loads on the structure is the sole responsibility of the project registered professional Structural Engineer.

B. Maximum support loads and seismic brace loads on the structure must be less than the maximum allowable loads defined by the project registered professional Structural Engineer, as shown on the plans.

C. Where maximum loads are not listed on the plans or the maximum allowable loads cannot be met, any additional support steel required to reduce support and seismic bracing loads on the structure shall be designed by the project registered professional Structural Engineer.

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D. Mechanical component supports and the means how they are attached to the component shall be designed for the forces and displacements determined in ASCE 7 Section 13.3.1 and 13.3.2. Such supports include structural members, braces, frames, skirts, legs, saddles, pedestals, cables, guys, stays, snubbers, and tethers, as well as elements forged or cast as a part of the mechanical component.

E. Mechanical supports are those members, assemblies of members, or manufactured elements, including braces, frames, legs, lugs, snubbers, hangers, saddles, or struts, and associated fasteners that transmit loads between nonstructural components and their attachments to the structure.

F. Mechanical attachments are the means how components or supports of nonstructural components are secured or connected to the seismic force-resisting system of the structure. Such attachments include anchor bolts, welded connections, and mechanical fasteners.

1.11 WARRANTY

A. Provide minimum one-year warranty from date of Substantial Completion, including all parts, material, labor and travel.

B. Refer to Section 230500 for additional warranty and Substantial Completion requirements.

PART 2 - PRODUCTS

2.1 INTENT

A. All seismic restraints described in this section shall be the product of a single manufacturer.

B. Refer to Section 230500 for additional guidelines for applicable supports and anchors.

C. Mason Industries products are the basis of these specifications; products of other manufacturers may be submitted for review provided their systems strictly comply with the specifications. Manufacturers: Mason Industries, Hilti Inc., B-Line/Tolco (Eaton), Anvil, Superstrut.

2.2 SEISMIC SWAY BRACING

A. Seismic sway braces shall consist of galvanized steel aircraft cables, steel angles or steel struts.

B. Cable braces shall be designed to resist seismic tension loads and steel braces shall be designed to resist both tension and compression loads. Brace end connections shall be steel assemblies that swivel to the final installation angle.

C. Cable brace assemblies shall have published strength and stiffness ratings based on testing per the ANSI/FM-1950 standard.

D. Angle or strut bracket assemblies shall be FM Approved except as noted below.

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E. Steel angles or struts, when required, shall be clamped to the threaded hanger rods at the seismic sway brace locations utilizing a minimum of two ductile iron clamps.

F. Cable and universal swivel sway brace bracket attachment assemblies shall be Mason Industries #SCB or #SCBH, or equal.

G. Solid and swivel brace bracket assemblies shall be Mason Industries #Type SSB or #SSBS, or equal.

H. Rod clamps shall be Mason Industries #SRC or #UCC, or equal.

I. Welded pipe hanger lug shall be Mason Industries #MW-WPL, or equal.

J. Pipe clamp with integral hanger lug shall be Mason Industries #MW-SPC, or equal.

K. Hanging Cables with Adjustable Fastener: Wire rope hangers for maximum point loads not exceeding 100 lbs. (45 Kg) for supporting rigid galvanized ductwork and suspended diffusers/grilles/terminal units.

1. Wire Rope: High tensile steel wire rope, to ASTM 1023/1023M, class A zinc coating; 7 by 7 or 7 by 19 cross-sectional construction; having a tensile strength of 256,000 psi (1,770 N per sq. mm); lengths, diameters, and wire construction to accommodate design loads and as indicated on Construction Shop Drawings.
2. Adjustable Fastener: Mild steel (type EN1A), bright zinc plated, one-channel body; encasing a series of Type 302 stainless-steel springs with serrated self-locking grade 40 chrome steel balls, adjustable by means of an integrated mechanism, capable of accommodating load of 100 lbs. (45 kg) (maximum per hanger).
3. Manufacturers: Gripple #Standard No. 2/3/4/5, Ductmate #Clutcher, or equal.

PART 3 - EXECUTION

3.1 GENERAL

A. Contractor’s Statement of Responsibility: Each contractor responsible for installing a Designated Seismic System or any seismic resisting component must submit a statement of responsibility prior to the commencement of work to include acknowledgment of awareness of the need for Special Inspections.

B. All seismic restraint systems must be installed in strict accordance with the manufacturers written instructions and all certified submittal data.

C. Installation of seismic restraints must not cause any change of position of equipment, piping or ductwork resulting in stresses or misalignment.

D. No connections between the piping or ductwork and the building structure shall be made that degrades the seismic restraint system herein specified.

E. Any conflicts with other trades due to inadequate space or other unforeseen conditions should be brought to the attention of the Owner’s Representative prior to installation. Corrective work necessitated by conflicts after installation shall be at the responsible contractor’s expense.

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