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In this issue of Engineering System Solutions, we provide a summary of the earthquake (seismic) provisions affecting HVAC systems that are included in the International Building Code (IBC). For designated building functions, the IBC can require that systems critical to life safety and fulfilling the building's intended purpose remain online immediately after a seismic event. This can affect the HVAC system and require that it be certified compliant for the same seismic design category as the building.

Because the IBC is the code for the building structure, it is not typically a document that is used by mechanical engineers. However, the mechanical design professional is responsible for identifying whether HVAC equipment is covered under IBC seismic provisions and specifying products that are certified compliant.

HVAC manufacturers are responsible for having equipment certified compliant by an approved, independent agency and providing proof of such compliance from the agency. The designer should require proof of compliance with each manufacturer's bid to avoid the risk of receiving non-compliant equipment.

McQuay has a number of compliant products that are certified to meet these provisions, and the expertise to assist in applying these products. For more information, contact your local McQuay representative or visit www.mcquay.com.

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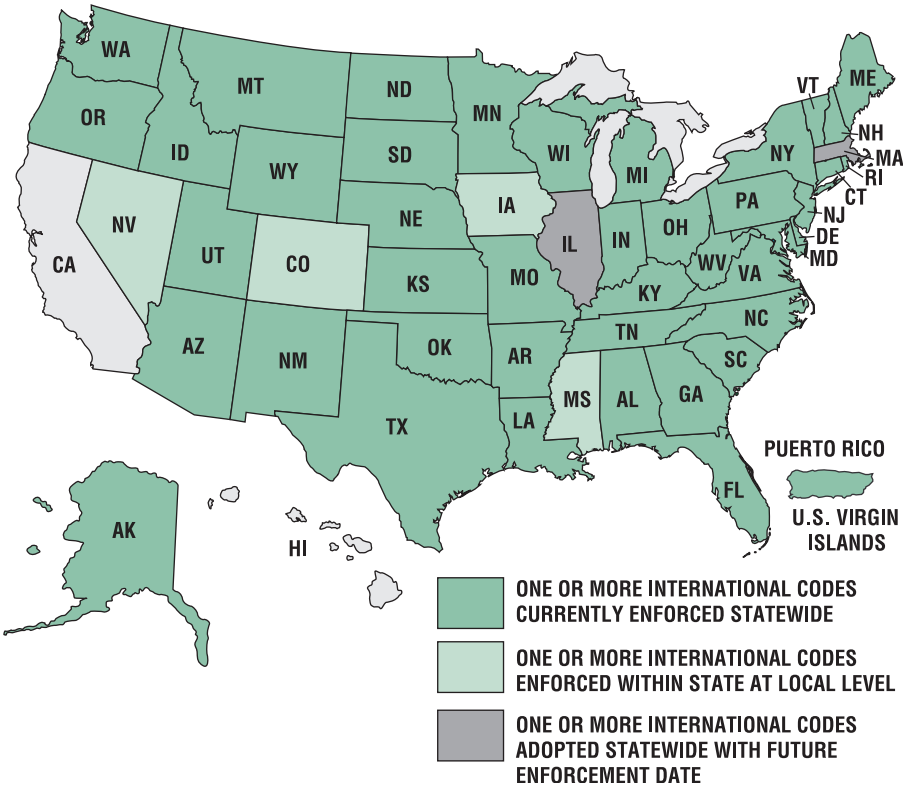
IBC Seismic Requirements and HVAC Systems – A Short Course

The IBC provides a modern, up-to-date building code addressing the design and installation of building systems through requirements emphasizing performance. Published by the International Code Council (ICC), this comprehensive code establishes minimum regulations for building systems using prescriptive and performance-related provisions that combine the scope of existing model codes, such as BOCA and ICBO Uniform Building Code (UBC).

In much the same way as ASHRAE standards, the ICC codes are available for adoption – in whole or in part – by jurisdictions throughout the United States. For example, as of June 9, 2005, 45 states, the District of Columbia and the U.S. Department of Defense have adopted some or all of the provisions of the IBC (Figure 1). The codes can also be adopted internationally.

Figure 1. – As of June 9, 2005, 45 states have adopted some or all of the provisions of the International Building Code.[1]



[1]*For map updates, visit http://www.iccsafe.org/government/adoption.html.*

McQuay® Air Conditioning

IBC and Seismic Requirements

The IBC adds a key new dimension for the mechanical design professional because its provisions cover building systems and components – not just the building structure. Code provisions require that building life safety systems remain online immediately after a seismic event. For critical building designations, systems required for the building to fulfill its intended use are also covered. In addition, the Code includes a clause that the interrelationship of components be considered so that the failure of any component does not cause the failure of any essential component. HVAC systems that are essential for life safety functions, that protect life safety functions or are essential for the building to fulfill its intended use must be certified compliant to meet the same seismic design category as the building (see Certification Requirements).

The remaining portions of this newsletter provide a summary of the provisions for determining whether seismic-resistant HVAC equipment is required to comply with the IBC, and the requirements for certifying HVAC equipment as IBC-compliant. All information references the 2000 version of the IBC. The 2003 version and the NFPA 5000 Code use the same methodology, but some variations exist in terminology. These variations are noted in this newsletter.

Determining Whether Seismic-Resistant HVAC Equipment Is Required

Four basic steps are required to determine whether an HVAC system is required to comply with the seismic-resistance provisions of the IBC:

1. Determine the Seismic Use Group of the structure.
2. Determine the Component Importance Factor (I_P) of the HVAC equipment.
3. Determine the Seismic Design Category of the structure.
4. Determine if the HVAC equipment is exempt from seismic requirements.

The *Seismic Sample Calculation* sidebar in this newsletter illustrates the procedure for a specific building and component.

1. Determine The Seismic Use Group Of The Structure

All structures are assigned to a Seismic Use Group based on their intended function, as indicated in Table 1604.5 of the Code. This designation is a basic element in determining the building's Seismic Design Category. The Seismic Use Groups that are applicable to HVAC equipment are listed below:[2]

- **Seismic Use Group III:** Structures that have essential facilities required for post earthquake recovery and those containing substantial quantities of hazardous substances, as indicated by Table 1604.5 or as designated by the building official. Examples from Table 1604.5 include:
  - Hospitals and other health care facilities having surgery or emergency treatment facilities.
  - Fire, rescue and police stations and emergency vehicle garages.
  - Designated earthquake, hurricane or other emergency shelters.
  - Designated emergency preparedness, communication and operation centers, and other facilities required for emergency response.
- **Seismic Use Group II:** Structures whose failure would result in a substantial public hazard due to occupancy or use as indicated by Table 1604.5 or as designated by the building official. Examples from Table 1604.5 include:
  - Buildings and other structures where more than 300 people congregate in one area (i.e. theaters, auditoriums, churches).
  - Buildings and other structures with elementary school, secondary school or day-care facilities with capacity greater than 250.
  - Health care facilities with a capacity of 50 or more resident patients, but not having surgery or emergency treatment facilities (i.e. nursing homes, outpatient clinics).
  - Jails and detention centers.
- **Seismic Use Group I:** Structures not assigned to Seismic Use Group II or III.

[2]The Seismic Use Group numbering used in this newsletter is from the IBC version published in 2000. This numbering was changed in the 2003 version, but definitions remain the same.

2. Determine The Component Importance Factor (I_P) Of The HVAC Equipment

A mechanical (HVAC) system becomes a Designated Seismic System based on its I_P and the building's determined Seismic Design Category. The 2000 version of the IBC recognizes two values for I_P. They are 1.0 and 1.5. Those architectural, electrical and mechanical systems and their components that require design in accordance with Section 1621 have a component importance factor greater than 1.0. The following I_P values, taken from the Code, have been interpreted to relate to HVAC equipment:

Component type	I_P Value
Life safety components required to function after an earthquake	1.5
Components containing hazardous or flammable materials in quantities that exceed the exempted amounts for an open system listed in Chapter 4	1.5
For structures in Seismic Use Group III, components needed for continued operation of the facility or whose failure could impair the continued operation of the facility	1.5
All other components	1

The Code does not specifically define for each Seismic Use Group what constitutes a "life safety system" or critical component for determining I_P. However, the following appear to be generally accepted:

- **Seismic Use Group I:** Not applicable.
- **Seismic Use Group II:** Anything associated with fire and smoke control systems.
- **Seismic Use Group III:** Anything included for Use Group II buildings plus all HVAC systems.

HVAC components that may have an I_P = 1.5 include:

- HVAC systems that perform as fire/smoke systems.
- Heating and cooling systems required for maintaining occupant health and safety (Use Group III structures).
- Heating systems required to prevent failure of life safety systems (fire sprinklers).
- Heating and cooling systems required to maintain critical life saving equipment (ICU's, heart/lung machines, etc. in Use Group III structures)
- Any component covered by the interrelationship clause.
- Natural gas heating systems. The Code does not specifically name natural gas systems as having an I_P = 1.5, but they are clearly identified in the IBC Commentary book that can be purchased with the code.

Finding Information on the IBC

The following chapters in the IBC describe the requirements for seismic design and equipment certification:

- Chapter 16 describes the requirements for seismic-resistant design. Code requirements and methodology are based on data developed in the 1997 National Earthquake Hazards Reduction Program (NEHRP) which was funded by the Federal Emergency Management Agency (FEMA). Section 1621.3.5 states the requirement to provide a compliant system.
- Chapter 17 describes the certification, testing and inspection requirements. It also covers requirements for special inspections, quality assurance plans, etc. Section 1702 defines Certificate of Compliance and Section 1703 states the requirements and definition of approvals, including approved agency and labeling.

The following resources provide information and assistance with the IBC and seismic requirements:

- A printed version of the 2003 IBC and software CD can be ordered online at www.icbo.org.
- The U.S. Geological Survey provides spectral maps on its website at http://eqhazmaps.usgs.gov/.
- The Building Seismic Safety Council of the National Institute of Building Sciences (NIBS) provides its National Earthquake Hazards Reduction Program (NEHRP) Recommended Provisions For Seismic Regulations For New Buildings and Other Structures (FEMA 450) at http://www.bssconline.org.
- McQuay representatives can help determine a building's Seismic Design Category and define its applicability to components. To locate your local representative, visit www.mcquay.com.

3. Determine The Seismic Design Category Of The Structure

All structures are assigned to a Seismic Design Category based on their assigned Seismic Use Group and determined Design Spectral Response. Use the following steps to arrive at the Seismic Design Category for a structure.

Step 1. Determine the Maximum Spectral Response Accelerations (S_S and S_1) for the area where the structure is located.

The maximum considered spectral response acceleration at 0.2 seconds (S_S) and at 1-second (S_1) can be determined using the spectral response maps provided in the printed version of the IBC or the accompanying software.

- **Maps—**Locate S_S and S_1 using the following maps provided in the Code:
  - Figure 1615(1): S_S , Mapped Maximum Considered Earthquake 0.2 Second Short Periods (5 Hz) Spectral Response Acceleration
  - Figure 1615(2): S_1 , Mapped Maximum Considered Earthquake 1.0 Second Spectral Response Acceleration
- **Software—**Locate S_S and S_1 using the software program, Seismic Design Parameters for Use with the 2000 IBC, provided with the printed Code. The software accepts either the zip code or latitude and longitude of the site.[3]

Note: Sites with S_S <0.15g and S_1 <0.04g are considered Seismic Design Category A.[4] Buildings on these sites, including Seismic Use Group III buildings, and components such as HVAC system must meet only the minimum structural design criteria unless specifically required by local code.

[3]In regions with steep gradients, it is more precise to use latitude and longitude as program inputs.

[4]The maps and software referenced above provide S_S and S_1 in %g. To determine g, divide the value for S_S and S_1 from the maps or software by 100 (i.e. if S_S = 5.5 on the map, then S_S = .055g).

Step 2. Determine the Site Class (A to F) and Site Coefficients (F_a and F_v)

The Site Class depends on the soil profile and properties, and ranges from A (hard rock) to F (very soft poor soil). Table 1615.1.1 defines each site class based on the soil properties present on a site. In the absence of a detailed soil analysis, the IBC allows you to use Site Class D unless it has been pre-determined that Site Class E or F soil is present at the site.

Site Coefficients F_a and F_v are based on the Site Class and the spectral response acceleration (S_S for F_a and S_1 for F_v). F_a can be determined using Table 1615.1.2(1) and F_v can be determined using Table 1615.1.2(2) in the printed version of the IBC. The software program accompanying the printed IBC can also be used to determine Site Coefficients.

Step 3. Calculate the Adjusted Maximum Accelerations (S_{MS} and S_{M1})

Using Site Coefficients F_a and F_v, calculate the adjusted Maximum Spectral Response Acceleration parameters at 0.2 seconds (S_{MS}) and one second (S_{M1}) as follows:

- $S_{MS} = F_a S_S$
- $S_{M1} = F_v S_1$

Step 4. Calculate the Design Spectral Response Acceleration Parameters (S_{DS} and S_{D1})

Use the values calculated for S_{MS} and S_{M1} in Step 3 to calculate the Design Spectral Response Acceleration parameters at 0.2 seconds (S_{DS}) and one second (S_{D1}) as follows:

- $S_{DS} = 2/3\ S_{MS}$
- $S_{D1} = 2/3\ S_{M1}$

Step 5. Determine the assigned Seismic Design Category

The Seismic Design Category can be determined using Tables 1616.3(1) and 1616.3.1(2) in the printed IBC document and have been reproduced below. The Seismic Design category is a function of the structure's designated Seismic Use Group and the values for S_{DS} and S_{D1} calculated in Step 4.

Table 1616.3(1): Seismic design category based on 0.2 second period response accelerations.

Value of S_{DS}	Seismic Design Category		
	Use Group I	Use Group II	Use Group III
S_{DS} < 0.167g	A	A	A
0.167g ≤ S_{DS} < 0.33g	B	B	C
0.33g ≤ S_{DS} < 0.50g	C	C	D
0.50g ≤ S_{DS}	D*	D*	D*

Table 1616.3(2): Seismic design category based on 1-second period response accelerations.

Value of S_{D1}	Seismic Design Category		
	Use Group I	Use Group II	Use Group III
S_{D1} < 0.067g	A	A	A
0.067g ≤ S_{D1} < 0.133g	B	B	C
0.133g ≤ S_{D1} < 0.20g	C	C	D
0.20g ≤ S_{D1}	D*	D*	D*

**Seismic Use Group I and II structures located on sites with mapped maximum considered earthquake spectral response acceleration at 1-second period, S_1, equal to or greater than 0.75g, shall be assigned to Seismic Design Category E, and Seismic Use Group III structures located on such sites shall be assigned to Seismic Design Category F.*

4a. Determine If The HVAC Equipment Is Exempt From Seismic Requirements

Mechanical equipment is covered under the seismic provisions of the Code unless one of the exceptions listed in Section 1621.1.1 apply. These exceptions are based on the Component Importance Factor and the determined Seismic Design Category. Specifically, mechanical equipment, including HVAC, is exempt when any of the following conditions apply (Refer to Section 1621.1.1 for complete descriptions):

- The building is Seismic Design Category A or B.
- The building is Seismic Design Category C and $I_P = 1$.
- The mechanical component is located within 4 feet of the floor, weighs less than 400 pounds and $I_P = 1$.
- The mechanical component weighs less than 20 pounds.

4b. Determining the Associated Seismic Design Force (F_P) for a Covered Component.

If the component is determined not to be exempt, calculate the required Seismic Force, F_P using the equations given in Section 1621.1.4 of the Code as follows:

$$F_p = \frac{0.4 a_p S_{DS} W_P}{(R_p/I_p)} \times (1 + 2z/h)$$

Where;

a_p = Component amplification factor that varies from 1 to 2.5 (selected from Table 1621.3 of the printed IBC 2000).

F_p = Seismic design force centered at the component's center of gravity and distributed relative to component's mass distribution.

I_p = Component importance factor that is either 1 or 1.5.

h = Average roof height of structure relative to base elevation.

R_p = Component response modification factor that varies from 1 to 5 (select an appropriate value from Table 1621.3 of the printed IBC 2000).

S_{DS} = Design spectral response acceleration at 0.2 seconds.

W_p = Component operating weight.

z = Height in structure at point of attachment of component. For items below the base, z shall be taken as 0. For items at or above the roof, z is not required to be taken as greater than the roof height h.

The component (or equipment) must be certified to meet the calculated value of F_P at a minimum.

What Constitutes a Certified Seismic-compliant Product?

Seismic-compliant products must have been reviewed and certified capable to withstand a given Seismic Force (F_P) by an Approved Agency. Section 1702 of the Code states that a label must be applied to the product that indicates that it has been inspected and evaluated by an approved agency (see sidebar on McQuay compliant products). The IBC outlines the requirements for an approved agency in Section 1703:

- **1703.1 Approved Agency**. An approved agency shall provide all information as necessary for the building official to determine that the agency meets the applicable requirements.
  - 1703.1.1 Independent. An approved agency shall be objective and competent. The agency shall also disclose any possible conflicts of interest so that objectivity can be confirmed.
  - 1703.1.2 Equipment. An approved agency shall have adequate equipment to perform required tests. The equipment shall be periodically calibrated.
  - 1703.1.3 Personnel. An approved agency shall employ experienced personnel educated in conducting, supervising and evaluating tests and/or inspections.

As with most Codes, an approved agency is one that can display proof of competency and that is found acceptable by the local approving authority (building code official). Manufacturers are not allowed to self-certify compliance as they can not pass the objectivity requirement in 1703.1.1.

McQuay Provides Seismic-Certified Products

McQuay has several products that are certified compliant and available for use in Seismic Use Group II or III buildings as defined in the IBC 2000 (Use Group III & IV in the 2003 edition). These products are certified to satisfy the worst case for Design Categories D (F_P = 2.88 g) and E/F (F_P = 4.42 g) to simplify specification once it has been determined that components are covered under the seismic provisions of the code. Products currently certified include:

- Applied Rooftop Systems (Models RDT, RPS, RCS, RFS and RPR)
- Vision Indoor Air Handler (Models CAH and CAC)
- Skyline Outdoor Air Handler (Models OAH and OAC) and Rooftop Air Handlers (Models RAH, RDS and RAR)
- AAF®-HermanNelson® Unit Ventilators (Models AV, AH, AZ, AE, and AE/ER)
- Air-cooled Packaged Screw Chillers (Model AGS)

As specified in IBC 2000 and 2003, all McQuay products that are designated as compliant have been analyzed, tested and certified by an independent agency, VMC Seismic Consulting Group, that is competent in seismic analysis and design. Each product includes:

- An appropriate Certificate of Compliance to be used at the time of specification and submittal for each compliant product, as specified in IBC 2000 and 2003.
- A label of compliance from the certifying agent is displayed on the product for the inspecting authority to review, as specified in IBC 2000 and 2003.
- Installation instructions for installing the product in a manner that supports compliance.

For more information on IBC seismic provisions and certified McQuay products, contact your McQuay representative or visit www.mcquay.com.

Sample Seismic Calculation and Specification

The following illustrates the process for determining whether a seismic-resistant HVAC system is required to comply with the IBC and how to state the requirement in a specification document. For this example, we will use a 3-story hospital with emergency treatment facilities located in Atlanta, GA (zip code 30080). To simplify the illustration, we will perform the calculation for a McQuay air handler that is part of a central system. All other components would require this same calculation. The figures, tables and sections referred to below can be found in the printed IBC 2000 or its accompanying software (where noted).

Step 1 **Determine the Seismic Use Group.**
From Table 1604.5, a hospital with emergency treatment facilities is designated a Seismic use Group III structure.

Step 2 **Determine The Component Importance Factor (I_P) Of The HVAC Equipment**
Per Section 1621.1.6, the Component Importance Factor (I_P) = 1.5 because the HVAC system is required to provide life safety functions and to maintain the continued operation of the facility.

Step 3.1 **Determine the Maximum Spectral Response Accelerations (S_S and S_1) for the area.**
Per Figure 1615(1) or the software, S_S = .271g
Per Figure 1615(2) or the software, S_1 = .114g

Step 3.2 **Determine the Site Class (A to F) and Site Coefficients (F_a and F_v)**
Because we have no soil analysis, the Code specifies that Site Class D be used for the soil profile.
Per Table 1615.1.2(1) or the software, F_a = 1.58
Per Table 1615.1.2(2) or the software, F_v = 2.34

Step 3.3 **Calculate the Adjusted Maximum Accelerations (S_{MS} and S_{M1})**
$S_{MS} = F_a S_S$ = 1.58 x .271g = .429g
$S_{M1} = F_v S_1$ = 2.34 x .114g = .267g

Step 3.4 **Calculate the Design Spectral Response Acceleration Parameters (S_{DS} and S_{D1})**
S_{DS} = 2/3 S_{MS} = 2/3 x .429 = .286g
S_{D1} = 2/3 S_{M1} = 2/3 x .267 = .178g

Step 3.5 **Determine the assigned seismic design category**
Per Table 1616.3(1), the Seismic Design Category based on 0.2 second response = C.
Per Table 1616.3(2), the Seismic Design Category based on 1.0 second response = D.
According to Section 1616.3, the structure shall be assigned the most severe category, which in this case is Seismic Design Category D.

Step 4 **a. Determine if the HVAC Equipment is Exempt from Seismic Requirements:**
The HVAC equipment does not meet any of the criteria for exemption. Therefore, it must meet the same Seismic Design Category as the structure.

b. Calculate the required F_P, independent of unit weight, for use in the HVAC equipment specification.
To simplify the specification, review and approval process, F_P can be calculated independent of equipment weight and specified in terms of a g-force rating. The manufacturer must provide a Certificate of Compliance from an approved, independent agency that the equipment as a building component, complies with the required F_P regardless of size or weight.

Determine the associated value of F_P.

$$F_p = \frac{0.4 a_p S_{DS} W_P}{(R_p/I_p)} \times (1 + 2z/h) = \frac{0.4\ (2.5)(.286)(1)}{(2.5/1.5)} \times (1 + (2)30/30) = 0.515g$$

Where;

- Component amplification factor (a_p) = 2.5 from Table 1621.3
- Component importance factor (I_p) = 1.5 from Step 2 above
- Average roof height (h) = 30 feet
- Component response modification factor (Rp) = 2.5 from Table 1621.3.
- Design spectral response acceleration at 0.2 seconds (S_{DS}) = .286 from Step 3d above
- Component operating weight (W_p) = 1 (reflecting that the calculation is independent of unit weight).
- Height in structure at point of attachment of component (z) = 30 because the air handler is located in a penthouse mechanical room.

For this example, the HVAC equipment specification shall reflect that the air handling equipment must be certified compliant to withstand a minimum F_P=0.515g

The data and suggestions in this document are believed current and accurate at the time of publication, but they are not a substitute for trained, experienced professional service. Individual applications and site variations can significantly affect the results and effectiveness of any information, the reader must satisfy him/herself regarding the applicability of any article and seek professional evaluation of all materials. McQuay disclaims any responsibility for actions based on this document.

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