GREENHECK
Fan Application
FA/125-10
PRODUCT APPLICATION GUIDE
A technical bulletin for engineers, contractors and students in the air movement and control industry.

Seismically Rated Fans

When a project calls for seismically rated equipment, there are a number of code requirements that need to be considered. This article outlines the methodology of the seismic certification process and considerations involved to properly determine the need for a seismically certified fan.

While the information referenced in this guide is a general overview of the 2009 International Building Code (2009 IBC) and the American Society of Civil Engineers Minimum Design Loads for Buildings and Other Structures (ASCE 7-05), always consult your local building codes for specific requirements. The need for a seismically rated fan is ultimately made by the structural engineer, and should be published in the structural plans.

There are two pertinent mandates for seismic certification of equipment — the International Building Code (IBC) and the Office of Statewide Health Planning and Development (HCAI).

The International Building Code (IBC)

The International Building Code is a model building code developed by the International Code Council (ICC). The IBC is designed to provide model code regulations that safeguard public health and safety in all communities. The 2009 IBC incorporates standards for the design of non-structural components subject to seismic events, including HVAC equipment and fans. The code states: *Every structure, and portion thereof, including non-structural components that are permanently attached to structures and their supports and attachments, shall be designed and constructed to resist the effects of earthquake motions in accordance with ASCE 7.*

These standards go beyond the need for position retention certification of components and now include certification of the mechanical equipment itself. The IBC has been adopted on the state or local level.

Office of Statewide Health Planning and Development (HCAI)

The Office of Statewide Health Planning and Development (HCAI) is one division within the California Health and Human Services Agency with the pertinent objective to ensure the safety of buildings used in providing health care. Though HCAI enforces building standards for health care facilities per the California Building Code, this code closely reflects the standards presented by the 2009 IBC.

Seismic Certification Methodology

There are three ways in which a component can be seismic certified per the 2009 IBC.

1. Shake table test.
2. Three-dimensional tests by an analytical method using dynamic characteristics and forces.
3. The use of experience data (historical data demonstrating acceptable seismic performance).

For certification of an entire product line represented by the OSP number, HCAI requires testing of the largest and smallest component of similar construction via shake table. To best encompass the requirements of both the 2009 IBC and HCAI Special Seismic Certification Preapproval (OSP), seismic certified fans shall be shake table tested. Fans are tested at an independent test facility in accordance

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with ICC-ES AC 156 and under the responsible charge and review of a California structural engineer.

Seismic Design Category

Each building and structure is assigned a Seismic Design Category (SDC) by the building structural engineer. The Seismic Design Category is a classification assigned to a structure based on its Occupancy Category and the severity of the design earthquake ground motion at the site. The SDC determines whether seismic certified equipment is required by the 2009 IBC. If a piece of equipment is assigned a SDC of C through F, and the importance factor for that piece of equipment is 1.5, the component is to be seismic certified per the 2009 IBC and HCAI (See table ASCE 7-05 Seismic Design Exceptions.) HVAC components will have the same Seismic Design Category rating as the building unless otherwise noted.

Calculating a Seismic Design Category

The following four steps can be used to determine the Seismic Design Category of a structure:

1. Determine the Occupancy Category of the structure by consulting the 2009 IBC Table 1604.5 - Occupancy Category of Buildings and Other Structures. (See Table 1-1 Occupancy Category of Buildings and Other Structures for Flood, Wind, Snow, Earthquake, and Ice Loads.) The Occupancy Categories are:
   - Occupancy Category I – buildings and other structures that represent a low hazard to human life in the event of failure.
   - Occupancy Category II - buildings and other structures except those listed in Occupancy Categories I, III and IV.
   - Occupancy Category III – buildings and other structures that represent a substantial hazard to human life in the event of failure.
   - Occupancy Category IV - buildings and other structures designated as essential facilities.
2. Determine the component's Importance Factor (Ip). The value for Ip will be 1.5 for any of the following conditions (otherwise it will be 1.0). Note: HCAI considers fans and air handlers to have an Importance Factor of 1.5.
   - The component is required to function for life-safety purposes after an earthquake.
   - The component contains hazardous materials.
   - The component is in or attached to an Occupancy Category IV structure and it is needed for continued operation of the facility.
3. Determine the designed spectral response acceleration parameters (S_{DS} and S_{D1}).
   - Establish the spectral response accelerations based on the building location. Decide the appropriate 0.2 Second Spectral Response Acceleration (S_s) and the 1.0 Second Spectral Response Acceleration (S_1) from the 2009 IBC Figures 1613.5(1) through 1613.5(14). Units of S_s and S_1 are in percentage of Earth's gravity (% g). These spectral response accelerations (S_s and S_1) can also be determined from USGS Seismic Hazard Curves and Uniform Hazard Response Spectra software. A free version is available via USGS at http://earthquake.usgs.gov/research/hazmaps/design/.
   - Determine the site class based on soil profile. Consult IBC-2009 table 1613.5.2 - Site Class Definitions, shown below, to determine site classification.

     A: Hard rock

     B: Rock

     C: Very dense soil and soft rock

     D: Stiff soil

     E: Soft clay soil

     F: Sandy clays

     Unknown, use D.

Table 1613.5.2

Site Class Definitions (IBC 2009)

Site Class	Soil Profile Name	Average Properties in Top 100 feet, See Section 1613.5.5		
		Soil shear wave velocity, $\bar{v}_S$, (ft/s)	Standard penetration resistance, $\bar{N}$	Soil undrained shear strength, $\bar{S}_U$, (psf)
A	Hard rock	$\bar{v}_S > 5{,}000$	N/A	N/A
B	Rock	$2{,}500 < \bar{v}_S \leq 5{,}000$	N/A	N/A
C	Very dense soil and soft rock	$1{,}200 < \bar{v}_S \leq 2{,}500$	$\bar{N} > 50$	$\bar{S}_U > 2{,}000$
D	Stiff soil profile	$600 \leq \bar{v}_S \leq 1{,}200$	$15 \leq \bar{N} \leq 50$	$1{,}000 \leq \bar{S}_U \leq 2{,}000$
E	Soft soil profile	$\bar{v}_S < 600$	$\bar{N} < 15$	$\bar{S}_U < 1{,}000$
E	---	Any profile with more than 10 feet of soil having the following characteristics: 1. Plasticity index PI>20, 2. Moisture content w≥40%, and 3. Undrained shear strength $\bar{S}_U < 500$ psf		
F	---	Any profile containing soils having one or more of the following characteristics: 1. Soils vulnerable to potential failure or collapse under seismic loading such as liquefiable soils, quick and highly sensitive clays, collapsible weakly cemented soils. 2. Peats and/or highly organic clays (H>10 feet of peat and/or highly organic clay where H = thickness of soil) 3. Very high plasticity clays (H>25 feet with plasticity index PI>75) 4. Very thick soft/medium stiff clays (H>120 feet)		

- Use the spectral response accelerations and site class found above to establish the site coefficients F_a and F_V from the 2009 IBC Tables 1613.5.3(1) and 1613.5.3(2) respectively shown below.

Table 1613.5.3 (1)

Values of Site Coefficient F_a[a]

Site Class	Mapped Spectral Response Acceleration at Short Period				
	$S_S \leq 0.25$	$S_S = 0.5$	$S_S = 0.75$	$S_S = 1.0$	$S_S \geq 1.25$
A	0.8	0.8	0.8	0.8	0.8
B	1.0	1.0	1.0	1.0	1.0
C	1.2	1.2	1.1	1.0	1.0
D	1.6	1.4	1.2	1.1	1.0
E	2.5	1.7	1.2	0.9	0.9
F	Note b				

a. Use straight-line interpolation for intermediate values of mapped spectral response acceleration at short periods, S_S.

b. Values shall be determined in accordance with Section 11.4.7 of ASCE 7.

Table 1613.5.3 (2)

Values of Site Coefficient F_v[a]

Site Class	Mapped Spectral Response Acceleration at 1-Second Period				
	$S_1 \le 0.1$	$S_1 = 0.2$	$S_1 = 0.3$	$S_1 = 0.4$	$S_1 \ge 0.5$
A	0.8	0.8	0.8	0.8	0.8
B	1.0	1.0	1.0	1.0	1.0
C	1.7	1.6	1.5	1.4	1.3
D	2.4	2.0	1.8	1.6	1.5
E	3.5	3.2	2.8	2.4	2.4
F	Note b				

a. Use straight-line interpolation for intermediate values of mapped spectral response acceleration at 1-second period, S_1.

b. Values shall be determined in accordance with Section 11.4.7 of ASCE 7.

- Calculate the MCE spectral response accelerations adjusted for site class effects (S_{MS} and S_{M1}) using the following equations:
  - $S_{MS} = F_a * S_s$
  - $S_{M1} = F_v * S_1$
- Calculate the design spectral response accelerations (S_{DS} and S_{D1}) using the following equations:
  - $S_{DS} = 2/3 * S_{MS}$
  - $S_{D1} = 2/3 * S_{M1}$

4. Establish the Seismic Design Category

- For Occupancy Category I, II, or III structures located where the mapped S_1 value is greater than or equal to 0.75 shall be assigned a Seismic Design Category E.
- For Occupancy Category IV structures located where the mapped S_1 value is greater than or equal to 0.75 shall be assigned a Seismic Design Category F
- Otherwise utilize the 2009 IBC Tables 1613.5.6(1) and 1613.5.6(2), shown below, to determine the Seismic Design Category based on the occupancy category and the design spectral response accelerations (S_{DS} and S_{D1}).

Table 1613.5.6 (1)

Seismic Design Category Based on Short-Period Response Accelerations

Value of S_{DS}	Occupancy Category		
	I or II	III	IV
$S_{DS} < 0.167g$	A	A	A
$0.167g \le S_{DS} < 0.33g$	B	B	C
$0.33g \le S_{DS} < 0.50g$	C	C	D
$0.50g \le S_{DS}$	D	D	D

Table 1613.5.6 (2)

Seismic Design Category Based on 1-Second Period Response Acceleration

Value of S_{D1}	Occupancy Category		
	I or II	III	IV
$S_{D1} < 0.067_g$	A	A	A
$0.067_g \leq S_{D1} < 0.133_g$	B	B	C
$0.133_g \leq S_{D1} < 0.20_g$	C	C	D
$0.20_g \leq S_{D1}$	D	D	D

- If two different seismic design categories are calculated, assign the worse of the two (A-F with F being the worst) to the structure.
- Exceptions where seismic certified components are not required are listed in the following table. *NOTE: If the Importance Factor (I_p) is 1.5, there are no exceptions for seismic design categories C - F.*

ASCE 7-05 Seismic Design Exceptions

Seismic Design Category (SDC)	Non-structural components exempt from seismic requirements
B	Architectural components other than parapets supported by bearing walls or shear walls provided that I_p=1.0 Mechanical and electrical components in SDC B
C	Mechanical and electrical components if I_p=1.0
D	Mechanical and electrical components where I_p=1.0 and either: Flexible connections between components and associated ductwork, piping, and conduit are provided OR Components are mounted at 4 ft. or less above a floor and weigh 400 lbs or less
E F	Mechanical and electrical components in SDC D, E, and F where Ip=1.0 and: Flexible connections between component and associated ductwork, piping, and conduit are provided AND The component weighs 20 lbs or less, or for distribution systems, weighing 5 lb/ft or less

Greenheck's Seismic Certification

Greenheck's tests incorporated the most severe seismic conditions anywhere in the United States including the most severe spectral response accelerations (S_{DS} = 2.28), an Importance Factor of 1.5, all Site Classes (F being the most severe), all Occupancy Categories (IV- essential facilities), and all Seismic Design Categories (F being the most severe).

Testing equipment for the worst case scenarios allows Greenheck to supply a seismic certified fan to a job anywhere in the United States regardless of location. For projects presided over by HCAI, please reference OSP-0105-10 and OSP-0113-10 for a listing of Greenheck equipment that meets Special Seismic Certification Preapproval.

Summary

The 2009 International Building Code (IBC) and the Office of Statewide Health Planning and Development (HCAI) both require seismic certification of non-structural mechanical equipment, including fans. Fans assigned to a seismic design category (SDC) of C through F and to an Importance Factor of 1.5 (I_p=1.5), shall be seismic certified to comply with the 2009 IBC and HCAI. To best encompass both standards, the equipment shall be tested on a shake table by an accredited laboratory. In addition to referencing the structural plans to determine the seismic design category of a fan, you can use the above steps to calculate the SDC value. Greenheck has achieved seismic certification through shake table testing for worst-case conditions in the United States on a number of its products. The certification process allows for its fans to be used anywhere in the United States.

References

- 2009 International Building Code
- American Society of Civil Engineers. Minimum Design Loads for Buildings and Other Structures

Table 1-1: Occupancy Category of Buildings and Other Structures for Flood, Wind, Snow, Earthquake, and Ice Loads

Nature of Occupancy	Occupancy Category
Buildings and other structures that represent a low hazard to human life in the event of failure, including, but not limited to: • Agricultural facilities • Certain temporary facilities • Minor storage facilities	I
All buildings and other structures except those listed in Occupancy Categories I, III, and IV	II
Buildings and other structures that represent a substantial hazard to human life in the event of failure, including, but not limited to: • Buildings and other structures where more than 300 people congregate in one area • Buildings and other structures with day care facilities with a capacity greater than 150 • Buildings and other structures with elementary school or secondary school facilities with a capacity greater than 250 • Buildings and other structures with a capacity greater than 500 for colleges or adult education facilities • Health care facilities with a capacity of 50 or more resident patients, but not having surgery or emergency treatment facilities • Jails and detention facilities Buildings and other structures, not included in Occupancy Category IV, with potential to cause a substantial economic impact and/or mass disruption of day-to-day civilian life in the event of failure, including, but not limited to: • Power generation stations • Water treatment facilities • Sewage treatment facilities • Telecommunication centers Buildings and other structures not included in Occupancy Category IV (including, but not limited to, facilities that manufacture, process, handle, store, use, or dispose of such substances as hazardous fuels, hazardous chemicals, hazardous waste, or explosives) containing sufficient quantities of toxic or explosive substances to be dangerous to the public if released. Buildings and other structures containing toxic or explosive substances shall be eligible for classification as Occupancy Category structures if it can be demonstrated to the satisfaction of the authority having jurisdiction by a hazard assessment as described in Section 1.5.2 that a release of the toxic or explosive substances does not pose a threat to the public.	III
Buildings and other structures designated as essential facilities, including, but not limited to: • Hospitals and other health care facilities having surgery or emergency treatment facilities • Fire, rescue, ambulance, 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 • Power generating stations and other public utility facilities required in an emergency • Ancillary structures (including, but not limited to, communication towers, fuel storage tanks, cooling towers, electrical substation structures, fire water storage tanks or other structures housing or supporting water, or other fire-suppression material or equipment) required for operation of Occupancy Category IV structures during an emergency • Aviation control towers, air traffic control centers, and emergency aircraft hangars • Water storage facilities and pump structures required to maintain water pressure for fire suppression • Buildings and other structures having critical national defense functions Buildings and other structures (including, but not limited to, facilities that manufacture, process, handle, store, use, or dispose of such substances as hazardous fuels, hazardous chemicals, or hazardous waste) containing highly toxic substances where the quantity of the material exceeds a threshold quantity established by the authority having jurisdiction. Buildings and other structures containing highly toxic substances shall be eligible for classification as Occupancy Category II structures if it can be demonstrated to the satisfaction of the authority having jurisdiction by a hazard assessment as described in Section 1.5.2 that a release of the highly toxic substances does not pose a threat to the public. This reduced classification shall not be permitted if the buildings or other structures also function as essential facilities.	IV

Cogeneration power plants that do not supply power on the national grid shall be designated Occupancy Category II.

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