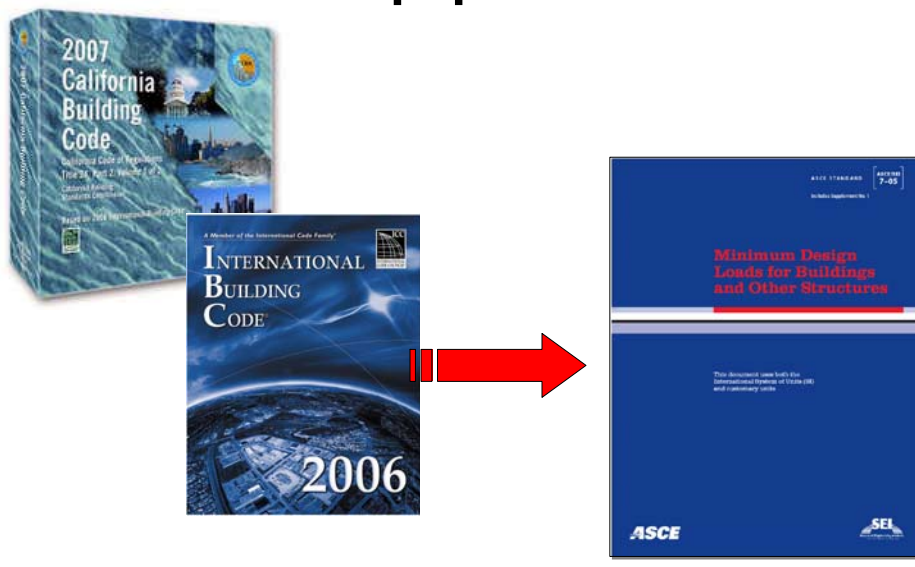
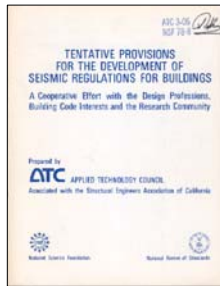


# Building Code Seismic Testing Requirements for Nonstructural Components

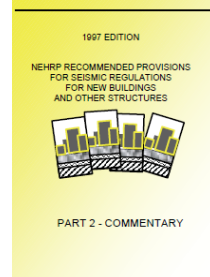
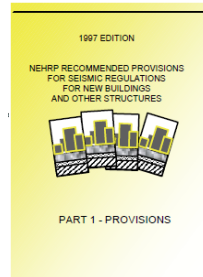
## CBC Seismic Requirements for Equipment



# NEHRP Provisions



*ATC 3.06 the Next Generation Building Code of the 70's*



- First published by BSSC in 1985
- Was updated on 3-year cycle (1988, 91, 94, 97, 00, 03), However now on 5 -6 year cycle
  - 1992 - Adopted by BOCA, SBCCI
  - 1993 - Adopted by ASCE 7 for Seismic
  - 1995 - IBC resolves to adopt as basis for IBC
  - 2006 - Adopting ASCE-7-05 as Reference Basis

## Occupancy Category and Importance Factors

- Occupancy Category I to IV and
- Importance Factor,  $I_E = 1.0$  to  $1.5$

	Occ. Cat.	$I_E$
Low Hazard	I	1.0
All Other	II	1.0
Important	III	1.25
<b>Essential</b>	<b>IV</b>	<b>1.50</b>

## Nonstructural Importance Factor - $I_p$



- Nonstructural Component Importance Factor,  $I_p$ , assigned to all components
- The values of  $I_p$  is either 1.0 or 1.5
- The value of  $I_p$  is based on:
  - Requirements of the component to function after a DBE (such as sprinkler systems), or
  - The component contains hazardous materials, or
  - Storage Racks open to general public; or,
  - The component is in or attached to an Occupancy Category IV structure
- Nonstructural components/systems which are assigned an  $I_p = 1.5$  are called “**Designated Seismic Systems**”.

## Seismic Qualification Requirements for Certain “Designated Seismic Systems”

Chapter 13 of ASCE 7-05



- Seismic qualification required for **Designated Seismic Systems** assigned to Seismic Design Categories C through F as follows:
  - Active mechanical and electrical equipment that are required to function following the DBE
  - Components containing hazardous contents

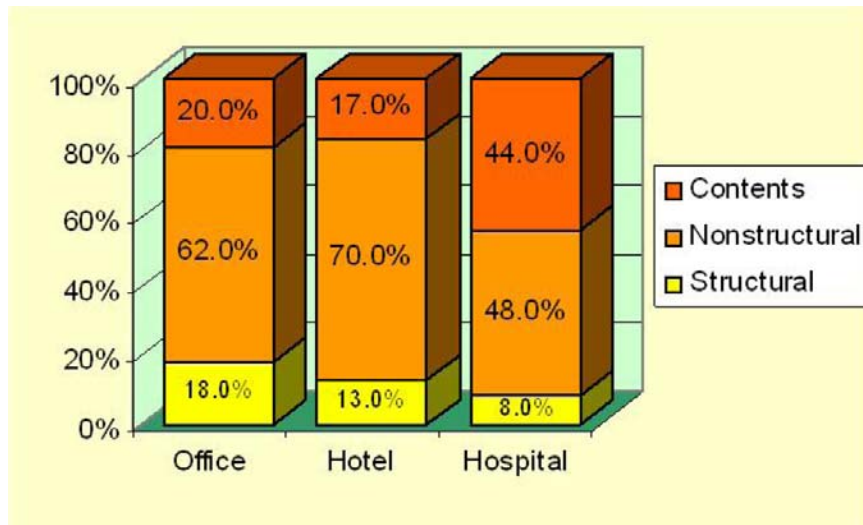
## Drivers of Change - Earthquake Lessons Learned



## Seismic Performance of Nonstructural Components

- Damage to nonstructural components can result in:
  - Significant economic losses
    - **Cost of building contents exceeds building cost**
  - Temporary partial/total loss of operation/functionality (downtime)
  - Injuries
  - Loss of Life
- Past emphasis : Life safety only
- Present: Performance Based

## Typical Investment in Building Construction



## Northridge Earthquake

Performance of all Buildings at 23 Hospital Sites with One or More Yellow or Red Tagged Buildings		
	Number (%) of Buildings	
Type of Damage	Pre Act	Post Act
Structural Damage		
Red tagged	12 (24%)	0 (0%)
Yellow tagged	17 (33%)	1 (3%)
Green tagged	22 (43%)	30 (97%)
Nonstructural Damage		
Major	31 (61%)	7 (23%)
Minor	20 (39%)	24 (77%)
Total Buildings	51	31

# Pre CBC-07 Seismic Qualification Requirements



ASCE 7-98

<p>Therefore, determine the fundamental period of the component as shown (2) from experimental studies as by a properly substantiated analysis.</p> <p><b>9.6.3.6 Component Certification</b></p> <p>The manufacturer's certificate of compliance with the force requirements of the Section shall be submitted to the regulatory agency when required by the contract documents or when required by the regulatory agency.</p>	<p>ASCE 7-98</p> <p><b>9.6.3.6 Component Certification</b></p> <p>The manufacturer's certificate of compliance with the force requirements of the Section shall be submitted to the regulatory agency when required by the contract documents or when required by the regulatory agency.</p>
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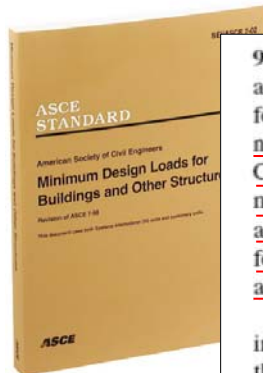
# Pre CBC-07 Seismic Qualification Requirements



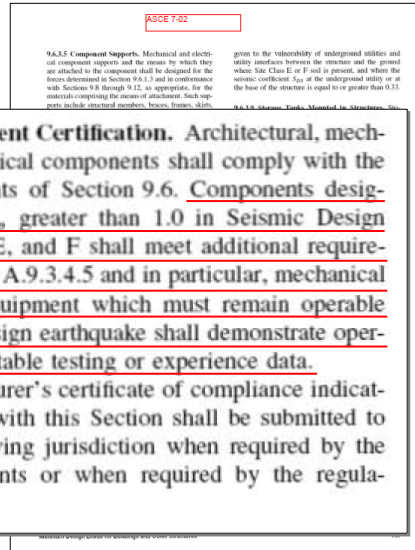
IBC 2000

<p>1707.7.2 Component and attachment testing. The component manufacturer shall test or analyze the component and the component mounting system or anchorage for the design forces in Chapter 16 for those components having a Component Importance Factor of 1.0 or 1.5 in accordance with Chapter 16. <u>The manufacturer shall submit a certificate of compliance for review and acceptance by the registered design professional responsible for the design, and for approval by the building official. The basis of certification shall be by test on a shaking table, by three-dimensional shock tests, by an analytical method using dynamic characteristics and forces from Chapter 16 or by more rigorous analysis.</u> The special inspector shall inspect the component and verify that the label, anchorage or mounting conforms to the certificate of compliance.</p>	<p>1707.7.2 Component and attachment testing. The component manufacturer shall test or analyze the component and the component mounting system or anchorage for the design forces in Chapter 16 for those components having a Component Importance Factor of 1.0 or 1.5 in accordance with Chapter 16. <u>The manufacturer shall submit a certificate of compliance for review and acceptance by the registered design professional responsible for the design, and for approval by the building official. The basis of certification shall be by test on a shaking table, by three-dimensional shock tests, by an analytical method using dynamic characteristics and forces from Chapter 16 or by more rigorous analysis.</u> The special inspector shall inspect the component and verify that the label, anchorage or mounting conforms to the certificate of compliance.</p>
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# Pre CBC-07 Seismic Qualification Requirements



ASCE 7-02

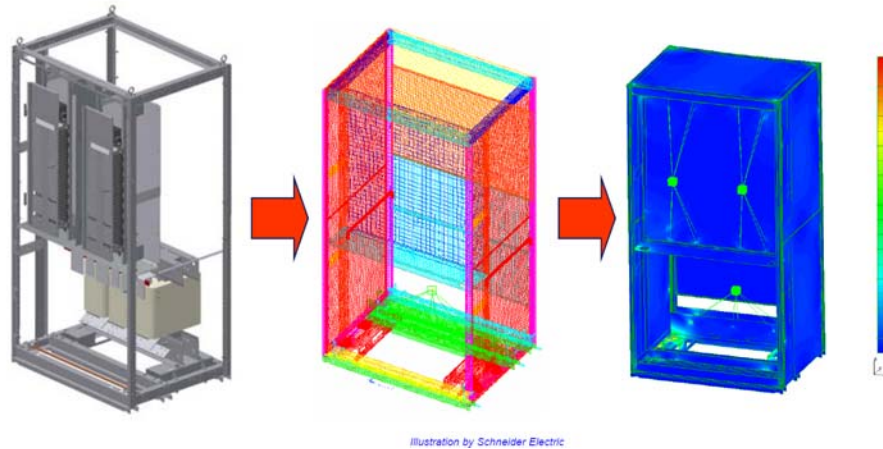


## Seismic Qualification Requirements for Certain Designated Seismic Systems

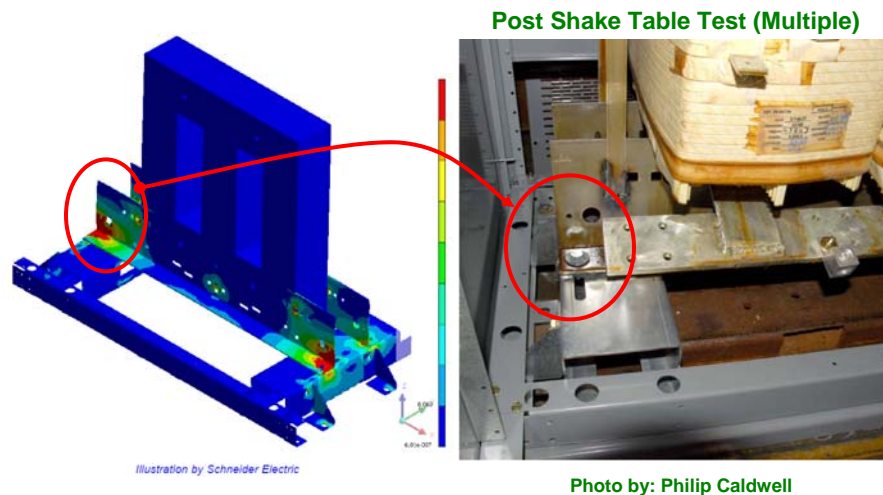
- Qualification to demonstrate functionality after being subject to a DBE to be determined by either:
  - Shake table testing
  - Experience Data
  - Analysis (extremely difficult for active equipment)
- Certification required by supplier indicating compliance



## Seismic Qualification by Analysis



## Seismic Qualification by Analysis



## Seismic Qualification by Testing



## Seismic Qualification by Experience Data

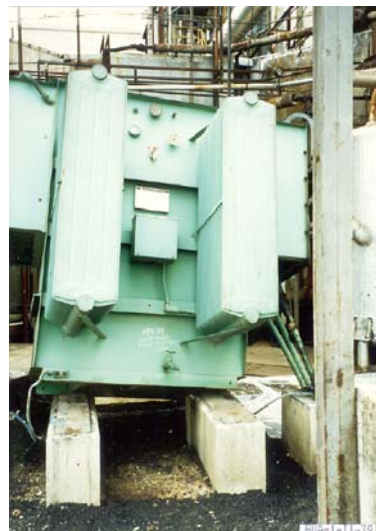
**SQUG**  
Seismic Experience Database

Type of Query: ☐ Category ☐ Field Search ☐ Keyword

CATEGORY: Earthquakes

1971 San Fernando Earthquake  
1973 Point Mugu Earthquake  
1975 Fendole Earthquake  
1979 Imperial Valley Earthquake  
1980 Humboldt County Earthquake  
1983 Coalinga Earthquake  
1984 Morgan Hill Earthquake  
1985 Chile Earthquake  
1985 Mexico Earthquake  
1986 Adak Earthquake  
1986 Chalfont Valley Earthquake  
1986 North Palm Springs Earthquake  
1986 San Salvador Earthquake  
1987 Bay of Plenty - New Zealand Earthquake  
1987 Cerro Prieto Mexico Earthquake  
1987 Superstition Hills Earthquake  
1987 Whittier Earthquake  
1988 Alum Rock, California  
1989 Loma Prieta Earthquake  
1990 Central Luzon - Philippines Earthquake

Version 2.2  
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## Seismic Qualification by Experience Data

- Requirements for qualification basis
  - Database of equipment categories
    - Subjected to known strong motion event
    - Detailed engineering studies of performance
    - Anchorage evaluation
    - Root cause of failure determined by experts
  - Project site lower demand than database
  - Equipment must be of equal or better construction

## Overview of Qualification Standards

- IEEE 344 – Safety related equipment qualification
- Not building code based
  - Different expectations
  - Linear-elastic performance
  - Operational through event
- Used as basis for other seismic standards
  - IEEE 693
  - Telcordia GR-63
  - ICC ES AC156

## Overview of Qualification Standards

- Telcordia GR-63 – Telephone Network Equipment
  - Targeted at telephone central office equipment
  - Seismic is only one of many GR-63 requirements
  - Not building code based



Photo by: Philip Caldwell

## Overview of Qualification Standards

- Prior to 2000 - No standard, ad-hoc testing protocol by labs

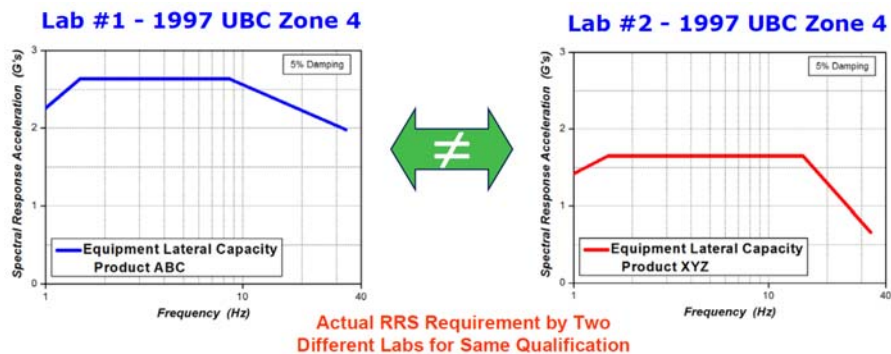


Illustration by Jeff Gatscher & Scott Littler

## Solution for Building Code Qualification Testing

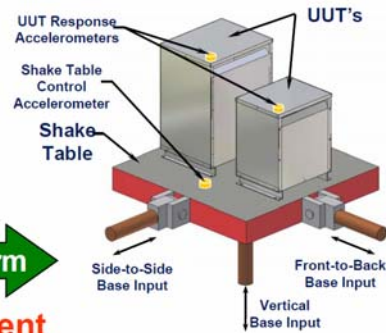
- Prior to 2000 – No standard, ad-hoc testing protocol by labs

$$F_p = \frac{0.4 a_p S_{DS}}{\left( \frac{R_p}{I_p} \right)} \left( 1 + 2 \frac{z}{h} \right) W_p$$

Code basis is static  
lateral push over force



Code Intent  
Missing

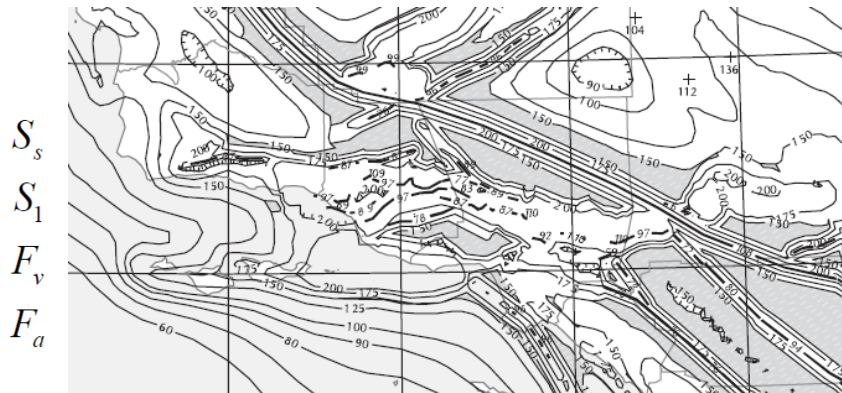


Shake table test  
dynamic demand

Illustration by Jeff Gatscher & Scott Litter

## Solution for Building Code Qualification Testing

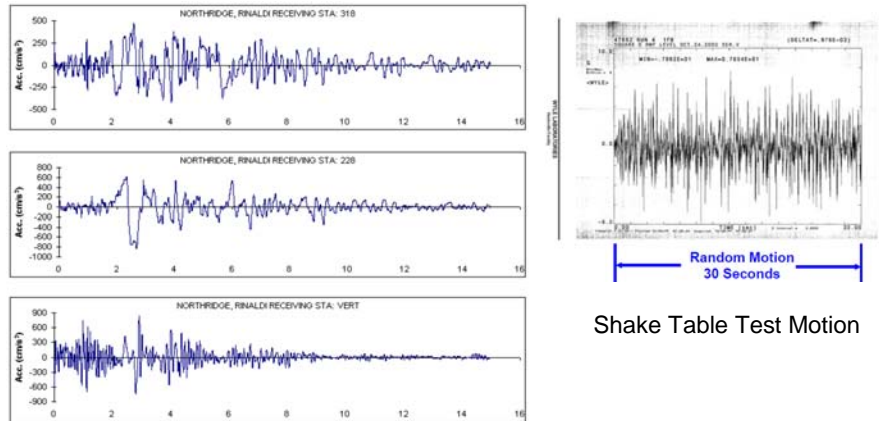
- Building code based test protocol needs
  - Based on site specific design parameters



Excerpt of Figure 3.3-3 from FEMA 450 Part 1 (2003 NEHRP Provisions) L.A. area -MCE ground motion 0.2 sec spectral response acceleration (5% of critical damping), site class B

## Solution for Building Code Qualification Testing

- Time history that envelopes a wide range of earthquakes



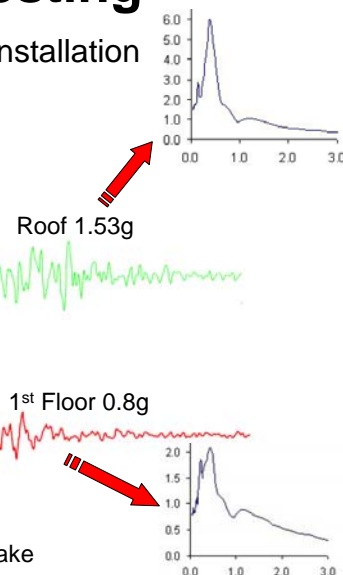
Shake Table Test Motion

## Solution for Building Code Qualification Testing

- Protocol accounts for above grade installation
  - Independent of building/structure type

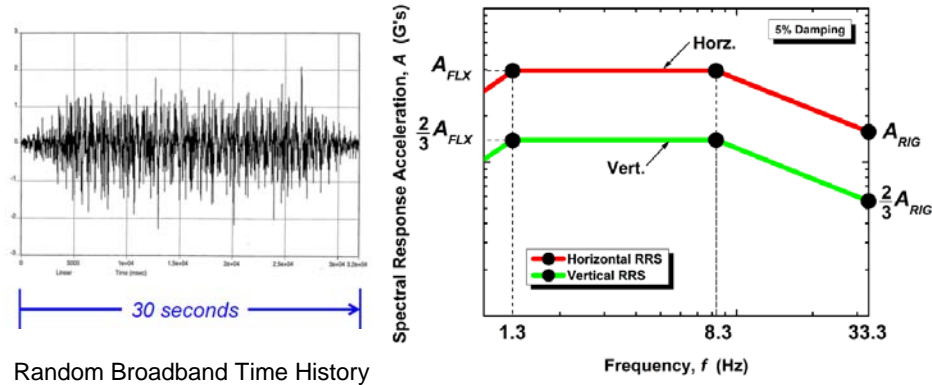


Olive View Hospital M. C., 1994 Northridge Earthquake



## Solution for Building Code Qualification Testing

- Building code based needs
  - Consistent and conservative dynamic test



## Solution for Building Code Qualification Testing

- Acceptance Criteria
  - Account for post event pass/fail criteria
    - Post event functionality for critical facilities



## Solution for Building Code Qualification Testing

- Account for post event pass/fail criteria
  - $I_p = 1.5$  Post test functionality verified



Photo by: Philip Caldwell

## Solution for Building Code Qualification Testing

- Protocol by national body of subject matter experts
  - Academia
  - Practice
  - Industry
  - Test facilities

ICC EVALUATION SERVICE, INC.  
Evaluate • Inform • Protect



ACCEPTANCE CRITERIA FOR  
SEISMIC QUALIFICATION BY SHAKE-TABLE TESTING  
OF NONSTRUCTURAL COMPONENTS AND SYSTEMS

AC156

Approved December 2006

Effective January 1, 2007

Previously approved June 2004, January 2000

## Solution for Building Code Qualification Testing

- ICC ES AC156 now referenced in ASCE/SEI 7-05

**13.2.5 Testing Alternative for Seismic Capacity Determination.** As an alternative to the analytical requirements of Sections 13.2 through 13.6, testing shall be deemed as an acceptable method to determine the seismic capacity of components and their supports and attachments. Seismic qualification by testing based upon a nationally recognized testing standard procedure, such as ICC-ES AC 156, acceptable to the authority having jurisdiction shall be deemed to satisfy the design and evaluation requirements provided that the substantiated seismic capacities equal or exceed the seismic demands determined in accordance with Sections 13.3.1 and 13.3.2.

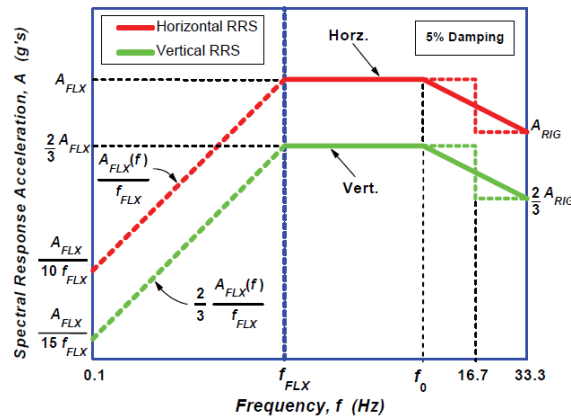
### AC-156 Seismic Qualification by Shake Table Testing of Nonstructural Components

- Companion Document to 2006 IBC/ASCE 7-05
- Acceptance Criteria published by ICC Evaluation Services
- First published in 2000, latest version 2007
- Provides testing protocol and test spectra definition
- Test Spectra is tied directly to  $F_p$  force equation
- Acceptance Criteria tied to  $I_p$  factor.
- For  $I_p = 1.5$ , Equipment to remain functional following the test

## AC-156 Test Spectra

At Roof (max):  $A_{FLX} = 1.6 S_{DS}$  and  $A_{RIG} = 1.2 S_{DS}$

At Ground :  $A_{FLX} = S_{DS}$  and  $A_{RIG} = 0.4 S_{DS}$



## Product Specific Certification Criteria Under Development

- Ceiling Systems –ASTM A 580
- HVAC Equipment -ARI
- Expect others soon

## Other Seismic Testing Specified in 2006 IBC/ASCE 7-05

- **Glazing – AAMA 501.6** –*Recommended Dynamic Test Method for Determining Seismic Drift Causing Glass Fallout from a Wall System, 2001*
- **Anchorage**
  - **ACI 355.2** *Evaluating the Performance of Post-Installed Mechanical Anchors in Concrete and Commentary, 2001*
  - **ICC ES 193** *Mechanical Anchors in Concrete Elements*
  - **ICC ES 308** *Post-installed Adhesive Anchors in Concrete Elements*

## 2007 Code Adoption Calendar

January							February							March						
S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S
1	2	3	4	5	6		1	2	3	4	5	6	7	8	9	10	11	12	13	14
14	15	16	17	18	19	20	11	12	13	14	15	16	17	18	19	20	21	22	23	24
21	22	23	24	25	26	27	18	19	20	21	22	23	24	25	26	27	28	29	30	31
28	29	30	31				25	26	27	28										

May							June							July						
S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S
1	2	3	4	5	6	7	1	2	3	4	5	6	7	8	9	10	11	12	13	14
13	14	15	16	17	18	19	10	11	12	13	14	15	16	17	18	19	20	21	22	23
20	21	22	23	24	25	26	17	18	19	20	21	22	23	24	25	26	27	28	29	30
27	28	29	30	31			24	25	26	27	28	29	30	31						

September							October							November						
S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S
1	2	3	4	5	6	7	1	2	3	4	5	6	7	8	9	10	11	12	13	14
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23	24	25	26	27	28	29	21	22	23	24	25	26	27	18	19	20	21	22	23	24
30							28	29	30	31				25	26	27	28	29	30	31



# OSHDP CANS and PINS

## POLICY INTENT NOTICE (PIN) INDEX

PIN FILE #	SUBJECT	DATE FIRST ISSUED	DATE REVISED
<a href="#">41</a>	Special Seismic Certification Deferred Submittal	7/1/08	
<a href="#">42</a>	Special Seismic Certification Exemption for Nonconforming OSHDP 1 Buildings	9/2/08	
<a href="#">43</a>	Special Seismic Certification for Equipment Emergency Replacement	9/2/08	

# OSHDP CANS and PINS

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<a href="#">42</a>	Special Seismic Certification Exemption for Nonconforming OSHDP 1 Buildings (rescinded - see <a href="#">CAN 2-1708A.5</a> )	9/2/08	1/26/09
<a href="#">43</a>	Special Seismic Certification for Equipment Emergency Replacement (rescinded - see <a href="#">CAN 2-1708A.5</a> )	9/2/08	1/26/09

**CODE APPLICATION NOTICE**

**Subject:** Certification of Equipment and  
Nonstructural Components

**CAN NO.** 2-1708A.5  
**EFFECTIVE:** 10/31/08  
**REVISED:** 1/26/09

**CODE SECTIONS**

Sections 1708A.2, 1708A.5, 1702A and 1707A.9  
2007 California Building Code (CBC)  
(see Appendix A)

Sections 13.2.1, 13.2.2, 13.2.5, 13.2.6, 13.1.3 and 13.1.4  
American Society of Civil Engineers (ASCE/SEI)  
7-05 Minimum Design Loads for Buildings and Other Structures  
(see Appendix A)

## Progress Today

- Several 100's of equipment qualified
- Several Testing facilities Available
- Available lists of tested equipment
  - OSHPD
  - Others

