PART 1: GENERAL

1.01 WORK INCLUDED

A. This Section provides minimum acceptance requirements for vibration isolation and seismic/wind restraints for all heating, ventilating, air-conditioning and refrigeration equipment, ductwork, and piping. Acceptance is determined by the Engineer of Record.

B. The determination of seismic and wind restraints required for non-structural components described in this Division is delegated to a qualified design engineer (Delegated Design Engineer) as defined by this Section.

C. This Section includes requirements for horizontal and vertical pipe support systems, including pipe risers, that use products specified in this Section to provide vibration isolation and to control and accommodate changes in pipe length due to thermal changes.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Concrete work is provided in Division 03.

B. Silencers and flexible connections for ductwork are specified elsewhere in Division 23.

C. Roof curbs and pedestals without isolation and not rated for seismic loads, along with additional requirements for curb products in this section, may be specified elsewhere in Division 23.

1.03 QUALITY ASSURANCE

A. Unless otherwise directed by the local authority having jurisdiction, the following codes and standards will apply and take precedence over any perceived or real conflict with this Section:
   1. American Society of Civil Engineers Standard ASCE/SEI 7-16
   2. 2020 BC-NYS

B. Project specific design values shall be used for determining seismic and wind design forces based on the information on the structural drawings. The values below are provided for reference only for the purpose of coordinating with suppliers and other trades. If a conflict exists between these values and the structural drawings, the values on the structural drawings will prevail. Where project documents do not provide values necessary to determine design forces, the Delegated Design Engineer may use values substantiated through the governing building code(s) or the authority having jurisdiction and subject to review and approval by the Engineer of Record.
   1. Risk Category: IV
   2. Seismic Design Category: C
   3. Short-period Spectral Response Acceleration parameter (SDS): 0.209g
   4. Basic wind speed: 125mph

C. All vibration isolation and restraint products and associated engineering work shall be provided by one supplying manufacturer. Preferred manufacturer is Vibro-Acoustics. Alternate manufacturers must request and obtain written approval by the Engineer of Record for substitutions. Supplying manufacturer shall be a full member in good standing with the Vibration Isolation and Seismic Control Manufacturers Association (VISCMA) as indicated on the association website: http://www.viscma.com/.

D. Isolation and restraint products shall be tested or analyzed for performance as appropriate and reports shall be made available to the Engineer of Record upon request.

E. All work to determine seismic and wind restraints shall be done by or under the direct supervision of a qualified professional engineer in responsible charge of the work acting as the Delegated Design Engineer. This Delegated Design Engineer must hold an active license in the state or province of the project.

F. The following guides may be used for supplemental information on typical seismic restraint installation practices. Where a conflict exists between the guides and these construction documents, the construction documents will preside.
   1. Federal Emergency Management Agency (FEMA) manuals 412, Installing Seismic Restraints for Mechanical Equipment and 414, Installing Seismic Restraints for Ductwork and Pipe.
   2. Sheet Metal and Air-conditioning Contractors' National Association's (SMACNA) Seismic Restraint Manual Guidelines for Mechanical Systems, 3rd ed., 2008
   3. American Society for Heating, Refrigerating and Air-conditioning Engineers' (ASHRAE) A Practical Guide to Seismic Restraint, 2nd ed.
   4. Manufacturers Standardization Society of the Valve and Fittings Industry MSS SP-127-2014a, Bracing for Piping Systems, Seismic – Wind – Dynamic Design, Selection, and Application.

1.04 SUBMITTALS

A. Provide a submittal report with cover page and summary that details the scope of supply along with project information. Submittals that include seismic and/or wind restraints or include pipe riser support systems shall be sealed per state or province requirements by the Delegated Design Engineer.

B. Provide calculations that indicate the applicable seismic and wind design forces for each non-structural component within the scope of work and that substantiate the selection of restraints and attachments, including anchorage to structure. Calculations must be project- and product-specific; generic calculations are not acceptable.

C. Provide submittal drawings for all products specified herein and as indicated and scheduled on the drawings. Submittals shall indicate product locations, installation instructions, and full compliance with the product specification in Part 2. Any deviation shall be specifically noted and subject to Engineer of Record approval. Submittals shall include product capacity, ratings, dimensions, placement, attachment, and anchorage requirements.

D. Provide summary reports of testing or analysis for any customized restraints, snubbers, and support structures such as equipment bases and roof curbs at Engineer of Record's request. The summary report shall indicate adequate capacity for the project design forces– including all gravity, wind, and seismic loads.

E. Provide a detailed submittal for pipe riser support systems as indicated in Part 3 of this Section or as shown on the Drawings that includes, as appropriate, initial load, initial deflection, change in deflection, and final load at all isolator and anchor support locations. Submittal shall indicate locations for all supports, anchors, expansion compensators, and guides.

PART 2: PRODUCTS

2.01 VIBRATION ISOLATORS:

A. Springs: All springs shall have a minimum additional travel to solid equal to 50% of the rated deflection. All springs except internal booster springs shall have an outside diameter not less than 0.8 of the compressed height of the spring. Ends of springs shall be square and ground for

stability. Laterally stable springs shall have kx/ky ratios of at least 0.8. All springs shall be fully color-coded to indicate capacity – color striping is not considered adequate.

B. Rubber Components: All rubber components shall be made of Neoprene or EPDM. Rubber compound shall be suitable for outdoor use to withstand UV and ozone exposure. Mounts, pads, or hanger elements of different durometers within a series shall be color coded for easy identification. Load vs. deflection test data shall be available upon request for all main isolation components and bottom cups that are located under springs.

C. Corrosion Protection: All springs shall be powder-coated enamel. Hardware shall be zinc-plated. Isolator housings shall be galvanized or powder-coated enamel for indoor use and hot-dip galvanized for indoor or outdoor use. Unless otherwise specified, stands, bases, brackets, anchors, guides, and steel frames shall be prime painted, zinc-plated, black oxide coated, or powder-coated enamel for indoor use and hot-dip galvanized for outdoor use.

D. Capacity Ratings: Products that are selected to withstand seismic and wind loads shall have their load capacities in all appropriate axes determined by testing in accordance with ANSI/ASHRAE 171 or through analyses or through an approved combination of both. Supporting test reports shall be made available upon request.

E. Vibration Isolation Pads:
   1. Type NP –Rubber pad type isolators, 7/8” (22 mm) minimum thickness molded from high strength compound with minimum 2,750 psi (19 MPa) tensile strength. Pads shall be color coded for capacity and sized to deflect 20% of the overall height (0.18” (4.5 mm) for 7/8” (22 mm) thick pad). Maximum allowable deflection is 25% of the overall height (0.22” (5.5 mm) for 7/8” thick pad). Pads shall allow for anchor bolts to be installed through them with or without clamping nuts and without altering the published load vs. deflection performance for a given size.
   2. Type N – Rubber pad type isolators, 3/8” (10 mm) minimum thickness and ribbed on both sides. Pads shall be sized to deflect 20% of the overall height (0.07” (2 mm) for 3/8” (10 mm) thick pad).
      a. Additional steel plates shall be furnished as required with pad type isolators either for stacking purposes to provide increased height or increased deflection, or for load distribution purposes. All layers shall be affixed together using appropriate glue or double sided tape to prevent delamination.

F. Grommet Washers: Type GW - Rubber grommet washers of sufficient size to accommodate USS standard washers, long enough to sleeve through 1/4” (6 mm) plate material, and with at least 1/8” (3 mm) thick material around bolt holes.

G. Rubber-in-Shear Floor Mounts: Type RD – “Double-deflection” rubber isolators, with rubber-coated metal surfaces, internal threaded holes for securing components, and bolt holes for securing to structure.

H. Restrained Rubber-in-Shear Floor Mounts: Type SRD- “Double-deflection” rubber isolators with mounting brackets and all-directional snubbers for seismic and wind restraint. Snubbers shall include elastomeric components to prevent metal-to-metal contact under normal operation and during a seismic or extreme wind event.

I. Free Spring Floor Mounted Isolators:
   1. Type FS – Free-standing, laterally stable, unhoused spring isolators with vertical studs for supporting, leveling, and securing equipment. Springs shall be supported with rubber cups with steel inserts that can be bolted to structure.
   2. Type FST – same as Type FS with the addition of top plates for supporting components.

J. Restrained Spring Floor Mounted Isolators:

1. Type CSR – Laterally stable, vertically restrained spring isolators with welded steel housings and heavy top plates for supporting components. Springs shall be supported with rubber cups with steel inserts. Housings shall include vertically restraining limit stops (hold-down plates). Minimum clearance between metal components before contact is made shall be 1/4” (6 mm). Top plates and restraining bolts shall be out of contact with housings during normal operation and rubber grommets shall be incorporated to minimize metal-to-metal contact.
2. Type SCSR – Laterally stable, restrained spring isolators with housings and heavy top plates for supporting components. Isolators shall be designed to withstand seismic and wind forces. Springs shall be supported with rubber cups with steel inserts. Housings shall be of welded high grade steel construction and include restraining limit stops (hold-down plates). Maximum clearance around restraining bolts shall be 1/4” (6 mm). Top plates and restraining bolts shall be out of contact with housings during normal operation and all-directional heavy duty snubbers shall be incorporated to minimize metal-to-metal contact. Isolators shall be furnished with factory installed oversized base plates for anchor load distribution purposes where required.
3. Type SFS – Laterally stable, restrained spring isolators with vertical studs for supporting and securing components. Springs shall be supported with rubber cups. Housings shall include integral all-directional limit stops and heavy duty snubbers preventing metal-to-metal contact and with minimum 1/4” clearance under normal operation.

K. Closed Mount Spring Isolators: Type CM – Floor mounted spring isolators with housings and telescoping equipment support plates with vertical studs for securing components. Springs shall be supported either with rubber cups or metal base plates complete with ribbed rubber pads, minimum 1/4” (6 mm) thick, bonded to base plates. Housings shall incorporate rubber stabilizers to minimize short circuiting and provide vertical damping.

L. Rubber Hangers: Type NH – “Double-deflection” rubber hanger isolators, complete with integral rubber sleeves through housing. Rubber elements shall be color-coded to identify load capacities and include either internal or external metal washers to prevent pull-out failure. NH hangers shall be furnished with vertical uplift stop washers where used to support seismically restrained components.

M. Spring Hangers: Vibration isolator hanger supports with steel springs and welded steel housings. Hangers rated for loads above 200 lbs (0.9 kN) shall be designed for a minimum of 15 degree angular misalignment from vertical before support rod contacts housing. Spring hangers shall be furnished with vertical uplift stop washers where used to support seismically restrained components.
   1. Type SH – Spring hanger isolators complete with springs, compression cups, and rubber washers.
   2. Type SHR – Combination spring and rubber hanger isolators complete with springs, compression cups, and rubber “double-deflection” elements at top of hangers. Isolators rated for 2000 lbs (8.9 kN) and above may use Type NP pad isolators in place of double-deflection elements.
   3. Type SHB – Spring hanger isolators with rubber bottom cups complete with springs, compression cups, and rubber cups under springs.
   4. Type SHRB – Combination spring and rubber hanger isolators with rubber bottom cups complete with springs, compression cups, rubber “double-deflection” elements at top of hangers, and rubber cups under springs.
   5. Type PSH – Pre-compressed spring hanger isolators complete with springs, compression cups, and hardware to compress springs prior to installation. Springs shall be shipped pre-compressed to 2/3 rated load.
   6. Type PSHR – Pre-compressed combination spring and rubber hanger isolators complete with springs, compression cups, rubber “double-deflection” elements at top of hangers, and hardware to compress springs prior to installation. Isolators rated for 2000 lbs (8.9 kN)

and above may use Type NP pad isolators in place of double-deflection elements. Springs shall be shipped pre-compressed to 2/3 rated load.

7. Type PSHB – Pre-compressed spring hanger isolators with rubber bottom cups complete with springs, compression cups, rubber cups under springs, and hardware to compress springs prior to installation. Springs shall be shipped pre-compressed to 2/3 rated load.
8. Type PSHRB – Pre-compressed combination spring and rubber hanger isolators with rubber bottom cups complete with springs, compression cups, rubber "double-deflection" elements at top of hangers, rubber cups under springs, and hardware to compress springs prior to installation. Springs shall be shipped pre-compressed to 2/3 rated load.

N. Thrust Restraints: Spring assemblies used to limit the motion of base-mounted (Type HCS) or suspended fans (Type AHCS) due to aerodynamic thrust forces. Thrust restraints shall be designed for use in pairs of assemblies and include all brackets and hardware necessary for installation, precompression, and adjustment. Operating clearances shall be nominal ¼" to ensure no short circuiting of isolation.

2.02 CURBS AND RAILS:

A. Seismic/Wind Rated Roof Curbs: Type RC – minimum 18 ga formed galvanized steel construction rooftop equipment support curbs. Curbs shall be designed to attach directly to roof structure with provisions for accommodating roof slope and maintaining equipment level. Minimum height of curbs shall be as required by the local authority or 14" (355 mm) to the tops of full-perimeter factory-attached 2x4 wood nailers, whichever is greater. Curbs shall provide continuous support for equipment and shall withstand the wind and seismic forces applicable to the project. Galvanized steel duct supports shall be provided as required. Curbs shall be manufactured, shipped, and installed without shipping splits and with minimal assembly on site except as required due to size or at contractor option. Shipping splits and lifting points shall be coordinated with the installing contractor. Provide acoustic barrier packages as scheduled.

B. Adjustable Curb-mounted Spring Isolation Rails: Type ARTR – Full perimeter adjustable vibration isolation rail with integral restrained spring isolators for installation on top of a rigid roof curb. Rails shall be constructed using minimum 16 ga (1.6 mm) formed galvanized steel. Integral housed spring isolators shall have zinc plated high grade steel housings designed to limit motion due to wind or seismic forces, and shall include integral all-directional limit stops with reinforced elastomeric grommets preventing metal-to-metal contact and short circuiting, with nominal 1/4" clearance under normal operation. The integral isolators shall be adjustable to ensure that the supported equipment stays level after installation. Rails shall be provided with weather seal materials consisting of closed cell sponge tape for installation between the equipment and the upper rails, and waterproof, flexible, reinforced EPDM strips for joining the outside perimeter of upper and lower rails. Solid top covers, framing for acoustical barrier installation, galvanized steel duct supports, and flexible duct connections shall be provided as scheduled or required. The rail shall be manufactured, shipped and installed as a single piece where size and shipping conditions permit. Shipping splits and lifting points shall be coordinated with the installing contractor.

C. Seismic/Wind Rated Spring Isolation Roof Curbs: Type VCR – Full perimeter adjustable vibration isolation curbs with integral restrained spring isolators. Curbs shall be designed to attach directly to roof structure with provisions for accommodating roof slope and maintaining equipment level. Lower portion of curbs shall be constructed with minimum 16 ga (1.6 mm) galvanized steel with seams continuously welded and complete with full-perimeter factory-attached 2x4 wood nailers; minimum height to top of nailers shall be as required by local authority or 14" (355 mm), whichever is greater. Curbs shall include all-directional limit stops with reinforced elastomeric components to eliminate metal-to-metal contact and with nominal ¼" clearance under normal operation. Curbs shall provide continuous support for equipment and shall withstand the wind and seismic forces applicable to the project. Curbs shall be provided with weather seal materials consisting of closed cell sponge tape for installation between the

equipment and curbs and waterproof, flexible, reinforced EPDM strips for joining the outside perimeter of upper and lower members. Internal insulation and additional weather seals for return air plenums, solid top covers, acoustical barrier packages, galvanized steel duct supports, and flexible duct connections shall be provided as scheduled or required. Curbs shall be manufactured, shipped and installed as a single piece where size and shipping conditions permit. Shipping splits and lifting points shall be coordinated with the installing contractor.

D. Isolation Rails: Type FSR – Free spring rails designed to continuously support equipment not vulnerable to lateral seismic or wind loads. Rails shall be constructed of formed galvanized sheet metal or structural steel members and include pre-drilled equipment mounting holes as scheduled or required. Springs shall be laterally stable. Rails shall include vertical restraints complete with integral snubbers to minimize vertical travel during changes in supported equipment weight. Snubbers shall include elastomeric components to minimize metal-to-metal contact.

2.03 BASES:

A. Steel Equipment Base: Bases shall be constructed of structural steel members with cross members to form an integral support platform. Steel deflection shall be limited to 1/360th of the longest span but not to exceed 1/4”. Minimum clearance under steel equipment bases shall be 1” (25 mm). Bases shall be designed for specific support points, both for the equipment on top and the support points below.
   1. Type CTB –bases typically used for cooling towers and consisting of W-shaped structural steel beam main supports and cross bracing to create a rectangular base with bolted or welded joints. Bases shall include pre-drilled holes for attaching equipment. Bases shall be engineered for all design lateral loads as well as vertical loads. Design calculations shall be available upon request.
   2. Type IFB –bases typically used for supporting fans and their associated motors with structural angle main support beams and cross braces. Bases for fans shall have adjustable motor slide rails as indicated on the Schedule and shall accommodate motor overhang where required.

B. Concrete Inertia Base: Inertia bases shall be of welded steel construction with concrete in-fill supplied by the installing contractor on site and shall incorporate minimum #4 (or 10M) reinforcing bars, welded 12” (300 mm) to 18” (455 mm) maximum on centers each way. Inertia bases for end suction and split case pumps shall be of sufficient size to accommodate supports for pipe elbows at pump suction and discharge connections. Inertia bases for fans shall include motor slide rails as required. The weight of each inertia base shall be at least equal to the weight of the equipment mounted thereon. Inertia bases shall be of minimum 6” (150 mm) thickness. Height-saving brackets or welded steel pockets shall be incorporated to ensure a 1-1/2” (40 mm) minimum clearance under each base. Equipment bolting templates shall be provided when required or scheduled. Bottom pans may be provided at contractor option but shall be minimum 16ga sheetmetal.
   1. Type CIB – Rectangular frame concrete inertia base typically used with fans, end suction pumps, and other base-mounted equipment.
   2. Type TCIB – T-Shaped frame concrete inertia base typically used with double suction pumps with suction and discharge piping supported on each side of the pump.
   3. Type LCIB – L-Shaped frame concrete inertia base typically used with double suction pumps with suction piping supported on one side.

2.04 SEISMIC/WIND RESTRAINTS:

A. Cable Restraints:
   1. Type BB– Preassembled, adjustable sway bracing restraints made with 7x19 galvanized steel aircraft cable, brackets or stake eyes, and thimbles sized to resist design loads and

packaged together in pairs. Cable restraints shall use securement devices with set and locking screws that allow quick cable length adjustment to remove excessive sag.
2. Type BBR – Type BB restraints with one end complete with a hook-style bracket suitable for retrofit applications.
3. Type SRK –sway bracing restraints made with 7x19 wire rope using brackets, thimbles, and wire rope clips for securement devices. Where restraints are exposed to corrosive environments they shall be made with stainless steel materials.

B. Rigid Restraints: Type RRK –rigid sway bracing restraints made with lengths of standard 1-5/8" square strut and heavy duty brackets made of high-strength, low alloy steel. Brackets shall be of a universal design for attachment to both structure and restrained component and shall accommodate retrofit installation.

C. Beam Clamps: Type BC – Seismically rated beam clamps for attachment of restraints to structural steel without drilling. Beam clamps shall be constructed of ductile cast frames, case hardened cone point set screws and related hardware.

D. Hanger Rod Stiffener Clamps: Type VAC – Formed steel clamps used to secure structural angles to threaded rod supports complete with securing bolts and locking nuts.

E. Support Stands:
1. Type SIPS – trapezoidal-shaped rigid support stands made of high strength, low alloy steel designed to be bolted to pipe flanges which support vertical inline pumps and other flanged components. Stands shall include cut-outs to accommodate pump body gussets and rubber grommet washers preinstalled in mounting holes for anchor bolts.
   a. Type SIPS-NP – Type SIPS stands complete with vibration isolation pads for reducing vibration transmission into the supporting structure.
2. Type SPS – rigid support stands made with round hollow steel sections, designed to support pipe weight and withstand lateral seismic forces.
3. Type SPSA – rigid support stands made with round hollow steel pipe or sections, designed with an adjustable element to accommodate different pipe sizes and elevations.

F. Brackets and Snubbers:
1. Type SRB – Formed steel brackets for securing floor-mounted equipment complete with pre-drilled holes. Brackets shall be furnished with grommet washers for vibration isolated equipment.
2. Type DAB – Formed steel brackets that allow use of two anchors to secure sway bracing restraints to structure. Brackets shall be designed for use with wood, monolithic concrete, and concrete on metal deck installations – both B-deck and W-deck versions shall be available.
3. Snubbers: Structural steel shapes with contact surfaces covered with rubber to cushion impact forces. Snubbers shall be designed to limit excessive vibration isolated equipment motion due to wind or seismic loads to no more than 1/4" (6 mm) in any direction.

G. Anchor Bolts:
1. Post-installed anchors in concrete and masonry shall be qualified for seismic/wind restraint applications as appropriate.
2. Mechanical anchor bolts: Concrete screw type, drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. Anchors shall be tested and qualified for use in accordance with ACI 355.2 and ICC-ES AC193.
3. Adhesive Anchor Bolts: Drilled-in and capsule anchor system containing polyvinyl or urethane methacrylate-based resin and accelerator, or injected polymer or hybrid mortar adhesive. Provide anchor bolts and hardware with zinc-coated steel for interior applications and stainless steel for exterior applications. Anchors shall be tested and qualified for use in accordance with ACI 355.4 and ICC-ES AC308.

2.05 FLEXIBLE CONNECTORS AND EXPANSION JOINTS:

A. Rubber Expansion Joints: Synthetic rubber tube and cover construction, molded and cured in hydraulic presses using either EPDM (Type EJE) or neoprene (Type EJN) as specified or as required by the application. Rubber expansion joints shall be reinforced with multi-ply Nylon tire cord fabric; internal reinforcing of metal wire or embedded rings are not acceptable. Rubber expansion joints shall either be single sphere (EJE1 OR EJN1) or double sphere (EJE2 OR EJN2) as specified or as required by the application. Double sphere rubber expansion joints shall have a factory installed steel body ring between the two spheres to control ballooning under high pressure/temperature situations. Rubber expansion joints for pipe sizes 1-1/2” and up will have floating steel flanges. The mating surface will be 100% rubber. For sizes 3/4” up to 3”, threaded female union connectors are also accepted. Control rods or cables shall be installed to prevent excessive elongation where required. Control rods shall utilize 1/4” thick rubber grommets to limit vibration transfer.

B. Metal Bellows Expansion Joints: Type EJM – Bellow pump connectors with series 300 stainless steel multi-ply bellows construction welded to carbon steel flanges. Metal bellows expansion joints shall have three factory installed tie rods to prevent excessive elongation, and to control the static pressure thrust at full rated working pressure of the connector. Tie rods shall utilize rubber grommets to limit vibration transfer.

C. Braided Metal Flexible Connectors: Corrugated 300 series stainless steel bellows (Type FCSS) or bronze bellows (Type FCB) flexible connectors with stainless steel or bronze braiding connected to braid collars and pipe fittings at each end.

D. Thermal and Seismic V-Connectors: Combination of two braided flexible connectors with stainless steel bellows and braids (Type SBS) or bronze bellows and braids(Type SBV), two 45° elbows and one 90° elbow configured in a V-shape layout for a total of 180° in pipe connection change. V-connectors shall allow movements as required by the application and of at least 2 inches (50 mm) along the 6 directions of XY, YZ and XZ planes. Large connectors shall be supplied with shipping bars tack welded at factory to maintain designed length before installation. For steam applications, a drain port and plug shall be specified and factory installed into the bottom of the 90° elbow to allow condensate to be drained.

E. Thermal Expansion Compensators: Type TEC – Thermal expansion compensators, constructed with two–ply series 300 stainless steel bellows and carbon steel shroud, internal liner and end fittings. Expansion compensators shall utilize anti-torque, anti-squirm devices and allow axial movements of 1-3/4” (44 mm) compression and 1/4” (6 mm) extension. In all applications, the compensator shall provide a minimum of 150% expected growth between anchors. Expansion compensator ends shall match piping connection methods.

F. Externally Pressurized Expansion Joints: Type XPEJ – Externally pressurized expansion joints, constructed using series 300 stainless steel formed bellows, external housing and pipe fittings. The externally pressurized expansion joints shall be rated to match the piping system and allow at least 4 inches (100 mm) of axial travel. Drain port and plug shall be provided factory installed where required.

2.06 ANCHORS AND GUIDES:

A. Spider Pipe Guides: Type SPG – Standard concentric spider type pipe alignment guides with heavy steel construction of sufficient strength to withstand lateral forces of at least 15% of calculated pipe anchor loads. Spider pipe guides shall provide space for specified insulation thickness and allow a minimum of 4 inches (100 mm) of axial movement (+/- 2 inches (50 mm)). For copper piping installations, dielectric spacers shall be furnished to prevent galvanic corrosion.

B. Pipe Riser Guides: Type PRG – Vertical sliding pipe riser alignment guides constructed with hollow structural shapes and welded steel plates and including rubber bushings between telescoping elements to eliminate metal-to-metal contact and minimize structure-borne noise transmission. Guides shall include support plates to accommodate attachment of pipe riser clamps or support brackets by welding or bolting. Guides shall be designed to be used in pairs with each associated pipe riser and accommodate vertical movement of at least 1-1/2” (38 mm) upwards or downwards from initial installed position.

C. Pipe Riser Anchors: Type PRA – All-directional pipe riser anchor resilient supports constructed with welded formed steel plate and including heavy duty rubber bushings to eliminate metal-to-metal contact and minimize structure-borne noise transmission. Anchors shall include support plates to accommodate attachment of pipe riser clamps or support brackets by welding or bolting. Anchors shall be designed to be used in pairs with each associated pipe riser and limit movement to less than ¼” in any direction.

PART 3: EXECUTION

3.01 GENERAL:

A. Coordinate size, doweling, and reinforcing of concrete equipment housekeeping pads and piers with vibration isolation and restraint manufacturer to ensure adequate space and prevent edge breakout failures. Pads and piers must be adequately doweled in to structural slab.

B. Coordinate locations and sizes of structural supports for systems and equipment with locations of anchors, guides, stands, curbs, vibration isolators, and restraints.

C. Isolated and restrained equipment, duct, and piping located on roofs must be attached to the structure. Intermediate supports between the restraint points that are not attached to the structure must be coordinated with the restraint manufacturer.

D. Coordinate project material requirements with isolation and restraints supplier, e.g., use stainless steel components or hot-dipped galvanized products where required.

3.02 VIBRATION ISOLATION:

A. Block and shim all bases level so that all ductwork, piping, and electrical connections can be made to a rigid system at the proper operating level before isolators are adjusted. Ensure that there are no rigid connections or incidental physical contacts between isolated equipment and the building structure or nearby systems.

B. Select and locate vibration isolators to provide similar loading and deflection, according to weight distribution of equipment.

C. Mount belt-driven fans, as indicated on the drawings, on structural steel vibration bases common to both fan and motor. There shall be a minimum operating clearance of 1” (25 mm) between steel bases and the structure.

D. Secure base-mounted pumps and equipment, as indicated in this Section or on the drawings, to concrete-filled inertia bases. Concrete in-fill shall be supplied by the installing contractor on site.

E. Coordinate materials and connection styles for inline flexible connectors and expansion joints with isolation supplier, e.g., 150# ANSI steel flanges for flanged pipe connections.

F. Types and Extent of Piping Isolation:

1. Isolate all piping larger than 1” (25 mm) nominal diameter rigidly connected to vibration isolated equipment with 1” (25 mm) static deflection spring isolators, except as described below, at spacing intervals in accordance with the following:

PIPE DIAMETER	DISTANCE FROM VIBRATING EQUIPMENT
1-1/4” (32 MM) TO 4" (100 MM)	50' (15 M)
6" (150 MM) AND 8" (200 MM)	60' (18 M)
10" (250 MM) AND LARGER	70' (21 M)

A. Horizontal: Floor supports for piping shall incorporate restrained spring floor isolators appropriate for the applicable design forces. Suspended piping shall be supported with Type SHR isolators, or PSHR at contractor option. The first 3 isolators shall be selected with the same nominal static deflection as the equipment isolators, but no greater than a nominal 2” (50 mm) deflection. The remaining isolators shall be selected with a nominal 1” (25 mm) static deflection.

B. Vertical: Piping shall be isolated from the supporting structure with spring floor isolators or spring and rubber isolator hangers selected with a nominal 1” (25 mm) static deflection.
   1. Spring hanger isolators shall be cut in to the hanger rods and installed after the associated piping system is filled or other provisions must be made to ensure piping does not change height significantly during installation and start-up. Contractor may choose at their option to use precompressed spring hangers (i.e., Type PSHR) to enable installation prior to filling pipe systems.
   2. Exemptions: Piping attached to isolated equipment with double sphere rubber expansion joints or flexible metal hose with minimum length equal to 10 pipe diameters, or to air handling units with internal vibration isolators meeting the requirements of these specifications is exempt from these requirements unless otherwise specified or indicated on the drawings.

C. Pipe Risers: All pipe risers extending more than 5 floors through the building shall include supports and guides suitable to control changes in the pipe length due to thermal changes. Support system design to be provided by the Delegated Design Engineer for review and approval by the Engineer of Record prior to installation.

D. Types and Extent of Ductwork Isolation:
   1. Isolate all ductwork that is rigidly connected to isolated or vibrating equipment, including grease hood exhaust ductwork, for a minimum distance of 50 feet (15 m) from the equipment. Ductwork attached to isolated or vibrating equipment with flexible connections or to air handling units with internal vibration isolators is exempt from these requirements.
      a. Suspended ductwork shall be supported with Type SHR isolators selected with a nominal 1” (25 mm) static deflection.
      b. Floor-supported ductwork shall be isolated from the structure with spring floor isolators selected with a nominal 1” (25 mm) static deflection.

E. Engine-generator set silencers and associated exhaust piping shall be supported with Type SHR isolators selected with a nominal 1” (25 mm) static deflection.

F. Equipment Isolation: See schedule(s) on drawings

G. Installing contractor shall ensure no rigid contact of isolated piping, ductwork, or equipment with other structure, building systems, or components such as shaft walls, floor slabs, partitions, or conduits.

H. Provide height-saving brackets (HSB) where specified for equipment stability or operating height requirements.

I. Where recommended by the manufacturer or required for restraint, floor mounted isolators shall be bolted to the supporting structure.

J. Provide spring-loaded thrust restraints for fans and any suspended equipment where movement due to fan operation under any operating condition will exceed 3/8” (10 mm).

K. Isolator hangers shall be installed with the housing a minimum of 1/4” (6 mm) below but as close to the structure as possible. Where isolator hangers would be concealed by non-accessible acoustical sub ceiling, install the hangers immediately below the sub ceiling for access.

3.03 SEISMIC/WIND RESTRAINTS:

A. General:
1. All equipment, piping and ductwork shall be restrained to resist seismic/wind forces as required by and in accordance with the applicable building code(s) as a minimum. Restraint attachments shall be made by bolts, welds or any other qualified fastening methods. Friction shall not be considered as positive attachment. All attachments shall be proven capable of accepting the required wind and seismic loads by testing or analysis.
2. Install seismic and wind restraints per the Delegated Design Engineer and manufacturer’s submittals. Any deviation from the manufacturer’s instructions shall be reviewed and approved by the manufacturer and the Delegated Design Engineer.
3. Attachment to structure for all restraints shall be as specified by the Delegated Design Engineer. Any changes or modifications shall be reviewed and approved by this engineer prior to installation or submission to the local authority.
4. Coordinate sizes and locations of cast-in-place inserts for attaching restraints to post-tensioned slabs with the restraint manufacturer and the Delegated Design Engineer.
5. Provide hanger rod stiffeners where indicated or as required by the Delegated Design Engineer to prevent buckling of threaded hanger rods due to uplift caused by design forces.
6. Where rigid restraints are used on equipment, ductwork, or piping components, the associated component support rods must be attached to structure with anchors rated for seismic use.
7. Install restraint cables so they do not bend across edges of adjacent components or building structure.

B. Concrete Anchors:
1. Follow all installation instructions and requirements as provided by anchor manufacturer. Use certified installers where required by anchor manufacturer.
2. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify the structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid any embedded items such as pre- or post-tensioned tendons, electrical and telecommunications conduit, and gas lines.
3. Do not drill holes in concrete or masonry for installing anchors until concrete, mortar, or grout has achieved full design strength.
4. Install rubber grommet washers on equipment anchor bolts or fill empty annular space with epoxy where clearance between anchors and equipment support holes exceeds 1/4” (6 mm).
5. Mechanical Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is fastened.

6. Adhesive Anchors: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.
7. Set anchors to manufacturer's recommended torque, using a torque wrench.

C. Equipment Restraints:
1. Restrain equipment as required by the Delegated Design Engineer. Install fasteners, straps, restraints, and brackets as required to secure equipment.
2. Install snubbers on equipment supported by floor-mounted vibration isolators that are not rated for the applicable lateral design forces. Locate snubbers as close as possible to vibration isolators and attach to both equipment or its base and to supporting structure as required.

D. Duct Systems:
1. Where required, space transverse seismic restraints at a maximum of 30’ o.c. (9 m), and longitudinal restraints at a maximum of 60' (18 m) o.c.
2. Where required, duct risers shall be restrained at floor penetrations every 30' (9 m) maximum spacing.
3. Fire damper locations may be used as restraint locations for all directions except away from the damper, provided that both the damper frame and the wall can withstand the design loads.
4. Install flexible duct assemblies in duct runs that cross building seismic joints, sized for the anticipated amount of movement.

E. Piping Systems:
1. Restraint spacing where required:
   a. For ductile piping, space transverse supports a maximum of 40' (12 m) o.c., and longitudinal supports a maximum of 80' (24 m) o.c.
   b. For non-ductile piping (e.g., cast iron, PVC) space transverse supports a maximum of 20' (6 m) o.c., and longitudinal supports a maximum of 40' (12 m) o.c.
   c. For piping with hazardous material inside (e.g., natural gas, medical gas) space transverse supports a maximum of 20' (6 m) o.c., and longitudinal supports a maximum of 40' (12 m) o.c.
   d. For vertical pipe risers, restrain the piping at floor penetrations using the same spacing requirements as above.
2. Longitudinal restraints for single pipe supports shall be attached directly to the pipe, not to the pipe hanger.
3. For supports with multiple pipes (e.g., trapezes), secure pipes to supporting member with clamps approved for application.
4. Piping on roller supports shall include a second roller support located on top of the pipe at each restraint location to provide vertical restraint. At the discretion of the Delegated Design Engineer, oversized U-bolts or other means may be used in lieu of a second roller.
5. Install thermal and seismic V-connectors in piping which crosses building seismic joints, sized for the anticipated amount of movement.
6. Install flexible piping connectors where adjacent sections or branches are supported by different structural elements, and where the connections terminate with connection to equipment that is anchored to a different structural element from the one supporting the connections as they approach equipment.
7. Coordinate restraints with thermal expansion compensators, guides and anchor points. Thermal expansion anchor points shall be designed to accommodate seismic forces.

3.04 INSPECTION AND CERTIFICATION:

A. After installation, arrange and pay for the vibration isolation product manufacturer, or representative, to visit the site to verify that the vibration isolation systems are installed and operating properly, and to submit a letter so stating. At a minimum, verify that isolators are properly adjusted, with springs perpendicular to bases or housing, adjustment bolts are tightened on equipment mountings, and hanger rods are not in contact with hanger isolator housings.

B. After installation, arrange and pay for the restraint product manufacturer, or representative and/or the Delegated Design Engineer or their representative to visit the site to verify that the restraint systems are installed properly, and to submit a letter so stating. The letter shall be sealed and signed by the Delegated Design Engineer.

END OF SECTION