UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated January 2021
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05/20, CHG 1: 08/20

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USACE / NAVFAC / AFCEC / NASA	**UFGS-13 48 73 (May 2020)** **Change 1 - 08/20** **----------**
Preparing Activity: USACE	**Superseding without Revision** **UFGS-13 48 00 (May 2018)**

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SECTION 13 48 73

SEISMIC CONTROL FOR MECHANICAL EQUIPMENT
05/20, CHG 1: 08/20

****
NOTE: This guide specification covers the requirements for seismic structural elements for protection of miscellaneous equipment.

This guide specification [also] covers all equipment bracing requirements (including mechanical, electrical and architectural) for antiterrorism protection from equipment falling on building occupants in accordance with UFC 4-010-01 DoD Minimum Antiterrorism Standards for Buildings.

Adhere to UFC 1-300-02 Unified Facilities Guide Specifications (UFGS) Format Standard when editing this guide specification or preparing new project specification sections. Edit this guide specification for project specific requirements by adding, deleting, or revising text. For bracketed items, choose applicable item(s) or insert appropriate information.

Remove information and requirements not required in respective project, whether or not brackets are present.

Projects only having antiterrorism equipment bracing requirements with no seismic protection requirements will require significant editing to this UFGS because most of the requirements apply to seismic protection. Projects having both antiterrorism equipment bracing and seismic protection requirements will require the specification to be edited such that the most stringent of both requirements is met.

Comments, suggestions and recommended changes for this guide specification are welcome and should be submitted as a Criteria Change Request (CCR).
****

PART 1 GENERAL

****

NOTE: The intent of this specification is to provide for adequate resistance to lateral forces induced by earthquakes for listed mechanical, electrical and miscellaneous equipment and systems. The design seismic lateral forces are in addition to the "normal" gravity forces (weight) acting on the components of a system. This guide specification will be used in conjunction with Sections 23 05 48.19 10 SEISMIC CONTROLS FOR HVAC, 01 45 35 SPECIAL INSTRUCTIONS, and 26 05 48.00 10 SEISMIC PROTECTION FOR ELECTRICAL EQUIPMENT

Seismic protection design for anchorage and bracing of all equipment will be based on UFC 3-301-01 Seismic Design for Buildings and UFC 4-010-01 DoD Minimum Antiterrorism Standards for Buildings.

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

1) Issue a contract requiring the Contractor to hire a registered structural 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.

2) Hire an A-E who will use this section and will submit calculations and drawings stamped by a registered structural 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. One of the disadvantages of this approach may be that the actual equipment dimensions, weights and mounting details may not be known until the equipment is acquired. The structural engineer should be retained during the construction phase to review seismic bracing shop drawings and perform field inspections as part of the final responsibility.

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. One of the disadvantages of this approach may be that the actual equipment dimensions, weights and mounting details may not be known until the equipment is acquired. The structural engineer should be retained during the construction phase to review seismic bracing shop drawings and perform field inspections as part of the final responsibility

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.

AMERICAN CONCRETE INSTITUTE (ACI)

ACI 355.2	(2007) Qualification of Post-Installed Mechanical Anchors in Concrete and Commentary
ACI 355.4	(2011) Qualification of Post-Installed Adhesive Anchors in Concrete (ACI 355.4) and Commentary

AMERICAN INSTITUTE OF STEEL CONSTRUCTION (AISC)

AISC 325	(2017) Steel Construction Manual

AMERICAN SOCIETY OF CIVIL ENGINEERS (ASCE)

ASCE 7-16	(2017; Errata 2018; Supp 1 2018) Minimum Design Loads and Associated Criteria for Buildings and Other Structures

ASTM INTERNATIONAL (ASTM)

ASTM A36/A36M	(2019) Standard Specification for Carbon Structural Steel
ASTM A53/A53M	(2020) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A153/A153M	(2016a) Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
ASTM A325	(2014) Standard Specification for Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength
ASTM A490	(2014a) Standard Specification for Structural Bolts, Alloy Steel, Heat Treated, 150 ksi Minimum Tensile Strength
ASTM A500/A500M	(2020) Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes
ASTM A563	(2015) Standard Specification for Carbon and Alloy Steel Nuts
ASTM A603	(2019) Standard Specification for Zinc-Coated Steel Structural Wire Rope
ASTM E488/E488M	(2015) Standard Test Methods for Strength of Anchors in Concrete and Masonry Elements
ASTM F1554	(2018) Standard Specification for Anchor Bolts, Steel, 36, 55, and 105-ksi Yield Strength

ICC EVALUATION SERVICE, INC. (ICC-ES)

ICC ES AC156	(2012) Acceptable Criteria for Seismic Certification by Shake-Table Testing of Nonstructural Components
ICC-ES AC23	(2012; R 2016) Acceptance Criteria for Sprayed Fire-resistant Materials (SFRMs), Intumescent Fire-resistant Coatings and Mastic Fire-resistant Coatings Used to Protect Structural Steel Members

INTERNATIONAL CODE COUNCIL (ICC)

ICC IBC	(2018) International Building Code

METAL FRAMING MANUFACTURERS ASSOCIATION (MFMA)

MFMA-4	(2004) Metal Framing Standards Publication

U.S. DEPARTMENT OF DEFENSE (DOD)

UFC 3-301-01	(2019) Structural Engineering
UFC 3-301-02	(2020) Design of Risk Category V Structures, National Strategic Military Assets
UFC 4-010-01	(2018;with Change 1, 2020) DoD Minimum Antiterrorism Standards for Buildings

VIBRATION ISOLATION AND SEISMIC CONTROL MANUFACTURERS ASSOCIATION (VISCMA)

VISCMA 412	(2014) Installing Seismic Restraints for Mechanical Equipment

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 RC V buildings that have a performance objective higher than non-mission critical, 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. This also includes Designated Seismic Systems that must remain operational after an earthquake.

Design done by the Contractor must be in accordance with UFC 3-301-01 and UFC 4-010-01. Loadings determined using UFC 3-301-01 are based on strength design; therefore, 2015 IBC, ASCE 7-16-10, and ASCE/SEI 41-13 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 and on the drawings, of the miscellaneous equipment and systems listed below, in accordance with UFC 3-301-01 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. Where there is a conflict between the specifications and the drawings, the specifications will take precedence. Accomplish resistance to lateral forces induced by earthquakes without consideration of friction resulting from gravity loads
.

1.2.2 Miscellaneous Equipment and Systems

****

NOTE: The designer must ensure that the lists 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. The lists should be broken out as follows: For nonstructural equipment, components and systems in Risk Category V structures, the designer should provide three separate lists of equipment and systems; non-Mission Critical (NMC), Mission Critical Level 1 (MC-1 equipment and components must be fully operational immediately after a seismic event), or Mission Critical Level 2 (MC-2 equipment and components must be repairable and operable within 3 days after a seismic event). For nonstructural equipment/components/systems in Risk Category I, II, III, or IV structures, two separate lists of nonstructural systems/components must be provided; components/systems with Ip = 1.0 and components/systems with Ip = 1.5 (Designated Seismic Systems).

****

Provide bracing and attachment for the following miscellaneous equipment and components developed by the [Contractor] [A-E] in accordance with the requirements of this specification:

[Equipment/Components with Ip = 1.0
Storage cabinets
Ornamentations
Storage Racks
Signs and Billboards
Shelving
Furnishings
Partitions
Stacks
Pole or frame supported equipment
Storage tanks for water and oil
[_____]]

[Equipment/Components with Ip = 1.5 (Designated Seismic Systems)
Insert edited list here similar to one above for Ip = 1.0]
[Non-Mission Critical (NMC) Equipment/Components in Risk Category V
Insert edited list here similar to one above for Ip = 1.0]
[Mission Critical Level 1 (MC-1) Equipment/Components in Risk Category V
Insert edited list here similar to one above for Ip = 1.0]
[Mission Critical Level 2 (MC-2) Equipment/Components in Risk Category V
Insert edited list here similar to one above for Ip = 1.0]

1.2.3 Contractor Designed Bracing

****

NOTE: Retain this paragraph when the Contractor will design the bracing. The designer will refer and/or modify the listings above or will list below the equipment and systems to receive seismic bracing. Delete this paragraph when all bracing

details and locations are indicated on the drawings and calculations are included in the Design Analysis.
****

Submit copies of the design calculations with the drawings. Calculations must be approved, certified, stamped and signed by a registered Professional Structural Engineer. Calculations must verify the capability of structural members to which bracing is attached for carrying the load from the brace. Design the bracing in accordance with UFC 3-301-01, UFC 4-010-01 and additional data furnished by the Contracting Officer. Resistance to lateral forces induced by earthquakes must be accomplished without consideration of friction resulting from gravity loads. UFC 3-301-01 uses parameters for the building, not for the equipment in the building; therefore, corresponding adjustments to the formulas must be required. Loadings determined using UFC 3-301-01 are based on strength design; therefore, AISC 325 Specifications must be used for the design. The bracing for the equipment designated in paragraph 1.2.2 must be developed by the Contractor. [Provide documentation of an independent design review for mission critical (MC) equipment bracing design. Documentation must be signed by the independent reviewer who must also be a registered structural engineer.]

1.3 SUBMITTALS

****

NOTE: Review submittal description (SD) definitions in Section 01 33 00 SUBMITTAL PROCEDURES and edit the following list, and corresponding submittal items in the text, to reflect only the submittals required for the project. The Guide Specification technical editors have classified 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. This includes Designated Seismic Systems and Mission Critical Systems that must remain operational after an earthquake.

For Army projects, fill in the empty brackets following the "G" classification, with a code of up to three characters 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.

The "S" classification indicates submittals required as proof of compliance for sustainability Guiding Principles Validation or Third Party Certification and as described in Section 01 33 00 SUBMITTAL PROCEDURES.

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" or "S" classification. Submittals not having a "G" or "S" classification are [for Contractor Quality Control approval.][for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government.] 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[, [_____]]

Anchor Bolts; G[, [_____]]

Vibration Isolators; G[, [_____]]

Snubbers; G[, [_____]]

SD-05 Design Data

Design Calculations; G[, [_____]]

SD-06 Test Reports

Anchor Bolts; G[, [_____]]

SD-07 Certificates

ICC ES AC156 Shake Table Test; 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

****

NOTE: Seismic Control Bracing does not guarantee that the equipment itself is rugged enough to survive earthquake shaking. When a piece of

equipment is required to remain operational after an earthquake, include paragraph 3.11 Special Testing for Seismic Resisting Equipment.
****

Submit detail drawings of bracing along with calculations, catalog cuts, templates, and erection and installation details, as appropriate, for the items listed in Paragraph 1.2.2. Indicate thickness, type, grade, class of metal, and dimensions; and show construction details, reinforcement, anchorage, and installation with relation to the building construction. Provide calculations and drawings that are stamped by a registered structural engineer, and that verify the capability of structural members to which bracing is attached for carrying the load from the brace. Design must be based on actual equipment and system layout. Design must include calculated dead loads, static seismic loads and capacity of materials utilized for the connection of the equipment or system to the structure. Analysis must detail anchoring methods.

Include drawing for [Mission Critical Equipment and] Designated Seismic System Equipment indicating the equipment location in the facility sufficient to be used for the installation. Equipment must be rigidly or flexibly mounted as indicated in the specifications and/or drawings depending on vibration isolation requirements as follows below. Roof mounted equipment both vibration isolated and nonisolated, must have support members designed and anchored to building structural steel or concrete as required for seismic restraint and wind loads.

2.1.1 Rigidly (Base and Suspended) Mounted Equipment

****
NOTE: 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.
****

Equipment furnished under this contract must be [rigidly mounted] [rigidly mounted using cast-in-place anchor bolts to anchor them or post-installed anchors that are qualified for earthquake loading in accordance with ACI 355.2 and ACI 355.4. Anchor bolts must conform to ASTM F1554-07ae1]. For any rigid equipment which is rigidly anchored, 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. Suspended equipment bracing attachments should be located just above the center of gravity to minimize swinging. [Mission critical base mounted and suspended equipment for Risk Category (RC) V,] and Designated Seismic Systems (DSS) RC IV buildings assigned to Seismic Design Category Coefficient (SDC) C, D, E, or F and Risk Category IV components needed for continued operation after an earthquake must have two nuts provided on each anchor bolt.

2.1.2 Nonrigid or Flexibly-Mounted Equipment

Select vibration isolation devices so that the maximum movement of equipment from the static deflection point is 6 mm 1/4 inch. Equipment

flexibly mounted on vibration isolators must have a bumper restraint or snubber in each horizontal direction and vertical restraints must be provided where require to resist overturning. Isolator housing and restraints must be constructed of ductile materials. A viscoelastic pad or similar material of appropriate thickness must be used between the bumper and components to limit the impact load. Restraints must be designed to resist the calculated horizontal lateral and vertical forces.

Spring vibration isolators must be seismically rated, restrained isolators for equipment subject to load variations and large external forces. The seismically rated housing must be sized to meet or exceed the force requirements applicable to the project and meet the required isolation criteria. Spring vibration isolator manufacturer's will be a member of VISCMA. Design force, Fp, must be doubled for vibration isolators with an air gap greater than 0.25 inches as specified in ASCE 7-16, Chapter 13.

2.2 BOLTS AND NUTS

Hex head bolts, and heavy hexagon nuts must be ASTM A325 or ASTM A490 bolts and ASTM A563 nuts. Provide bolts and nuts galvanized in accordance with ASTM A153/A153M when used underground or exposed to weather.

2.3 SWAY BRACING

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

a. Plates, rods, and rolled shapes, ASTM A36/A36M.

b. Wire rope, ASTM A603.

c. Tubes, ASTM A500/A500M, Grade B.

d. Pipes, ASTM A53/A53M, Grade B.

e. Angles, ASTM A36/A36M.

f. Channels (Struts) with in-turned lips and associated hardware for fastening to channels at random points conforming to MFMA-4.

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. Install cables at a 45-degree slope. Where interference is present, the slope may be minimum

of 30 degrees or a maximum of 60 degrees per VISCMA 412.

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 equipment bracing design.

****

Do not attach sway braces for equipment to two dissimilar structural elements of a building that may respond differentially during an earthquake unless a flexible joint is provided. Bracing must be capable of accommodating building drift due to seismic displacements.

3.3 ANCHOR BOLTS

3.3.1 General

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

Ensure housekeeping pads have adequate space to mount equipment and seismic restraint devices allowing adequate edge distance and embedment depth for restraint anchor bolts. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength. Install neoprene grommet washers or till the gap with epoxy on equipment anchor bolts where clearance between anchor and equipment support hole exceeds 0.125 inches.

3.3.2 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 3-301-01. 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 templates to locate cast-in-place bolts accurately and securely in formwork. Provide anchor bolts with 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 must either extend into concrete floor or the foundation or be increased in depth to

accommodate bolt lengths. Use templates to locate cast-in-place bolts accurately and securely in formwork.

3.3.3 Drilled-In Anchor Bolts

****

NOTE: Verify if restrictions exist on the type of drilling equipment to be used for the project.

****

Drill holes with rotary impact hammer drills. Drill bits must be of diameters as specified by the anchor manufacturer. Unless otherwise shown on the drawings, all holes must be drilled perpendicular to the concrete surface. Where anchors are permitted to be installed in cored holes, use core bits with matched tolerances as specified by the manufacturer. Properly clean cored hole per manufacturer's instructions. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Exercise care in coring or drilling to avoid damaging existing reinforcing or embedded items. Notify the COR if reinforcing steel or other embedded items are encountered during drilling. Take precautions as necessary to avoid damaging prestressing tendons, electrical and telecommunications conduit, and gas lines. Unless otherwise specified, do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength. Perform anchor installation in accordance with manufacturer instructions. For Wedge Anchors, Heavy-Duty Sleeve Anchors, and Undercut Anchors, protect threads from damage during anchor installation. Heavy-duty sleeve anchors must be installed with sleeve fully engaged in part to be fastened. Set anchors to manufacturer's recommended torque, using a torque wrench. Following attainment of 10 percent of the specified torque, 100 percent of the specified torque must be reached within 7 or fewer complete turns of the nut. If the specified torque is not achieved within the required number of turns, the anchor must be removed and replaced unless otherwise directed by the Engineer.

For Cartridge Injection Adhesive Anchors where approved for seismic application, clean all holes per manufacturer instructions to remove loose material and drilling dust prior to installation of adhesive. Inject adhesive into 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. Follow manufacturer recommendations to ensure proper mixing of adhesive components. Sufficient adhesive must be injected in the hole to ensure that the annular gap is filled to the surface. Remove excess adhesive from the surface. Shim anchors with suitable device to center the anchor in the hole. Do not disturb or load anchors before manufacturer specified cure time has elapsed. For Capsule Anchors where approved for seismic application, perform drilling and setting operations in accordance with manufacturer instructions. Clean all holes to remove loose material and drilling dust prior to installation of adhesive. Remove water from drilled holes in such a manner as to achieve a surface dry condition. Capsule anchors must be installed with equipment conforming to manufacturer recommendations. Do not disturb or load anchors before manufacturer specified cure time has elapsed. Observe manufacturer recommendations with respect to installation temperatures for cartridge injection adhesive anchors and capsule anchors.

3.3.4 Anchor Bolt 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 must be performed on random anchor bolts as described below.

3.3.4.1 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 must 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 must 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 must be retightened and retested to the specified torque; if the anchor still fails the test it must be replaced.

3.3.4.2 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. Testing must be done in accordance with ASTM E488/E488M or ICC-ES AC23. At least [5] [_____] percent of the anchors, but not less than [3] [_____] per day must be tested. Apply the load to the anchor without removing the nut; when that is not possible, the nut must be removed and a threaded coupler must 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 must 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 must have no observable movement at the test load. If any anchor fails the test, similar anchors not previously tested must be tested until [10] [_____] consecutive anchors pass. Failed anchors must be retightened and retested to the specified load; if the anchor still fails the test it must 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, select anchor bolts for vibration isolation devices and/or snubbers for equipment base and foundations that follow the same procedure as in paragraph ANCHOR BOLTS, except use an equipment weight equal to [five] [_____] times the actual equipment weight.

3.4.1 Spring-Type Vibration Devices

****
NOTE: Designer must double design force Fp for vibration isolators where maximum movement of equipment from static deflection point is greater than 0.25 inches as specified in ASCE 7-16, Table 13.6-1, footnote b.
****

Select vibration isolation devices so that the maximum movement of equipment from the static deflection point is 13 mm 1/2 inch. Equipment flexibly mounted on vibration isolators must have a bumper restraint or snubber in each horizontal direction and vertical restraints must be provided where required to resist overturning. Isolator housing and restraints must be constructed of ductile materials. A viscoelastic pad or similar material of appropriate thickness must be used between the bumper

and components to limit the impact load. Restraints must be designed to resist the calculated horizontal lateral and vertical forces.

Spring vibration isolators must be seismically rated, restrained isolators for equipment subject to load variations and large external forces. The seismically rated housing must be sized to meet or exceed the force requirements applicable to the project and meet the required isolation criteria. Spring vibration isolator manufacturers will be a member of VISCMA.

3.4.2 Multidirectional Seismic Snubbers

****

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

Designer must double design force Fp for vibration isolators where maximum movement of equipment from static deflection point is greater than 0.25 inches as specified in ASCE 7-16, Table 13.6-1, footnote b.

****

Install multidirectional seismic snubbers employing elastomeric pads on floor- or slab-mounted equipment. Use snubbers that provide 6 mm 1/4 inch free vertical and horizontal movement from the static deflection point. Provide snubber medium consisting 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 EQUIPMENT SWAY BRACING

3.5.1 Suspended Equipment

****

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 must be checked structurally and specific seismic bracing and/or anchoring requirements must be 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.

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Provide equipment sway bracing for items supported from floor, overhead floor or roof structural systems. Provide braces that consist of angles, rods, wire rope, bars, channels (struts) or pipes arranged as shown in bracing submittals 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 3-301-01 without exceeding safe working stress of bracing components. Provide, for approval, specific force calculations in accordance with UFC 3-301-01 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.

3.5.2 Floor or Pad Mounted Equipment

3.5.2.1 Shear Resistance

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

3.5.2.2 Overturning Resistance

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NOTE: See UFC 3-301-01 for guidance on design of anchor bolts.

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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.

3.6 SPECIAL TESTING FOR SEISMIC-RESISTING EQUIPMENT

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NOTE: Include this paragraph only for special testing for seismic-resisting equipment and components designated as Risk Category V Mission Critical Level 1 (MC-1) by the building owner and specified by the Structural Engineer. MC-1 equipment and components must be fully operable immediately after a seismic event. This paragraph may also apply to Designated Seismic System (DSS)(assigned to SDC C thru F) equipment and components that must remain operational after an earthquake to function for life safety purposes or is needed for continued operation in a Risk Category IV structure.

This paragraph will be applicable to both new buildings designed according to UFC 3-301-01 STRUCTURAL ENGINEERING, UFC 3-301-02 DESIGN OR RISK CATEGORY V STRUCTURES, NATIONAL STRATEGIC MILITARY ASSETS, and to existing building seismic

rehabilitation designs.

The designer must indicate on the drawings all locations and all components for which special inspection and testing is required for MC-1 equipment.

Add any additional requirements as necessary.
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Equipment and components designated as [MC-1 (Mission Critical Level 1)] Designated Seismic Systems required to remain operational after an earthquake will be seismic qualified by shake table testing conforming to ICC ES AC156 Shake Table Test procedures. The manufacturer is to provide a certification by a fully qualified testing agency for the specific equipment and/or components. Prequalified certifications are acceptable unless noted otherwise.[Seismic component qualification documentation for each piece of equipment must contain the information required in UFC 3-301-02, Section 2-17.2.5 Component Qualification Documentation.]

Miscellaneous components that are required to be certified must bear permanent marking or nameplates constructed of a durable heat and water resistant material. Nameplates must be mechanically attached to such nonstructural components and placed on each component for clear identification. The nameplate must not be less than 5 inches x 7 inches with red letters 1 inch in height on a white background stating "Certified Equipment." The following statement must be on the nameplate: "This equipment/component is certified. No modifications are allowed unless authorized in advance and documented in the Equipment Certification Documentation file." The nameplate must also contain the component identification number in accordance with the drawings/specifications and the O&M manuals.

3.7 SPECIAL INSPECTION FOR SEISMIC-RESISTING SYSTEMS AND EQUIPMENT

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NOTE: Include this paragraph only for special inspection of seismic-resisting systems that serve Risk Category V Structures; designated seismic systems and equipment per IBC 1705.12.4; and storage racks per IBC 1705.12.7. The designer must indicate on the drawings all locations and all features for which special inspection is required. This includes indicating the locations of all structural components and connections requiring inspection. Designated Seismic Systems are required to be operational after a design earthquake. MC-1 equipment and components must be fully operable immediately after a seismic event. MC-2 equipment and components must be repairable and operable within 3 days after a seismic event. This paragraph will be applicable to both new buildings designed according to UFC 3-301-01 SEISMIC DESIGN FOR BUILDINGS, and to existing building seismic rehabilitation designs.
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Perform special inspections for seismic-resisting systems, equipment and components [for structures assigned to Risk Category V;] designated

seismic systems and equipment per ICC IBC 1705.12.4; and storage racks per ICC IBC 1705.12.7. Periodic special inspections will be conducted on miscellaneous equipment as required by Section 1705.12 of the International Building Code and paragraph 2-2.4.3 of UFC 3-301-01. Provide a Statement of Special Inspections and Final Report in accordance with paragraph 2-2.4.3 of UFC 3-301-01.

-- End of Section --