ICC EVALUATION SERVICE®

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November 22, 2024

TO: **PARTIES INTERESTED IN SEISMIC CERTIFICATION BY SHAKE-TABLE TESTING OF NONSTRUCTURAL COMPONENTS**

SUBJECT: Proposed Revisions to the Acceptance Criteria for Seismic Certification by Shake-Table Testing of Nonstructural Components, Subject AC156-0225-R2 (YM/MC)

Hearing Information:
WebEx Event Meeting
Wednesday, February 19, 2025
8:00 am Pacific Standard Time
Click the date above to register

Dear Colleague:

You are invited to comment on proposed revisions to ICC-ES Acceptance Criteria for Seismic Certification by Shake-Table Testing of Nonstructural Components, (AC156), which will be discussed at the Evaluation Committee hearing noted above. During the September 2024 alternate agenda, we proposed revisions to update AC156 to the 2024 IBC. In response to public comments received, ICC-ES is proposing revisions to AC156 as presented during the September 2024 alternate agenda. The following revisions to the criteria have been developed in conjunction with input from Jeff Gastscher, Robert Bachman, Jakub Valigura and Andy Coughlin as shown in their October 22, 2024 letter (enclosed). The revisions can be summarized as follows:

1. Update criteria to the 2024 IBC. As a result of changes to Equation 13.3-1 of ASCE 7-22, a new section (Section 6.5.1) has been added to address determination of required response spectrum (RRS) used in shake table testing under the 2024 IBC. Current ICC-ES report holder wishing to update their evaluation reports under the 2024 IBC, will not be required to submit new data.

2. Revise language in Section 6.5.2 of AC156 for 2021 and earlier codes. Although the language has been revised from previous version, the RRS determined under the 2021 IBC and earlier codes remains unchanged. The main change is that the RRS has been redefined to coincide with Section 11.4.5 of ASCE 7-16. This revision will not affect current report holders.

New ICC-ES report holders wishing to include evaluation under multiple code editions, should consider the RRS under Sections 6.5.1 and 6.5.2 that will result in higher accelerations.

Should the committee approve the proposed revisions to the criteria, the ICC-ES staff will not recommend a mandatory compliance date. Compliance with the revised criteria will therefore be at the option of existing report holders. However, it should be noted that current applicants for new reports will be required to address any changes that are approved by the committee.

You are invited to submit written comments on this or any other agenda item, or to attend the Evaluation Committee hearing and present your views in person. If you wish to contribute to the discussion, please note the following:

1. Regarding written comments and presentations:

    a. You should submit these via e-mail to es@icc-es.org by the applicable due date.

    b. Comments are to be received by **December 18, 2024.** These written comments will be forwarded to the committee before the meeting, and will also be posted on the ICC-ES web site shortly after the deadline for submission. Written comments that are not submitted by this deadline will not be considered at the meeting.

    c. Rebuttal comments, from the proponent noted in this letter, are to be received by **January 9, 2025**. They will be forwarded to the committee before the meeting, and will also be posted on the ICC-ES web site shortly after the deadline for submission. Written rebuttal comments that are not submitted by the deadline will not be considered at the meeting.

    d. If you want to make a visual presentation at the hearing, it must be received in PowerPoint format. The presentation is to be received by **January 24, 2025.** These will be forwarded to the committee before the meeting, and will also be posted on the ICC-ES web site after the deadline for submission. Presentations that are not submitted by the deadline cannot be presented at the meeting. **Note:** Videos will not be posted on the web site.

       Presentations will be retained with other records of the meeting.

    e. ICC-ES will post to the web site, on **February 5, 2025**, memos by the ICC-ES staff, responding to the previously received public comments.

    f. If you miss the deadlines for submission of written comments and visual presentations, your verbal comments can be presented at the meeting.

    g. Proposed criteria, written public comments, visual presentations, and responses by ICC-ES staff for this agenda item are all available on our website.

2. Regarding verbal comments and presentations:

    Please plan to speak for not more than ten minutes. As noted above, visuals are to be in PowerPoint format.

3. Keep in mind that all materials submitted for committee consideration are part of the public record and will not be treated as confidential. It is the presenter's responsibility to certify to ICC-ES staff that no materials infringe copyright.

4. Please do not communicate with committee members before the meeting about any items on the agenda.

We appreciate your interest in the work of the Evaluation Committee. If you have any questions, please contact me at (800) 423-6587, extension 3691, or Manuel Chan, S.E., Principal Structural Engineer, at extension 3288. You may also reach us by e-mail at es@icc-es.org.

Yours very truly,

Yamil Moya, P.E.
Senior Staff Engineer

YM/ls

Encl.

cc: Evaluation Committee

To: ICC-ES Evaluation Committee

From: Jeff Gatscher, Fellow Engineer, Schneider Electric

Robert Bachman, Sr. Principal, RE Bachman Consulting SE

Jakub Valigura, Senior Engineer, Arup

Andy Coughlin, Principal Engineer, Pre Compliance

Subject: Updated Comments on Proposed ICC-ES AC156 September 2024 Draft

Date: October 22, 2024

Introduction

Based on our discussions with ICC-ES staff on October 8th regarding our Sept 28, 2024 comments and suggested changes to the Proposed ICC-ES AC-156 September 2024 draft, we have updated our suggested changes to the test spectral demands. We are of the opinion that our changes are compatible with the new ASCE 7-22 nonstructural force equations along with the Design Earthquake response spectra. The following provides background along with our proposed new test spectral demand formulations.

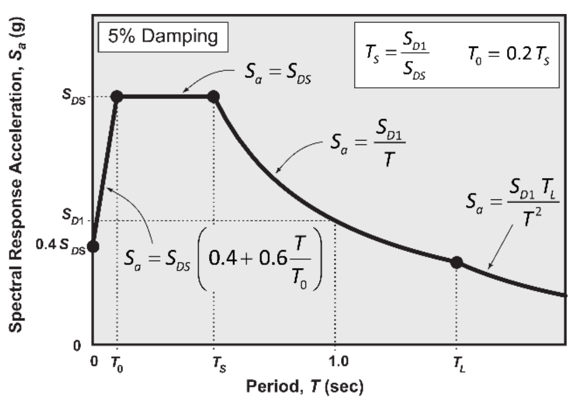
The ASCE/SEI 7-22 code cycle enacted substantive changes in seismic provisions that directly affect nonstructural component testing applications. As ICC-ES staff recognized, with the introduction of multi-period design response spectra using the S_a parameter in Chapter 11 and the new in-structure building amplification factor, (H_f/R_μ) in Chapter 13, there is a need to define the nonstructural demands that are used for seismic qualification testing within the ASCE/SEI 7 Section 13.2.6 Testing Alternative for Seismic Capacity Determination.

The commenters listed are a special task group formed at the request of the ASCE 7 TC-8 Chairman (TC-8 is responsible for developing new seismic provisions for Chapter 13 of ASCE 7) to develop provisions to address what the test spectral demands need to be for inclusion in Chapter 13 of ASCE 7-28. To that end, an ASCE/SEI 7-28 change proposal is in the works to identify test spectral demands (A_{FLX-H}, A_{RIG-H}, A_{FLX-V} and A_{RIG-V}) in Section 13.2.6 of the standard. The recommended changes have not yet been reviewed by the ASCE 7 TC-8 Committee or the ASCE 7-28 Seismic Subcommittee or the ASCE 7 Main Committee. Therefore, it should be treated as a draft. However, in our opinion, the following test spectral demand formulations are likely to be very similar to what becomes adopted in ASCE 7-28 Chapter 13 provisions and would be much preferred to what has been developed by ICC-ES staff in the AC-156 September 2024 draft.

We are also of the opinion that it would be far better for the profession that the proposed changes to the test spectral demands do not change in the updated version of AC-156 just to change again when ASCE 7-28 is adopted. We are inviting ICC-ES staff to participate in the deliberations of TC-8 regarding the new test spectral demand section which will allow ICC-ES staff to tweak the test spectral demands to be consistent with the version that is adopted into ASCE 7-28. Finally, the changes we are proposing have the significant advantage of supporting the use of prior testing from previous versions of AC-156, since the legacy test spectral demands envelope the proposed new test spectra and therefore are still valid.

Technical Narrative

The AC156 Figure 1 shake-table test spectrum is equivalent to a generic building floor spectrum that is correlated to the ASCE/SEI 7 earthquake hazard design level ground motion demands. At grade plane elevation and below, the AC156 horizontal test spectrum must be equivalent in response acceleration to the ASCE/SEI design response spectrum as shown in ASCE/SEI 7-22 Figure 11.4-1 (shown below for reference). Thus, at grade plane elevation A_{FLX-H} must equal the peak response acceleration, S_{DS}, and A_{RIG-H} must equal the response acceleration at zero period (at $T = 0$) which is defined as $0.4 \times S_{DS}$. It should be noted; the ratio between peak response and zero period response is 2.5 (1/0.4).



Taken from ASCE/SEI 7-22 Figure 11.4-1 two-period design response spectrum.

For nonstructural component installations located above grade plane elevation, the AC156 test spectrum must account for in-structure building amplification to account for the anticipated dynamic response of the building or nonbuilding structure. In-structure building amplification uses the building height ratio z/h, where z is the height in building structure at point of component attachment and h is the average roof height of building structure relative to base elevation. Thus, the building height ratio equals zero at grade plane elevation and below (z/h = 0) and equals one at roof height elevation (z/h = 1).

Thus, the AC156 test spectrum is constructed by combining peak response and zero period response accelerations from the ASCE/SEI 7-22 design response spectrum from Chapter 11 with the in-structure building amplification factors contained in Chapter 13 lateral force equation. Since, the ASCE/SEI 7-22 made substantive changes to both Chapter 11 design response spectra with the addition of multi-period design spectra and in Chapter 13 with a new in-structure building amplification factor, in our opinion, the following changes to AC156 are required.

Proposed AC156 Changes:

Our proposed revision to AC156 Sections 6.5.1 and 6.5.2 is as follows (or use similar narratives).

6.5 Multi-frequency Seismic Simulation Tests:

6.5.1 Derivation of Seismic RRS under 2024 IBC: The component earthquake effects shall be determined for combined horizontal and vertical load effects. The required response spectra for the horizontal direction shall be developed based on the normalized response spectra shown in Figure 1, and the formula for total design horizontal force, F_p. The required response spectra for the vertical direction shall be developed based on two-thirds of the ground-level base horizontal acceleration. The seismic parameters specified in Section 4.3 shall be used to calculate the RRS levels as defined by A_{FLX-H}, A_{RIG-H}, A_{FLX-V}, and A_{RIG-V}. The RRS shall be defined using a damping value equal to 5 percent of critical damping.

The required response spectra for both horizontal and vertical directions shall be developed based on the formula for total design horizontal force, Fp, as follows:

~~When the building dynamic characteristics are not known or specified, t~~The horizontal force requirements shall be as determined using Equation 13.3-1 of ASCE 7-22, which reads as follows:

$$F_p = 0.4\, S_{DS}\, I_p\, W_p \left[\frac{H_f}{R_\mu}\right]\left[\frac{C_{AR}}{R_{po}}\right]$$

The equation parameters [C_{AR}/R_{po}] represent the dynamic characteristics and capacity of the component. Some nonstructural components are stiff, and others are more flexible and more likely in tune with ground/floor motion’s dynamic amplification properties and therefore typically result in larger resonant amplifications (i.e., dynamic characteristics).

Also, some components are stronger, and some are weaker. The dynamic characteristics and strength of the component do not affect the shake-table test demand motion. Under seismic testing demands, flexible components will respond more to the input excitation than stiff (i.e., rigid) components. Thus, the ratio of [C_{AR}/R_{po}] is not included in the test demand (i.e., set to 1.0) since the dynamic characteristic and strength is already inherently included in the resulting response of the item being tested.

The equation parameters [H_f/R_μ] represent in-structure building amplification to amplify ground motion for component installations located above grade plane elevation, where H_f is the demand amplification factor as a function of the building height ratio and R_μ is function of the structure's ductility reduction factor. The H_f factor is defined in Section 13.3.1.1 of the ASCE/SEI 7-22 standard. For component applications where the building height ratio equals zero (z/h = 0), H_f shall be taken as 1.0. Where the dynamic characteristics of the building or nonbuilding structure are unknown or unspecified, H_f shall be taken as 3.5 for component applications where the building height ratio equals one (z/h = 1). The R_μ factor is defined in Section 13.3.1.2 of the ASCE/SEI 7-22 standard. For component applications where the building height ratio equals zero (z/h = 0), R_μ shall be taken as 1.0. Where the dynamic characteristics of the building or nonbuilding structure are unknown or unspecified, R_μ shall be taken as 1.3 for component applications where the building height ratio equals one (z/h = 1).

The equipment importance factor, I_p, is not used to increase the seismic testing demand when conducting shake-table testing. The equipment importance factor, I_p, greater than one (e.g., I_p = 1.5) is used to designate the component application is for special certification requirements for designated seismic systems. Active mechanical and electrical components under special certification requirements must remain functional following shake-table testing.

Component applications at grade plane elevation and below, the test spectral demand is equivalent in response acceleration to the ASCE/SEI 7-22 two-period format design earthquake response spectrum. Thus, the equation parameter 0.4 S_{DS} represents the site hazard design earthquake response spectral acceleration at zero-period (T = 0), where S_{DS} is the peak spectral response acceleration at 0.2 s period (T = 0.2) for two-period format ground motion spectra. The ground motion peak spectral response acceleration, S_{DS}, is 2.5 times the zero-period response acceleration. IBC 2024 introduced the use of multi-period format ground motion spectra, S_a, alongside of the two-period format spectra. Since the ASCE 7-22 nonstructural equation is based on the two-period spectrum, the peak response acceleration for multi-period design response spectra applications is converted to the two-period format spectrum in accordance with ASCE 7-22 Section 21.4. Section

21.4 specifies that S_{DS} is equal to 0.9 times the maximum value for S_a at any period within the range from 0.2 to 5 s, inclusive, where S_a is the design, 5% damped, spectral response acceleration parameter at multiple periods. The zero-period response acceleration (0.4 S_{DS}) is used to define A_{RIG} test spectral demands and the peak response acceleration, S_{DS}, is used to define A_{FLX} test spectral demands.

Component applications located above grade plane elevation (in-structure elevations), the test spectral demands are increased by the [H_f/R_μ] amplification factor. The 2.5 ratio between peak response acceleration and zero-period response acceleration at in-structure elevations is maintained until the maximum spectral demand value of 1.6 S_{DS} occurs.

The factor for force amplification as a function of height in the structure, H_f, accounts for nonstructural components supported at or below grade plane where the H_f is 1.0 and above grade-level where the H_f must be calculated in accordance with Equation 13.3-5 of ASCE 7-22 where the maximum *z/h* value must not exceed 1.0. The H_f value is acting as a force increase factor to recognize building amplification as you move up within the primary structure. The site-specific ground spectral acceleration factor, S_{DS}, varies per geographic location and site soil conditions. The S_{DS} factor is used to define the general design earthquake response spectrum curve and is used to determine the design seismic forces for the primary building structure. The R_{po} factor is considered to be a design reduction factor to account for inelastic response and represents the allowable inelastic energy absorption capacity of the component's force-resisting system. During the seismic simulation test, the UUT will respond to the excitation and inelastic behavior will naturally occur. The importance factor, I_p, does not increase the seismic test input motion but does affect the requirement for the UUT to demonstrate a level of functionality following seismic simulation testing, and is used in this criteria to determine post-test UUT functionality compliance in accordance with Section 6.7. Therefore, the R_{po} and I_p factors shall be set equal to 1, which is indicative of an unmodified response. The structure ductility reduction factor, R_μ, accounts for the response modification factor for the building or nonbuilding structure supporting the components. For components supported at or below grade plane, R_μ is 1.0. When the seismic force resisting system of the building or nonbuilding structure is not specified, R_μ shall be taken as 1.3 for components above grade plane. The component resonance ductility factor, C_{AR}, acts as a force increase factor by accounting for probable amplification of response associated with the inherent flexibility of the nonstructural component supported at or below grade plane or above grade by building structure. The C_{AR} factor shall be taken from the formal definition of flexible and rigid components. By definition, for fundamental frequencies less than 16.7 Hz the component is considered flexible (maximum C_{AR} factor of 2.8 when installed above grade plane or 2.2 when installed at or below grade plane as determined in accordance with Section 13.3.1.3

~~of ASCE 7-22), which corresponds to the amplified region of the RRS. For fundamental frequencies greater than 16.7 Hz the component is considered rigid (minimum C_{AR} factor of 1.0 as determined in accordance with Section 13.3.1.3 of ASCE 7-22), which corresponds to the ZPA. Other C_{AR} factor may need to be considered depending on the UUT.~~ This results in two normalizing acceleration factors, that when combined, defines the horizontal component certification RRS:

~~$$A_{FLX-H} = \frac{1.12\,S_{DS}}{R_{\mu}}\left(1+2.5\frac{z}{h}\right) \quad \text{and} \quad A_{RIG-H} = \frac{0.4\,S_{DS}}{R_{\mu}}\left(1+2.5\frac{z}{h}\right)$$~~

$$A_{FLX-H} = S_{DS}\left(\frac{H_f}{R_{\mu}}\right) \quad \text{and} \quad A_{RIG-H} = 0.4\,S_{DS}\left(\frac{H_f}{R_{\mu}}\right)$$

where $A_{FLX\text{-}H}$ is limited to a maximum value of 1.6 times S_{DS} or value of 3.2, whichever is higher.

For vertical response, the in-structure building amplification, (H_f/R_{μ})~~z~~ may be taken to be ~~0~~1.0 for all attachment heights, which results in:

~~$$A_{FLX-V} = 0.59\,S_{DS} \quad \text{and} \quad A_{RIG-V} = 0.27\,S_{DS}$$~~

$$A_{FLX-V} = \left(\frac{2}{3}\right)S_{DS} \quad \text{and} \quad A_{RIG-V} = \left(\frac{2}{3}\right)0.4\,S_{DS}$$

~~In lieu of determining the spectral acceleration as described in this section, equivalent provisions based on ASCE 7-22 Equation 13.3-7 shall be permitted for structure-specific applications.~~

6.5.2 Derivation of Seismic RRS under 2021 IBC and earlier codes: The component earthquake effects shall be determined for combined horizontal and vertical load effects. The required response spectra for the horizontal direction shall be developed based on the normalized response spectra shown in Figure 1, and the formula for total design horizontal force, F_p. The required response spectra for the vertical direction shall be developed based on two-thirds of the ground-level base horizontal acceleration. The seismic parameters specified in Section 4.3 shall be used to calculate the RRS levels as defined by $A_{FLX\text{-}H}$, $A_{RIG\text{-}H}$, $A_{FLX\text{-}V}$, and $A_{RIG\text{-}V}$. The RRS shall be defined using a damping value equal to 5 percent of critical damping.

The required response spectra for both horizontal and vertical directions shall be developed based on the formula for total design horizontal force, F_p, as follows:

When the building dynamic characteristics are not known or specified, the horizontal force requirements shall be as determined using Equation 13.3-1 of ASCE 7-16 (and earlier editions), which reads as follows:

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

The equation parameters (a_p/R_p) represent the dynamic characteristics of the component. Some components are stiff (i.e., rigid), and others are more flexible. The dynamic characteristics of the component do not affect the shake-table input motion. Under seismic testing demands, more flexible components will naturally respond more to the input excitation than rigid components. Thus, the ratio of (a_p/R_p) is set to 1.0 since the dynamic characteristics and strength of the component are inherently considered in the testing.

The equation parameters ($1 + 2\, z/h$) represent in-structure building amplification to amplify ground motion for component installations located above grade plane elevation, where the building height ratio, z/h, is defined as either grade plane elevation (which includes below grade plane), where z/h equals zero, and/or roof height elevation, where z/h equals one.

The equipment importance factor, I_p, is not used to increase the seismic testing demand when conducting shake-table testing. The equipment importance factor, I_p, greater than one (e.g., $I_p = 1.5$) is used to designate the equipment application is for special certification requirements for designated seismic systems. Active mechanical and electrical equipment under special certification requirements must remain functional following shake-table testing.

The equation parameter 0.4 S_{DS} represents the site hazard design earthquake response acceleration at zero period ($T = 0$), where S_{DS} is the peak response acceleration at 0.2 s period ($T = 0.2$) for two-period format ground motion spectra. The ground motion peak response, S_{DS}, is 2.5 times the zero period response acceleration. The zero period response acceleration (0.4 S_{DS}) is used to define A_{RIG} test spectral demands and the peak response acceleration, S_{DS}, is used to define A_{FLX} test spectral demands.

The height factor ratio (z / h) accounts for above grade-level component installations within the primary supporting structure and ranges from zero at grade–level to one at roof level, essentially acting as a force increase factor to recognize building amplification as you move up within the primary structure. The site-specific ground spectral acceleration factor, S_{DS}, varies per geographic location and site soil conditions. The S_{DS} factor is used to define the general design earthquake response spectrum curve and is used to determine the design

~~seismic forces for the primary building structure. The ratio of R_p over I_p (R_p / I_p) is considered to be a design reduction factor to account for inelastic response and represents the allowable inelastic energy absorption capacity of the component's force-resisting system. During the seismic simulation test, the UUT will respond to the excitation and inelastic behavior will naturally occur. Therefore, the ratio (R_p / I_p) shall be set equal to 1, which is indicative of an unreduced response. The importance factor, I_p, does not increase the seismic test input motion but does affect the requirement for the UUT to demonstrate a level of functionality following seismic simulation testing, and is used in this criteria to determine post-test UUT functionality compliance in accordance with Section 6.7. The component amplification factor, a_p, acts as a force increase factor by accounting for probable amplification of response associated with the inherent flexibility of the nonstructural component. The component amplification factor, a_p, shall be taken from the formal definition of flexible and rigid components. By definition, for fundamental frequencies less than 16.7 Hz the component is considered flexible (maximum amplification a_p = 2.5), which corresponds to the amplified region of the RRS. For fundamental frequencies greater than 16.7 Hz the component is considered rigid (minimum a_p = 1.0), which corresponds to the ZPA.~~ This results in two normalizing acceleration factors, that when combined, defines the horizontal component certification RRS:

$$A_{FLX-H} = S_{DS}\left(1+2\frac{z}{h}\right) \quad \text{and} \quad A_{RIG-H} = 0.4\,S_{DS}\left(1+2\frac{z}{h}\right)$$

where $A_{FLX\text{-}H}$ is limited to a maximum value of 1.6 times S_{DS} and under the 2021, 2018 and 2015 IBC $A_{FLX\text{-}H}$ is not required to exceed 3.2.

For vertical response, z may be taken to be 0.0 for all attachment heights, which results in:

~~$A_{FLX-V} = 0.67\,S_{DS}$ and $A_{RIG-V} = 0.27\,S_{DS}$~~

$$A_{FLX-V} = \left(\frac{2}{3}\right)S_{DS} \quad \text{and} \quad A_{RIG-V} = \left(\frac{2}{3}\right)0.4\,S_{DS}$$

In lieu of determining the spectral acceleration as described in this section, equivalent provisions based on ASCE 7-16 Equation 13.3-4 shall be permitted for structure-specific applications.

Respectfully,

Jeff Gatscher, Fellow Engineer		October 22, 2024
Schneider Electric	Signature	Date
Robert Bachman, Sr. Principal		October 22, 2024
RE Bachman Consulting SE	Signature	Date
Jakub Valigura, Senior Engineer		October 22, 2024
Arup	Signature	Date
Andy Coughlin, Principal Engineer		October 22, 2024
Pre Compliance	Signature	Date

ICC EVALUATION SERVICE, LLC, RULES OF PROCEDURE FOR THE EVALUATION COMMITTEE

1.0 PURPOSE

The purpose of the Evaluation Committee is to review and approve acceptance criteria on which evaluation reports may be based.

2.0 MEMBERSHIP

2.1 The Evaluation Committee has a membership of not fewer than nine, with one of the members named by the ICC-ES president each year to serve as the chairperson–moderator.

2.2 All members of the committee shall be representatives of a body enforcing regulations related to the built environment.

2.3 Persons are appointed to the committee by the ICC-ES president, from among individuals who have formally applied for membership.

2.4 The ICC-ES Board of Managers, using simple majority vote, shall ratify the nominations of the president.

2.5 Committee membership is for one year, coinciding with the calendar year. Members may be renominated and reappointed.

2.6 In the event that a member is unable to attend a committee meeting or complete a term on the committee, the ICC-ES president may appoint a replacement to fill in at the meeting or for the remainder of the member's term. Any replacement appointed for only one meeting must have prior experience as a member of the Evaluation Committee. Appointments under this section (Section 2.6) are subject to ratification as noted in Section 2.4.

3.0 MEETINGS

3.1 The Evaluation Committee shall schedule meetings that are open to the public in discharging its duties under Section 1.0, subject to Section 3.0.

3.2 All scheduled meetings shall be publicly announced. There shall be three to six meetings per year (as necessary).

3.3 More than half of the Evaluation Committee members, counting the chairperson, shall constitute a quorum. A majority vote of members present is required on any action. To avoid any tie vote, the chairperson may choose to exercise or not exercise, as necessary, their right to vote.

3.4 In the absence of the chairperson–moderator, Evaluation Committee members present shall elect an alternate chairperson from the committee for that meeting. The alternate chairperson shall be counted as a voting committee member for purposes of maintaining a committee quorum and to cast a tie-breaking vote of the committee.

3.5 Minutes shall be kept and shall be the official record of each meeting.

3.6 An electronic record of meetings may be made by ICC-ES if deemed necessary; no other audio, video, electronic recordings of the meetings will be permitted. Visual aids (including, but not limited to, charts, slides, videos, or presentation software) viewed at meetings shall be permitted only if the presenter provides ICC-ES before the presentation with a copy of the visual aid in a medium which can be retained by ICC-ES with its record of the meeting and which can also be provided to interested parties requesting a copy.

3.7 Parties interested in the deliberations of the committee should refrain from communicating, whether in writing or verbally, with committee members regarding agenda items. All written communications and submissions regarding agenda items must be delivered to ICC-ES and shall be considered nonconfidential and available for discussion in open session of an Evaluation Committee meeting. Such materials will be posted on the ICC-ES web site (www.icc-es.org) prior to the meeting. Comments and submissions not meeting the following deadlines will not be considered at the meeting:

- Initial comments on agenda items shall be submitted at least 28 days before the scheduled meeting.
- A rebuttal comment period shall follow, whereby rebuttal comments to the initial comments may be submitted by the proponent at least 21 days before the scheduled meeting.
- Those planning on giving a visual presentation at the meeting must submit their presentation, in PowerPoint format only, at least 10 days before the scheduled meeting.

The committee reserves the right to refuse recognition of communications which do not comply with the provisions of this section.

4.0 CLOSED SESSIONS

Evaluation Committee meetings shall be open except that at the discretion of the chairperson, staff counsel may be necessary. Also, matters related to clients or potential clients covered by confidentiality requirements of ICC-ES Rules of Procedure for Evaluation Reports are discussed only during closed meetings.

5.0 ACCEPTANCE CRITERIA

5.1 Acceptance criteria are established by the committee to provide a basis for issuing ICC-ES evaluation reports on products and systems under codes referenced in Section 2.0 of the Rules of Procedure for Evaluation Reports. They also clarify conditions of acceptance for products and systems specifically regulated by the codes.

Acceptance criteria may involve a product, material, or method of construction. Consideration of any acceptance criteria must be in conjunction with a current and valid application for an ICC-ES evaluation report, an existing ICC-ES evaluation report, or as otherwise determined by the ICC-ES President.

EXCEPTIONS: The following acceptance criteria are controlled by the ICC-ES executive staff and are not subject to committee approval:

- The Acceptance Criteria for Quality Documentation (AC10)
- The Acceptance Criteria for Test Reports (AC85)
- The Acceptance Criteria for Inspections and Inspection Agencies (AC304)

5.2 Procedure:

5.2.1 Proposed acceptance criteria shall be developed by the ICC-ES staff and discussed in open session with the Evaluation Committee during a scheduled meeting, except as permitted in Section 4.0 of these rules.

5.2.2 Proposed acceptance criteria shall be available to interested parties at least 30 days before discussion at the committee meeting.

5.2.3 The committee shall be informed of all pertinent written communications received by ICC-ES.

5.2.4 Attendees at Evaluation Committee meetings shall have the opportunity to speak on acceptance criteria listed on the meeting agenda, to provide information to committee members. In the interest of fairness, each speaker requesting to testify on a proposed acceptance criteria or proposed changes to an existing acceptance criteria will be given the same amount of time, as follows:

a. A 10-minute time limit applies to speakers giving their first testimony on any item, which applies to both verbal testimony and/or visual presentations.

b. A 5-minute time limit applies to speakers returning to the microphone to offer additional testimony and/or to rebut testimony given by others.

c. A 2-minute time limit applies to speakers offering testimony on the staff recommendation to criteria.

Should a company have multiple speakers, the speaker time limits above apply the company, in that multiple speakers from the same company shall share the testimony time, i.e., multiple speakers from the same company shall not each get their own testimony times. Time limits do not include time needed to answer questions from the staff and/or committee members. The chairperson–moderator shall have limited authority to modify time limitations on testimony. The chairperson–moderator shall also have the authority to adjust time limits as necessary in order to get through the hearing agenda.

An automatic timing device shall keep time for testimony and shall provide the time remaining to the speaker testifying. Interruptions during testimony will not be tolerated. It is the responsibility of the chairperson–moderator to maintain decorum and order during all testimony.

5.3 Approval of any action on an acceptance criteria shall be as specified in Section 3.3 of these rules. Possible actions made by the Evaluation Committee include: Approval; Approval with Revisions; Disapproval; or Further Study. The Evaluation Committee must give the reason(s) for any Disapproval or Further Study actions with specific recommendations.

5.4 Actions of the Evaluation Committee may be appealed in accordance with the ICC-ES Rules of Procedure for Appeal of Acceptance Criteria or the ICC-ES Rules of Procedure for Appeals of Evaluation Committee Technical Decisions.

6.0 COMMITTEE BALLOTING FOR ACCEPTANCE CRITERIA

6.1 Acceptance criteria may be revised without a public hearing following a 30-day public comment period and a majority vote for approval by the Evaluation Committee (i.e., alternative criteria development process), when at the discretion of the ICC-ES executive staff, the subject is a revision that requires formal action by the Evaluation Committee.

6.2 Negative votes must be based upon one or more of the following, for the ballots to be considered valid and require resolution:

a. *Lack of clarity*: There is insufficient explanation of the scope of the acceptance criteria or insufficient description of the intended use of the product or system; or the acceptance criteria is so unclear as to be unacceptable. (The areas where greater clarity is required must be specifically identified.)

b. *Insufficiency*: The criteria is insufficient for proper evaluation of the product or system. (The provisions of the criteria that are in question must be specifically identified.)

c. *The subject of the acceptance criteria is not within the scope of the applicable codes*: A report issued by ICC-ES is intended to provide a basis for approval under the codes. If the subject of the acceptance criteria is not regulated by the codes, there is no basis for issuing a report, or a criteria. (Specifics must be provided concerning the inapplicability of the code.)

d. *The subject of the acceptance criteria needs to be discussed in public hearings*. The committee member requests additional input from other committee members, staff or industry.

6.3 An Evaluation Committee member, in voting on an acceptance criteria, may only cast the following ballots:

- Approved
- Approved with Comments
- Negative: Do Not Proceed

7.0 COMMITTEE COMMUNICATION

Direct communication between committee members, and between committee members and an applicant or concerned party, with regard to the processing of a particular acceptance criteria or evaluation report, shall take place only in a public hearing of the Evaluation Committee. Accordingly:

7.1 Committee members receiving an electronic ballot should respond only to the sender (ICC-ES staff). Committee members who wish to discuss a particular matter with other committee members, before reaching a decision, should ballot accordingly and bring the matter to the attention of ICC-ES staff, so the issue can be placed on the agenda of a future committee meeting.

7.2 Committee members who are contacted by an applicant or concerned party on a particular matter that will be brought to the committee will refrain from private communication and will encourage the applicant or concerned party to forward their concerns through the ICC-ES staff in writing, and/or make their concerns known by addressing the committee at a public hearing, so that their concerns can receive the attention of all committee members.■

Revised May 2024

PROPOSED REVISIONS TO THE ACCEPTANCE CRITERIA FOR SEISMIC CERTIFICATION BY SHAKE-TABLE TESTING OF NONSTRUCTURAL COMPONENTS

AC156

Proposed November 2024

Previously approved October 2010, December 2006, June 2004, January 2000

(Previously editorially revised December 2020, September 2019, November 2018, May 2015, February 2012)

PREFACE

Evaluation reports issued by ICC Evaluation Service, LLC (ICC-ES), are based upon performance features of the International family of codes, and may include other codes, as applicable.

For alternative materials, design and methods of construction and equipment, see Section 104.2.3 of the 2024 *International Building Code*® (IBC), Section R104.2.2 of the 2024 *International Residential Code*® (IRC), Section 104.11 of the 2021 IBC and earlier editions, and Section R104.11 of the 2021 IRC and earlier editions.

ICC-ES may consider alternate criteria for report approval, provided the report applicant submits data demonstrating that the alternate criteria are at least equivalent to the criteria set forth in this document, and otherwise demonstrate compliance with the performance features of the codes. ICC-ES retains the right to refuse to issue or renew any evaluation report, if the applicable product, material, or method of construction is such that either unusual care with its installation or use must be exercised for satisfactory performance, or if malfunctioning is apt to cause injury or unreasonable damage.

Acceptance criteria are developed for use solely by ICC-ES for purposes of issuing ICC-ES evaluation reports

PROPOSED REVISIONS TO THE ACCEPTANCE CRITERIA FOR SEISMIC CERTIFICATION BY SHAKE-TABLE TESTING OF NONSTRUCTURAL COMPONENTS (AC156)

1.0 INTRODUCTION

1.1 Purpose: The purpose of this criteria is to establish minimum requirements for the seismic certification by shake-table testing of nonstructural components to be evaluated in ICC Evaluation Service, LLC, (ICC-ES) evaluation reports in accordance with the 2024, 2021, 2018, 2015, 2012, 2009 or 2006 *International Building Code*® (IBC). The basis of evaluation is 2024 IBC Section 104.2.3 (2021, 2018, 2015, 2012, 2009 or 2006 IBC Section 104.11).

The reason for the development of this criteria is to provide detailed procedures for seismic certification by testing of nonstructural components as an alternative to code-prescribed requirements.

1.2 Scope: This acceptance criteria is applicable for shake-table testing of nonstructural components that have fundamental frequencies greater than or equal to 1.3 Hz, as permitted by Section 13.2.6 of ASCE/SEI 7-22 (Section 13.2.5 of ~~ASCE~~ASCE/SEI 7-16). This criteria is not intended to evaluate effects of relative displacements on nonstructural components as required by Section 13.3.2 of ~~ASCE~~ASCE/SEI 7. Testing done in accordance with this criteria is intended to support data for the seismic certification of architectural, mechanical, electrical and other nonstructural systems, components, and elements permanently attached to structures, as specified in Section 1705.14.2 of the 2024 and 2021 IBC, Section 1705.13.2 of the 2018 and 2015 IBC, Section 1705.12.3 of the 2012 IBC, Section 1708.4 of the 2009 IBC or Section 1708.5 of the 2006 IBC, and Section 13.2 of ~~ASCE~~ASCE/SEI 7.

1.3 Codes and Referenced Standards:

1.3.1 2024, 2021, 2018, 2015, 2012, 2009 and 2006 *International Building Code*® (IBC), International Code Council.

1.3.2 ASCE/SEI 7-22 (for the 2024 IBC), Minimum Design Loads for Buildings and Other Structures, American Society of Civil Engineers/Structural Engineering Institute.

1.3.3 ASCE/SEI 7-16 with Supplement 1 (for the 2021 IBC), Minimum Design Loads for Buildings and Other Structures, American Society of Civil Engineers.

1.3.4 ASCE Standard, SEI/ASCE 7-16 (for the 2018 IBC), Minimum Design Loads for Buildings and Other Structures, American Society of Civil Engineers.

1.3.5 ASCE Standard, SEI/ASCE 7-10 Including Supplement 1 (for the 2015 IBC), Minimum Design Loads for Buildings and Other Structures, American Society of Civil Engineers.

1.3.6 ASCE Standard, SEI/ASCE 7-10 (for the 2012 IBC), Minimum Design Loads for Buildings and Other Structures, American Society of Civil Engineers.

1.3.7 ASCE Standard, SEI/ASCE 7-05 (for the 2009 and 2006 IBC), Minimum Design Loads for Buildings and Other Structures, American Society of Civil Engineers.

1.3.8 FEMA 461, Interim Testing Protocols for Determining the Seismic Performance Characteristics of Structural and Nonstructural Components, June 2007, Federal Emergency Management Agency.

1.3.9 IEEE Standard 344-2004, IEEE Recommended Practice for Seismic Qualification of Class 1E Equipment for Nuclear Power Generating Stations, IEEE.

2.0 NOMENCLATURE:

The following symbols and notations have the noted meaning in this document:

S_{DS} = Design spectral response acceleration at short period, as determined in Section 1613.~~2~~1 of the 2024 IBC, Section 1613.2.4 of the 2021 and 2018 IBC; Section 1613.3.4 of the 2015 and 2012 IBC; or Section 1613.5.4 of the 2009 or 2006 IBC.

S_a = 5 percent damped design spectral acceleration parameter at any period as defined in Section 11.4.5 of ASCE/SEI 7-22 (Section 11.4.6 for ASCE/SEI 7-16).

z = Height of structure (in feet or mm) with respect to grade, at point of attachment of the component. For items at or below the base, z shall not be taken to be less than 0.0.

h = Average building/structure roof height (in feet or mm) relative to the base elevation.

z/h = Height factor ratio. For nonstructural components located at grade or below, z/h = 0.

H_f = Force amplification factor as a function of height. For nonstructural components supported at or below grade plane, H_f is 1.0. For nonstructural components supported above grade plane, H_f must be determined in accordance with Equation 13.3-5 of ASCE/SEI 7-22.

R_p = Component response modification factor. R_p represents the energy absorption capability of the component structure and its attachments, set forth in Table 13.5-1 or 13.6-1 of ~~ASCE~~ASCE/SEI 7, as applicable.

R_{po} = Component strength factor. R_{po} represents the inherent overstrength of the component and its attachment, set forth in Table 13.5-1 or 13.6-1 of ASCE/SEI 7-22.

R_u = Structure ductility reduction factor. R_u represents the factor associated with the building or nonbuilding structure supporting the components. R_u must be determined in accordance with Section 13.3.1.2 of ASCE/SEI 7-22.

I_p = Component importance factor, as set forth in Section 13.1.3 of ~~ASCE~~ASCE/SEI 7.

$A_{FLX\text{-}H}$ = Horizontal spectral acceleration calculated for flexible components.

$A_{FLX\text{-}V}$ = Vertical spectral acceleration calculated for flexible components at z/h = 0.

A_{RIG-H} = Horizontal spectral acceleration calculated for rigid components.

A_{RIG-V} = Vertical spectral acceleration calculated for rigid components at z/h = 0.

a_p = In-structure component amplification factor. The a_p represents the dynamic amplification of the component at the fundamental frequency of the building structure as defined in Table 13.5-1 or 13.6-1 of ASCE/SEI 7.

C_{AR} = Component resonance ductility factor. The C_{AR} shall be assigned on whether the component is supported at or below grade plane or above grade plane by a building or nonbuilding structure as defined in Table 13.5-1 or 13.6-1 of ASCE/SEI 7-22.

F_p = Horizontal seismic design force centered at the component's center of gravity, and distributed relative to the equipment's mass distribution (lbf or N).

W_p = Component operating weight (lbf or N).

3.0 DEFINITIONS:

3.1 Attachments: The means by which components are secured or restrained to the supporting structure or foundation. Examples may include anchor bolting, welded connections, mechanical fasteners and isolators.

3.2 Biaxial Test: A dynamic test in which the test specimen is subjected to acceleration in one principal horizontal axis and the vertical axis simultaneously. The horizontal and vertical acceleration components are derived from two different input signals that are phase-incoherent.

3.3 Build-hold-decay (BHD): The time interval envelope (5 + 0 / – 3 seconds, 20 + 6 / – 0 seconds and 5 + 0 / – 3 seconds, respectively) imposed on the drive signal of the shake table to simulate the nonstationary nature of an earthquake event. The build time includes time necessary for acceleration ramp-up, the hold time represents the earthquake strong motion time duration, and the decay time includes the de-acceleration ring down time. A straight linear approximation is acceptable.

3.4 Damping: An energy dissipation mechanism that reduces the amplification and broadens the vibratory response in the region of resonance in the frequency domain. Damping is expressed as a percentage of critical damping. This criteria is based on 5 percent of critical damping.

3.5 Flexible Component: Component, including its attachments and force-resisting structural members, having a fundamental period greater than 0.06 second (less than 16.67 Hz).

3.6 Component Force-resisting System: Those members or assemblies of members, including braces, frames, struts and attachments that provide structural stability for the connected components and transmit all loads and forces between the component and the supporting structure or foundation.

3.7 Octave: The interval between two frequencies that have a frequency ratio of 2.

3.8 One-third Octave: The interval between two frequencies that have a frequency ratio of $2^{1/3}$.

3.9 One-sixth Octave: The interval between two frequencies that have a frequency ratio of $2^{1/6}$.

3.10 Required Response Spectrum (RRS): The response spectrum generated using the formulas and normalized spectra detailed in Section 6.5.1 or Section 6.5.2 of this acceptance criteria. The RRS constitutes a requirement to be met.

3.11 Ring-down Time: The time required for vibration of the shake table to decrease to a negligible level following excitation.

3.12 Rigid Component: A component, including its attachments and force-resisting structural members, having a fundamental period less than or equal to 0.06 second (greater than or equal to 16.67 Hz).

3.13 Subassemblies: A grouping or assemblage of sub-components and/or structural elements that require attachment to the component's primary force resisting system to achieve structural stability.

3.14 Seismic Capacity: Seismic capacity of a component, for the purposes of this criteria, is defined as capacity, associated with the component's internal structure and its attachments, to resist seismically induced forces and deformations, and maintain structural integrity. Post-test functionality shall be maintained for components with I_p = 1.5,

3.15 Test Response Spectrum (TRS): The acceleration response spectrum that is developed from the actual time history of the motion of the shake table test as measured by reference control accelerometers mounted on the shake table at a location near the base of the UUT.

3.16 Transmissibility: The nondimensional ratio of the response acceleration amplitude of a system in steady-state forced vibration to the excitation amplitude and is used to characterize resonant modes of structural vibration. One approach to estimating this value is the ratio of the Fourier Transform of the system's acceleration to that of the excitation.

3.17 Triaxial Test: A dynamic test in which the test specimen is subjected to acceleration in two principal horizontal axes and the vertical axis simultaneously. The two horizontal and the vertical acceleration components are derived from three different input signals that are phase-incoherent.

3.18 Uniaxial Test: A dynamic test in which the test specimen is subjected to acceleration in one principal axis. The acceleration components are derived from a single input signal.

3.19 Unit Under Test (UUT): The component item to be certification-tested.

3.20 Zero Period Acceleration (ZPA): The peak acceleration of motion time-history that corresponds to the high-frequency asymptote on the response spectrum. This acceleration corresponds to the maximum peak acceleration of the time history used to derive the spectrum. For use in this acceptance criteria, the ZPA is assumed to be the acceleration response at 33.3 Hz or greater.

4.0 UUT REQUIRED INFORMATION

Sections 4.1 through 4.6 detail the necessary information to be provided for each UUT. Section 4 shall be a complete document, submitted by the UUT manufacturer or the manufacturer's representative and included as an appendix to the Test Plan described in Section 6.1. A qualification test plan shall be submitted to and approved by ICC-ES staff prior to any testing being conducted.

4.1 Manufacturer and Testing Laboratory Contact Information: The following contact information shall be specified:

4.1.1 Manufacturer's contact information as follows:

Manufacturer: Company name.

Address: Company address.

Primary contact: Representative's name.

Phone number: Representative's phone number.

E-mail: Representative's e-mail address.

4.1.2 Testing laboratory's contact information as follows:

Testing Laboratory: Laboratory name.

Address: Laboratory address.

Primary contact: Representative's name.

Phone number: Representative's phone number.

E-mail: Representative's e-mail address.

4.2 UUT Description: A description of the UUT shall be provided, including the following items:

Name: Product name

UUT designation: Short alphanumeric UUT designator used for plotting and test run purposes.

UUT function: A general description of the primary function or end use of the product.

Description: A detailed description of the UUT configuration. This should include a listing of major subassemblies and sub-components (e.g., bills of material) and any other applicable product differentiation.

Identification no.: Supply UUT's unique identification number or serial number. Product identification shall be in accordance with the product identification provisions of the ICC-ES Rules of Procedure for Evaluation Reports.

Dimensions: Height = xx in. (mm); Width = xx in. (mm); Depth = xx in. (mm).

Weight: Approximately xxx lbs. (kg) and, if known, center of mass.

Restrictions: Provide any product restrictions or limitations on use.

UUT mounting: Description of mounting method and configuration, including fastenings as applicable.

Component Importance Factor for Test: *Ip* = X.X

4.3 Seismic Parameters

The seismic parameters used to establish maximum UUT seismic test requirements shall be provided as shown in Table 1 below.

Table 1—Shake Table Test Parameters

BUILDING CODE	TEST CRITERIA	S_{DS} (g)	z/h	HORIZONTAL		VERTICAL	
				A_{FLX-H}	A_{RIG-H}	A_{FLX-V}	A_{RIG-V}
IBC 20**	ICC-ES AC156						

4.4 Functionality Requirements: A listing and detailed description shall be provided of the functionality requirements and/or tests used to verify pre- and post-seismic-testing functional compliance of components.

Each test and/or requirement should be listed as a separate line item.

4.5 Component Product Line Extrapolation and Interpolation: Testing every single configuration of a given component product line may not be feasible. Therefore, it may be necessary to select test specimens that adequately represent the entire component product line.

Details for establishing a test plan shall be taken from requirements set forth in the applicable acceptance criteria for product. A qualification test plan shall be submitted to and approved by ICC-ES staff prior to any testing being conducted.

The following criteria shall be used to establish UUT configuration requirements for representing a component product line (UUT configuration rationale shall be provided):

4.5.1 Structural Features: A rationale shall be provided explaining that the selected UUT's structural configurations are offering the least seismic capacity compared to other options that are available within the product line being qualified. The UUT's force-resisting systems shall be similar to the major structural configurations being supplied in the product line. If more than one major structure is a configurable option, then these other structural configurations shall be considered in the component product line extrapolation and interpolation rationalization process.

4.5.2 Mounting Features: A rationale shall be provided that explains that the selected UUT's mounting configurations are offering the least seismic capacity compared to other mounting options that are available within the product line being qualified. The configuration mounting of the UUT to the shake-table shall simulate mounting conditions for the product line. Seismic testing of components may be conducted using the smallest diameter tie-down bolt size (or minimum weld size) that can be accommodated with the provided tie-down clearance holes (or base structural members) on the components. If several mounting configurations are used, they shall be simulated in the test.

Use of specific test results shall be limited to the mounting type and configuration. Where individual components of a multi-component system are certified by test, the flexibility of the supporting structure in the component to point of anchorage shall be replicated in the test setup. Alternately, the input motions for the test setup may be modified to account for this flexibility using a rational analytical method. The components from the mounting brackets to the supporting structure shall have equivalent flexibility and strength to what is used in the component certification test and may be certified by a supporting analysis.

4.5.3 Subassemblies: A rationale shall be provided explaining that the selected UUT's subassemblies are representative of production hardware and offer the least seismic capacity of the UUT compared to other subassembly options that are available within the product line being qualified. The major subassembly components shall be included in the UUT. These components shall be mounted to the specimen structure at locations similar to those specified for proposed installations. The components shall be mounted to the structure using the same type of mounting hardware specified for proposed installations. Substitution of nonhazardous materials and fluids is permitted for verification of components or subassemblies that contain hazardous materials or fluids, provided the substitution does not reduce the functional demand on the component or subassembly.

4.5.4 Mass Distribution: A rationale shall be provided explaining that the selected UUT's mass distribution is one contributing to the least seismic capacity of the UUT compared to other mass distribution options that are available within the product line being qualified. The weight and mass distribution shall be similar to the typical weight and mass distribution of the component being represented. Weights equal to or greater than the typical weight shall be acceptable.

4.5.5 Component Variations: A rationale shall be provided explaining that the selected UUT's overall variations contribute to the least seismic capacity of the UUT compared to other variations that are available within the product line being qualified. Other component variations, such as number of units/components in production assemblies, indoor and outdoor applications, etc., shall be considered in the component product line extrapolation and interpolation rationalization process.

4.6 Installation Instructions: Instructions shall include the following items:

1. Description of how the UUT will be installed in the field.
2. Description of how the UUT will be installed during the certification test.

5.0 TESTING LABORATORIES AND REPORTS OF TESTS:

5.1 Testing Laboratories: Testing laboratories shall comply with Section 2 of the ICC-ES Acceptance Criteria for Test Reports (AC85) and Section 4.2 of the ICC-ES Rules of Procedure for Evaluation Reports.

5.2 Test Reports:

5.2.1 General: Test reports shall comply with AC85.

5.2.2 Specific: Reports of all tests noted in Section 6 are required. In addition, the following items must be reported:

5.2.2.1 Identification of component being qualified along with their dimensions and weights.

For a custom product line, where subcomponents in each assembled product can potentially be different, all qualified subcomponents along with their dimensions and weights shall be listed. If there is more than one manufacturer or material for any subcomponent, each manufacturer's subcomponent for each material shall be treated as a separate product. Different operating conditions for components for which equipment is certified shall be listed.

5.2.2.2 Seismic parameters and derived RRS levels for the component that is being qualified in accordance with Section 4.3.

5.2.2.3 Results of pre- and post-test structural integrity and functionality requirements and/or testing.

5.2.2.4 Testing facility location and a list of observers present for test/functionality verification.

5.2.2.5 Testing equipment description, including size and capacity of the shake table and verification of calibration of instruments used in the test.

5.2.2.6 Component mounting details, including all interface connections.

Photographs of component set-up on the shake table before and after test including detailed photographs of anomalies observed during or after test.

5.2.2.7 Results of test data, including proof of performance, TRS plots, acceleration time histories of the shake table motion, acceleration transmissibility plots, UUT dimensions and measured weight, etc.

5.2.2.7.1 TRS plots in each of the three directions shall show corresponding RRS, 90 percent RRS, and 130 percent of RRS. Damping ratio used in generating RRS and TRS shall be indicated on the TRS plots. TRS plots for each certification test conducted shall be provided. For traceability, the TRS plots shall reference the name of the corresponding data file.

5.2.2.7.2 The resonance frequency in each of the three directions for each UUT shall be included in the report similar to Table 2 below.

TABLE 2—UNIT UNDER TEST (UUT) RESONANCE FREQUENCY

UUT	RESONANCE FREQUENCY (Hz)		
Identification	Front-to-Back	Side-to-Side	Vertical

5.2.2.7.3 Verification that simultaneous shake table motion in three orthogonal directions are phase-incoherent (statistically independent) shall be provided.

5.2.2.8 Test results and conclusions including any anomalies observed during or after the test, and justification that the component is still qualified. Resolution of all significant anomalies, which affect either component force resisting system or functionality of components with *Ip* = 1.5, shall be addressed in the test report.

5.2.2.9 UUT required information in accordance with Section 4.0 shall be added to the test report as an appendix.

5.3 Product Sampling: Sampling of components for tests under this criteria shall comply with Section 3.1 of AC85.

6.0 SEISMIC CERTIFICATION TEST PROCEDURE

6.1 Seismic Certification Test Plan: The UUT shall be subjected to a seismic certification test program, considering all elements noted in this section. The seismic certification test plan is intended to satisfy the requirements of Section 1705.14.2 of the 2024 and 2021 IBC, Section 1705.13.2 of the 2018 and 2015 IBC, Section 1705.12.3 of the 2012 IBC, Section 1708.4 of the 2009 IBC or Section 1708.5 of the 2006 IBC and Section 13.2 of ~~ASCE~~ASCE/SEI 7 for components. References for setting the test plan and objectives include ANSI/IEEE 344 and FEMA 461. A qualification test plan shall be submitted to and approved by ICC-ES staff prior to any testing being conducted.

6.2 Pre-test Inspection: Upon arrival at the test facility, the UUT shall be visually examined and results documented by the testing laboratory, to verify that no damage has occurred during shipping and handling.

6.3 Pre-test Functional Compliance Verification: Functionality requirements and/or tests, as specified in Section 4.4, shall be performed by an accredited testing laboratory to verify pre-test functional performance. Functional testing could be performed at either the test facility or at the UUT manufacturing facility. Test description and results shall be documented in accordance with Section 5.2 (Test Reports).

6.4 Seismic Simulation Test Setup: Seismic ground motion occurs simultaneously in all directions in a random fashion. The requirement is to perform qualification testing in all three principal axes, two horizontal and vertical. However, for certification test purposes, uniaxial, biaxial or triaxial test machines are allowed in accordance with the following test requirements.

6.4.1 Triaxial, Biaxial, and Uniaxial Testing Requirements: The preferred method of performing testing is using a triaxial shake table. However, it is recognized that capable triaxial testing facilities are limited in number, and this may restrict testing access. Use of biaxial or uniaxial testing shall consider component configuration in determining orientations that permit the largest response to shake table accelerations. The following requirements shall be used when performing triaxial, biaxial, or uniaxial testing.

6.4.1.1 Triaxial Testing: If a triaxial test is performed, the test shall be performed in one stage with the two principal horizontal axes and the vertical axis of the UUT simultaneously tested.

6.4.1.2 Biaxial Testing: If a biaxial test is performed, the test shall be performed in two stages, with the UUT rotated 90 degrees about the vertical axis for the second stage.

6.4.1.3 Uniaxial Testing: If a uniaxial test is performed, the test shall be performed in three distinct stages, with the UUT rotated after each stage, such that all three principal axes of the UUT have been tested.

6.4.2 Weighing: The UUT shall be weighed prior to performing the Seismic Simulation Tests. The measured UUT weight shall be recorded in the Test Report as set forth in Section 5.2.

6.4.3 Mounting: The UUT shall be mounted on the shake table in a manner that simulates the intended service mounting in accordance with Section 4.5.2. The mounting method shall be the same as that recommended for actual service, and shall use the minimum recommended bolt size, bolt type, bolt torque, configuration, weld pattern and type (if applicable), etc. The orientation of the UUT during the tests shall be such that the principal axes of the UUT are collinear with the axes of excitation of the shake table. A description of any interposing fixtures and connections between the UUT and the shake table shall be provided.

6.4.4 Monitoring: Sufficient vibration response monitoring instrumentation shall be used to allow determination of the applied acceleration levels in the principal horizontal and vertical axes of the shake table. Reference control accelerometers shall be mounted on the shake table at a location near the base of the UUT. Vibration response monitoring instrumentation shall also be used to determine the response of the UUT, at those points within the structure that reflect the UUT's response associated with its structural fundamental frequencies. Placement locations for the response sensors shall be at the discretion of the UUT manufacturer or the manufacturer's representative and approved by the test laboratory prior to testing. Sensors shall be installed, calibrated and approved by the test laboratory prior to testing. The accredited laboratory shall document the location, orientation, and calibration of all vibration monitoring sensors.

6.4.5 Resonant Frequency Search: The resonant frequency search test is for determining the resonant frequencies and damping of components. The data obtained from the search test is an essential part of an component certification; however, the search test does not constitute a seismic test certification by itself. A low-level amplitude (0.1± 0.05 g peak input; a lower input level may be used to avoid component damage) single-axis sinusoidal sweep from 1.3 to 33.3 Hz shall be performed in each orthogonal UUT axis to determine resonant frequencies. The sweep rate shall be two octaves per minute, or less, to ensure adequate time for maximum response at the resonant frequencies. Transmissibility plots of the in- line UUT response monitoring sensors shall be provided along with a table showing resonant frequencies in accordance with Section 5.2.2.7.2.

6.5 Multi-frequency Seismic Simulation Tests:

6.5.1 Derivation of Seismic RRS under 2024 IBC: The component earthquake effects shall be determined for combined horizontal and vertical load effects. The required response spectra for the horizontal direction shall be developed based on the normalized response spectra shown in Figure 1, and the formula for total design horizontal force, F_p. The required response spectra for the vertical direction shall be developed based on two-thirds of the ground-level base horizontal acceleration. The seismic parameters specified in Section 4.3 shall be used to calculate the RRS levels as defined by A_{FLX-H}, A_{RIG-H}, A_{FLX-V}, and A_{RIG-V}. The RRS shall be defined using a damping value equal to 5 percent of critical damping.

The required response spectra for both horizontal and vertical directions shall be developed based on the formula for total design horizontal force, F_p, as follows:

The horizontal force requirements shall be as determined using Equation 13.3-1 of ASCE/SEI 7-22, which reads as follows:

$$F_p = 0.4 S_{DS}\, I_p W_p \left[\frac{H_f}{R_\mu}\right]\left[\frac{C_{AR}}{R_{po}}\right]$$

The equation parameters [C_{AR}/R_{po}] represent the dynamic characteristics and capacity of the component. Some nonstructural components are stiff, and others are more flexible and more likely in tune with ground/floor motion's dynamic amplification properties and therefore typically result in larger resonant amplifications (i.e., dynamic characteristics). Also, some components are stronger, and some are weaker. The dynamic characteristics and strength of the component do not affect the shake-table test demand motion. Under seismic testing demands, flexible components will respond more to the input excitation than stiff (i.e., rigid) components. Thus, the ratio of [C_{AR}/R_{po}] is not included in the test demand (i.e., set to 1.0) since the dynamic characteristic and strength is already inherently included in the resulting response of the item being tested.

The equation parameters [$\frac{H_f}{R_\mu}$] represent in-structure building amplification to amplify ground motion for component installations located above grade plane elevation, where H_f is the demand amplification factor as a function of the building height ratio and R_μ is a function of the structure's ductility reduction factor. The H_f factor is defined in Section 13.3.1.1 of the ASCE/SEI 7-22 standard. For component applications where the building height ratio equals zero (z/h = 0), H_f shall be taken as 1.0. Where the dynamic characteristics of the building or nonbuilding structure are unknown or unspecified, H_f shall be taken as 3.5 for component applications where the building height ratio equals one (z/h = 1). The R_μ factor is defined in Section 13.3.1.2 of the ASCE/SEI 7-22 standard. For component applications where the building height ratio equals zero (z/h = 0), R_μ shall be taken as 1.0. Where the dynamic characteristics of the building or nonbuilding structure are unknown or unspecified, R_μ shall be taken as 1.3 for component applications where the building height ratio equals one (z/h = 1).

The equipment importance factor, I_p, is not used to increase the seismic testing demand when conducting shake-table testing. The equipment importance factor, I_p, greater than one (e.g., I_p = 1.5) is used to demonstrate a level of functionality following seismic simulation testing, and is used in this criteria to determine post-test UUT functionality compliance in accordance with Section 6.8.

Component applications at grade plane elevation and below, the test spectral demand is equivalent in response acceleration to the ASCE/SEI 7-22 two-period format design earthquake response spectrum. Thus, the equation parameter 0.4 S_{DS} represents the site hazard design earthquake response spectral acceleration at zero-period (T = 0), where S_{DS} is the peak spectral response acceleration at 0.2 s period (T = 0.2) for two-period format ground motion spectra. The ground motion peak spectral response acceleration, S_{DS}, is 2.5 times the zero-period response acceleration. 2024 IBC introduced the use of multi-period format ground motion spectra, S_a, alongside of the two-period format spectra. Since the ASCE/SEI 7-22 nonstructural equation is based on the two-period spectrum, the peak response acceleration for multi-period design response spectra applications is converted to the two-period format spectrum in accordance with ASCE/SEI 7-22 Section 21.4. Section 21.4 specifies that S_{DS} is equal to 0.9 times the maximum value for S_a at any period within the range from 0.2 to 5 s, inclusive, where S_a is the design, 5% damped, spectral response acceleration parameter at multiple periods. The zero-period response acceleration (0.4 S_{DS}) is used to define A_{RIG} test spectral demands and the peak response acceleration, S_{DS}, is used to define A_{FLX} test spectral demands.

Component applications located above grade plane elevation (in-structure elevations), the test spectral demands are increased by the [H_f/R_μ] amplification factor. The 2.5 ratio between peak response acceleration and zero-period response acceleration at in-structure elevations is maintained until the maximum spectral demand value of 1.6 S_{DS} occurs.

This results in two normalizing acceleration factors, that when combined, defines the horizontal component certification RRS:

$A_{FLX-H} = S_{DS}\left(\frac{H_f}{R_\mu}\right)$ and $A_{RIG-H} = 0.4S_{DS}\left(\frac{H_f}{R_\mu}\right)$

where A_{FLX-H} is limited to a maximum value of 1.6 times S_{DS} or value of 3.2, whichever is higher.

For vertical response, the in-structure building amplification, $\frac{H_f}{R_\mu}$ may be taken to be 1.0 for all attachment heights, which results in:

$$A_{FLX-V} = \frac{2}{3}S_{DS} \text{ and } A_{RIG-V} = \frac{2}{3}0.4S_{DS}$$

6.5.2 Derivation of Seismic RRS under 2021 IBC and earlier codes: The component earthquake effects shall be determined for combined horizontal and vertical load effects. The required response spectra for the horizontal direction shall be developed based on the normalized response spectra shown in Figure 1, and the formula for total design horizontal force, F_p. The required response spectra for the vertical direction shall be developed based on two-thirds of the ground-level base horizontal acceleration. The seismic parameters specified in Section 4.3 shall be used to calculate the RRS levels as defined by A_{FLX-H}, A_{RIG-H}, A_{FLX-V}, and A_{RIG-V}. ~~A_{FLX-H}, A_{RIG-H}, A_{FLX-V}, and A_{RIG-V}.~~ The RRS shall be defined using a damping value equal to 5 percent of critical damping.

The required response spectra for both horizontal and vertical directions shall be developed based on the formula for total design horizontal force, F_p, as follows:

When the building dynamic characteristics are not known or specified, the horizontal force requirements shall be as determined using Equation 13.3-1 of ~~ASCE~~ASCE/SEI 7-16 (and earlier editions), which reads as follows:

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

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

The equation parameters (a_p/R_p) represent the dynamic characteristics of the component. Some components are stiff (i.e., rigid), and others are more flexible. The dynamic characteristics of the component do not affect the shake-table input motion. Under seismic testing demands, more flexible components will naturally respond more to the input excitation than rigid components. Thus, the ratio of (a_p/R_p) is set to 1.0 since the dynamic characteristics and strength of the component are inherently considered in the testing.

The equation parameters (1 + 2 z/h) represent in-structure building amplification to amplify ground motion for component installations located above grade plane elevation, where the building height ratio, z/h, is defined as either grade plane elevation (which includes below grade plane), where z/h equals zero, and/or roof height elevation, where z/h equals one.

The equipment importance factor, I_p, is not used to increase the seismic testing demand when conducting shake-table testing. The equipment importance factor, I_p, greater than one (e.g., I_p = 1.5) is used to demonstrate a level of functionality following seismic simulation testing, and is used in this criteria to determine post-test UUT functionality compliance in accordance with Section 6.8.

The equation parameter 0.4 S_{DS} represents the site hazard design earthquake response acceleration at zero period (T = 0), where S_{DS} is the peak response acceleration at 0.2 s period (T = 0.2) for two-period format ground motion spectra. The ground motion peak response, S_{DS}, is 2.5 times the zero period response acceleration. The zero period response acceleration (0.4 S_{DS}) is used to define A_{RIG} test spectral demands and the peak response acceleration, S_{DS}, is used to define A_{FLX} test spectral demands.

~~The height factor ratio (z / h) accounts for above grade-level component installations within the primary supporting structure and ranges from zero at grade-level to one at roof level, essentially acting as a force increase factor to recognize building amplification as you move up within the primary structure. The site-specific ground spectral acceleration factor, S_{DS}, varies per geographic location and site soil conditions. The S_{DS} factor is used to define the general design earthquake response spectrum curve and is used to determine the design seismic forces for the primary building structure. The ratio of R_p over I_p (R_p / I_p) is considered to be a design reduction factor to account for inelastic response and represents the allowable inelastic energy absorption capacity of the component's force-resisting system. During the seismic simulation test, the UUT will respond to the excitation and inelastic behavior will naturally occur. Therefore, the ratio (R_p / I_p) shall be set equal to 1, which is indicative of an unreduced response. The importance factor, I_p, does not increase the seismic test input motion but does affect the requirement for the UUT to demonstrate a level of functionality following seismic simulation testing, and is used in this criteria to determine post-test UUT functionality compliance in accordance with Section 6.7. The component amplification factor, a_p, acts as a force increase factor by accounting for probable amplification of response associated with the inherent flexibility of the nonstructural component. The component amplification factor, a_p, shall be taken from the formal definition of flexible and rigid components. By definition, for fundamental frequencies less than 16.7 Hz the component is considered flexible (maximum amplification a_p = 2.5), which corresponds to the amplified re gion of the RRS. For fundamental frequencies greater than 16.7 Hz the component is considered rigid (minimum a_p = 1.0), which corresponds to the ZPA.~~ This results in two normalizing acceleration factors, that when combined, defines the horizontal component certification RRS:

$$A_{FLX-H} = S_{DS}\left(1+2\frac{z}{h}\right) \text{ and } A_{RIG-H} = 0.4\,S_{DS}\left(1+2\frac{z}{h}\right)$$

where A_{FLX-H}~~A_{FLX-H}~~ is limited to a maximum value of 1.6 times S_{DS} ~~S_{DS}~~ and under the 2021, 2018 and 2015 IBC A_{FLX-H}~~A_{FLX-H}~~ is not required to exceed 3.2.

For vertical response, z may be taken to be 0.0 for all attachment heights, which results in:

~~$A_{FLX\text{-}V}$ = 0.67*S_{DS} and $A_{RIG\text{-}V}$ = 0.27* S_{DS}~~

$$A_{FLX-V} = \frac{2}{3}S_{DS} \; and \; A_{RIG-V} = \left(\frac{2}{3}\right)0.4S_{DS}$$

In lieu of determining the spectral acceleration as described in this section, equivalent provisions based on ~~ASCE~~ASCE/SEI 7-16 (and earlier editions) Equation 13.3-4 shall be permitted for structure-specific applications.

6.5.3 Derivation of Test Input Motion: To meet the required response spectra as defined in Section 6.5.1 or 6.5.2, as applicable, the corresponding shake-table drive signals shall be nonstationary broadband random excitations having an energy content ranging from 1.3 to 33.3 Hz. The drive signal composition shall be multiple-frequency random excitations, the amplitudes of which adjusted either manually or automatically based on multiple-frequency bands. The exact bandwidth of individual bands employed shall be left to the discretion of the test laboratory. Typically, one-third-octave bandwidth resolution is used with analog synthesis equipment. However, the use of digital synthesis equipment may require narrower frequency bands on the order of one sixth-octave bandwidth. The process involves use of an aggregate of multiple narrowband signals that is input to the shake-table with each band adjusted until the TRS envelops the RRS according to the criteria specified in Section 6.5.~~3~~4. The total duration of the input motion shall be 30 seconds (nominal), with the non-stationary character being synthesized by an input signal build-hold-decay envelope specified in Section 3.3. The input duration of the time history tests shall contain at least 20 seconds of strong motion. Strong motion durations greater than 20 seconds shall be considered acceptable. Independent random signals that result from an aggregate of the narrowband signals shall be used as the excitation to produce phase incoherent motions in the principal horizontal and vertical axes of the shake table.

6.5.4 Test Response Spectrum Analysis: The test response spectrum (TRS) shall be computed using either justifiable analytical techniques or response spectrum analysis equipment using the control accelerometers located at the UUT base per Section 6.4.3. The TRS shall be calculated using a damping value equal to 5 percent of critical damping. The TRS must envelop the RRS based on a maximum-one-sixth octave bandwidth resolution over the frequency range from 1.3 to 33.3 Hz. The amplitude of each narrowband signal shall be independently adjusted in each of the principal axes until the TRS envelops the RRS. It is recommended that the TRS should not exceed the RRS by more than 30 percent over the amplified region of the RRS. Any acceleration-signal filtering performed within the range of analysis must be defined. The general requirement for the enveloping of the RRS by the TRS can be modified under the following conditions:

6.5.4.1 Amplified Region of RRS: In the performance of a test program, the TRS may not fully envelop the amplified region of the RRS (frequencies less than or equal to 8.3 Hz). The general requirement for a retest may be exempted if the following criteria are met:

6.5.4.1.1 In those cases in which it can be shown by use of the resonance search in Section 6.4.5 that no resonance response phenomena exist below 5 Hz, the TRS is required to envelop the RRS only down to 3.5 Hz. Excitation must continue to be maintained in the 1.3 Hz to 3.5 Hz range, within the limitations of the shake table.

6.5.4.1.2 When resonance phenomena exist below 5 Hz, the TRS is required to envelop the RRS only down to 75 percent of the lowest frequency of resonance.

6.5.4.1.3 When the absence of resonance response phenomena below 5 Hz cannot be justified, the general requirement applies and the low-frequency enveloping should be maintained down to 1.3 Hz.

6.5.4.1.4 A single point of the TRS may fall below the RRS (for frequencies less than or equal to 8.3 Hz) by 10 percent or less, provided the adjacent one-sixth-octave points are at least equal to the RRS.

6.5.4.1.5 A maximum of two of the one-sixth-octave analysis points may be below the RRS (for frequencies less than or equal to 8.3 Hz), as under the same constraints as noted in 6.5.~~3~~4.1.4.

6.5.4.2 ZPA Region of RRS: In the performance of a test program the TRS may not fully envelop the ZPA region of the RRS (frequencies greater than 8.3 Hz). The general requirement for a retest may be exempted if the following criteria are met:

6.5.4.2.1 A single point of the TRS may fall below the RRS (for frequencies greater than 8.3 Hz) by 10 percent or less, provided the adjacent one-sixth-octave points are at least equal to the RRS.

6.5.4.2.2 A maximum of two of the one-sixth-octave analysis points may be below the RRS (frequencies greater than 8.3 Hz), as under the same constraints as noted in Section 6.5.~~3~~4.2.1.

6.5.4.2.3 To achieve the minimum acceleration requirements specified by ~~ASCE~~ASCE/SEI 7, the peak shake table acceleration shall equal or exceed 90 percent of A_{RIG}.

6.6 Post-test Inspection: The UUT shall be visually examined and results documented upon completion of the multi-frequency seismic simulation tests performed in accordance with Section 6.5 to determine whether the UUT has adequate seismic capacity. The following conditions shall apply:

6.6.1 Structural integrity of the component attachment system shall be maintained. Limited yielding of the attachments shall be acceptable. Component design must ensure that the anchored UUT will not leave its mounting and cause damage to other building components or injury to personnel during the seismic event.

6.6.2 Components Force-resisting System: Structural integrity of the component force-resisting system shall be maintained. Structural damage, such as limited yielding, to UUT force-resisting members is acceptable and structural members and joints not comprising the UUT force-resisting system shall be allowed minor fractures and anomalies.

6.7 Post-test Functional Compliance Verification: Based upon the specified UUT importance factor in Section 4.2, the component being qualified must be capable of performing its intended functions after the seismic event.

6.8 Functionality requirements and/or tests, as specified in Section 4.4, shall be performed on the UUT to verify post-test functional compliance. Functional testing may be performed by an accredited testing laboratory at either the test facility or at the UUT manufacturing facility when required test equipment is not available at the test facility. Requirements of this section are satisfied if one of the following criteria is met.

6.8.1 Components with I_p = 1.0: At the completion of the seismic testing, the UUT does not pose a life or limb safety hazard due to collapse or due to major subassemblies becoming separated. Structural integrity of anchorage system and component force-resisting system shall be maintained. Structural damage, such as limited yielding, to UUT force-resisting members is acceptable and structural members and joints not comprising the UUT force-resisting system shall be allowed minor fractures and anomalies.

6.8.2 Components with I_p = 1.5: The component is deemed to be essential to the continued operation of a facility, and/or essential to maintaining critical life support systems, and/or contains materials deemed to be hazardous, to humans or the environment, in quantities greater than the exempted amounts listed in the code. After completion of the seismic testing, the UUT shall satisfy the functional and requirements and/or tests specified in Section 4.4, with equivalent results to those of the pre-test functional compliance testing of Section 6.3. UUT materials deemed to be hazardous shall not have been released into the environment in quantities greater than the exempted amounts listed in the code. In addition, at the completion of the seismic testing, the UUT does not pose a life-safety hazard due to collapse or major subassemblies becoming separated. Structural integrity of anchorage and component force-resisting system shall be maintained. Structural damage, such as limited yielding, to UUT force-resisting members is acceptable and structural members and joints not comprising the UUT force-resisting system shall be allowed minor fractures and anomalies. Minor repairs to the UUT (such as replacing a bulb) are allowed for the component to satisfy this section. Any repairs shall be documented and included in the final test report noted in Section 5.2. ■

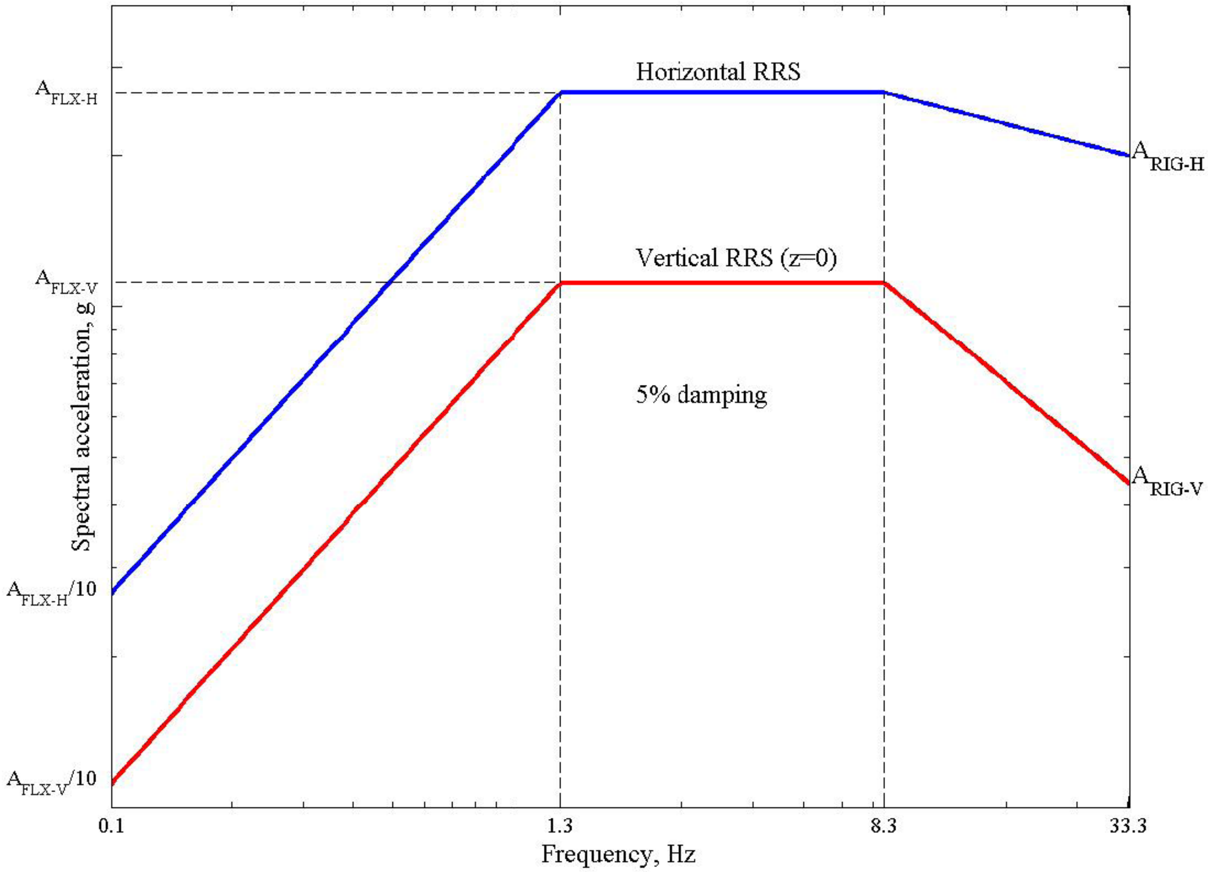


FIGURE 1—REQUIRED RESPONSE SPECTRUM, NORMALIZED FOR THE COMPONENT