

## The Fundamentals of Seismic Compliance and Heating, Ventilation and Air-Conditioning Systems (HVAC)

Earthquakes are a real problem and not just in California anymore. Recent destruction in Haiti and Japan may seem far away, but closer to home, earthquakes in places like Virginia are surprising previously quiet regions. These recent quakes have revealed vulnerabilities, which in turn require more in our codes for equipment and building. Seismic regulations and compliance are no longer limited to locations that have been known to have earthquakes and no longer apply only to building structures. This newsletter will provide basic knowledge of seismic codes, address requirements for seismic certification, and the key things to look for when evaluating HVAC equipment for seismic compliance.

A great deal of confusion has resulted over the years as to what it means to be seismic compliant. The true meaning of terms like qualified, certified and approved agencies has gotten lost. Previously, manufacturers claimed to be certified by providing calculations as proof that equipment would maintain operation after a seismic event. In critical applications, such as in hospitals or data centers, nonstructural systems must be designed to do more than just survive an earthquake; they must keep operating after an earthquake has passed. If equipment and its distribution network are damaged from a quake in these critical applications, it can result in significant economic losses, temporary loss of operation (downtime), injuries and even loss of life.

For this reason, it has become increasingly necessary for engineers and building developers everywhere to know and comply with earthquake protection codes. The regulations have been evolving over the last ten years and their reach has been expanding into nonstructural building systems, including mechanical, electrical, plumbing and HVAC components.

Did you know that all 50 states have experienced an earthquake and the U.S. has 10 moderate earthquakes a year? The U.S. Geological Survey has been continuously updating its seismic ground acceleration maps and the result

is that vast areas of the continental U.S. require manufacturers to protect against seismic damage (see Figure 1: United States Geological Survey Hazard Map).

### Rating Components for Seismic Force

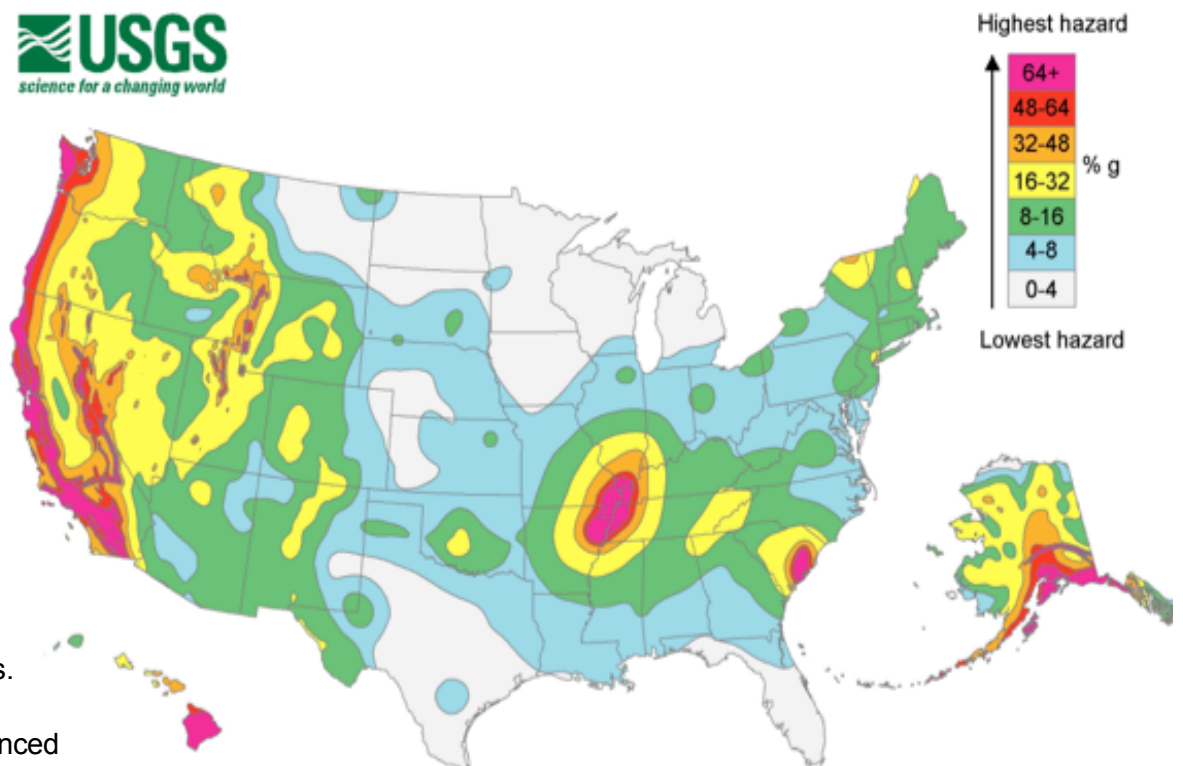


Figure 1: USGS Hazard Map (<http://earthquake.usgs.gov/hazards/products/>)



## Seismic Demand - Spectral Response Acceleration

State	Maximum $S_{DS}$	State	Maximum $S_{DS}$
California	2.49	Vermont	0.30
Tennessee	2.04	North Carolina	0.28
Missouri	2.01	Georgia	0.27
Kentucky	1.94	Alabama	0.27
Alaska	1.91	Virginia	0.22
Arkansas	1.88	New Hampshire	0.20
Hawaii	1.78	New Jersey	0.19
Nevada	1.73	Massachusetts	0.18
Illinois	1.73	West Virginia	0.18
Wyoming	1.61	Connecticut	0.18
Oregon	1.59	Ohio	0.15
South Carolina	1.27	Pennsylvania	0.15
Utah	1.15	Louisiana	0.14
Montana	1.14	Delaware	0.13
Idaho	1.14	Maryland	0.13
Washington	1.11	Rhode Island	0.12
Arizona	0.65	North Dakota	0.11
Mississippi	0.64	Nebraska	0.11
Indiana	0.48	South Dakota	0.11
New Mexico	0.42	Kansas	0.11
Texas	0.42	Florida	0.09
New York	0.37	Iowa	0.08
Oklahoma	0.33	District of Columbia	0.08
Maine	0.32	Michigan	0.08
Colorado	0.32	Wisconsin	0.07
		Minnesota	0.06

Table 1: Seismic Demand - Spectral Response Acceleration  
(<http://geohazards.usgs.gov/designmaps/us/regions.php>)

Table 1 (Seismic Demand - Spectral Response Acceleration) shows the level of earthquake demand by state from highest to lowest.  $S_{DS}$  is an acronym for Spectral Response Acceleration at Short Period. It is a measurement used to determine the seismic compliance of equipment. If the equipment's  $S_{DS}$  is above 2.5, it is most likely to be in seismic compliance with all current standards for non-structural equipment in all 50 states. If it is above 1.8, the equipment will be in compliance for most locations, all but six states, based on current standards as seen in table 1.

**The higher the  $S_{DS}$  rating your equipment has, the better it is able to withstand seismic forces and continue to operate safely.**

## Certification Assurance

Qualification of equipment ensures that a product design correctly and completely implements a specification and meets the proper standards. This could include passing

or successfully satisfying a test or analysis requirement. Qualification involves a one-time sample product performance evaluation by test or analysis, which is the first step toward certification. Certification adds third-party review for compliance to industry standards. Certification also ensures that the manufacturer has a quality control program so that all future products manufactured will meet the original qualification and performance guarantee. (Source: [http://petraseismicdesign.com/docs/ABCs\\_of\\_IBC\\_Compliance.pdf](http://petraseismicdesign.com/docs/ABCs_of_IBC_Compliance.pdf))

For HVAC equipment to meet seismic certification it must be tested by third party approved agencies on a "three dimensional shake table," in a lab, according to specific test requirements. Figures 2 and 3 show Carrier units on three dimensional shake tables.



Figure 2: Carrier Products on Three Dimensional Shake Table

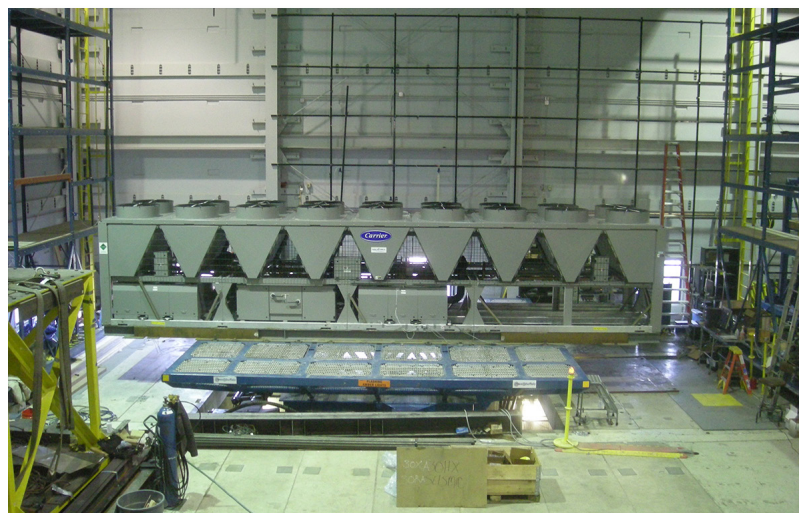


Figure 3: Carrier Chiller on Three Dimensional Shake Table



## Seismic Building Codes: Testing Requirements

Initially, there were several important building policies but since 2000, more regulations have been based on or are strictly compliant to the regulations developed by the International Building Code (IBC) and the Office of Statewide Health and Planning Development (OSHPD) in California.

The most common testing procedure used for IBC and OSHPD applications is the International Code Council Evaluation Services Acceptance Criteria 156 (ICC-ES AC156). ICC Evaluation Service, Inc., a non-profit organization, has developed a test plan AC-156 — Acceptance Criteria for Special Seismic Qualification by Shake Table Testing of Nonstructural Components and Systems, which is acceptable to IBC, Uniform Building Code (UBC), OSHPD and other local building code governing agencies.

AC-156 outlines procedures for seismic certification by testing of nonstructural components. Testing done in accordance with this criterion is intended to support data for the seismic certification of architectural, mechanical, electrical and other nonstructural systems, components, and elements permanently attached to structures. This criterion specifies a specific input motion to which nonstructural components should be subjected.

## International Building Code (IBC)

The scope of this code covers all buildings except three-story, one, and two-family dwellings and townhomes. The code includes structural, and fire and life safety provisions covering means of egress, interior finish requirements, comprehensive roof provisions, seismic engineering provisions, innovative construction technology, occupancy classifications, and the latest industry standards in material design. The IBC code, used in all 50 states, requires that HVAC equipment in critical facilities (e.g., hospitals, data centers, police and fire) must withstand an earthquake and still operate.

IBC Code Supplements occur every 18 months, with new full editions every three years, with IBC-2012 the most current. Keeping up with this code requires knowledge of their testing

and procedures. Compliance with AC-156 ensures compliance with IBC as well. This testing is commonly available at certified testing facilities.

The results required by the testing are as follows:

1. **Structural Integrity** of components, supports, and attachments shall be maintained.
2. **Functionality** of components shall be maintained.

*Functionality test shall be similar to what manufacturer normally performs prior to delivery of the components for use*

- Active and energized equipment/components shall be certified exclusively on the basis of shake table testing.
- ONLY connecting elements, attachments, and supports can be justified by supporting analysis.





## Office of Statewide Health and Planning Development (OSHPD)

In the state of California, OSHPD created the Special Seismic Certification program. Each manufacturers' specified model family has to have a minimum of two shake table tests for seismic capacity, meet the requirements of ICC-ES AC-156 and be certified by independent third party structural engineers. Equipment must meet these requirements and must be reviewed by the OSHPD office and issued an OSHPD Special Seismic Certification Preapproval (OSP) number (Source: <http://www.oshpd.ca.gov/fdd/Pre-Approval/>). See Figure 4 (Application for Preapproval) and Figure 5 (Special Seismic Certification) for examples of the OSHPD preapproval and certification forms.

OSHPD Special Seismic Certification denotes compliance to the OSHPD standard, and ensures compliance with the other standards. What is required in the testing that leads to seismic certification? Some of the requirements of the OSHPD certification include:

- Verification of similarities for a sampling of units. If the units are to be qualified for **different support, mounting, or attachment conditions**:
  - With and without vibration isolators (internal and external isolators are NOT equivalent), or
  - Different mounting types, such as wall mounted vs. floor mounted, etc.
- **Test of two units** shall be required for each **anchorage or mounting configuration** if the **units are made of different materials**: (E.g. carbon steel vs. stainless steel, etc.)
- **Test of two units** shall be required for **each active and energized components/subcomponents**.
- **At least one test** is required for non-active subcomponents (provided there are at least two component tests) such as sheet metal housing. If **sub-components are made by different manufacturers**.
- **Test of two units** shall be required for **each manufacturer**.
- **Special Seismic Certification** pre-approval is valid for components with design, construction, and quality control equivalent to units tested. Multiple units can be tested on a single shake table simultaneously.

- **Testing laboratory shall have ISO 17025 accreditation** or testing shall be under the responsible charge of an independent California licensed engineer. **Test reports shall be prepared by a California licensed engineer, and test reports shall be reviewed and accepted by an independent California licensed structural engineer.**

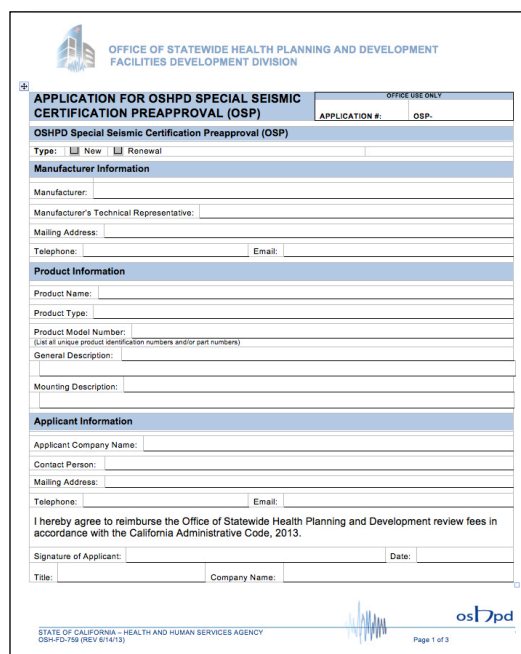


Figure 4: Application for Preapproval

Outside of California some states accept calculations only, but the experts agree that it is near impossible to accurately calculate an HVAC product and that the only accurate method is to do testing like AC-156 requires.

## Meeting the Compliance Challenge

Several hundreds of models of HVAC equipment have already been qualified. You can request the seismic certifications of compliance from the manufacturer. Make sure that the manufacturer has performed seismic testing (shake table test) of the specified model family as per ICC-ES AC-156 by a recognized/accredited third party approving agency. There are now many qualified testing facilities available. At a minimum, it is recommended that the manufacturer should provide certification to AC-156. Note that OSHPD pre-approval meets that certification requirement.

When planning a project, determine which building code(s) your customer's project must comply with, and when possible, ensure there is a need for the seismic option before any specifications are released for bid. If the building is being constructed as per IBC codes, the building will be categorized



Figure 5: Special Seismic Certification for Carrier

and drawings for anchor requirements and mounting considerations for seismic applications. Mounting requirement details such as anchor brand, type, embedment depth, edge spacing, anchor-to-anchor spacing, concrete strength, special inspection and attachment to non-building structures must be outlined and approved by the engineer of record for the project or building. Structural floors and housekeeping pads must also be seismically designed and approved by the project or building engineer of record to withstand seismic anchor loads as defined on installation drawings. The installing contractor is responsible for the proper installation of all anchors and mounting hardware, observing the mounting requirements detailed in the seismic installation drawings and additionally outlined by the engineer of record.

#### SUMMARY OF STEPS TO ENSURE COMPLIANCE FOR YOUR PROJECT:

1. Determine the building codes for the project and the seismic requirements in those codes.
2. Request seismic certifications of compliance from your HVAC manufacturer.
3. If certification is not yet achieved, analyze manufacturer's testing plans for compliance.
4. Make sure that certifications are adequate for IBC or OSHPD compliance and include shake table testing.
5. Verify the testing facility qualifications.
6. Adhere to seismic installation requirements from manufacturer during the course of the project.

based on occupancy level and equipment importance factor. If the equipment under consideration is not already certified, it does not mean it cannot be used for the project, but it must go through the testing procedure as required by ICC-ES AC-156.

Refer to the manufacturer supplied seismic installation instructions

## Carrier Seismic Certified Equipment

Carrier has an extensive product line that is seismic certified meeting both OSHPD and IBC requirements. Carrier's water-cooled chillers (19XR(V), 23XRV, 30HX and 30MP) air-cooled chillers (30XA, 30RB, 30RAP) and split systems (38AP/09DP) product families are special seismic compliant and their OSP numbers are listed in Table 2, along with product that is AC-156 certified. For your next project requiring seismic certification, contact your local Carrier sales engineer for more information.

CARRIER SEISMIC CERTIFIED PRODUCTS		
	OSP Number	AC-156 Approved
<b>Water Cooled Chillers</b>		
Evergreen® 19XRV Centrifugal	OSP-0026-10	✓
Evergreen® 23XRV Screw	OSP-0135-10	✓
Evergreen® 30HX Screw	OSP-0161-10	✓
Evergreen® 30MP Screw	OSP-0184-10	✓
<b>Air Cooled Chillers</b>		
AquaForce® 30XA Screw	OSP-0184-10	✓
AquaSnap® 30RB Scroll	OSP-0135-10	✓
AquaSnap® 30RAP Scroll	OSP-0184-10	✓
<b>Split Systems</b>		
Gemini® Select 38AP/09DP	OSP-0184-10	✓
<b>Rooftops</b>		
WeatherMaster® 48/50HC/HCQ		✓
WeatherMaker® 48/50TC/TCQ	OSP-0153-10	✓
<b>Room Fan Coils</b>		
Airstream™ 42B, 42C, 42D		✓

Table 2: Carrier Seismic Certified Products

## Conclusion

Seismic compliance is no longer only necessary for earthquake-prone locations or only for buildings and structures. Building codes in more and more locations now require HVAC equipment to be certified. The standards have been growing more stringent and more focused every year and staying ahead of new developments will make your project planning more efficient – saving time and money and providing a safer project outcome.

For more information on Seismic Compliance and Carrier HVAC equipment go to [www.commercial.carrier.com](http://www.commercial.carrier.com).