WHAT CAUSES EARTHQUAKES?
Figure 4  World map showing relation between the major tectonic plates and recent earthquakes and volcanoes. Earthquake epicenters are denoted by the small dots, and the volcanoes by large dots.
Figure 3  Diagram showing the three main types of fault motion.
Figure 6  Diagram illustrating the forms of ground motion near the ground surface in four types of earthquake waves. [From Bruce A. Bolt, *Nuclear Explosions and Earthquakes: The Parted Veil* (San Francisco: W. H. Freeman and Company. Copyright © 1976).]
SEISMIC WAVE PROPAGATION

FIGURE 1-3
MAGNITUDE OF FORCE
## APPROXIMATE RELATIONSHIP BETWEEN MAGNITUDE & INTENSITY

<table>
<thead>
<tr>
<th>Magnitude</th>
<th>Maximum Energy-Released (Ergs)</th>
<th>G†</th>
<th>Distance Expected Felt (Miles)</th>
<th>Intensity (Maximum Modified Mercalli)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.0 - 3.9</td>
<td>$4.0 \times 10^{17}$</td>
<td>0.04</td>
<td>15</td>
<td>II - III</td>
</tr>
<tr>
<td>4.0 - 4.9</td>
<td>$8.8 \times 10^{18}$</td>
<td>0.04</td>
<td>30</td>
<td>IV - V</td>
</tr>
<tr>
<td>5.0 - 5.9</td>
<td>$4.0 \times 10^{20}$</td>
<td>0.15</td>
<td>70</td>
<td>VI - VII</td>
</tr>
<tr>
<td>6.0 - 6.9</td>
<td>$8.8 \times 10^{21}$</td>
<td>0.30</td>
<td>125</td>
<td>VII - VIII</td>
</tr>
<tr>
<td>7.0 - 7.9</td>
<td>$4.0 \times 10^{23}$</td>
<td>0.45</td>
<td>250</td>
<td>IX - X</td>
</tr>
<tr>
<td>8.0 - 8.9</td>
<td>$8.8 \times 10^{24}$</td>
<td>0.5</td>
<td>450</td>
<td>XI - XII</td>
</tr>
</tbody>
</table>

**BIKINI 1946 = 10^{19} ERGS**

ERG = DYNE CM = .0328 #Ft/Sec\(^2\)

$10G E = 11.8 + 1.5$ (Richter Mag)

E EXPRESSED IN ERGS

†1 G = 32 Ft/Sec\(^2\)

* Earthquakes that will do little damage to the structure, but may do considerable damage to the mechanical and electrical systems.
EARTHQUAKE INTENSITY

The Modified Mercalli Intensity Scale is used to describe the relative strength of ground shaking experienced at a particular site during an earthquake. Unlike logarithmic magnitude scales, which are related to the energy release at the earthquake source, the 12-increment intensity scale refers to the observed effects of ground shaking at individual localities. Seismologists assign intensity to specific sites on the basis of the effects of the shaking on people, damage to buildings, and changes in the landscape. The factors which determine the intensity level experienced at a given site include distance from the causative fault, direction of rupture propagation, and soil conditions beneath the site. The intensity scale outlined below is a very abbreviated version of the Modified Mercalli Intensity Scale of 1931 by Harry Wood and Frank Neumann.

Intensity Scale

I. Not felt by a very few under especially favorable circumstances.
II. Felt only by a few persons at rest, especially on upper floors of buildings.
III. Felt quite noticeably indoors, especially on upper floors of buildings.
IV. During the day, felt indoors by many: outdoors by few. At night some awakened.
V. Felt by nearly everyone: many awakened. Some dishes, windows broken: a few instances or cracked plaster: unstable objects overturned.
VI. Felt by all: many frightened and run outdoors. Some heavy furniture moved: a few instances of fallen plaster or damaged chimneys. Damage slight.
VII. Damage negligible in buildings of good design and construction: slight to moderate in well-built ordinary structures: considerable in poorly built or badly designed structures. Some chimneys broken.
VIII. Damage slight in specially designed structures: considerable in ordinary substantial buildings, with partial collapse: great in poorly built structures. Fall of chimneys, factory stacks, columns, monuments, walls.
IX. Damage considerable in specially designed structures: well-designed frame structures thrown out of plumb: great in substantial buildings.
X. Some well-built wooden structures destroyed: most masonry and frame structures destroyed with foundations: ground badly cracked. Rails bent.
XI. Few masonry structures remain standing. Bridges destroyed.
XII. Damage total. Lines of sight and level distorted. Objects thrown upward into the air.
Figure 1. Isoseismal lines of intensity (Modified Mercalli scale) in the New Madrid, Missouri, earthquake on December 16, 1811. The felt radius of the earthquake extended to the East and Gulf coasts. Intensity in the then sparsely populated area west of the epicenter is unknown. Intensity values at specified points are given in Arabic numerals, and the isoseismals are labeled by Roman numerals. [Courtesy of D. Noll and Bull. Seism. Soc. Am.]
Damage in Charleston, South Carolina, from the earthquake of August 31, 1886. This earthquake is the largest ever reported in the eastern region of the United States. [Courtesy of J. K. Hillers, USGS.]
BUILDING CODE SOLUTION

‘STATIC ANALYSIS’
BUILDING CODE REQUIREMENTS
INTERNATIONAL BUILDING CODE ADOPTION MAP

The IBC is in use or adopted in 50 states, the District of Columbia, the U.S. Virgin Islands, NYC, Guam and the Northern Marianas Islands.

Code adoptions as of 04/20/10.
DETERMINATION OF SEISMIC DESIGN CATEGORY (Sds, Sd1)
\[ S_{ds} = \frac{2}{3} F_a S_s \]
\[ S_{d1} = \frac{2}{3} F_v S_1 \]
LOCATION (Ss, S1)
## SITE CLASSIFICATION

Default = D

<table>
<thead>
<tr>
<th>Site Class</th>
<th>$\bar{v}_g$</th>
<th>$\bar{N}$ or $\bar{N}_{cr}$</th>
<th>$\bar{s}_u$</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Hard rock</td>
<td>&gt;5,000 ft/s</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>B. Rock</td>
<td>2,500 to 5,000 ft/s</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>C. Very dense soil and soft rock</td>
<td>1,200 to 2,500 ft/s</td>
<td>&gt;50</td>
<td>&gt;2,000 psf</td>
</tr>
<tr>
<td>D. Stiff soil</td>
<td>600 to 1,200 ft/s</td>
<td>15 to 50</td>
<td>1,000 to 2,000 psf</td>
</tr>
<tr>
<td>E. Soft clay soil</td>
<td>&lt;600 ft/s</td>
<td>&lt;15</td>
<td>&lt;1,000 psf</td>
</tr>
</tbody>
</table>

Any profile with more than 10 ft of soil having the following characteristics:
—Plasticity index $PI > 20$,
—Moisture content $w \geq 40\%$,
—Undrained shear strength $\bar{s}_u < 500$ psf

F. Soils requiring site response analysis in accordance with Section 21.1

See Section 20.3.1

For SI: $1 \text{ ft/s} = 0.3048 \text{ m/s}; 1 \text{ lb/ft}^2 = 0.0479 \text{ kN/m}^2$. 
### Table 11.4-1 Site Coefficient, $F_a$

<table>
<thead>
<tr>
<th>Site Class</th>
<th>$S_T \leq 0.25$</th>
<th>$S_T = 0.5$</th>
<th>$S_T = 0.75$</th>
<th>$S_T = 1.0$</th>
<th>$S_T \geq 1.25$</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>0.8</td>
<td>0.8</td>
<td>0.8</td>
<td>0.8</td>
<td>0.8</td>
</tr>
<tr>
<td>B</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>C</td>
<td>1.2</td>
<td>1.2</td>
<td>1.1</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>D</td>
<td>1.6</td>
<td>1.4</td>
<td>1.2</td>
<td>1.1</td>
<td>1.0</td>
</tr>
<tr>
<td>E</td>
<td>2.5</td>
<td>1.7</td>
<td>1.2</td>
<td>0.9</td>
<td>0.9</td>
</tr>
<tr>
<td>F</td>
<td>See Section 11.4.7</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: Use straight-line interpolation for intermediate values of $S_T$.

### Table 11.4-2 Site Coefficient, $F_v$

<table>
<thead>
<tr>
<th>Site Class</th>
<th>$S_T \leq 0.1$</th>
<th>$S_T = 0.2$</th>
<th>$S_T = 0.3$</th>
<th>$S_T = 0.4$</th>
<th>$S_T \geq 0.5$</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>0.8</td>
<td>0.8</td>
<td>0.8</td>
<td>0.8</td>
<td>0.8</td>
</tr>
<tr>
<td>B</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>C</td>
<td>1.7</td>
<td>1.6</td>
<td>1.5</td>
<td>1.4</td>
<td>1.3</td>
</tr>
<tr>
<td>D</td>
<td>2.4</td>
<td>2.0</td>
<td>1.8</td>
<td>1.6</td>
<td>1.5</td>
</tr>
<tr>
<td>E</td>
<td>3.5</td>
<td>3.2</td>
<td>2.8</td>
<td>2.4</td>
<td>2.4</td>
</tr>
<tr>
<td>F</td>
<td>See Section 11.4.7</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: Use straight-line interpolation for intermediate values of $S_T$. 
### Table 1.5-1 Risk Category of Buildings and Other Structures for Flood, Wind, Snow, Earthquake, and Ice Loads

<table>
<thead>
<tr>
<th>Use or Occupancy of Buildings and Structures</th>
<th>Risk Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>Buildings and other structures that represent a low risk to human life in the event of failure</td>
<td>I</td>
</tr>
<tr>
<td>All buildings and other structures except those listed in Risk Categories I, III, and IV</td>
<td>II</td>
</tr>
<tr>
<td>Buildings and other structures, the failure of which could pose a substantial risk to human life.</td>
<td>III</td>
</tr>
<tr>
<td>Buildings and other structures, not included in Risk 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.</td>
<td></td>
</tr>
<tr>
<td>Buildings and other structures not included in Risk 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 toxic or explosive substances where their quantity exceeds a threshold quantity established by the authority having jurisdiction and is sufficient to pose a threat to the public if released.</td>
<td></td>
</tr>
<tr>
<td>Buildings and other structures designated as essential facilities.</td>
<td>IV</td>
</tr>
<tr>
<td>Buildings and other structures, the failure of which could pose a substantial hazard to the community.</td>
<td></td>
</tr>
<tr>
<td>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 sufficient quantities of highly toxic substances where the quantity exceeds a threshold quantity established by the authority having jurisdiction to be dangerous to the public if released and is sufficient to pose a threat to the public if released.*</td>
<td></td>
</tr>
<tr>
<td>Buildings and other structures required to maintain the functionality of other Risk Category IV structures.</td>
<td></td>
</tr>
</tbody>
</table>

*Buildings and other structures containing toxic, highly toxic, or explosive substances shall be eligible for classification to a lower Risk Category 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 substances is commensurate with the risk associated with that Risk Category.
User Note: Electronic values of mapped acceleration parameters, and other seismic design parameters, are provided at the USGS Web site at http://earthquake.usgs.gov/designmaps, or through the SEI Web site at http://content.seicentre.org.
(which utilizes USGS hazard data available in 2008)

Site Coordinates 34.85271°N, 82.39412°W
Site Soil Classification Site Class D – "Stiff Soil"
Risk Category IV (e.g. essential facilities)

USGS Provided Output

\[ S_s = 0.280 \text{ g} \quad S_{ss} = 0.442 \text{ g} \quad S_{ss} = 0.294 \text{ g} \]
\[ S_s = 0.107 \text{ g} \quad S_{ss} = 0.253 \text{ g} \quad S_{ss} = 0.169 \text{ g} \]

For information on how the SS and S1 values above have been calculated from probabilistic (risk-targeted) and deterministic ground motions in the direction of maximum horizontal response, please return to the application and select the "2009 NEHRP" building code reference document.

MCEa Response Spectrum

Design Response Spectrum
User Note: Electronic values of mapped acceleration parameters, and other seismic design parameters, are provided at the USGS Web site at http://earthquake.usgs.gov/designmaps, or through the SEI Web site at http://content.seinstitute.org.

Site Coordinates  35.60086°N, 82.55369°W
Site Soil Classification  Site Class D – “Stiff Soil”
Risk Category  IV (e.g. essential facilities)

USGS-Provided Output

\[
\begin{align*}
S_s &= 0.308 \, g \\
S_d &= 0.108 \, g \\
S_m &= 0.479 \, g \\
S_{sa} &= 0.256 \, g \\
S_{so} &= 0.319 \, g \\
S_{st} &= 0.171 \, g
\end{align*}
\]

For information on how the SS and S1 values above have been calculated from probabilistic (risk-targeted) and deterministic ground motions in the direction of maximum horizontal response, please return to the application and select the “2009 NEHRP” building code reference document.
Table 1.5-2 Importance Factors by Risk Category of Buildings and Other Structures for Snow, Ice, and Earthquake Loads

<table>
<thead>
<tr>
<th>Risk Category from Table 1.5-1</th>
<th>Snow Importance Factor, $I_s$</th>
<th>Ice Importance Factor—Thickness, $I_t$</th>
<th>Ice Importance Factor—Wind, $I_w$</th>
<th>Seismic Importance Factor, $I_e$</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>0.80</td>
<td>0.80</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>II</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>III</td>
<td>1.10</td>
<td>1.25</td>
<td>1.00</td>
<td>1.25</td>
</tr>
<tr>
<td>IV</td>
<td>1.20</td>
<td>1.25</td>
<td>1.00</td>
<td>1.50</td>
</tr>
</tbody>
</table>

*The component importance factor, $I_p$, applicable to earthquake loads, is not included in this table because it is dependent on the importance of the individual component rather than that of the building as a whole, or its occupancy. Refer to Section 13.1.3.*
<table>
<thead>
<tr>
<th>Period (sec)</th>
<th>Centroid Sa (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.2</td>
<td>0.280 (Ss)</td>
</tr>
<tr>
<td>1.0</td>
<td>0.107 (S1)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Period (sec)</th>
<th>Centroid Sa (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.2</td>
<td>0.442 (SMs, Fa = 1.576)</td>
</tr>
<tr>
<td>1.0</td>
<td>0.253 (SM1, Fv = 2.374)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Period (sec)</th>
<th>Centroid Sa (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.2</td>
<td>0.294 (SDs)</td>
</tr>
<tr>
<td>1.0</td>
<td>0.169 (SD1)</td>
</tr>
</tbody>
</table>
### Asheville, NC

<table>
<thead>
<tr>
<th>Period (sec)</th>
<th>Centroid Sa (g)</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.2</td>
<td>0.308</td>
<td>(Ss)</td>
</tr>
<tr>
<td>1.0</td>
<td>0.108</td>
<td>(S1)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Period (sec)</th>
<th>Centroid Sa (g)</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.2</td>
<td>0.479</td>
<td>(SMs, Fa = 1.554)</td>
</tr>
<tr>
<td>1.0</td>
<td>0.256</td>
<td>(SM1, Fv = 2.367)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Period (sec)</th>
<th>Centroid Sa (g)</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.2</td>
<td>0.319</td>
<td>(SDs)</td>
</tr>
<tr>
<td>1.0</td>
<td>0.171</td>
<td>(SD1)</td>
</tr>
</tbody>
</table>
13.1.4 Exemptions

The following nonstructural components are exempt from the requirements of this section:

1. Furniture (except storage cabinets as noted in Table 13.5-1).
2. Temporary or movable equipment.
3. Architectural components in Seismic Design Category B other than parapets supported by bearing walls or shear walls provided that the component importance factor, $I_p$, is equal to 1.0.
4. Mechanical and electrical components in Seismic Design Category B.
5. Mechanical and electrical components in Seismic Design Category C provided that the component importance factor, $I_p$, is equal to 1.0.
6. Mechanical and electrical components in Seismic Design Categories D, E, or F where all of the following apply:
   a. The component importance factor, $I_p$, is equal to 1.0;
   b. The component is positively attached to the structure;
   c. Flexible connections are provided between the component and associated ductwork, piping, and conduit; and either
      i. The component weighs 400 lb (1,780 N) or less and has a center of mass located 4 ft (1.22 m) or less above the adjacent floor level; or
      ii. The component weighs 20 lb (89 N) or less or, in the case of a distributed system, 5 lb/ft (73 N/m) or less.

13.1.3 Component Importance Factor

All components shall be assigned a component importance factor as indicated in this section. The component importance factor, $I_p$, shall be taken as 1.5 if any of the following conditions apply:

1. The component is required to function for life-safety purposes after an earthquake, including fire protection sprinkler systems and egress stairways.
2. The component conveys, supports, or otherwise contains toxic, highly toxic, or explosive substances where the quantity of the material exceeds a threshold quantity established by the authority having jurisdiction and is sufficient to pose a threat to the public if released.
3. The component is in or attached to a Risk Category IV structure and it is needed for continued operation of the facility or its failure could impair the continued operation of the facility.
4. The component conveys, supports, or otherwise contains hazardous substances and is attached to a structure or portion thereof classified by the authority having jurisdiction as a hazardous occupancy.

All other components shall be assigned a component importance factor, $I_p$, equal to 1.0.
PIPE AND DUCT EXEMPTIONS

HVAC, Plumbing and Gas Piping:
- For Seismic Design Category C where Ip is greater than 1.0, the nominal pipe size shall be 2” or less.
- For Seismic Design Categories D, E or F and values of Ip are greater than 1.0, the nominal pipe size shall be 1” or less.
- For Seismic Design Categories D, E or F where Ip =1.0, the nominal pipe size shall be 3” or less.

Ductwork:
- Rectangular ductwork less than 6 square feet in cross-section.
- Round duct less than 28” diameter.

Other:
- Any pipe or duct run suspended within 12” of the supporting structure for the entire length of run.
METHOD OF CALCULATION
SUBMITTAL DATA

PROJECT: NEA BAPTIST HOSPITAL, JONESBORO, AR
ARCHITECT:
ENGINEER:
CONTRACTOR: MCC MECHANICAL
P.O. NUMBER: 11213J02
COMMENTS:
WCM-1 - WCM-4, AHU-5

DATE: 09/01/2011
M.I. No.: 490857
<table>
<thead>
<tr>
<th>Equipment Tag(s)</th>
<th>Manufacturer</th>
<th>Isolation Type</th>
<th>Defl.</th>
<th>Seismic Material</th>
<th>Mason Ind. Dwg. No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seismic Force Levels</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WCM-1 - WCM-4</td>
<td>TRANE</td>
<td>CVHF1300</td>
<td>1.00</td>
<td></td>
<td>F-434768</td>
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<tr>
<td>HPA</td>
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</tr>
<tr>
<td>REF. DWG.</td>
<td>SLR50EBP</td>
<td>S-171</td>
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</tr>
<tr>
<td>Certificate of Compliance AHU-6</td>
<td>AIR ENTERPRISES</td>
<td></td>
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<td>F-434789</td>
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<td>AHU-6</td>
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<td>F-434792</td>
</tr>
<tr>
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<td>SAST</td>
<td>S-105</td>
<td></td>
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</tr>
<tr>
<td>HG</td>
<td></td>
<td>S-420</td>
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<td>SSFFH</td>
<td></td>
<td>S-237</td>
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<tr>
<td>Frability Data References</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>A-31270-2</td>
</tr>
</tbody>
</table>

Seismic restraints and vibration isolation (where applicable) have been added to the above listed equipment per job specifications. I hereby certify that these documents listed above were prepared or approved by me, and I am a duly licensed professional engineer under the laws of the state of the project. No other responsibility is taken or implied by this engineer.
IBC 2006 SECTION 1613 / ASCE 7-05 CHAPTER 13

SEISMIC DESIGN PARAMETER:

\[ F_s = \left[0.4x10^{3}\mu x_{s} x_{d} x_{c} x_{y} x_{z} x_{h}\right]^{0.5} \]

- \( F_s \) is not required to be greater than \( \left[1.8x10^{3}\mu x_{s} x_{c} x_{y} x_{z} x_{h}\right]^{0.5} \)
- \( F_s \) shall not be less than \( \left[0.2x10^{3}\mu x_{s} x_{c} x_{y} x_{z} x_{h}\right]^{0.5} \)

**DEFINITIONS:**

- \( S_x \): Mapped Spectral Response Acceleration at Short Period
- \( F_s \): Site Class Coefficient for Site Specific Soil
- \( S_{55} \): Design Spectral Response Acceleration, \( S_{55} = 55 \times F_s \)
- \( F_y \): Horizontal Seismic Forces (Gs)
- \( F_m \): Vertical Seismic Forces (Gs)
- \( k_c \): Component Amplification Factor
- \( R_u \): Component Response Modification Factor
- \( l \): Importance Factor
  - \( l_s = 1.5 \) for Life Safety, Hazardous, and Essential systems and
  - \( l_s = 1.0 \) for all other components.
- \( z \): Attachment Height within Building
- \( h \): Roof Elevation

<table>
<thead>
<tr>
<th>Component of System within Building</th>
<th>( R_u )</th>
<th>( F_m )</th>
<th>( F_y )</th>
<th>( F_s )</th>
<th>( F_s ) for Air Handling Equipment</th>
<th>( F_s ) for HVAC Equipment</th>
<th>( F_s ) for Response Isolation Equipment</th>
<th>( F_s ) for Building Activity Equipment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ground</td>
<td>0.25</td>
<td>0.30</td>
<td>0.30</td>
<td>0.30</td>
<td>0.30</td>
<td>0.30</td>
<td>0.30</td>
<td>0.30</td>
</tr>
<tr>
<td>1/8 of Roof, Hr.</td>
<td>0.30</td>
<td>0.35</td>
<td>0.35</td>
<td>0.35</td>
<td>0.30</td>
<td>0.30</td>
<td>0.30</td>
<td>0.30</td>
</tr>
<tr>
<td>1/4 of Roof, Hr.</td>
<td>0.33</td>
<td>0.35</td>
<td>0.35</td>
<td>0.35</td>
<td>0.30</td>
<td>0.30</td>
<td>0.30</td>
<td>0.30</td>
</tr>
<tr>
<td>Full Height</td>
<td>0.33</td>
<td>0.35</td>
<td>0.35</td>
<td>0.35</td>
<td>0.30</td>
<td>0.30</td>
<td>0.30</td>
<td>0.30</td>
</tr>
</tbody>
</table>

**High Deformability:** Steel and copper piping with welded, brazed, or bolted flange connections.

**Low Deformability:** Cast iron pipe, ductile iron pipe, PVC pipe with no hub connectors and any other pipe system with connections that rely on friction.

**Limited Deformability:** All piping that is not classified as either high or Low Deformability, including steel or copper piping with screwed joints, or PVC piping with solvent-weld joints.
**PLAN VIEW OF VIBRATION ISOLATION AND SEISMIC RESTRAINT SYSTEM**

"SEE HOUSEKEEPING PAD ANCHORAGE DETAIL PER ORIG. F.434787.
IF HPA'S ARE NOT USED TO SECURE THE HOUSEKEEPING PAD, RESPONSIBILITY FOR ANCHORAGE IS BY OTHERS."

**NOTE:**
Manufacturer to verify support as shown is acceptable.

**1/4" FILLET WELD**
3" LONG MIN.
("1" shown, 2" top) by OTHERS.

**ELEVATION VIEW OF SYSTEM ALONG LENGTH**

**DATE:** 09/01/11
**DWG. NO.** F-434787
**Type SLRSOE BP RATINGS**

<table>
<thead>
<tr>
<th>Size</th>
<th>Rated Load (lbs)</th>
<th>Rated Spring (ft-lb)</th>
<th>C Rating</th>
<th>Attach to Concrete/Steel</th>
<th>Spring Color</th>
</tr>
</thead>
<tbody>
<tr>
<td>4-C2-0150</td>
<td>1250</td>
<td>3.75</td>
<td>1</td>
<td>0.75</td>
<td>Gray</td>
</tr>
<tr>
<td>4-C2-0200</td>
<td>1600</td>
<td>4.00</td>
<td>1.5</td>
<td>1.5</td>
<td>Gray</td>
</tr>
<tr>
<td>4-C2-0250</td>
<td>2000</td>
<td>4.50</td>
<td>2</td>
<td>2.0</td>
<td>Gray</td>
</tr>
<tr>
<td>4-C2-0375</td>
<td>3000</td>
<td>6.00</td>
<td>3</td>
<td>3.0</td>
<td>Gray</td>
</tr>
<tr>
<td>4-C2-0500</td>
<td>5000</td>
<td>8.00</td>
<td>4</td>
<td>4.0</td>
<td>Gray</td>
</tr>
</tbody>
</table>

* with RED inner spring

**Type SLRSOE BP DIMENSIONS (inches)**

<table>
<thead>
<tr>
<th>Size</th>
<th>L</th>
<th>W</th>
<th>H</th>
<th>Z</th>
<th>A</th>
<th>U2</th>
<th>C2</th>
</tr>
</thead>
<tbody>
<tr>
<td>C2</td>
<td>2.75</td>
<td>5</td>
<td>0.63</td>
<td>0.65</td>
<td>0.58</td>
<td>1.10</td>
<td></td>
</tr>
</tbody>
</table>

**Type SLRSOE BP DRAWING 6-171**

REFERENCE DRAWING S-171
HOW IS EQUIPMENT AFFECTED?
INVESTIGATE REASONS FOR FAILURE
SPRING MOUNTED MASS MOVEMENTS
SEISMIC RESTRAINT PRODUCTS
CAPTIVE NEOPRENE MOUNT
RESTRAINED SPRING MOUNT
AIR SPRINGS MUST BE INSTALLED WITH LEVELING VALVES
SEISMIC SNUBBER

STEEL BUSHING

ALL-DIRECTIONAL BRIDGE BEARING QUALITY NEOPRENE BUSHING

SNUBBER BOLT AND WASHER

RESTRAINING ANGLE

Z-1225 ALL-DIRECTIONAL SEISMIC SNUBBER
OSHPD PRE-APPROVAL No. 0196

ŷ SEISMIC SNUBBER
PIPING SWAY RACING

NOTE: A ROD STIFFENER ANGLE MAY BE REQUIRED AS SHOWN. FOR ADDITIONAL INFORMATION, REF. PAGE B1. BRACE ANGLE RATIO MAY BE INCREASED TO 2/VERT. 1/HORIZ. REFER TO SECTION A FOR LIMITATIONS. REFER TO PAGE X2 FOR PROPER INSTALLATION OF THE SCBHS.
SCB, SCBH, AND SCBV CABLE RESTRAINTS
OSPD PRE-APPROVAL NO. 0202
ROOFTOP APPLICATIONS
SUSPENDED EQUIPMENT
"12 INCH RULE" FOR PIPES, CONDUITS OR CABLE TRAYS

SUPPORT STRUCTURE

CONNECTION CANNOT DEVELOP A MOMENT (PER 1987 UBC)

≤ 12 IN. (305 mm)

PIPE OR CONDUIT

SUPPORT STRUCTURE

1/4 IN. (6 mm) MAX. CLEARANCE

≤ 12 IN. (305 mm)

PIPE OR CONDUIT

SUPPORT STRUCTURE

CONNECTIONS CANNOT DEVELOP MOMENTS (PER 1987 UBC)

≤ 12 IN. (305 mm)

PIPE, CONDUIT OR CABLE TRAY

SUPPORT STRUCTURE

3/8 IN. (10 mm) MAX. CLEARANCE

1/4 IN. (6 mm)

PIPE, CONDUIT OR CABLE TRAY
Note: Refer to Page 12, note 1 for additional requirements of the “12 Inch Rule".

"12 INCH RULE" FOR DUCTWORK

SUPPORT STRUCTURE

CONNECTIONS CANNOT DEVELOP MOMENTS (PER 1997 UBC)

1 IN. (25 mm)

SUPPORT STRUCTURE

3/8 IN. (10 mm) MAX. CLEARANCE

1/4 IN. (6 mm)

SUPPORT STRUCTURE

SHEET METAL STRAPS

(2) #10 SHEET METAL SCREW

SHEET METAL SCREW AS REQUIRED

DUCT

≤ 12 IN. (305 mm)

≤ 12 IN. (305 mm)

≤ 2 IN. (51 mm)
ALL-DIRECTIONAL SEISMIC CABLE BRACE HOOK GUIDELINES FOR SPRING-ISOLATED RECTANGULAR/oval DUCT

SCB ANCHORAGE REF. SECTION D

SCBH ONLY SHOWN IN TRANSVERSE DIRECTION FOR CLARITY. ADDITIONAL SCBHs ARE REQUIRED AS SHOWN IN PLAN VIEW BELOW.

ADDITIONAL UPPER SUPPORT REF. PAGE E4

REQUIRED CLEARANCES REF. PAGE H4

SCBH OPTIONAL ATTACHMENT DETAIL

AIRCRAFT CABLE REF. SECTION D

SCBH - SEISMIC CABLE BRACE HOOK REF. SECTION D

PC30N ISOLATION HANGER

VERTICAL LIMIT STOP AT RESTRAINT LOCATIONS

ROD COUPLING

SRC - SEISMIC ROD CLAMP IF REQUIRED REF. PAGE E1 OR E2

THREADED ROD REF. PAGE E1 OR E2

ROD STIFFENER ANGLE IF REQUIRED REF. PAGE E1 OR E2

ROD COUPLING FOR LOWER ROD ATTACHMENT

No. 10 SELF-TAPPING SHEET METAL SCREWS MAXIMUM 12 IN. (305 mm) O.C

TRAPEZE SUPPORT REF. PAGE E3

1 IN. (25 mm)

3/8 IN. (10 mm) MAXIMUM CLEARANCE

1/4 IN. (6mm)
WALL MOUNTED EQUIPMENT
PB Mount with SAS
Seismic Anchor Stud

All Hardware is Electro-Galvanized
All Neoprene is Bridge Bearing Quality
FLEXIBLE CONNECTIONS
PIPE CONNECTION TO CHILLER

An excellent example of equipment failure at the piping interface. Both the restrained equipment and piping move out of phase during an earthquake and the cast shells are not designed to accept the force necessary to drag the piping. Cast component failures are common. The solution is installation of a spherical twin sphere rubber expansion joint to allow for the motion.
The metal flexible hose prevented pipe.
Twin-Sphere SAFE FLEX SFDEJ

- Hooked Interlock
- Solid Steel Ring
- Molded-In Reinforcing Ring
- Flange Stops
- Split Baked Enamel Ductile Iron Floating Flanges
- Multi-Layered Kevlar® Tire Cord Fabric Reinforcement with PEROXIDE CURED EPDM Cover, Liner and Fabric Frictioning
CAN EQUIPMENT SURVIVE?