Earthquake Environments

WHITE PAPER

This white paper outlines various standards related to electrical infrastructure and details the methods used to test and certify nVent HOFFMAN enclosures for earthquake resistance.

INTRODUCTION

Every day, hundreds of small to medium earthquakes rattle homes, buildings and other high-value structures globally. Casualties and structural damage from a given quake depend on many variables, including but not limited to:

- building codes;
- code enforcement rigor;
- structure age;
- construction materials;
- foundation design and reinforcement;
- soil properties;
- intensity (magnitude);
- depth;
- fault/thrust type;
- distance from epicenter.

Evidence from small and large quakes globally points to strict building codes, enforcement, and preparedness as key factors in mitigating injuries, fatalities, and structural losses. Moderate to large quakes in countries such as Haiti (2010, 7.0 M, 315,000 deaths), China (Tangshan, 1976, 7.5 M, 242,000 deaths), and Turkmenistan (Ashgabat, 1948, 7.2 M, 110,000 deaths) caused mass destruction and hundreds of thousands of fatalities. In quakes like these, unwitting inhabitants were no match for lax building codes, unreinforced masonry and concrete, or even corruption among some unscrupulous contractors and building officials.

Conversely, certain epic seismic events in recent history spared many lives, in part, due to more rigorous seismic design, code enforcement, and preparedness, for instance:

- Chile, 2010, 8.8 M, 500+ deaths, including 150 tsunami-related;
- Japan, 2011, 9.0 M, 20,000+ deaths, most tsunami-related.

Yet with so many uncontrolled variables, strict building codes alone are insufficient to preclude all human casualties or prevent damage to even the best engineered structures.

SCOPE

In the event of an earthquake, the type of electrical cabinet used to house equipment and components is often the deciding factor in whether or not the equipment will remain active, and selecting the proper electrical cabinet could mean the difference between failure and continued functionality.

Most manufacturers of electrical cabinets offer products that are marketed as offering earthquake-resistant cabinets; however, there can be significant differences in the standards used to achieve those certifications, and thus, major disparities in the level of protection that those products provide.

In addition, electrical substation cabinets are part of the electrical generation, transmission and distribution system, so they take on a relevant importance when an Earthquake occurs. For this reason, nVent HOFFMAN has additionally certified the most common configuration used for electrical substations, standard combinable enclosure mounting with a swing frame.

This white paper provides an overview of the different standards relating to the electrical infrastructure and also explains the methods used to test and certify nVent HOFFMAN's enclosures as earthquake-resistant.

STANDARDS

There are a number of standards and regulations relating to earthquake protection.
As already stated, building safety is often the primary concern. In certain regards, the standards adopt very different approaches according to the scientific discipline – civil engineering, electrical engineering or information technology.

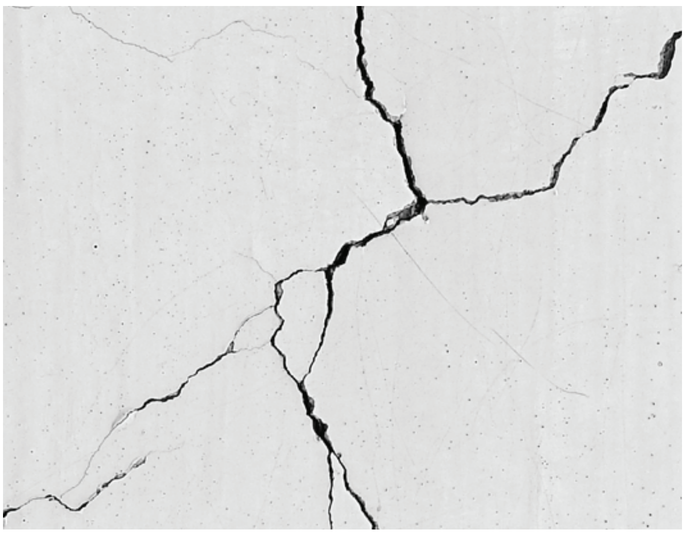
According to seismic codes, earthquake-resistant enclosures are intended to withstand the largest earthquake of a certain probability that is likely to occur at their location. This means the collapse of the structure should be minimized for rare earthquakes while the loss of the functionality should be limited for more frequent ones.

Nowadays, different standards may be applied, depending on the application, such as civil engineering, IT and telecommunications, and electrical engineering. Furthermore, the applicable standards also differ according to the geographical location.

Mainly, there are three relevant standards for switchgear systems and other electrical infrastructures:

DIN EN/IEC 60068-3-3
It is a set of documents that contains information on environmental testing procedures. It is published by the International Electrotechnical Commission and deals with environmental tests for electrical, electro-mechanical or electronic equipment and devices, their subassemblies and constituent parts and components.

Telcordia GR-63-CORE
Although the GR-63-CORE generic requirements originally developed by Telcordia are not a formal standard as such, they form a very commonly stipulated requirement in contracts, especially in the United States. The document refers to the designated zones in the United States (zones 0 to 4), where zone 0 represents a very low risk and zone 4 a high risk of earthquakes (see table 3).



Test Selection

TEST SELECTION

Nowadays, there are many possibilities and standards available to certify enclosures as earthquake resistant. nVent HOFFMAN, aiming to fulfil all customer requirements, has tested its combinable floor standing range, in particular MCS, to certify it according to:

- Telcordia GR-63-CORE

Telcordia GR-63-CORE

Within Telcordia GR-63-CORE, the document refers to different zones in the United States, from zone 0 up to 4, representing zone 0, a very low risk, and zone 4, a high risk of earthquakes.

Comparing with other standards, such as DIN EN/IEC 60068-3-3, Telcordia GR-63-CORE requirements are higher, which is another reason why it is the most popular seismic certification in the market. For instance, referring to seismic zone, values for Upper Floor Acceleration (g) are as follows:

	Coordinate Point	Frequency (Hz)	Values for Upper Floor Acceleration (g)
Zones 1 and 2	1	0.3	0.2
	2	0.6	2.0
	11	5.0	2.0
	12	15.0	0.6
	13	50.0	0.6
Zone 3	1	0.3	0.2
	2	0.6	2.0
	7	1.0	3.0
	8	5.0	3.0
	9	15.0	1.0
	10	50.0	1.0
Zone 4	1	0.3	0.2
	2	0.6	2.0
	3	2.0	5.0
	4	5.0	5.0
	5	15.0	1.6
	6	50.0	1.6

Table 1. Upper Floor Acceleration (g). Telcordia GR-63-CORE

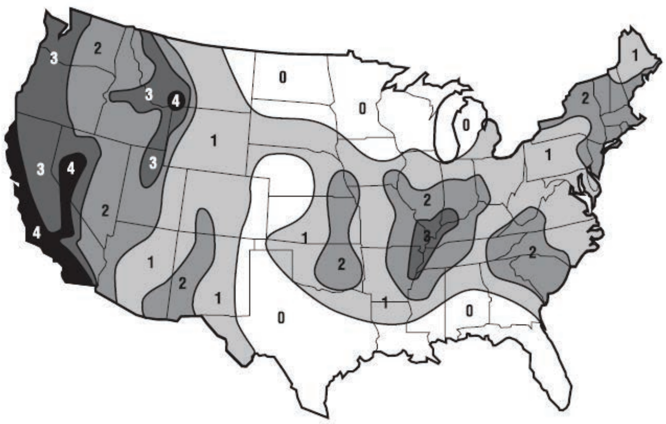


Figure 1. Telcordia Seismic Zones

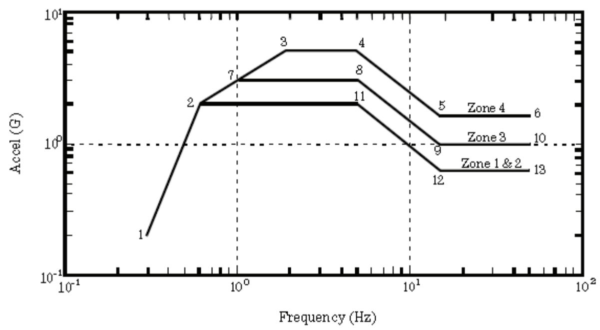


Figure 2. Required Response Spectra

Standard	ÖN 1998-1	DIN EN 1998-1	SIA 261	NF EN 1998-1	OPCM 28	Gna 1998-1	1997 UBC
Zone 0	a < 0.035 g	0.0g	—	—	—	—	0.0 g
Zone 1	0.035 g < a < 0.05 g	0.04 g	0.06 g	a < 0.07 g	a < 0.05 g	a < 0.16 g	0.075 g
Zone 2	0.05 g < a < 0.075 g	0.06 g	0.1g	0.07 g < a < 0.11 g	0.05 g < a < 0.15 g	0.16 g < a < 0.24 g	0.15 g
Zone 3	0.075 g < a < 0.1 g	0.08 g	0.13 g	0.11 g < a < 0.16 g	0.15 g < a < 0.25 g	0.24 g < a < 0.36 g	0.3 g
Zone 4	0.1 g < a	0.16 g	0.16 g < a < 0.3 g	0.25 g < a < 0.3 g	0.4 g	—	—

Table 2. Upper Floor Acceleration. Other standards.

Test Method

nVent HOFFMAN, continuously gathering customer feedback, has been focused on certifying its combinable floor standing enclosure as seismic zone 3 (according to Point 5 . 4 . 1, Earthquake Test Methods, of Telcordia Technologies Generic Requirements, "GR-63-CORE", Issue 4, March 2012), without using any seismic accessory, and Zone 4 by using a seismic kit, to fulfil the market requirements. Thus, nVent HOFFMAN has carried out four different seismic tests in independent laboratories.

Both Zone 3 tests were carried out in Virlab S.A. Division of Urbar Ingenieros S.A. facilities, a company accredited by ENAC, Spanish National Accreditation Entity (certificate number 54/LE131). And both Zone 4 tests were carried out in Element, a leading global provider of Testing, Inspection, and Certification (TIC) services.

A short summary regarding each seismic test is included in the sections below.

To simulate a real application, the mounting plate was loaded with 155 kg, in five trays separated by 370 mm, with approximately 31 kg on each one.

The Electrical Cabinet was submitted to the tests described below:

1. Resonance search tests, between 1 and 50 Hz, with an acceleration level of 0.2 g, independently performed in each one of the three main directions of the Cabinet, front-to-back (X), side-to-side (Y) and vertical (Z);
2. Seismic tests, consisting of one test, 30 second duration, independently applied in horizontal direction, "X" (front-to-back) and "Y" (side-to-side); and in vertical, "Z" direction. The applicable Required Response Spectra, RRS (2% damping), considers a Zero Period Acceleration of 1.0 g.

Test procedure for combinable enclosure according to Telcordia GR-63-CORE, Seismic Zone 3.

Equipment tested: MCS20086R5	
Cabinet Drawing number:	MCS20086R5/ MCS20086PER5, revision 1
IP 55 Type 12, IK 10;	
Dimensions:	800 (width) × 600 (depth) × 2000 (height) mm
Mounting plate height:	1894 mm
Width mounting plate:	694 mm
Maximum cabinet useful depth:	559 mm
Weight:	132 kg
Accessories:	
PS1060 + PF1080 (Plinth);	
Plinth Drawing number:	PS1060 and PF1080, revision 1
Dimensions:	800 (width) × 600 (depth) × 100 (height) mm
Weight:	6 kg

Figure 3. MCS20086R5
With swing frame

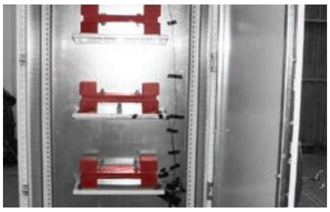


Figure 4. MCS20086R5
Loaded mounting plate

Test Method

Test procedure for combinable enclosure with swing frame, according to Telcordia GR-63-CORE, Seismic Zone 3.

Equipment tested: MCS20086R5	
Cabinet Drawing number:	MCS20086R5/ MCS20086PER5, revision 1
IP 55 Type 12, IK 10	
Dimensions:	800 (width) × 600 (depth) × 2000 (height) mm
Mounting plate height:	1894 mm
Width mounting plate:	694 mm
Maximum cabinet useful depth:	559 mm
Weight:	132 kg
Accessories:	
ESFC406 (Swing Frame)	
Swing Frame Drawing number:	ESFC406, revision 1
Dimensions:	500 (width) × 2000 (height) mm
Weight:	17 kg
PS1060 + PF1080 (Plinth)	
Plinth Drawing number:	PS1060 and PF1080, revision 1
Dimensions:	800 (width) × 600 (depth) × 100 (height) mm
Weight:	6 kg

Figure 5. MCS20086R5
With swing frame

Figure 6. MCS20086R5
Loaded mounting plate
and swing frame

To simulate a real application, the mounting plate was loaded with 155 kg, in five trays separated by 370 mm, with approximately 31 kg on each one, the swing frame was loaded with 65 kg, in five trays separated by 370 mm, with approximately 13 kg on each one.

The Electrical Cabinet was submitted to the tests described below:

1. Resonance search tests, between 1 and 50 Hz, with an acceleration level of 0.2 g, independently performed in each one of the three main directions of the Cabinet, front-to-back (X), side-to-side (Y) and vertical (Z);
2. Seismic tests, consisting of one test, 30 second duration, independently applied in horizontal direction, "X" (front-to-back) and "Y" (side-to-side); and in vertical, "Z" direction. The applicable Required Response Spectra, RRS (2% damping), considers a Zero Period Acceleration of 1.0 g.

Test Method

Test procedure for combinable enclosure according to Telcordia GR-63-CORE, Seismic Zone 4.

Equipment tested: MCS20088R5	
Cabinet Drawing number:	MCS20088R5/ MCS20088PER5, revision 1
IP 55, Type 12, IK 10	
Dimensions:	800 (width) × 800 (depth) × 2000 (height) mm
Mounting plate height:	1894 mm
Width mounting plate:	694 mm
Maximum cabinet useful depth:	759 mm
Weight:	453 kg (1000 lbs)
Accessories:	
SBK20XX8Z4 (Seismic Kit)	
Seismic Kit Drawing number:	SBK20XX8Z4, revision 1
Dimensions:	800 (width) × 800 (depth) × 2000 (height) mm
Weight:	23 kg
PSB0808Z4 (Seismic Plinth)	
Plinth Drawing number:	PSB0808Z4, revision 1
Dimensions:	800 (width) × 800 (depth) × 100 (height) mm
Weight:	14 kg

Figure 8. MCS20088R5
With seismic kit, seismic plinth and loaded mounting plate.

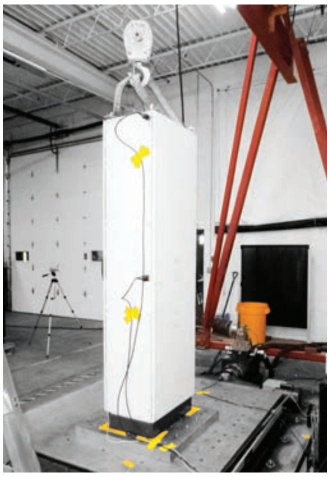


Figure 9. MCS20088R5
With seismic kit and seismic plinth

To simulate a real application, the mounting plate was loaded with 1000 lbs (453 kg), evenly distributed. The Electrical Cabinet was submitted to the tests described below:

1. Resonance search tests, between 1 and 50 Hz, with an acceleration level of 0.2 g, independently performed in each one of the three main directions of the Cabinet, front-to-back (X), side-to-side (Y) and vertical (Z);
2. Seismic tests, consisting of one test, 30 second duration, independently applied in horizontal direction, “X” (front-to-back) and “Y” (side-to-side); and in vertical, “Z” direction. The applicable Required Response Spectra, RRS (2% damping), considers a Zero Period Acceleration of 1.6 g.

Test Method

Test procedure for combinable enclosure according to Telcordia GR-63-CORE, Seismic Zone 4.

Equipment tested: MCS20064R5	
Cabinet Drawing number:	MCS20064R5/ MCS20064PER5, revision 1
IP 55, Type 12, IK 10	
Dimensions:	600 (width) × 400 (depth) × 2000 (height) mm
Mounting plate height:	1894 mm
Width mounting plate:	494 mm
Maximum cabinet useful depth:	359 mm
Weight:	272 kg (600 lbs)
Accessories:	
SBK20XX4Z4 (Seismic Kit)	
Seismic Kit Drawing number:	SBK20XX4Z4, revision 1
Dimensions:	600 (width) × 400 (depth) × 2000 (height) mm
Weight:	47 kg
PSB0604Z4 (Seismic Plinth)	
Plinth Drawing number:	PSB0604Z4, revision 1
Dimensions:	600 (width) × 600 (depth) × 100 (height) mm
Weight:	12 kg

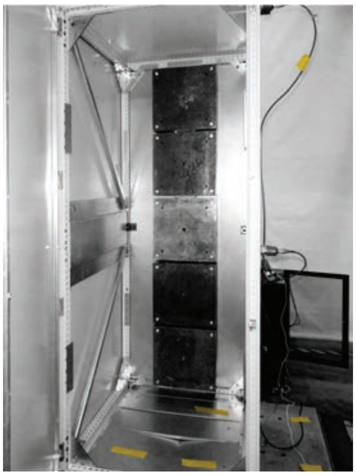


Figure 10. MCS20064R5
With seismic kit, seismic plinth and loaded mounting plate.

To simulate a real application, the mounting plate was loaded with 272 kg (600 lbs), evenly distributed. The Electrical Cabinet was submitted to the tests described below:

1. Resonance search tests, between 1 and 50 Hz, with an acceleration level of 0.2 g, independently performed in each one of the three main directions of the Cabinet, front-to-back (X), side-to-side (Y) and vertical (Z);
2. Seismic tests, consisting of one test, 30 second duration, independently applied in horizontal direction, "X" (front-to-back) and "Y" (side-to-side); and in vertical, "Z" direction. The applicable Required Response Spectra, RRS (2% damping), considers a Zero Period Acceleration of 1.6 g.

Conclusion

Results

Combinable enclosures tested have successfully passed the Seismic Tests, to which they have been subjected, maintaining their structural integrity, without any anomaly or structural deterioration having been detected.

In summary, four tests have been succeeded:

Combinable enclosure	Accessories	Tested installed weight	Standard	Tested by
MCS20086R5	PF1080 PS1060	On mounting plate: 155 kg (341 lbs)	Telcordia GR-63-CORE, seismic Zone 3	Virlab S.A
MCS20086R5	ESFC406 PF1080 PS1060	On mounting plate: 155 kg (341 lbs) On swing frame: 65 kg (143 lbs)	Telcordia GR-63-CORE, seismic Zone 3	Virlab S.A
MCS20088R5	SBK20XX8Z4 PSB0808Z4	On mounting plate: 453 kg (1000 lbs)	Telcordia GR-63-CORE, seismic Zone 4	Element
MCS20064R5	SBK20XX4Z4 PSB0604Z4	On mounting plate: 251 kg (600 lbs)	Telcordia GR-63-CORE, seismic Zone 4	Element

Applicability of the tests

Although tests were carried through with combinable enclosure with dimensions 2000 mm x 800 mm (w) x 600 mm (d) and 2000 mm (h) x 800 mm (w) x 800 mm (d), and the enclosure's certification is only valid for the size and configuration tested, nVent HOFFMAN states that other combinable enclosure dimensions are reliable regarding the same earthquake resistance, as long as the following criteria are met:

- The combinable enclosure has been built according to nVent HOFFMAN's mounting instructions;
- Total height (with or without plinth) shall not exceed 2100 mmm or center of mass is lower than 1000 mm;
- Base area is equal or bigger than the tested enclosure;
- The earthquake standard and the frequency spectrum is similar;
- Mounted weight is equal to or less than the tested enclosures;
- Weight distribution is similar to the tests.