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DIVISION 13 - SPECIAL CONSTRUCTION

SECTION 13 48 00

SEISMIC PROTECTION FOR MISCELLANEOUS EQUIPMENT

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designer will ensure that the A-E and/or Contractor has access to UFC 3-310-04.

The designer has 3 options to provide seismic protection for a project:

- 1) Hire an A-E who will use this section and will submit calculations and drawings stamped by a registered engineer. The Contracting Officer will "accept" the design but the registered engineer (Engineer of Record) will have final responsibility for the adequacy of the structural members and their connections.
- 2) Issue a contract requiring the Contractor to hire a registered engineer to submit the stamped calculations and drawings in accordance with this section. The contracting Officer will "accept" the design but the registered engineer (Engineer of Record) will have final responsibility for the adequacy of the structural members and their connections.
- 3) Perform the design in house, in which case the Government designer will have final responsibility for the adequacy of the structural members and their connections.

Regardless of who performs the design, this section, properly edited, must be included in the construction documents to allow the Contractor to install the seismic protection features.

This section can be used for bracing details of medical equipment by editing the specification accordingly.

1.1 REFERENCES

NOTE: This paragraph is used to list the publications cited in the text of the guide specification. The publications are referred to in the text by basic designation only and listed in this paragraph by organization, designation, date, and title.

Use the Reference Wizard's Check Reference feature when you add a Reference Identifier (RID) outside of the Section's Reference Article to automatically place the reference in the Reference Article. Also use the Reference Wizard's Check Reference feature to update the issue dates.

References not used in the text will automatically be deleted from this section of the project specification when you choose to reconcile references in the publish print process.

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASME INTERNATIONAL (ASME)

- ASME B18.2.1 (2012; Errata 2013) Square and Hex Bolts and Screws (Inch Series)
- ASME B18.2.2 (2010) Nuts for General Applications: Machine Screw Nuts, Hex, Square, Hex Flange, and Coupling Nuts (Inch Series)

ASTM INTERNATIONAL (ASTM)

- ASTM A153/A153M (2016) Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
- ASTM A307 (2014) Standard Specification for Carbon Steel Bolts and Studs, 60 000 PSI Tensile Strength
- ASTM A325 (2014) Standard Specification for Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength
- ASTM A325M (2014) Standard Specification for Structural Bolts, Steel, Heat Treated, 830 MPa Minimum Tensile Strength (Metric)
- ASTM A36/A36M (2014) Standard Specification for Carbon Structural Steel
- ASTM A500/A500M (2013) Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes
- ASTM A53/A53M (2012) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
- ASTM A563 (2015) Standard Specification for Carbon and Alloy Steel Nuts
- ASTM A563M (2007; R 2013) Standard Specification for Carbon and Alloy Steel Nuts (Metric)
- ASTM A572/A572M (2015) Standard Specification for High-Strength Low-Alloy Columbium-Vanadium Structural Steel
- ASTM A603 (1998; R 2014) Standard Specification for Zinc-Coated Steel Structural Wire Rope
- ASTM A653/A653M (2015; E 2016) Standard Specification for

Steel Sheet, Zinc-Coated (Galvanized) or
Zinc-Iron Alloy-Coated (Galvannealed) by
the Hot-Dip Process

ASTM E488/E488M

(2015) Standard Test Methods for Strength
of Anchors in Concrete and Masonry Elements

U.S. DEPARTMENT OF DEFENSE (DOD)

UFC 3-310-04

(2013) Seismic Design for Buildings

1.2 SYSTEM DESCRIPTION

1.2.1 General Requirements

NOTE: Designer should verify that specified details do not interfere with the performance of the cathodic protection system (when used) or of the vibration isolation systems.

For systems and equipment in buildings that have a performance objective higher than life-safety, the designer should show a "G" classification for the items under SD-02 Shop Drawings in the SUBMITTALS paragraph. This will allow the Engineer of Record (EOR) to: 1) Do a QC review on the anchorage and bracing details of these essential systems, and 2) Assess the impact of the bracing and anchorage details on the structural supporting system of the essential building.

Design done by the Contractor must be in accordance with UFC 3-310-04. Loadings determined using UFC 3-310-04 are based on strength design; therefore, the AISC 325 specifications should be used to design the steel members in the bracing and anchorage systems.

Apply the requirements for seismic protection measures, described in this section, to the mechanical equipment and systems outlined in Section 13 48 00.00 10 SEISMIC PROTECTION FOR MECHANICAL EQUIPMENT, the electrical equipment and systems outlined in Section 26 05 48.00 10 SEISMIC PROTECTION FOR ELECTRICAL EQUIPMENT, and the miscellaneous equipment and systems listed below, in accordance with UFC 3-310-04 and additional data furnished by the Contracting Officer. Provide seismic protection measures in addition to any other requirements called for in other sections of these specifications. The design for seismic protection shall be based on a Seismic Use Group [I] [II] [IIIH] [IIIE] building occupancy and on site response coefficients for $S_{MS} = []$ and $S_{M1} = []$. Accomplish resistance to lateral forces induced by earthquakes without consideration of friction resulting from gravity loads. The basic force formulas, for Ground Motions A and B in UFC 3-310-04, use the design spectral response acceleration parameters for the performance objective of the building, not for equipment in the building; therefore, corresponding adjustments to the formulas are required.

1.2.2 Miscellaneous Equipment and Systems

NOTE: The designer must ensure that the list below includes all miscellaneous items to be braced. Delete the items which are not part of the project and add items which are not included in the list. For equipment and systems in buildings with a performance objective greater than life-safety, the designer should provide two separate lists of equipment and systems; 1) Items that are essential to the higher level of post-earthquake performance, and 2) Items that are not essential but are necessary to provide a life-safety level of earthquake protection.

The bracing for the following miscellaneous equipment and systems shall be developed by the [A-E] [Contractor] in accordance with the requirements of this specification:

Storage cabinets
Ornamentations
Storage Racks
Signs and Billboards
Shelving
Furnishings
Partitions
[_____]

1.3 SUBMITTALS

NOTE: Review submittal description (SD) definitions in Section 01 33 00 SUBMITTAL PROCEDURES and edit the following list to reflect only the submittals required for the project.

The Guide Specification technical editors have designated those items that require Government approval, due to their complexity or criticality, with a "G." Generally, other submittal items can be reviewed by the Contractor's Quality Control System. Only add a "G" to an item, if the submittal is sufficiently important or complex in context of the project.

For submittals requiring Government approval on Army projects, a code of up to three characters within the submittal tags may be used following the "G" designation to indicate the approving authority. Codes for Army projects using the Resident Management System (RMS) are: "AE" for Architect-Engineer; "DO" for District Office (Engineering Division or other organization in the District Office); "AO" for Area Office; "RO" for Resident Office; and "PO" for Project Office. Codes following the "G" typically are not used for Navy, Air Force, and NASA projects.

Use the "S" classification only in SD-11 Closeout Submittals. The "S" following a submittal item indicates that the submittal is required for the Sustainability Notebook to fulfill federally mandated sustainable requirements in accordance with Section 01 33 29 SUSTAINABILITY REPORTING.

Choose the first bracketed item for Navy, Air Force and NASA projects, or choose the second bracketed item for Army projects.

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for [Contractor Quality Control approval.][information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government.] Submittals with an "S" are for inclusion in the Sustainability Notebook, in conformance to Section 01 33 29 SUSTAINABILITY REPORTING. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Bracing; G[, [____]]
Resilient Vibration Isolation Devices; G[, [____]]
Equipment Requirements; G[, [____]]

SD-03 Product Data

Bracing; G[, [____]]
Equipment Requirements; G[, [____]]

SD-06 Test Reports

Anchor Bolts; G[, [____]]

PART 2 PRODUCTS

NOTE: Appropriate materials for structural supports must be used in corrosive environments. Dissimilar metals must be isolated.

2.1 EQUIPMENT REQUIREMENTS

Submit detail drawings along with calculations, catalog cuts, templates, and erection and installation details, as appropriate, for the items listed below. Indicate thickness, type, grade, class of metal, and dimensions; and show construction details, reinforcement, anchorage, and installation with relation to the building construction. For equipment and systems in buildings that have a performance objective higher than life-safety, the drawings shall be stamped by the registered engineer who stamps the calculations. Calculations shall be stamped, by a registered engineer, and verify the capability of structural members to which bracing is attached for carrying the load from the brace.

2.1.1 Rigidly Mounted Equipment

NOTE: Rigidly mounted equipment is defined as having a period of vibration of 0.06 seconds or less for the equipment plus its mounting. Equipment with a fundamental period greater than 0.06 seconds should be assumed to be flexibly mounted or nonrigid. The designer may allow a reduction to the design seismic forces applied to ground-mounted equipment when properly justified in the calculations. List items that may require additional reinforcements (internally) to prevent permanent deformation, dislocations, separation of components, or other damage, which would render the equipment inoperative for significant periods of time following an earthquake and to meet the specified requirements. Coordinate with note in paragraph BRACING.

The following specific items of equipment: [_____] to be furnished under this contract shall be constructed and assembled to withstand the seismic forces specified in UFC 3-310-04. For any rigid equipment which is rigidly attached on both sides of a building expansion joint, provide flexible joints for piping, electrical conduit, etc., that are capable of accommodating displacements equal to the full width of the joint in both orthogonal directions.

2.1.2 Nonrigid or Flexibly-Mounted Equipment

NOTE: The appropriate lateral force coefficient for nonrigid or flexibly-mounted equipment, should be calculated and inserted in the blank space.

The following specific items of equipment to be furnished: [_____] shall be constructed and assembled to resist a horizontal lateral force of [_____] times the operating weight of the equipment at the vertical center of gravity of the equipment.

2.2 BOLTS AND NUTS

Squarehead and hexhead bolts, and heavy hexagon nuts, ASME B18.2.1, ASME B18.2.2, or [ASTM A307 for bolts and ASTM A563M ASTM A563 for nuts] [ASTM A325M ASTM A325 for bolts and nuts]. Provide bolts and nuts galvanized in accordance with ASTM A153/A153M when used underground and/or exposed to weather.

2.3 SWAY BRACING

NOTE: Designer should determine an appropriate specification for steel angles used for sway bracing depending on availability of the materials from local suppliers and insert the designation in blank space below.

Material used for members listed [in this section] [and] [on the drawings], shall be structural steel conforming with the following:

- a. Plates, rods, and rolled shapes, [ASTM A36/A36M] [ASTM A572/A572M, Grade 503]. If the Contractor does the design, both ASTM A36/A36M and ASTM A572/A572M, grade 503 will be allowed.
- b. Wire rope, ASTM A603.
- c. Tubes, ASTM A500/A500M, Grade [B] [_____].
- d. Pipes, ASTM A53/A53M, Type [E] or [S], Grade B.
- e. Light gauge angles, less than 6 mm 1/4 inch thickness, [ASTM A653/A653M] [_____].

PART 3 EXECUTION

3.1 BRACING

NOTE: Designs must include complete seismic details showing bracing requirements. The design is for the supports of the equipment, not the equipment itself. Bracing does not guarantee that the equipment is rugged enough to survive earthquake shaking. When a piece of equipment is required to remain operational after an earthquake, the manufacturer should be consulted regarding the capabilities of the equipment to withstand seismic loading.

Provide bracing conforming to the arrangements shown. Secure trapeze-type hanger with not less than two 13 mm 1/2 inch bolts.

3.2 BUILDING DRIFT

NOTE: The designer will be guided by the results of the seismic analysis to determine the expected drift of the building; this information is needed for the pipe joint designs required in Section 13 48 00.10 SEISMIC PROTECTION FOR MECHANICAL EQUIPMENT.

Sway braces for a piping run shall not be attached to two dissimilar structural elements of a building that may respond differentially during an earthquake unless a flexible joint is provided.

3.3 ANCHOR BOLTS

Submit copies of test results to verify the adequacy of the specific anchor and application, as specified.

3.3.1 Cast-In-Place

NOTE: The designer will ensure that foundations and anchor bolts for pad-mounted or floor-mounted equipment are detailed and designed in accordance with UFC 3-310-04. When the designer has the necessary size, weight, and other information for a piece of equipment, the anchorage details including sizes, length and number of bolts, thickness and reinforcing of pads and foundations for that piece of equipment will be shown by the designer on the drawings. When this information is not available, it will be the A-E responsibility to design the support and anchorage for the equipment in accordance with the specified requirements.

If the calculated seismic forces would cause the equipment to uplift, the anchor bolts should be designed for combined shear and tension.

Use cast-in-place anchor bolts, conforming to ASTM A307, for floor or pad mounted equipment, except as specified below. Provide [one nut] [two nuts] on each bolt. Anchor bolts shall have an embedded straight length equal to at least 12 times nominal diameter of the bolt. Anchor bolts that exceed the normal depth of equipment foundation piers or pads shall either extend into concrete floor or the foundation or be increased in depth to accommodate bolt lengths.

3.3.2 Expansion or Chemically Bonded Anchors

NOTE: Cast-in-place anchors should be used to anchor equipment for seismic loads since there is considerable experience suggesting that expansion and chemically bonded anchors may come loose during a fire, and do not perform well for vibrating equipment or for other types of cyclic loading, such as earthquakes.

Expansion and chemically bonded anchors should only be allowed when test data show they are applicable for seismic loading. ASTM E488/E488M provides a means of testing expansion anchors for seismic loading. In lieu of tests, the designer may specify approval of the expansion anchors by a governmental organization such as the City of Los Angeles or the State of California Office of Statewide Health Planning and Development (OSHPD).

The edge distance and spacing between anchor bolts greatly affect the shear and tension capacity of the bolts. The spacing will depend on the type of anchor, the diameter, and the length of embedment. The manufacturer should provide data for the minimum edge distance and bolt spacing needed to achieve the rated values and also ways to reduce the allowables if the edge distance or spacing is less than

required.

Do not use expansion or chemically bonded anchors: 1)Unless test data in accordance with ASTM E488/E488M has been provided to verify the adequacy of the specific anchor and application. 2)To resist pull-out in overhead and wall installations if the adhesive is manufactured with temperature sensitive epoxies and the location is accessible to a building fire. Install expansion and chemically bonded anchors in accordance with the manufacturer's recommendations. Adjust the allowable forces for the spacing between anchor bolts and the distance between the anchor bolt and the nearest edge, as specified by the manufacturer.

3.3.2.1 General Testing

NOTE: Expansion and chemically bonded anchors should be tested after installation. Testing every expansion anchor is not necessary or practical; therefore a reasonable rate of testing should be developed depending on the importance of the job. There are two methods of testing: Torque wrench and pullout testing. The torque test is easier and cheaper and usually gives a good indication of installation quality; the pullout test gives a better indication of the strength of both expansion and chemically bonded anchors. The torque test does not apply to expansion bolts which are anchored by hammering the sleeve over a cone such as self drilling anchors.

Test in place expansion and chemically bonded anchors not more than [24] [_____] hours after installation of the anchor, conducted by an independent testing agency; testing shall be performed on random anchor bolts as described below.

3.3.2.2 Torque Wrench Testing

NOTE: Delete this paragraph for expansion anchors which are not anchored by an applied torque, such as self drilling anchors.

Torque wrench testing verifies that a torqued expansion anchor has seated properly. If it has not seated, the applied torque on the nut will cause the bolt to twist in the hole. Torque wrench testing does not load the bolt up to allowable load and therefore does not verify the capacity of the installed bolt.

Perform torque wrench testing on not less than [50] [_____] percent of the total installed expansion anchors and at least [one anchor] [[_____] anchors] for every piece of equipment containing more than [two] [_____] anchors. The test torque shall equal the minimum required installation torque as required by the bolt manufacturer. Calibrate torque wrenches at the beginning of each day the torque tests are performed. Recalibrate

torque wrenches for each bolt diameter whenever tests are run on bolts of various diameters. Apply torque between 20 and 100 percent of wrench capacity. Reach the test torque within one half turn of the nut, except for 9 mm 3/8 inch sleeve anchors which shall reach their torque by one quarter turn of the nut. If any anchor fails the test, test similar anchors not previously tested until [20] [_____] consecutive anchors pass. Failed anchors shall be retightened and retested to the specified torque; if the anchor still fails the test it shall be replaced.

3.3.2.3 Pullout Testing

NOTE: Pullout testing is expensive and labor intensive because of the apparatus needed to pull on the anchor bolt. Pullout testing determines the tension capacity of the anchor bolt. The amount of load to be applied can vary between 0.5 to 2 times the calculated load, depending on the importance of the bolt. There is not a significant cost difference between testing to 0.5 or 2 times the calculated load; since most anchor bolts have a factor of safety of 4, testing to twice the specified load should not cause any distress. The typical tension failure causes a shear cone to be pulled out of the concrete, the slope of the cone is about a 45 degree angle so there should be nothing on the concrete surface in the vicinity of the bolt to prevent the cone from pulling out. Shear testing is usually not needed unless the bolt is heavily loaded in shear and close to an edge.

Test expansion and chemically bonded anchors by applying a pullout load using a hydraulic ram attached to the anchor bolt. At least [5] [_____] percent of the anchors, but not less than [3] [_____] per day shall be tested. Apply the load to the anchor without removing the nut; when that is not possible, the nut shall be removed and a threaded coupler shall be installed of the same tightness as the original nut. Check the test setup to verify that the anchor is not restrained from withdrawing by the baseplate, the test fixture, or any other fixtures. The support for the testing apparatus shall be at least 1.5 times the embedment length away from the bolt being tested. Load each tested anchor to [1] [_____] times the design tension value for the anchor. The anchor shall have no observable movement at the test load. If any anchor fails the test, similar anchors not previously tested shall be tested until [20] [_____] consecutive anchors pass. Failed anchors shall be retightened and retested to the specified load; if the anchor still fails the test it shall be replaced.

3.4 RESILIENT VIBRATION ISOLATION DEVICES

Where the need for these devices is determined, based on the magnitude of the design seismic forces, selection of anchor bolts for vibration isolation devices and/or snubbers for equipment base and foundations shall follow the same procedure as in paragraph ANCHOR BOLTS, except that an equipment weight equal to [five] [_____] times the actual equipment weight shall be used.

3.4.1 Resilient and Spring-Type Vibration Devices

NOTE: Retain either this paragraph or the one below, as required by the project. Remove the paragraph not needed.

Select vibration isolation devices so that the maximum movement of equipment from the static deflection point is 13 mm 1/2 inch.

3.4.2 Multidirectional Seismic Snubbers

NOTE: Details of multidirectional seismic snubbers will be shown in drawings if paragraph is retained.

Install multidirectional seismic snubbers employing elastomeric pads on floor- or slab-mounted equipment. These snubbers shall provide 6 mm 1/4 inch free vertical and horizontal movement from the static deflection point. Snubber medium shall consist of multiple pads of cotton duct and neoprene or other suitable materials arranged around a flanged steel trunnion so both horizontal and vertical forces are resisted by the snubber medium.

3.5 SWAY BRACES FOR PIPING

The bracing requirements shown below are based on flexible piping. Supports for flexible piping must consider an additional amplification of the piping being in resonance with the building.

Provide transverse sway bracing for steel and copper pipe at intervals not to exceed those shown on the drawings. Transverse sway bracing for pipes of materials other than steel and copper shall be provided at intervals not to exceed the hanger spacing as specified in Section 22 00 00 PLUMBING, GENERAL PURPOSE. Provide bracing consisting of at least one vertical angle 50 by 50 mm by 16 gauge 2 by 2 inch by 16 gauge and one diagonal angle of the same size.

3.5.1 Longitudinal Sway Bracing

Provide longitudinal sway bracing in accordance with Section 13 48 00.00 10 SEISMIC CONTROL FOR MECHANICAL EQUIPMENT.

3.5.2 Anchor Rods, Angles, and Bars

Anchor rods, angles, and bars shall be bolted to either pipe clamps or pipe flanges at one end and cast-in-place concrete or masonry insert or clip angles bolted to the steel structure on the other end. Rods shall be solid metal or pipe as specified below. Anchor rods, angles, and bars shall not exceed lengths given in the tabulation below.

3.5.3 Maximum Length for Anchor Braces

Type	Size (mm) (in)	Maximum Length* (m) (ft-in)
Angles	38 x 38 x 6 1-1/2 x 1-1/2 x 1/4	1.54-10
	50 x 50 x 62 x 2 x 1/4	2.06-6
	64 x 38 x 6 2-1/2 x 1-1/2 x 1/4	2.58-0
	75 x 64 x 63 x 2-1/2 x 1/4	2.58-10
	75 x 75 x 63 x 3 x 1/4	3.09-10
Rods	913/4	1.03-1
	227/8	1.03-8
Flat Bars	38 x 61-1/2 x 1/4	0.41-2
	50 x 62 x 1/4	0.41-2
	50 x 102 x 3/8	0.51-9
Pipes (40s)	251	2.07-0
	321-1/4	2.89-0
	401-1/2	3.210-4
	502	4.013-1

3.5.4 Bolts

Bolts used for attachment of anchors to pipe and structure shall be not less than 13 mm 1/2 inch diameter.

3.6 EQUIPMENT SWAY BRACING

3.6.1 Suspended Equipment and Light Fixtures

NOTE: Equipment weighing more than one-fifth of the dead load of slabs above grade at the equipment level or equipment weighing more than one-tenth of the building weight must be checked by structural analysis to conform with building seismic provisions. Such equipment has a pronounced effect on the response of the building. The following items shall be checked structurally and specific seismic requirements incorporated on appropriate drawings and in the relevant specifications.

Pole or frame supported equipment.

Storage tanks for water and oil.

Storage racks with upper storage level more than 2.4 m 8 feet in height.

Smoke stacks taller than 15 m 50 feet in height.

See UFC 3-310-04 to compute the force needed to fill in the bracketed blank.

Provide equipment sway bracing for items supported from overhead floor or roof structural systems, including light fixtures. Braces shall consist of angles, rods, wire rope, bars, or pipes arranged as shown and secured at both ends with not less than 13 mm 1/2 inch bolts. Provide sufficient braces for equipment to resist a horizontal force as specified in UFC 3-310-04 without exceeding safe working stress of bracing components. Provide, for approval, specific force calculations in accordance with UFC 3-310-04 for the equipment in the project. Submit details of equipment bracing for acceptance. In lieu of bracing with vertical supports, these items may be supported with hangers inclined at 45 degrees directed up and radially away from equipment and oriented symmetrically in 90-degree intervals on the horizontal plane, bisecting the angles of each corner of the equipment, provided that supporting members are properly sized to support operating weight of equipment when hangers are inclined at a 45-degree angle.

3.6.2 Floor or Pad Mounted Equipment

3.6.2.1 Shear Resistance

Bolt to the floor, floor mounted equipment. Requirements for the number and installation of bolts to resist shear forces shall be in accordance with paragraph ANCHOR BOLTS.

3.6.2.2 Overturning Resistance

NOTE: See UFC 3-310-04 for guidance on design of anchor bolts.

Use the ratio of the overturning moment from seismic forces to the resisting moment due to gravity loads to determine if overturning forces need to be considered in the sizing of anchor bolts. Provide calculations to verify the adequacy of the anchor bolts for combined shear and overturning.

3.7 SPECIAL INSPECTION AND TESTING FOR SEISMIC-RESISTING SYSTEMS

NOTE: Include this paragraph only when special inspection and testing for seismic-resisting systems is required by Appendix 11A of ASCE 7.

This paragraph will be applicable to both new buildings designed according to UFC 3-310-04 SEISMIC DESIGN FOR BUILDINGS, and to existing building seismic rehabilitation designs.

The designer must indicate on the drawings all locations and all features for which special inspection and testing is required in accordance with UFC 3-310-04 and Appendix 11A of ASCE 7. This includes indicating the locations of all structural components and connections requiring inspection.

Add any additional requirements as necessary.

Perform special inspections and testing for seismic-resisting systems and components in accordance with Section 01 45 35 SPECIAL INSPECTIONS.

-- End of Section --