

PART 1 - GENERAL

1.1 SECTION INCLUDES

- .1 Systems and devices intended to protect against any shock effect caused by earthquakes, static and elastic supporting technical material (i.e.: vibration isolated), including mechanical systems and equipment, laboratory fume and exhaust hoods, electrical and mechanical installations' control devices, electrical lighting equipments, current transformers, motors command centers, uninterruptible power supply systems, diesel fuel generators, emergency supply systems, and fire protection installations.

1.2 RELATED SECTIONS

- .1 Section 21 00 00/26 00 00 – Specific Conditions – Mechanical/Electrical.

1.3 REFERENCES

- .1 Unless otherwise indicated, all the works must be done in accordance with the latest edition of the Quebec Construction Code (QCC).
- .2 Furthermore, works must be designed and carried out in accordance with any other code or standard having jurisdiction, as per the latest edition, including, but not limited to:
 - .1 American Iron and Steel Institute (AISI).
 - .1 AISI, Specification for the Design of Cold-Formed Steel Structural Members.
 - .2 Factory Mutual (FM).
 - .1 FM Global 2-0, Installation Guidelines for Automatic Sprinklers.
 - .2 FM Global 2-8, Earthquake Protection for Water-Based Fire Protection Systems.
 - .3 American National Standards Institute (ANSI) / National Fire Protection Association (NFPA).
 - .1 ANSI/NFPA 13, Installation of Sprinkler Systems.
 - .4 American Society of Civil Engineers (ASCE).
 - .1 ASCE 96, Structural Applications of Steel Cables for Buildings.

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- .5 American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE).
 - .1 ASHRAE, A Practical Guide to Seismic Restraint.
- .6 American Society for Testing Materials (ASTM).
 - .1 ASTM A53/A53M, Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
 - .2 ASSTM A307, Standard Specification for Carbon Steel Bolts and Studs, 60,000 PSI Tensile Strength.
 - .3 ASTM A475, Standard Specification for Zinc-Coated Steel Wire Strand.
 - .4 ASTM A603, Standard Specification for Zinc-Coated Steel Structural Wire Rope.
 - .5 ASTM A1011/A1011M, Standard Specification for Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, and Ultra-High Strength.
 - .6 ASTM E488, Standard Test Methods for Strength of Anchors in Concrete and Masonry Elements.
- .7 Canadian Standards Association (CSA) / CSA International.
 - .1 CSA G40.20/G40.21, General Requirements for rolled or Welded Structural Quality Steel / Structural Quality Steel.
- .8 Sheet Metal and Air-Conditioning Contractors' National Association (SMACNA).
 - .1 ANSI/SMACNA 001, Seismic Restraint Manual: Guidelines for Mechanical Systems.

1.4 SEISMIC RESTRAINT SYSTEMS CHARACTERITICS

- .1 Seismic restraint systems must be entirely integrated and compatible with the following items:
 - .1 Specified acoustic and anti-vibrations devices;
 - .2 Design characteristics of building and electrical and mechanical installations.
- .2 Each Specialized Contractor is responsible for seismic restraint systems regarding its field.

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- .3 In the event of an earthquake, earthquake-resistant devices must be able to withstand, without damage, the maximum relative structural displacement provided for during the construction of the building. Seismic restraint systems are intended to prevent equipment from moving or rolling over in order to protect occupants during an earthquake.
- .4 Design of seismic restraint systems must be done by an engineer, specialized in seismic engineering and recognized in the Province of Quebec.

1.5 SUBMITTALS

- .1 Submit all documents and samples required in Section 21 00 00/26 00 00 – Specific Conditions – Mechanical/Electrical.
- .2 Submit the following:
 - .1 Detailed version of the design criteria;
 - .2 Execution drawings (of same quality and format as the drawings part of the contractual documents), lists of materials and equipment, schematic representations as well as detailed specifications for all the elements of each earthquake-resistant device;
 - .3 Design documents, work sheets and charts, including the calculation of the strain rates attributed to seismic forces, as per the QCC;
 - .4 Separate shop drawings for each earthquake-resistant device or system, as well as for each of their elements;
 - .5 Document specifying the location of each device or system;
 - .6 Lists of the different types of earthquake-resistant devices or systems and their related elements;
 - .7 Document showing or indicating the details of anchoring and mounting devices, anchoring loads as well as mounting methods to the frame;
 - .8 Document specifying instructions and installation methods.
- .3 Submit documents, signed and sealed by an Engineer, specialized in this field and recognized in the Province of Quebec, certifying that the products, materials and equipment comply with specified physical characteristics and performance criteria.
- .4 Submit manufacturer's installation instructions.

1.6 CLOSEOUT SUBMITTALS

- .1 Submit all required closeout submittals and integrate them into the "Operating and Maintenance Manual", according to Section 21 00 00/26 00 00 – Specific Conditions – Mechanical/Electrical.
- .2 Include instructions regarding control of seismic restraint systems and devices to maintenance sheets.

1.7 PROTECTION LEVEL

- .1 Install earthquake-resistant anchoring and stabilization devices for ventilation ducts, equipment, tanks and piping other than those provided for fire safety, in accordance with the "ASHRAE, A Practical Guide to Seismic Restraint" manual and ANSI/SMACNA 001 standard.
 - .1 Design criteria:
 - .1 City: [Sept-Îles_____]
 - .2 Risk level: [_____]
 - .3 Location category: [_____]
 - .2 Protection level for building:
 - .1 SHL-"[]" for piping and ducts;
 - .2 SHL-"[]" for toxic or explosive gas pipes;
 - .3 SHL-"[]" for flat-bottom tanks;
 - .4 SHL-"[]" for flat-bottom tanks containing toxic or explosive products;
 - .5 SHL-"[]" for equipment;
 - .6 SHL-"[]" for tanks;
 - .7 SHL-"[]" for tanks containing toxic or explosive products;
 - .8 SHL-"[]" for natural gas pipes.
 - .9 SHL-"[]" []
- .2 Install earthquake-resistant anchoring and stabilization devices for fire safety piping, in accordance with the provisions of standard NFPA 13. Protection level required is $V_p = [xx W_p]$.

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PART 2 - PRODUCTS

2.1 SUPPLY SOURCE

- .1 The devices and earthquake-resistant systems must be supplied by only one manufacturer possessing experience in that subject area.
- .1 Acceptable products: Mason Industries; Hilti; Tolco.

2.2 GENERAL

- .1 Earthquake-resistant devices must prevent permanent displacements, as well as damages caused by horizontal, vertical and reversing movements.
- .2 Earthquake-resistant devices must be compatible with the electromechanical design. They must not impede the normal operation of the electromechanical systems.
- .3 Earthquake-resistant devices and systems must provide gentle, steady cushioning action, and be capable of working in every direction in order to mitigate shock effects.
- .4 The mountings and attachment points must be able to resist the same maximal loads as the earthquake-protection devices.
- .5 Mounting of the earthquake-resistant devices and systems to reinforced concrete frames:
 - .1 Anchors used must be of expansive type and must present a high degree of mechanical strength;
 - .2 No anchor must be secured by a nail gun;
 - .3 Acceptable products: Hilti, HSL type.
- .6 No device, connected holder nor electrical contact rivet must yield before the frame or the structure yields.
- .7 Earthquake-resistant devices composed of cast iron, threaded tubes or other frangible materials will not be accepted.
- .8 Earthquake-resistant devices must not obstruct the operation of fire-stop devices nor compromise their integrity.
- .9 Stabilize all accessories, such as diffusers and lighting appliances installed in suspended ceilings.

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2.3 STEEL ANGLES

- .1 Angle made from cold shaped steel plate and meeting AISI requirements, with minimum ultimate stress value, $F_u = 410 \text{ MPa}$ (59 ksi) and an elastic limit stress of $F_y = 300 \text{ MPa}$ (43 ksi).

2.4 "C" CHANNELS

- .1 "C" channel manufactured following ASTM A1011/A1011M GR 33 standard and CSA G40.20/G40.21 standard.

2.5 STRUCTURAL PIPING

- .1 Structural piping, manufactured following ASTM A53/A53M standard, type E or S, grade B.

2.6 CABLE

- .1 Cable manufactured following ASTM A603 or ASTM A475 standard, with at least seven (7) wires, and class A coating.
- .2 Connection parts, meeting ASCE 96 standard requirements and tested to hold at least 110% of the ultimate tensile stress of the cable.

2.7 BOLTS

- .1 Bolts manufactured in accordance with ASTM A307 standard, grade A, hex head.

2.8 SEISMIC RESTRAINT FOR EQUIPMENT REQUIRING STATIC SUPPORT

- .1 Attach equipment to hanging supports mounted on the structure.
- .2 Install devices in order to avoid horizontal oscillation, vertical tipping over as well as axial sliding or buckling.
- .3 Use buckling resistant suspension rods.

2.9 SEISMIC RESTRAINT FOR EQUIPMENT REQUIRING ELASTIC SUPPORT

- .1 Attach equipment to hanging supports attached to the structure by means of rigid rods on the three axes.
- .2 Restraint devices must act with flexibility and in a continuous manner. To do so, they must contain elastomeric elements, or any other parts meant to minimize impacts.

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- .3 Seismic restraint devices must not impact the efficiency of noise and anti-vibration elements. During normal operations, the clearance between seismic restraint devices and equipment must be between 6 mm (1/4 in.) and 12 mm (1/2 in.).
- .4 If aseismic isolators are used, they shall be designed and installed in order to hold minimum acceleration forces.
- .5 Devices must never be compressed at the point of loss of efficiency.
- .6 Seismic restraint devices must avoid the complete discharge of anti-vibration devices.
- .7 If standard isolators are used, seismic restraint devices must be incorporated to anti-vibration elements in order to prevent them from tipping over.

PART 3 - EXECUTION

3.1 GENERAL

- .1 Attachment points and fastening devices:
 - .1 Verify that anchoring bolts, dowel diameters, recesses depths in the concrete and weld lengths comply with drawings submitted for approval.
 - .2 Bolt to the frame or structure all the material that is not insulated against the transmission of vibrations.
 - .3 Oblong drillings for the adjustment of bolts is prohibited.
 - .4 For earthquake-resistant purposes, small diameter lines may be attached to bigger diameter lines that will hold them. The reverse practice is prohibited.
 - .5 Anchoring points inside concrete slabs must be moved away from the edges as per ASTM E-488 standard and anchor manufacturer's recommendations.
 - .6 The anchorage depth in concrete slabs must be at least eight (8) times their diameter.
 - .7 Install restraining straps on every C-clamp used to support piping, in order to hold them in place in the event of an earthquake. Straps must be provided by the C-clamp manufacturer.
- .2 Holding cables:
 - .1 Link the holding cables to hanging appliances so that their axial incidence corresponds to the gravity center of the protected appliances.

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- .2 Tighten the cables following manufacturer's recommendations.
- .3 Use wire ways, lugs and other appropriate hardware to ensure alignment of earthquake-resistant devices and to prevent cables from bending at fastening points.
- .4 For equipment hanging from the ceiling, set the holding cables at a 90° angle and secure them to the building's frame at a 45° angle.
- .5 Adjust the tension of the lines in a manner that they do not seem loose but that they do not bother the normal operation of anti-vibration devices.
- .6 Tighten cables to reduce slack to 40 mm (1½ in.) under thumb pressure. In normal operations, lines must not support the weight of the equipment held.
- .3 Tighten bolts to the C-channel using the following torque:
 - .1 NPS ½: 68 Nm (50 ft-lb);
 - .2 NPS ¾: 169 Nm (50 ft-lb).
- .4 Install earthquake-resistant devices and systems at least 25 mm (1 in.) from any other appliance or utility line.
- .5 Miscellaneous equipment not insulated against vibrations:
 - .1 Bolt equipment to the assembly base then to the frame using crossing anchor bolts.
- .6 Coordinate connecting operations with other building trades.
- .7 Vertical tanks:
 - .1 Anchor the tanks to their assembly base then to the frame using crossing anchor bolts.
 - .2 Install retaining collars in steel strips above the gravity center.
- .8 Horizontal tanks:
 - .1 Plan for at least two bucking straps, with anchoring bolts secured to the frame.
- .9 Brace the equipments independently from the ventilation ducts.
- .10 Never use two types of bracing in the same direction.
- .11 Do not stabilize equipment whose hanging rods are smaller than 300 mm (12 in.) long.

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- .12 Do not install seismic restraint devices at a horizontal angle over 60° or under 45°.
- .13 Install transversal seismic restraint devices, perpendicular to the direction of the duct or pipe, with a maximum variation angle of 2.5°.
- .14 Install longitudinal seismic restraint devices parallel to the direction of the duct or pipe, with a maximum variation angle of 2.5°.
- .15 Install at least two (2) transversal and one (1) longitudinal seismic restraint device or system on every straight piping segment.
- .16 Install transversal and longitudinal seismic restraint devices at a maximum distance of 100 mm (4 in.) from a vertical support, which must be reinforced as needed.

3.2 MANUFACTURER INSTRUCTIONS

- .1 Comply with manufacturer's requirements, recommendations and written specifications, including any available technical bulletin, instructions regarding handling, storage and installations of the products, and indications from the technical sheets.

3.3 SERVICE AND UTILITY ENTRANCE INTO BUILDING

- .1 Provide means for ensuring the flexibility of service and utility lines to prevent any line breaks in the event of an earthquake.

3.4 ONSITE QUALITY CONTROL

- .1 Once installation work is complete, seismic restraint devices must be inspected and certified by an engineer specialized in this field and recognized in the Province of Quebec.
- .2 Provide a written report and compliance certificate to the Engineer.
- .3 If needed, the Contractor must make necessary corrections and adjustments according to the Specialized Engineer's written report.

3.5 DOCUMENTS NEEDED FOR START-UP

- .1 Once certification is complete and the report accepted, submit to the Engineer a complete copy of the project record reviewed and annotated to show as-built conditions.

3.6 INSTALLATION FOR PIPING AND FIRE PROTECTION

- .1 Perform installation and design of earthquake-resistant systems as per [FM Global 2-8] [ANSI/NFPA 13 standard].

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- .2 Install standard flexible mechanical joints for grooved piping on pipes NPS 2½ or greater, at following locations:
 - .1 Within 610 mm (24 in.) from the upper slab of supply column, if longer than 0.9 m (3 ft.);
 - .2 Within 305 mm (12 in.) from the floor of supply column;
 - .3 Within 610 mm (24 in.) horizontally of a fitting on a supply column;
 - .4 Within 610 mm (24 in.) from the building's expansion joints;
 - .5 Within 610 mm (24 in.) of the top of the supply columns;
 - .6 Within 610 mm (24 in.) of the top of the tallest supply column support attached to the structure, shelving or mezzanine;
 - .7 Within 610 mm (24 in.) of the bottom of the supply columns.
- .3 Install seismic separation assemblies wherever piping crosses a seismic separation within the building. Stabilize this assembly transversely, vertically and longitudinally within 1.83 m (6 ft.) of either side of the separation.
- .4 A minimum of every 12.2 m (40 ft.), stabilize transversely all water main pipes regardless of size and all branch pipes of NPS 2½ or more.
- .5 The distance between the tip of the pipe to stabilize and the longitudinal support must not exceed 1.8 m (6 ft.).
- .6 Stabilize transversely the final section of a water main pipe.
- .7 The transversal seismic restraint system or device of a piping section of NPS 2½ and over can also be used as a longitudinal seismic restraint system or device for a piping section of the same dimension installed perpendicularly to the first section, if the bracings are located within 610 mm (24 in.) from an elbow or a "T" fitting.
- .8 Stabilize transversely water mains within 610 mm (24 in.) of flexible mechanical joints other than the requisite flexible mechanical joints indicated above.
- .9 At least every 24.4 m (80 ft.), stabilize longitudinally all water main pipes.
- .10 The distance between the end of the pipe to be stabilized and the longitudinal support must not exceed 12.2 m (40 ft.).
- .11 Do not transversely stabilize piping suspended by supports, located less than 150 mm (6 in.) from the structure. This exception does not apply to longitudinal stabilization.

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- .12 Every 7.6 m (25 ft.), stabilize transversely, vertically and longitudinally the top of vertical columns over 1 m (3 ft.) in length.

3.7 INSTALLATION FOR VENTILATION DUCTS

- .1 Perform installation and design of earthquake-resistant systems as per “ASHRAE, A Practical Guide to Seismic Restraint” manual and ANSI/SMACNA 001 standard.
- .2 Stabilize the rectangular and oblong ventilation ducts whose surface is 0.55 m² (6 ft²) and over, and the circular ducts whose diameter is 700 mm (28 in.) and over.
- .3 A transversal seismic restraint device or system installed to stabilize a duct section can also be used as a longitudinal seismic restraint device or system to stabilize another duct section of same or smaller dimensions, if the two duct sections are mounted perpendicular to each other and if the seismic restraint device or system is installed within 600 mm (24 in.) from the intersection.
- .4 A wall (including a gypsum wall) can be used as a transversal seismic restraint system, if the duct is solidly attached around its wall perimeter.
- .5 Install the mechanical restraint devices according to the following minimum frequency:
 - .1 For vertical stabilization:
 - .1 Vertical stabilization is provided by regular supports.
 - .2 For transversal stabilization: 9.1 m (30 ft.).
 - .3 For longitudinal stabilization: 18.3 m (60 ft.).
- .6 Do not stabilize ducts hanging by supports that are located less than 300 mm (12 in.) below structure. Supports must be mounted on ducts using at least two (2) no. 10 metal screws, installed at least 50 mm (2 in.) from the top of the duct.

3.8 RIGID RODS AND ATTACHMENT POINTS

- .1 Link restraint rods to the hanging equipment so that their axial incidence passes through the gravity center of the equipment to protect.
- .2 Use rods with adequate diameters and in accordance with seismic support manufacturer's requirements.
- .3 Vertical, lateral and longitudinal rods must be installed as per support manufacturer's recommendations.

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END OF SECTION

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