



# Wind/Seismic Restraint & Vibration Isolation of Mechanical Equipment

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# Lee Chiddention

HVAC Market Manager,  
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- Degree in electrical engineering from University of Kent, England
- Company specializes in designing and manufacturing products to control noise and vibration
- Responsible for technical marketing materials, product development & testing for all HVAC products



# ***Wind/Seismic Restraint & Vibration Isolation of Mechanical Equipment***

## **Purpose and Learning Objectives**

The purpose of this presentation is to provide a basic understanding of Wind/Seismic restraint and vibration isolation of mechanical equipment.

At the end of this presentation you will be able to:

1. Explain the changes in wind codes and its effects on the industry.
2. Describe the basic requirements for Wind/Seismic restraint.
3. Identify basic vibration isolation selection for mechanical equipment.
4. Determine basic Seismic exemptions per code.



# Need for Wind Restraint



# One Approach to Wind Restraint



# Exposure Category & Wind Speed

Exposure Category and Basic Wind Speed are defined in the Basis of Design usually found on the first sheet of the structural drawings.

# Exposure Category & Wind Speed

WIND LOAD DESIGN DATA (ASCE 7-10):

MAIN WIND FORCE RESISTING SYSTEM

BASIC WIND SPEED, V

120 MPH

EXPOSURE

C

OCCUPANCY/RISK CATEGORY

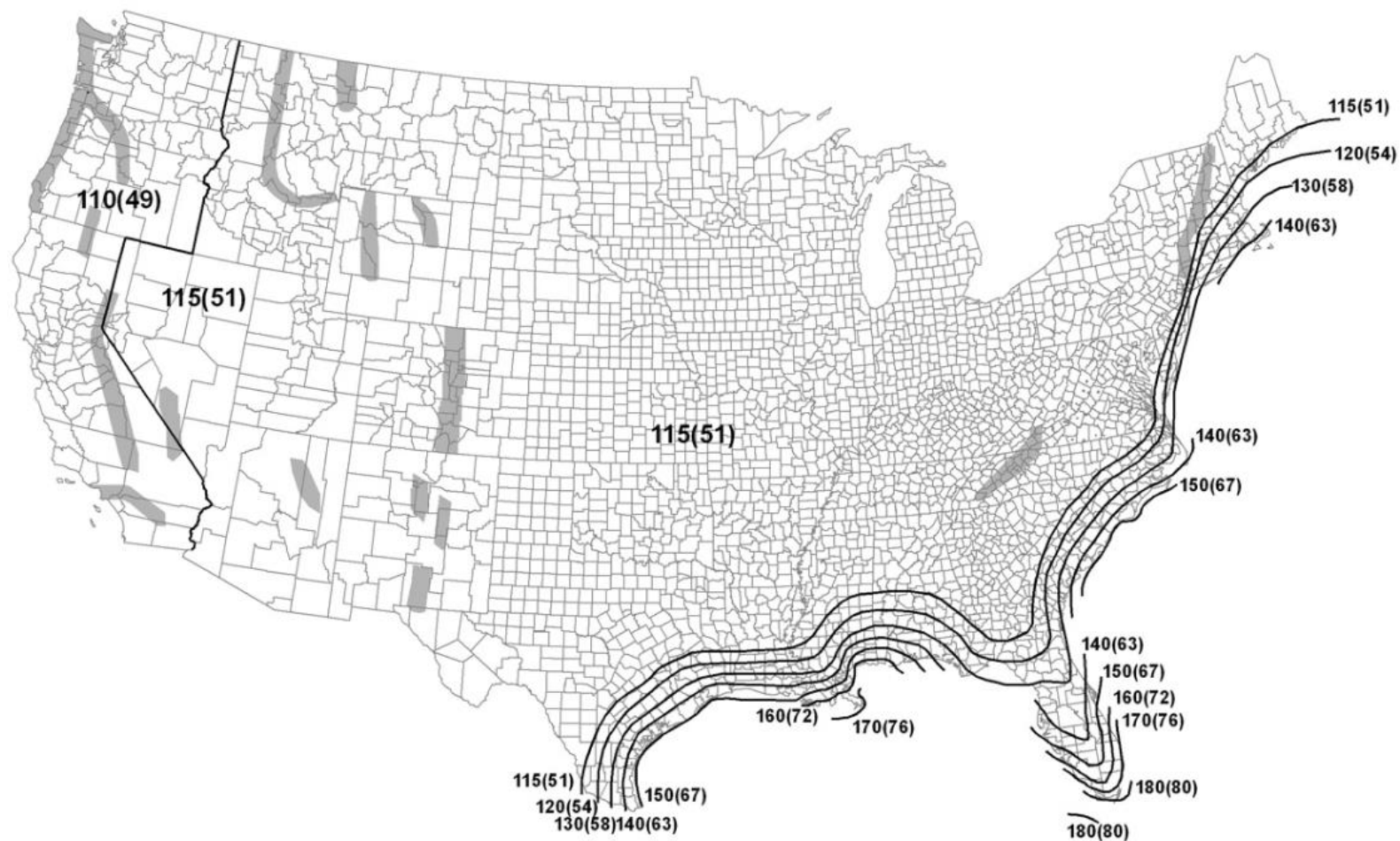
III

INTERNAL PRESSURE COEFFICIENT

$\pm 0.18$



# Wind Speed Requirements





# Occupancy/Risk Categories I & II

- Buildings and structures whose failure would pose a low hazard to human life.
- These include:
  - Agricultural buildings
  - Certain temporary buildings & structures
  - Minor storage buildings & structures

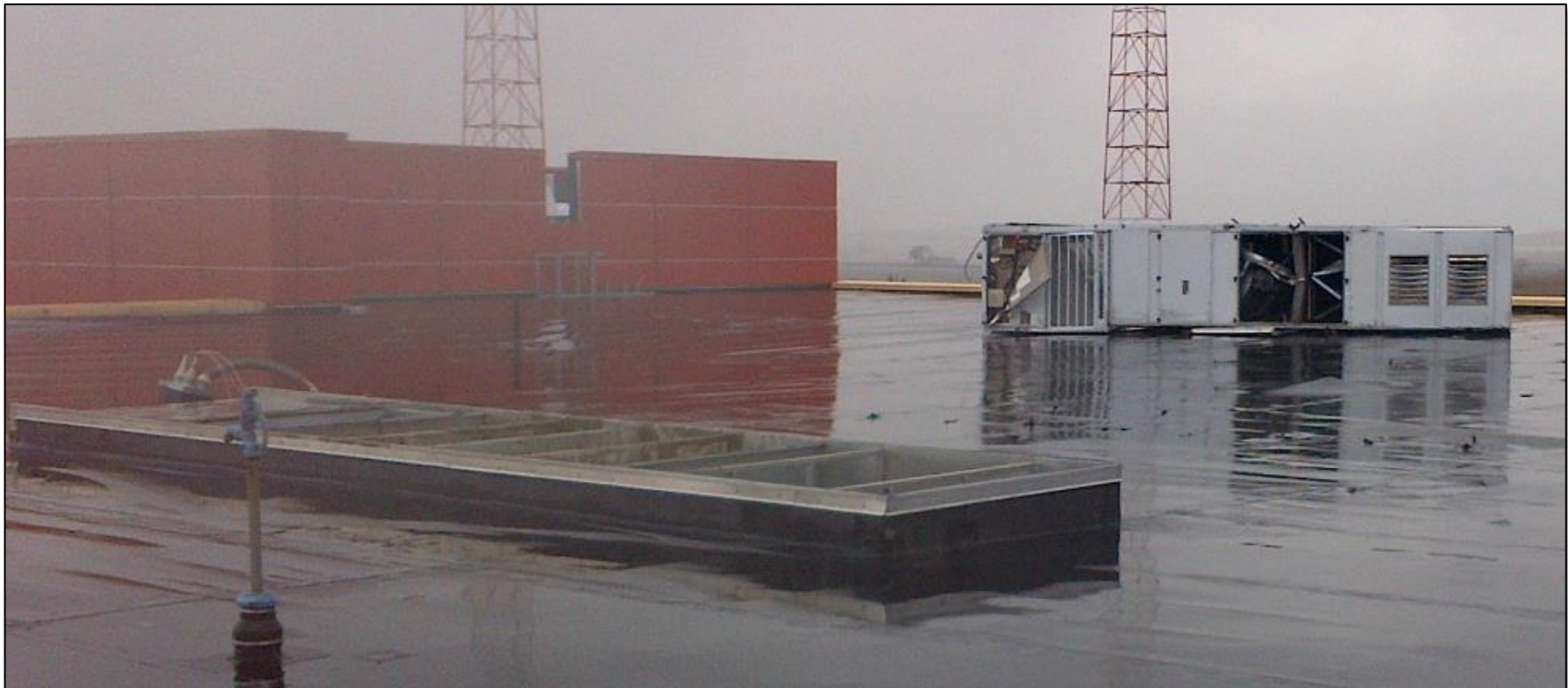
## Occupancy/Risk Categories III

- Buildings and structures in which failure would pose a substantial hazard to human life
- Buildings where more than 300 people may gather in one place
- Daycare facilities with a capacity greater than 50
- Elementary and secondary school facilities with a capacity greater than 250 & colleges and adult education facilities with a capacity greater than 500
- Healthcare facilities with 50 or more resident patients that do not have surgery or emergency care facilities
- Jails, prisons & detention facilities

## Occupancy/Risk Category IV

- Buildings and structures designated as essential. Some of which are:
  - Hospitals and healthcare facilities with surgical & emergency treatment facilities
  - Fire, rescue, ambulance, police stations & emergency vehicle garages
  - Designated emergency shelters
  - Aviation control towers, air traffic control center
  - Facilities designated for emergency response & preparedness

# Wind Requirements within the IBC code



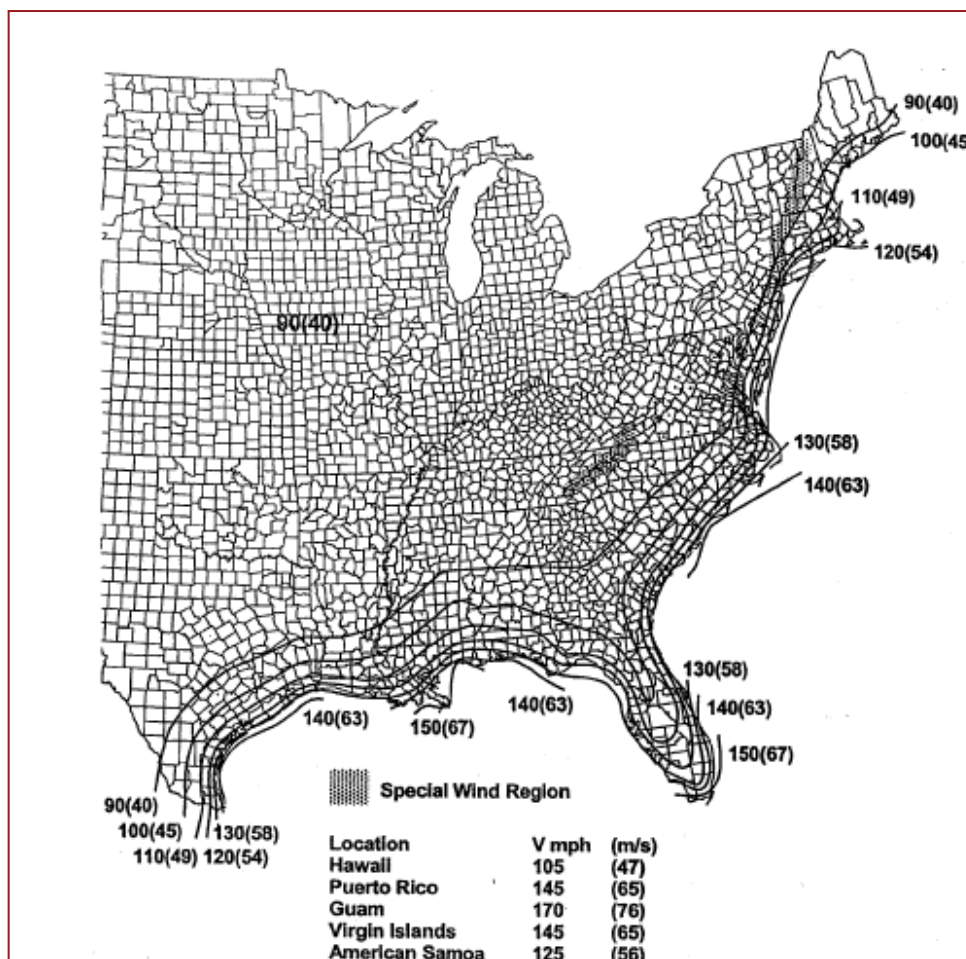
What is changing regarding the way we design wind restraint?

# Wind Load Requirements within the IBC 2003, IBC 2006 & ASCE 7-05/10

- Horizontal force nearly doubled from 03 to 06 based on the fact that equipment was now considered a “Main Wind Force Resisting System”.
- It is recommended in ASCE 7-05 that designers should consider uplift in the calculations.
- IBC Section 1609.1 – “Decreases in wind loads shall not be made for the effect of shielding by other structures.”
- ASCE 7-10 wind loads on rooftop equipment limited to buildings greater than 60' tall.



# Wind Speed Requirements



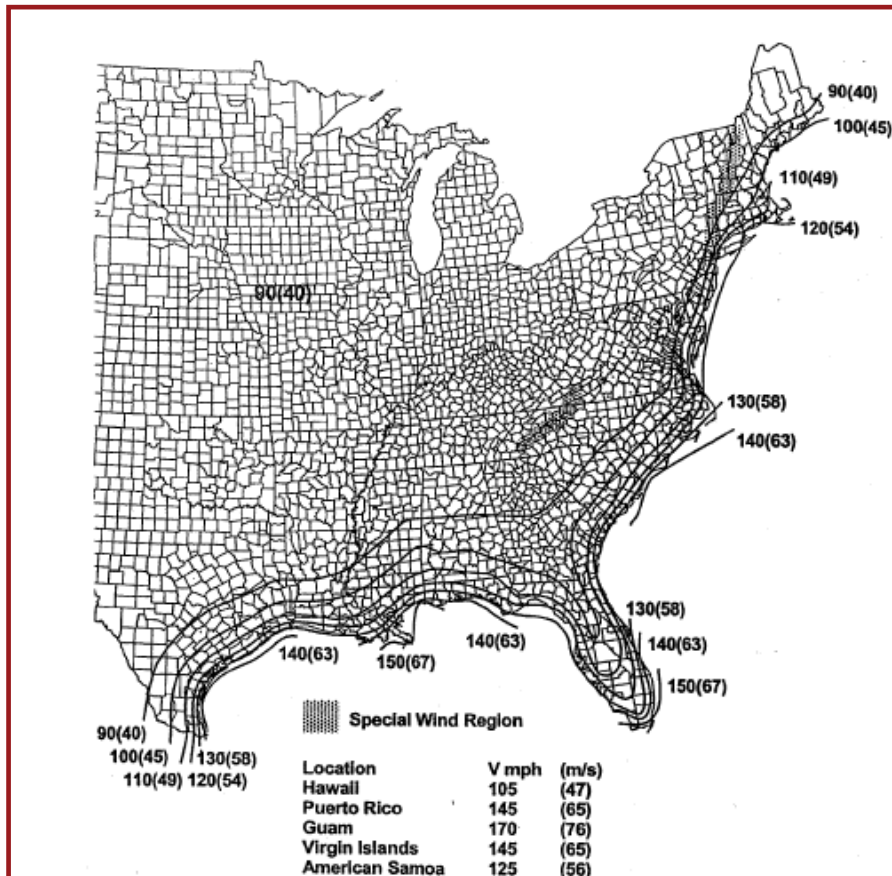
IBC 2003/06/09

## The Future – IBC 2012 & UP

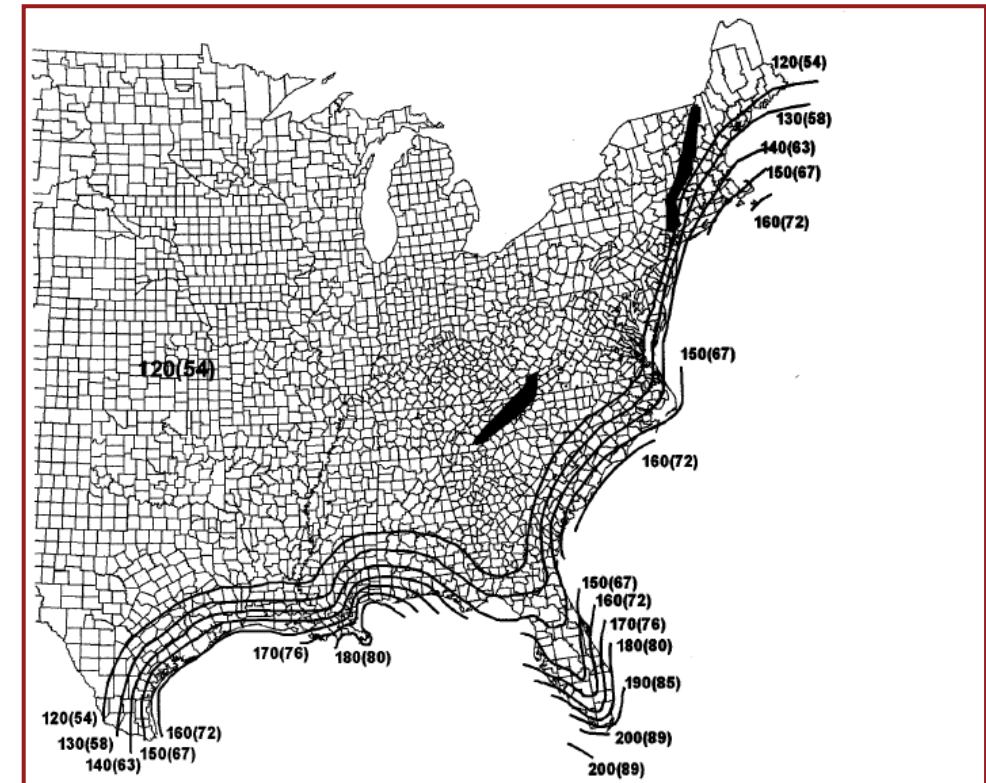
- Wind speeds have increased
- Uplift is mandatory in the wind load calculations
- Occupancy category is introduced, and the wind speeds will vary by category
- ASCE 7-16, Provisions must apply to rooftop equipment on buildings of all heights

# Wind Speed Requirements

IBC 2006/09

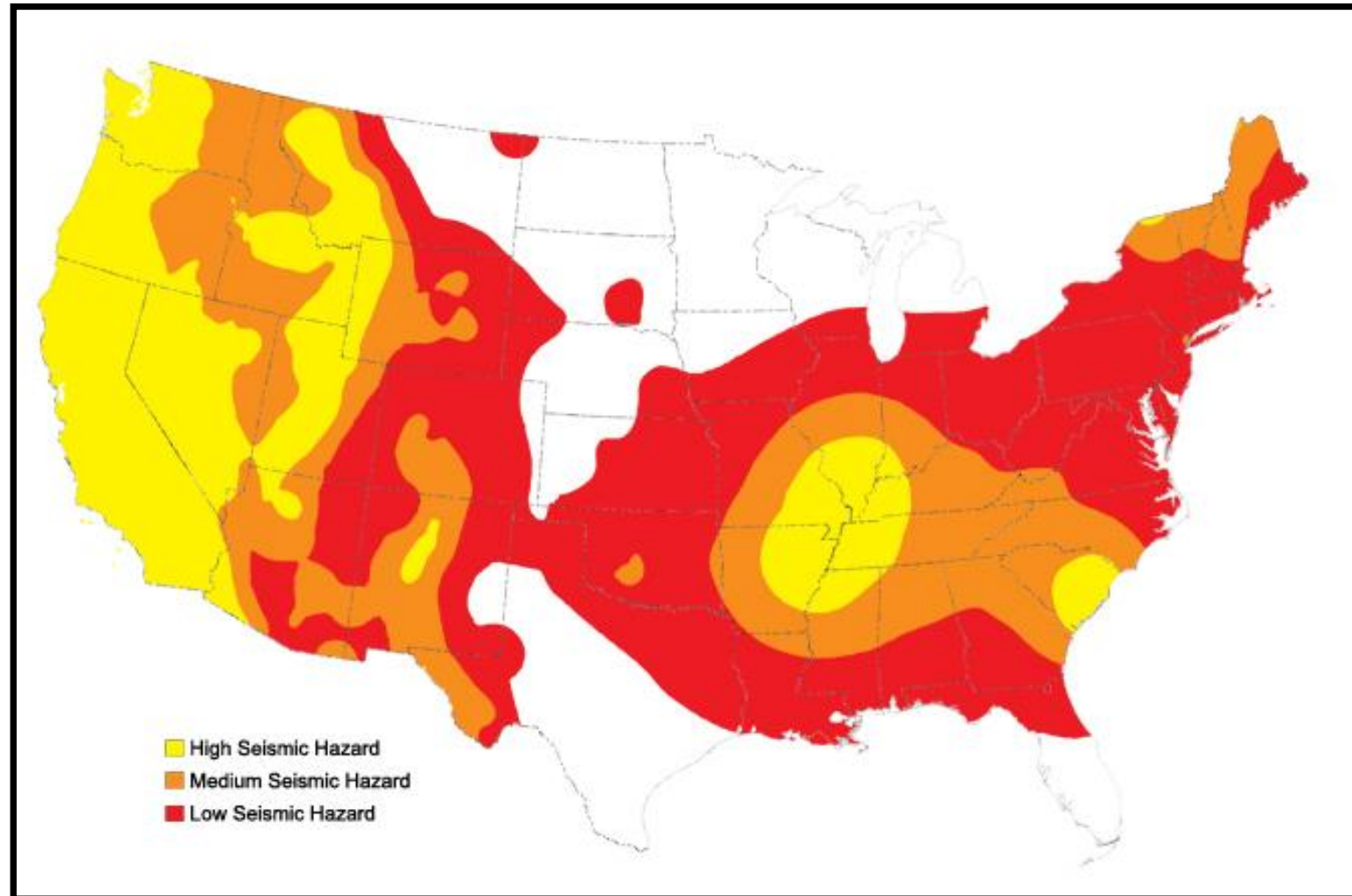


IBC 2012



# Is Seismic Restraint Required On My Project?

# Areas of Concern





## Seismic Must Be Addressed If:

- Project is a new build under 2000, 2003, 2006, 2009 and 2012 IBC
- Project owner requires it
- Project is a renovation which will impact the loads applied to the existing structure

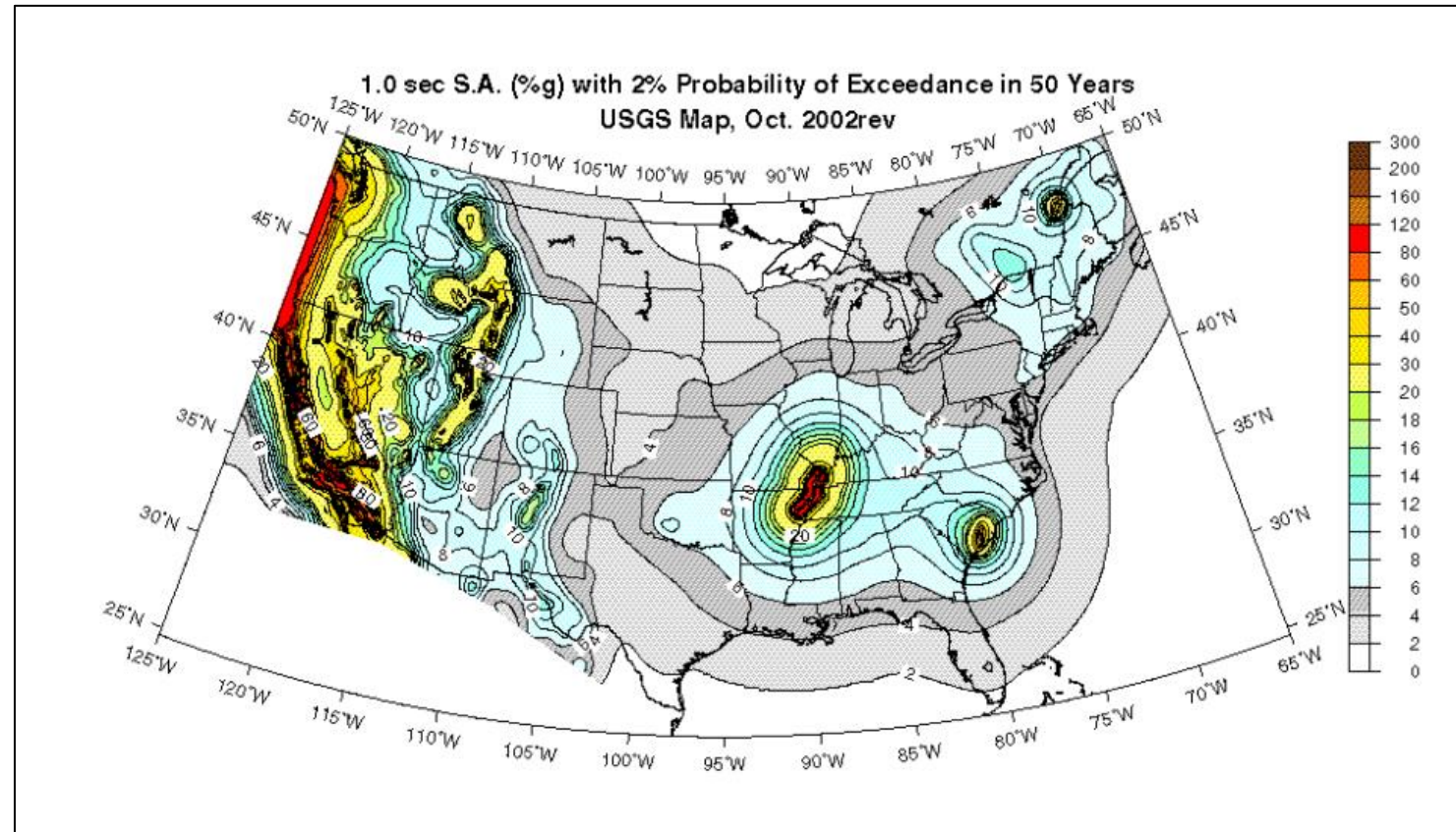
# Seismic Design/Risk Category is determined by the Structural Engineer

## Seismic Design Category Factors:

1. Building Occupancy Category
2. Mapped Ground Motion – Long and Short Period Accelerations.
3. Type of Soil Underlying the project

# Short Period Response

## Mapped Ground Motion



# Soil Types

- ❖ A – Hard Rock
- ❖ B – Rock
- ❖ C – Dense Soil/Soft Rock
- ❖ D – Stiff Soil (Default condition if no information is given)
- ❖ E – Soft Soil
- ❖ F – Very Poor (Back Fill, Swamp)

# Seismic Design/Risk Category

- The Seismic Design/Risk Category is assigned to each building by the structural engineer.
- It will have a letter designation that varies from **A** to **F**. With **A** signifying the least stringent requirements and **F** the most stringent.
- This quantity indicates to the design professionals the level of seismic restraint and detailing required to match the durability of the building structure itself.



**BUILDING CODE:**

2012 EDITION OF THE INTERNATIONAL BUILDING CODE, WITH CITY OF TUCSON AMENDMENTS.

**DESIGN LOADS:**

ROOF DEAD LOAD = 7.5 PSF (VERIFY WITH PEMB).

ROOF LIVE LOAD = 20 PSF

FLOOR LIVE LOAD = 80 PSF

FLOOR DEAD LOAD = 145 PSF

**WIND:**

120 MPH BASIC WIND SPEED (ULTIMATE), EXPOSURE C.

$I_w = 1.0$ .

INTERNAL PRESSURE COEFFICIENT ( $G C_{pi}$ ) = .18 EXPOSURE CATEGORY = C.

**SEISMIC:**

OCCUPANCY CATEGORY = II.

$I_e = 1.0$ .

DESIGN CATEGORY = B.

SITE CLASS D.

$S_s = .267$ ,  $S_1 = .076$ ,

$S_{ds} = .283$ ,  $S_{d1} = .122$ .

$F_a = 1.59$ ,  $F_v = 2.40$ .

$R = 3$ . BASIC SEISMIC FORCE – RESISTING SYSTEM, STEEL SYSTEM NOT SPECIFICALLY DESIGNED FOR SEISMIC.



# Component Importance Factor $I_P$

- Is assigned to the component by the design professional of record responsible for the system.
- $I_P$  will be either 1.0 or 1.5.
- The Component Importance Factor for each piece of equipment & system should be listed in the **equipment schedule**.

- $I_P=1.5$  If the component or system is required to function for Life-Safety purposes after an earthquake, this includes fire protection sprinkler systems. Any piping, ductwork, power, and/or control cables that are attached to such a system will also have a Component Importance Factor,  $I_P=1.5$ .
- **Note:** The Component Importance Factor ( $I_P$ ) is not necessarily the same as that for the building ( $I$ ).

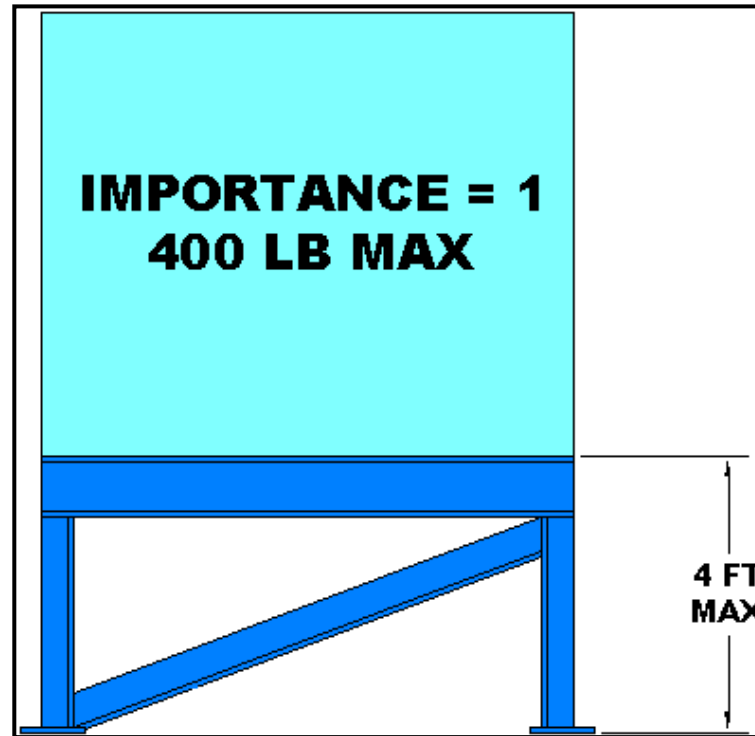
# Global Exemptions

- Seismic Design Categories **A** & **B** – All mechanical & electrical components & systems.
- Seismic Design Category **C** – Mechanical & electrical components & systems whose Component Importance Factor  $I_p=1.0$ .

# Equipment Exemptions

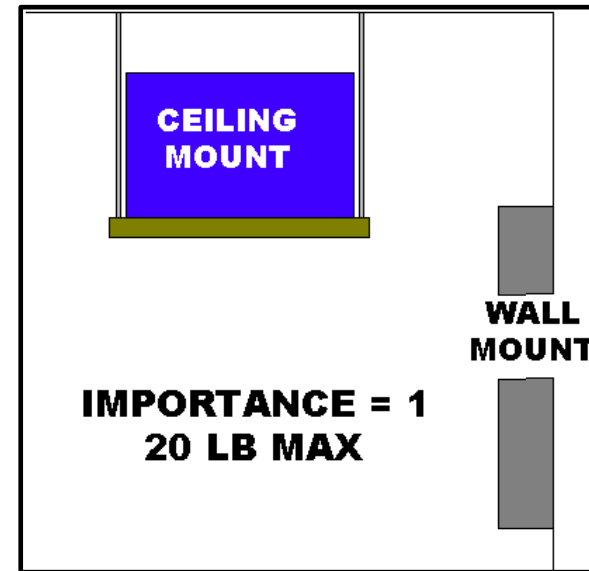


# Equipment Exemption



For Seismic design category D, E or F. Floor mounted equipment under 400 lbs.

# Size Exemptions



1. Seismic Design Categories D , E, or F: Mechanical & electrical components weighing 20 lbs. or less Mounted to walls or ceiling with  $I_p = 1.0$  and flex connections for all services.

# Duct Mounted Exemption



Equipment hard mounted on at least one end to duct and weighing 75 lbs. or less can be considered part of the duct and restrained or “exempted” as part of the duct.

# Christchurch, NZ – 2011



6.3 Magnitude



# Damage to Nonstructural Component During NZ Earthquake

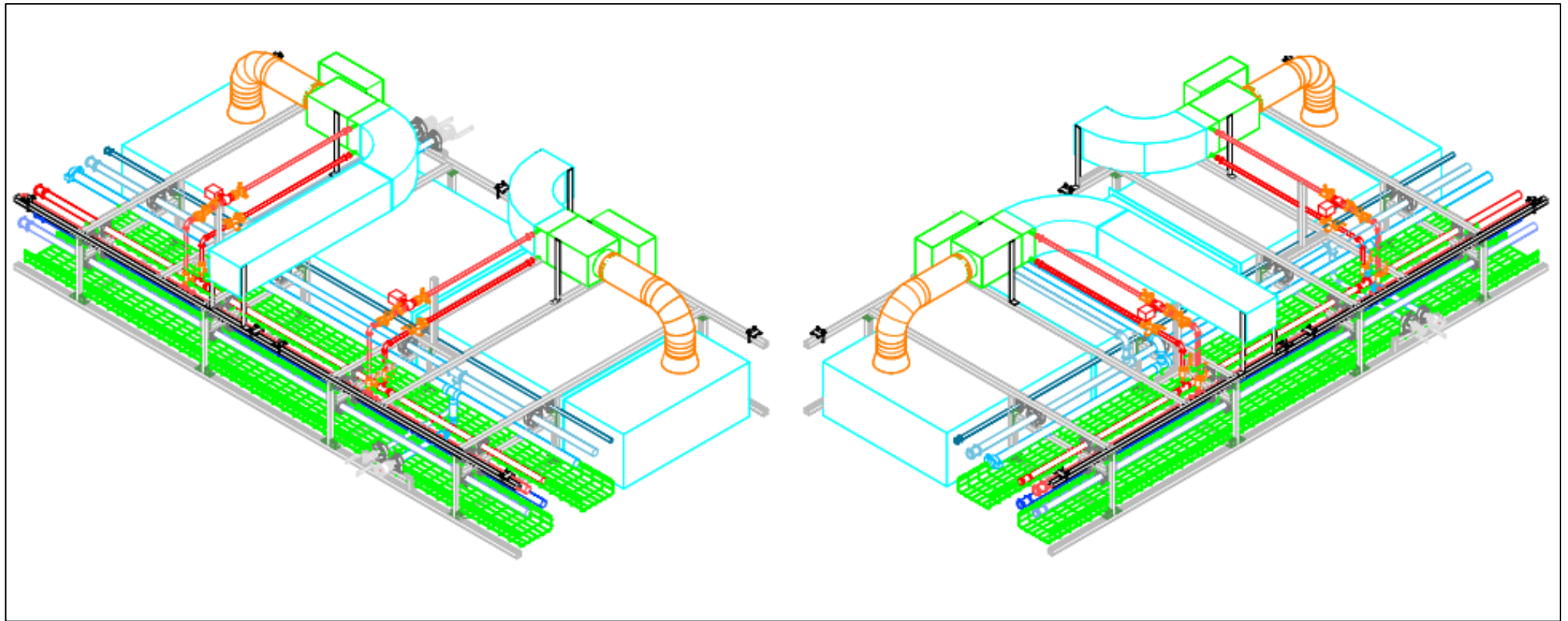




# Owner gets what Owner wants



# Owning the Seismic Bracing



# Vibration Isolation

## *What is Vibration?*

Vibration is unwanted motion that is transmitted to the building structure and occupants, generally from rotating HVAC equipment.

# How is Vibration Mitigated?

By resiliently decoupling the equipment from the building structure by the use of vibration isolators.



# Specifying Isolation

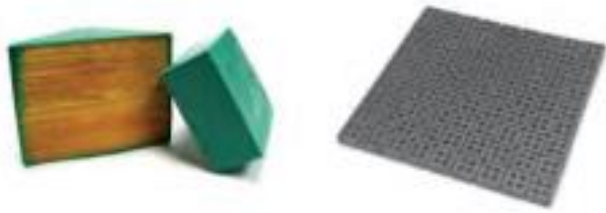
- ❖ Isolation performance is a function of the system's natural frequency which depends on the driving frequency, the mass being isolated, and the stiffness of the isolators.
- ❖ Almost all vibration isolation specifications define the required isolation by the static deflection of the isolators, the deflection under the dead load alone.



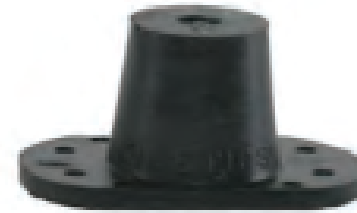
# Vibration Isolation



# Selection



**ASHRAE Type 1**



**ASHRAE Type 2**



**ASHRAE Type 3**



**ASHRAE Type 4**

# Selection

## Thrust Restraint



**ASHRAE Type 5**

# Example PG.7 of Selection Guide

Equipment Type:

## Centrifugal Fans\*

Equipment Location												
Equipment Category	Floor Span											
	Slab on Grade			Up to 20 ft (6 m)			20 to 30 ft (6 - 9 m)			30 to 40 ft (9-12 m)		
	Base Type	ASHRAE Type	Isolator Defl.	Base Type	ASHRAE Type	Isolator Defl.	Base Type	ASHRAE Type	Isolator Defl.	Base Type	ASHRAE Type	Isolator Defl.
Up to 22 in. diameter	B	2	0.25" (6)	B	3	0.75" (19)	B	3	0.75" (19)	B	3	1.50" (38)
24 in. diameter and up												
≤40 HP												
RPM Up to 300	B	3	2.50" (64)	B	3	3.50" (89)	B	3	3.50" (89)	B	3	3.50" (89)
RPM 301 to 500	B	3	1.50" (38)	B	3	1.50" (38)	B	3	2.50" (64)	B	3	2.50" (64)
RPM 501 and up	B	3	0.75" (19)	B	3	0.75" (19)	B	3	0.75" (19)	B	3	1.50" (38)
≥50 HP												
RPM Up to 300	C	3	2.50" (64)	C	3	3.50" (89)	C	3	3.50" (89)	C	3	3.50" (89)
RPM 301 to 500	C	3	1.50" (38)	C	3	1.50" (38)	C	3	2.50" (64)	C	3	2.50" (64)
RPM 501 and up	C	3	1.00" (25)	C	3	1.50" (38)	C	3	1.50" (38)	C	3	2.50" (64)

\*Data from 2015 ASHRAE Handbook. See back cover for additional notes on **Fans**.

# Example PG.7 of Selection Guide

Equipment Location												
Equipment Category	Floor Span											
	Slab on Grade			Up to 20 ft (6 m)			20 to 30 ft (6 - 9 m)			30 to 40 ft (9-12 m)		
	Base Type	ASHRAE Type	Isolator Defl.	Base Type	ASHRAE Type	Isolator Defl.	Base Type	ASHRAE Type	Isolator Defl.	Base Type	ASHRAE Type	Isolator Defl.
Up to 22 in. diameter	B	2	0.25" (6)	B	3	0.75" (19)	B	3	0.75" (19)	B	3	1.50" (38)

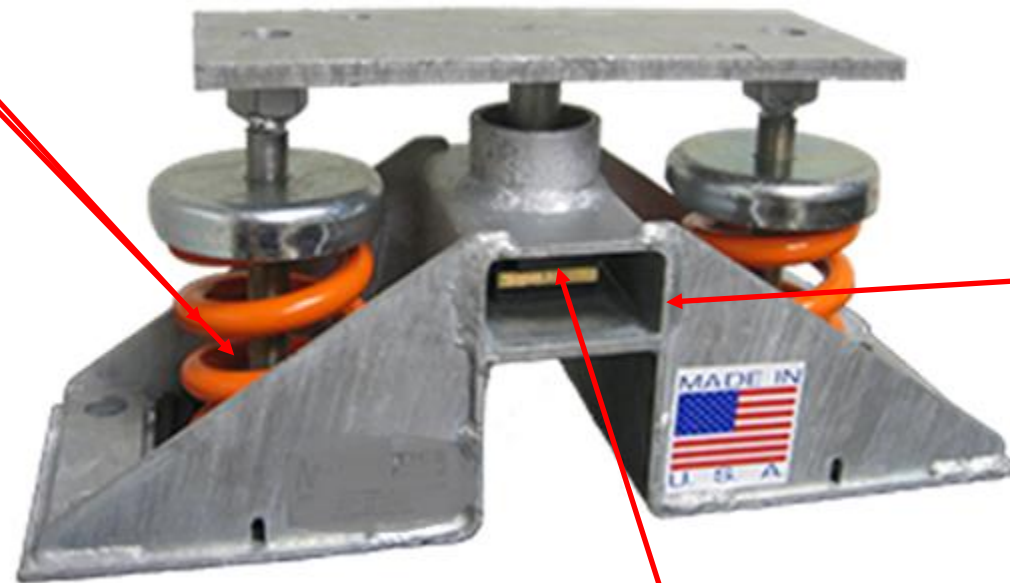


# Restraint of Isolated Equipment

How to isolate the equipment, yet allow it to be restrained for Wind/Seismic forces?

# Single Restraint Plate Type Seismic Isolator

Free  
Standing  
Isolator

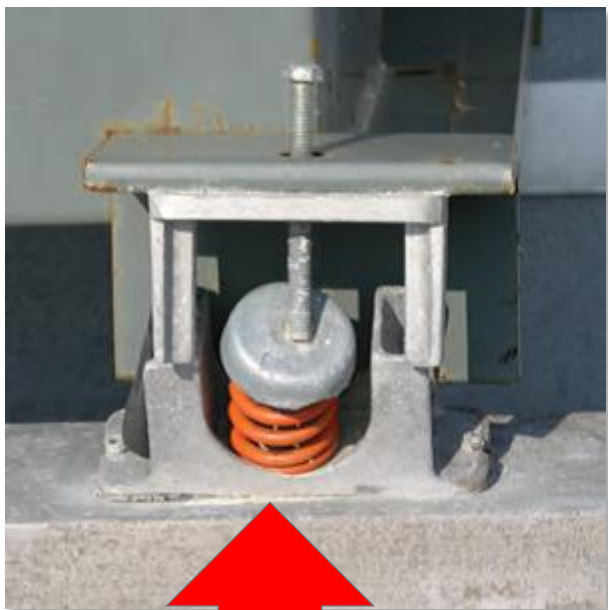


Restraint  
Housing

Three  
Axis  
Snubber

# Choose the Proper Isolators

Off-the-shelf solution not sufficient for the application



# Choose the Proper Isolators



Restrained spring  
Wind/Seismic



# Roof Curb for HVAC Units

Isolators  
with Three  
Axis  
Restrains



HVAC Unit Must be  
Securely Attached to the  
Isolated Rail using  
an Engineered design  
to Resist the Wind Loads

Securely Attach  
to Structure



# Clear Direction

## Equipment Schedule

VIBRATION CONTROL AND SEISMIC/WIND RESTRAINT DEVICES - PART 1													
EQUIPMENT TAG		BSF-1	CT-3	CWP-3A & 3B	DBF-1	DEF-1 THRU 9	DOAS-1 & 2	EF-1	EF-2 & 3	EF-3 & 5	EF-6	FCU-1 THRU 9	RTU-1 & 2
EQUIPMENT / COMPONENT DESCRIPTION		BASIN SWEEPER FILTER SKID WITH INTEGRAL PUMP(S)	COOLING TOWER	CONDENSER WATER PUMPS (HEAT INJECTION SYSTEM)	DRYER BOOSTER FANS	DRYER EXHAUST FANS	DEDICATED OUTDOOR AIR SYSTEM AIR HANDLING UNITS	SQUARE INLINE CENTRIFUGAL FANS	GENERAL EXHAUST FANS	GENERAL EXHAUST FANS	SPUN ALUMINUM EXHAUST FAN	FAN COIL UNITS (VRF)	PACKAGED DX ROOFTOP UNITS
EQUIPMENT / COMPONENT IMPORTANCE FACTOR		1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
DELEGATED DESIGN REQUIREMENTS	VIBRATION CONTROL	●	●	●	●	●	●	●	●	●	●	●	●
	SEISMIC												
	WIND		●				●						●
EQUIPMENT MOUNTING METHOD		FLOOR	ROOF, ELEVATED STRUCTURAL STEEL PLATFORM	FLOOR	OVERHEAD SUSPENDED FROM UNDERSIDE FRAMING OF FLOOR/ROOF ABOVE W/ THREADED ROD	ROOF, CURB	ROOF, ELEVATED STRUCTURAL STEEL PLATFORM	OVERHEAD SUSPENDED FROM UNDERSIDE FRAMING OF FLOOR/ROOF ABOVE W/ THREADED ROD	OVERHEAD SUSPENDED FROM UNDERSIDE FRAMING OF FLOOR/ROOF ABOVE W/ THREADED ROD	OVERHEAD SUSPENDED FROM UNDERSIDE FRAMING OF FLOOR/ROOF ABOVE W/ THREADED ROD	ROOF, CURB	OVERHEAD SUSPENDED FROM UNDERSIDE FRAMING OF FLOOR/ROOF ABOVE W/ THREADED ROD	ROOF, CURB
	FLOOR TYPE	CONCRETE SLAB	N/A	CONCRETE SLAB	CONCRETE SLAB	N/A	N/A	CONCRETE SLAB	CONCRETE SLAB	N/A	N/A	CONCRETE SLAB	N/A
	SLAB THICKNESS	4-INCH	N/A	4-INCH	4-INCH	N/A	N/A	4-INCH	4-INCH	N/A	N/A	4-INCH	N/A
ADDITIONAL INFORMATION FOR FLOOR FROM WHICH EQUIPMENT IS MOUNTED, ELEVATED, OR SUSPENDED		BELOW SLAB FRAMING	STEEL W-SHAPE JOISTS SPACED ≤ 6'-4" O.C.	N/A	STEEL W-SHAPE JOISTS SPACED ≤ 6'-4" O.C.	N/A	N/A	STEEL W-SHAPE JOISTS SPACED ≤ 6'-4" O.C.	STEEL W-SHAPE JOISTS SPACED ≤ 6'-4" O.C.	N/A	N/A	STEEL W-SHAPE JOISTS SPACED ≤ 6'-4" O.C.	N/A
		ADDITIONAL HOUSEKEEPING PAD	YES	N/A	YES	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		HOUSEKEEPING PAD THICKNESS	4-INCHES	N/A	4-INCHES	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
ADDITIONAL INFORMATION FOR ROOF FROM WHICH EQUIPMENT IS MOUNTED, ELEVATED, OR SUSPENDED		ROOF TYPE	N/A	CONCRETE MASS ROOF WITH BUILT-UP INSULATION	N/A	N/A	CONCRETE MASS ROOF WITH BUILT-UP INSULATION	CONCRETE MASS ROOF WITH BUILT-UP INSULATION	N/A	N/A	CONCRETE MASS ROOF WITH BUILT-UP INSULATION	CONCRETE MASS ROOF WITH BUILT-UP INSULATION	CONCRETE MASS ROOF WITH BUILT-UP INSULATION
		ROOF FRAMING	N/A	STEEL W-SHAPE JOISTS SPACED ≤ 6'-4" O.C.	N/A	N/A	STEEL W-SHAPE JOISTS SPACED ≤ 6'-4" O.C.	STEEL W-SHAPE JOISTS SPACED ≤ 6'-4" O.C.	N/A	N/A	STEEL W-SHAPE JOISTS SPACED ≤ 6'-4" O.C.	STEEL W-SHAPE JOISTS SPACED ≤ 6'-4" O.C.	STEEL W-SHAPE JOISTS SPACED ≤ 6'-4" O.C.
BASE TYPE		TYPE A DIRECT ISOLATION	TYPE B2 STRUCTURAL RAILS	TYPE C CONCRETE BASE	N/A	N/A	TYPE B2 STRUCTURAL RAILS	N/A	N/A	N/A	N/A	N/A	TYPE D CURB ISOLATION
ISOLATOR TYPE		TYPE 3 OPEN SPRING ISOLATORS	TYPE 4 RESTRAINED SPRING ISOLATORS	TYPE 3 OPEN SPRING ISOLATORS	TYPE 3H SPRING HANGERS	N/A	TYPE 4 RESTRAINED SPRING ISOLATORS	TYPE 3H SPRING HANGERS	TYPE 2H RUBBER HANGERS	TYPE 2H RUBBER HANGERS	N/A	TYPE 3H SPRING HANGERS	TYPE 4 RESTRAINED SPRING ISOLATORS
MINIMUM DEFLECTION (IN.)		0.75	2.50	0.75	0.50	N/A	1.50	0.75	0.50	0.50	N/A	0.50	1.50
EQUIPMENT-TO-DUCTWORK CONNECTION		N/A	N/A	N/A	FLEXIBLE CONNECTOR	FLEXIBLE CONNECTOR	FLEXIBLE CONNECTOR WITH THRUST RESTRAINTS	FLEXIBLE CONNECTOR WITH THRUST RESTRAINTS	FLEXIBLE CONNECTOR	FLEXIBLE CONNECTOR	FLEXIBLE CONNECTOR	FLEXIBLE CONNECTOR	FLEXIBLE CONNECTOR
EQUIPMENT-TO-PIPING CONNECTION		SPHERICAL RUBBER CONNECTOR	DIRECT (HARD) CONNECTION	SPHERICAL RUBBER CONNECTORS	N/A	N/A	BRAIDED FLEXIBLE CONNECTOR	N/A	N/A	N/A	N/A	DIRECT (HARD) CONNECTION	BRAIDED FLEXIBLE CONNECTOR
APPLICABLE SPECIFICATIONS		230548.13 232116	230548.13	230548.13 232116	230548.13	230548.13 233300	230548.13 232116 233300	230548.13 233300	230548.13 233300	230548.13 233300	230548.13 233300	230548.13 233300	230548.13 232116 233300
REMARKS		1 THRU 4	1 THRU 4, 6	1 THRU 4	1 THRU 4, 8	1 THRU 4	1 THRU 5	1 THRU 4	1 THRU 4	1 THRU 4	1 THRU 4, 7	1 THRU 4	1 THRU 5

### REMARKS:

1. BASE TYPE, ISOLATOR TYPE, AND MINIMUM DEFLECTION AS SCHEDULED ARE PRELIMINARY AND BASED ON THE GENERAL REQUIREMENTS OUTLINED IN ASHRAE APPLICATIONS HANDBOOK (2015), CHAPTER 48, TABLE 47.
2. SELECTION OF VIBRATION CONTROL, SEISMIC, AND WIND RESTRAINT DEVICES IS A DELEGATED DESIGN TO THE CONTRACTOR.
3. VERIFY VIBRATION CONTROL DEVICE SELECTIONS WITH FINAL EQUIPMENT SHOP DRAWING DIMENSIONS, WEIGHTS, OPERATING DATA, AND INSTALLATION INSTRUCTIONS.
4. REFER TO "SEISMIC AND WIND DESIGN CRITERIA" SCHEDULE AS REQUIRED.
5. LOCKDOWN VIBRATION CONTROL DEVICES INTERNAL TO UNIT.
6. VIBRATION CONTROL & WIND RESTRAINT DEVICES FURNISHED WITH COOLING TOWER. INSTALL PER TOWER MANUFACTURER'S INSTALLATION INSTRUCTIONS.
7. SECURE TO CURB OR SUPPORT STAND AND PROVIDE TIE-DOWNS AS REQUIRED TO RESIST UPLIFT AT DESIGN WIND SPEEDS.
8. FLEXIBLE CONNECTORS FURNISHED AS ACCESSORIES WITH FAN. REFER TO FAN SCHEDULE.

# Clear Direction

## Equipment Schedule

EQUIPMENT TAG		BSF-1	CT-3
EQUIPMENT / COMPONENT DESCRIPTION		BASIN SWEEPER FILTER SKID WITH INTEGRAL PUMP(S)	COOLING TOWER
EQUIPMENT / COMPONENT IMPORTANCE FACTOR		1.0	1.0
DELEGATED DESIGN REQUIREMENTS	VIBRATION CONTROL	●	●
	SEISMIC		
	WIND		●
EQUIPMENT MOUNTING METHOD		FLOOR	ROOF, ELEVATED STRUCTURAL STEEL PLATFORM
ADDITIONAL INFORMATION FOR FLOOR FROM WHICH EQUIPMENT IS	FLOOR TYPE	CONCRETE SLAB	N/A
	SLAB THICKNESS	4-INCH	N/A
	BEAM OR JOIST FRAMING	STEEL W-SHAPE JOISTS	N/A

# Clear Direction

## Equipment Schedule

VIBRATION CONTROL AND SEISMIC			
EQUIPMENT TAG		SEF-1	SEF-2
EQUIPMENT / COMPONENT DESCRIPTION		TUBE AXIAL SMOKE EXHAUST FAN	SPUN ALUMINUM SMOKE EXHAUST FAN
EQUIPMENT / COMPONENT IMPORTANCE FACTOR		1.5	1.5
DELEGATED DESIGN REQUIREMENTS	VIBRATION CONTROL	●	●
	SEISMIC	●	●
	WIND		
EQUIPMENT MOUNTING METHOD		OVERHEAD SUSPENDED FROM UNDERSIDE FRAMING OF FLOOR/ROOF ABOVE W/ THREADED ROD	ROOF, CURB
ADDITIONAL INFORMATION FOR FLOOR FROM WHICH EQUIPMENT IS MOUNTED, ELEVATED, OR SUSPENDED	FLOOR TYPE	N/A	N/A
	SLAB THICKNESS	N/A	N/A
	BELOW SLAB FRAMING	N/A	N/A
	ADDITIONAL HOUSEKEEPING PAD	N/A	N/A
	HOUSEKEEPING PAD THICKNESS	N/A	N/A

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# Questions?



# NEXT PROGRAM

Join us for our next **AMCA *insite*<sup>™</sup>** Webinar:

- Wednesday, November 18
- 1:00-2:00pm CT
- ***TOPIC: High Wind Testing and Certification of Fans***
- Presenter: Daniel Hernandez-Reyes, Product Manager, AMCA Member Company

**>> For additional webinar dates go to: [www.amca.org/webinar](http://www.amca.org/webinar)**