



Protecting data centers from seismic activity

Understanding enclosure standards is critical to protecting equipment

Author: Joel Young, engineer at Crenlo

Abstract

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

Most manufacturers of data center racks and enclosures offer products that are marketed as offering “seismic protection”; however, there can be significant differences in the standards used to achieve those labels, and thus, major disparities in the level of protection that those products provide.

There are two standards by which enclosures are deemed seismic — Telcordia Technologies GR-63-CORE Network Equipment Building Systems (NEBS) requirements and the International Building Code (IBC). While both serve an important purpose, many would argue that they are too different to apply the same label to a product.

In order for a data center manager to select an enclosure that will offer the appropriate level of protection, he or she must have a firm grasp on NEBS and IBC requirements and understand how each corresponds to the level of protection offered by a particular enclosure.

This white paper will discuss the history of each standard, explain the methods used to test and certify enclosures as compliant with each standard and outline how data center managers can select the best type of seismic enclosures for their applications.

Protecting data centers from seismic activity

When building a data center in a seismically active region, data center managers must select enclosures rated to protect their equipment in the event of an earthquake. With an abundance of options on the market, all being marketed as “seismic” enclosures, how does a buyer decide which product offers the right seismic solution for the application?

Given the matching labels, the cost-conscious choice might seem prudent. However, before acquiring earthquake protection for critical data center equipment, data center managers should understand that all seismic-rated enclosures are not created equal. In fact, there can be significant disparities in the testing achievements behind manufacturers’ seismic labels — and a corresponding variance in the caliber of earthquake protection provided to electronic equipment.

There are two standards by which enclosures are deemed seismic — Telcordia Technologies GR-63-CORE Network Equipment Building Systems (NEBS) requirements and the International Building Code (IBC). While both standards are often used to achieve the same label, one should not assume that all seismic enclosures offer the same level of protection, regardless of which standard was used for certification.

In order for a data center manager to select an enclosure that will offer the appropriate level of protection, he or she must have a firm grasp on NEBS and IBC requirements and understand how each corresponds to the level of protection offered by a particular enclosure. To better understand the differences between the two standards, it is important to understand their origins.

History

In the years following AT&T’s monopoly lawsuit, a flood of competitive local exchange carriers arose, bringing a set of new and varied network equipment to the once homogenous collection of AT&T equipment housed in central offices throughout the country. It quickly became apparent that there was a need for a standard to which network equipment had to adhere in order to ensure network compatibility and uptime. What came to be were the NEBS requirements, of which, section GR-63 applied specifically to protecting equipment in the event of seismic activity. Because of the essential nature of telephone communication service, GR-63 requires that in the event of an earthquake, “The equipment shall sustain operation without replacement of components, manual rebooting and human intervention.” In other words, an enclosure must provide a level of protection such that the network remains active *during* an earthquake.

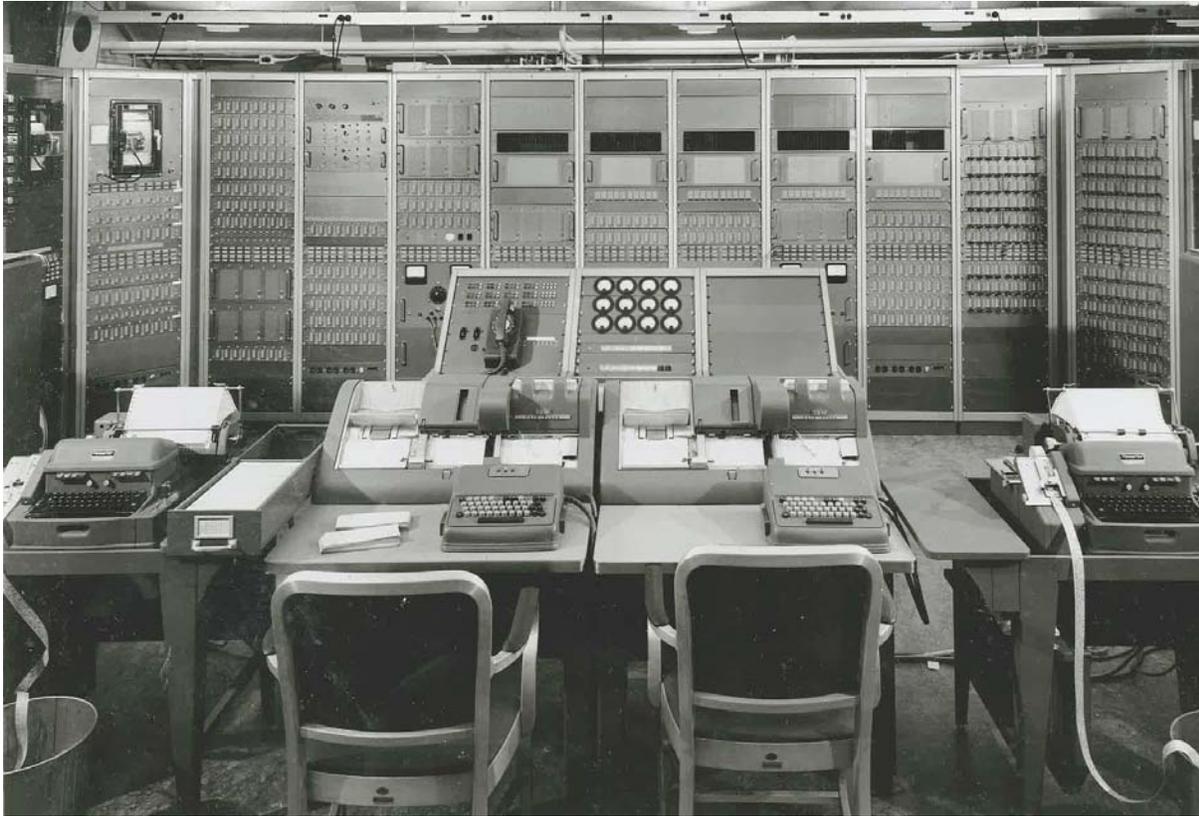


Image: Bell Telephone Labs, using Emcor® enclosures, circa the 1960s

While GR-63's history is based on preventing network downtime, IBC was formed as a broad collection of structural building requirements to prevent human injury and reduce equipment damage during an earthquake. Following the 1994 earthquakes in Los Angeles — during which more than 40 percent of the \$80 billion in damages were non-structural — it became apparent there was a need to create guidelines for securing objects within buildings to the floors, walls or ceilings. In 2000, IBC was created as a guideline to which businesses must adhere in order to receive funding from the Federal Emergency Management Agency (FEMA) in the aftermath of an earthquake. In short, the IBC is a set of guidelines on how to mount objects, so that they do not tip over during an earthquake.

With two very different origins, there are bound to be inconsistencies in what these standards measure, how they are measured and how they are applied. While GR-63 requirements and testing procedures are consistent across the board, IBC requirements are site-specific, and thus differ from city to city, state to state, building to building and floor to floor. So, not only are GR-63 and IBC inconsistent with each other, but there can be major inconsistencies from one IBC-compliant enclosure to the next. Many of these inconsistencies are related to the varying methods of calculation, testing and certification.

Calculation, testing and certification

To achieve GR-63 compliance, enclosure manufacturers turn to independent, third-party testing facilities. An enclosure is loaded to its capacity and mounted to a shaker table. The shaker table then simulates an earthquake, shaking in every potential direction at varying levels of intensity equivalent to an earthquake in a particular seismic zone — Zone 1 is the least intense; Zone 4 is the most intense. Accelerometers are attached to the enclosure to measure its vibration and sway during the test. In order to pass the test and achieve the seismic rating, the enclosure must not sway more than 3 inches in any direction and all components must remain operable during and after the test. This test is the same for every manufacturer of an enclosure product, regardless of where that enclosure is going to be used or its intended purpose. The only difference between one GR-63-compliant enclosure and another would be the seismic zone to which it has been tested and deemed compliant.

IBC compliance on the other hand, can be achieved through three different methods, each of which analyzes the enclosure and its contents as part of the entire building system, rather than analyzing the enclosure itself. The fact that there are three varying methods of arriving at the answer, however, is often confusing for a buyer.

The most stringent of these three methods requires a shaker table test similar to the one used in GR-63 certification. In fact, in most cases, a GR-63-compliant enclosure would also be IBC-compliant for the simple fact that the acceleration used in a shaker table test for GR-63 is more intense than the waveform used in the ICC-ES AC156 shaker table test used to certify IBC compliance.

The other two methods of calculating IBC compliance is where the confusion often lies — one being a mathematical equation that compares potential seismic effects to objects mounted in a building and the other being the use of experience data. The latter would require the manufacturer to reference an enclosure's performance during a specific earthquake, and design the enclosure to the same specifications as the enclosure from the referenced event. The issue with this method is that there are a number of variables that are often difficult to account for with historical record, for instance, how the enclosure was mounted and loaded.

The equation used to calculate IBC compliance utilizes the variables that are difficult to account for with experience data. These variables revolve around where and how the enclosure is being installed in order to arrive at the design horizontal seismic force (F_p) acting on the enclosure at its center of gravity.

A value called the “design spectral response” (S_{DS}) is calculated based on site-specific variables, including the site soil classification factor (F_a), the maximum short-period ground accelerations (S_s) and the seismic design category, which ranges from Category A (the lowest risk of earthquake) to Category F (the highest risk of earthquake). S_{DS} is calculated as the product of F_a and S_s multiplied by a factor of either $3/4$ (for Category A) or $2/3$ (for all other categories).

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

Amplification Factor

Component Response Factor

Amplification over height of structure

The enclosure is also given a value called the “component importance factor,” which is either 1.0 or 1.5, depending on the type of building in which it will be mounted. An enclosure mounted in an “essential” building — such as a hospital, where uptime is critical — is given the 1.5 value, whereas an enclosure mounted in a “non-essential” building is given the 1.0 value. The essential value would require that the electronics continue to function in the event of an earthquake whereas the non-essential value would simply require the enclosure to remain standing.

The taller the building, the more flexible it becomes, which is why the amplification takes into account the height of the building and the height of the floor where the enclosure will be mounted. Lastly, the total weight of the loaded enclosure (W_p) is taken into account.

The advantage to using this equation is that it accounts for all factors that could potentially affect an enclosure’s ability to protect equipment from an earthquake, yet compliance using this method does not require physical testing, which can be costly, thus leading to a very affordable seismic-rated product.

Crenlo’s approach to seismic certification

Crenlo offers two seismic products — a line of Emcor® seismic enclosures and the Emcor® IBC kit. The Emcor® seismic enclosures are GR-63-compliant enclosures meant for essential facilities, and the IBC kit is a hardware set that can be attached to existing enclosures for easy and affordable compliance with IBC in non-essential facilities.

GR-63 testing

Emcor® seismic enclosures are available in three standard options — the light-duty (400-pound capacity), the medium-duty (600-pound capacity) and the heavy-duty (800-pound capacity) — each of which has been loaded to capacity and tested on a shaker table to meet seismic Zone 4 requirements.

Seismic Zone 4 requirements are the most stringent of all, requiring that Crenlo's enclosures stay intact while experiencing the equivalent of an earthquake measuring up to 8.3 on the Richter scale.



At Intertek — a third-party test facility — Crenlo's enclosures were tested to the standard GR-63 compliance test known as Waveform Test Procedure 5.4.1.5. The procedure tested side-to-side, front-to-back and vertical framework axes as follows:

- Crenlo's enclosures were subjected to low-level sine sweep to verify the resonance point was greater than 2 Hz, as outlined in requirement R4-48 of GR-63. The frequency was swept from 1 to 50 Hz at a sweep rate of 1.0 octave per minute, with an acceleration level of 0.2 g.
- Crenlo's enclosures were verified for functionality as outlined in requirement R4-50 and objective O4-49, and the physical condition was verified as described in requirements R4-46, R4-47, and R4-48 as well as objective O4-49.
- Crenlo's enclosures were subjected to the Zone 4 acceleration-time waveform, known as VERTEQII. A Test Response Spectra (TRS) was generated by analyzing the time domain acceleration data measured at the control accelerometer located on the shaker table. The TRS exceeded the Required Response Spectrum (RSS) for seismic Zone 4 in the range from 1.0 to 50 Hz.
- Crenlo's enclosures were thoroughly inspected, and all changes in physical condition were noted. The results show that Crenlo's enclosure is compliant with all requirements and objectives associated with the most stringent form of GR-63 for Zone 4 compliance.

IBC calculation

The Emcor® IBC kit is available for mounting onto existing enclosures in order to achieve IBC compliance in non-essential facilities. The kit is mounted using four brackets attached to the floor to properly constrain the loads.

The kit's compliance with IBC has been certified using the aforementioned equation as follows:

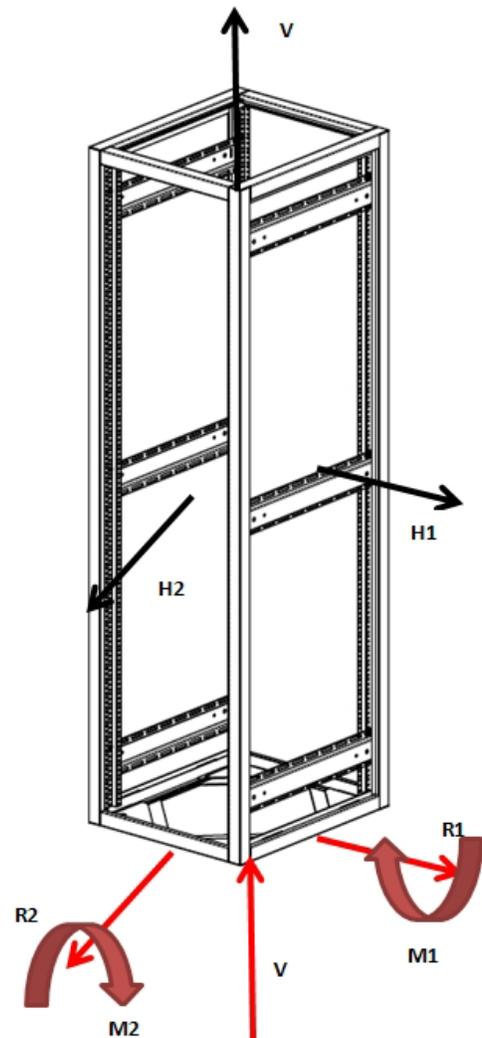
The figure to the right shows the horizontal (H1, H2) and vertical (V) seismic forces acting at the center of gravity (COG).

The resulting forces are shown in red and include the horizontal forces (R1, R2) and moments (M1, M2) at the base of the frame. These forces are transmitted to the support structure through the tie-down brackets and four Hilti KB-TZ concrete stud anchors which attach the four brackets to the floor.

For nonstructural components, such as an enclosure, seismic design requirements stipulate that the force F_p shall be applied independently in at least two orthogonal directions. Then, the maximum moment (either longitudinal or transverse) is used in the calculations.

H1 and H2 are based on the seismic equation for F_p . The vertical seismic force (V) is calculated as $0.2 * S_{DS} * W_p$. The moments are the horizontal seismic force $F_p * \text{half the height of the frame}$. The shear load on the concrete anchors is calculated by the vector sum of the two horizontal loads. The tension load on the concrete anchors is calculated by combining the vertical force (V) with the couples, due to the two moments, M1 and M2.

These calculations are used to help the structural engineer determine the appropriate length and tensile strength of the concrete anchors used to install the enclosure. Crenlo consults with the customer to make installation recommendations based on floor type, floor height, building height and weight of the loaded enclosure.



Installation

Regardless of which standard is used to certify a product and how stringently that standard is applied, an enclosure can only offer sufficient protection from seismic activity if properly mounted and loaded.

IBC-compliant mounting is generally achieved through the certification of a building engineer. Crenlo works directly with customers and their engineers to recommend minimum requirements for bolt diameter and depth, as well as minimum compressive strength of the concrete floor.

On the other hand, GR-63 requires that the bolts be a minimum of 3.5 inches long and 0.5 inches in diameter. These are the size of bolts used in testing procedures and thus, are meant to correspond to the real-world scenario. If a GR-63 enclosure also needs to be compliant with IBC, Crenlo can work with the customer and their engineer to determine installation requirements for compliance with both standards.

When it comes to loading, IBC and GR-63 are actually quite similar. All the standard rules of physics still apply. It is important to remember that the lower the center of gravity, the more stable an enclosure will be. So, when loading to capacity, the heaviest items should be loaded toward the bottom and the lightest toward the top. Both standards account for weight, but it is the responsibility of the installer to ensure the weight is distributed as low as possible, as both standards assume.

Conclusion

Both standards serve an important purpose, but buyers often fail to recognize the differences between the two, which often leads to purchasing a product that isn't the best solution for the application.

For buyers that require electronics to continue functioning throughout an earthquake, a GR-63 compliant enclosure will provide the best solution. For those buyers that need to be in compliance with IBC at a non-essential facility, but do not want to replace their existing enclosures (whether due to cost or convenience), an IBC kit that can easily be attached to existing enclosures is an easy and affordable solution.

Regardless of the type of enclosure, it's important to consult with a structural or building engineer during installation in order to ensure the enclosure is properly installed in accordance with the standard being used. Furthermore, it's important for a buyer to select a manufacturer that has the knowledge and capabilities to determine which product is right for their application and has the knowledge to consult with a structural engineer regarding installation. Crenlo has the capabilities to consult with customers and deliver the product that best suits their needs,

whether that means a standard, off-the-shelf product, a modification of a standard product or a completely custom solution.

About Crenlo

Crenlo, under their Emcor® brand of enclosures, offers a versatile selection of consoles and enclosures, each of which can be modified and configured to meet the needs of almost any application. For those applications that fall outside of the standard lineup of Emcor products, Crenlo can design and build completely custom solutions to meet the needs of individual customers.

For more than 60 years, top companies in the technology, aerospace, data communications, test and measurement, and defense industries have put trust in Crenlo and its Emcor brand of enclosures, to meet exact standards with high-quality, dependable solutions for protecting electronic equipment.

General inquiries

Crenlo
1600 4th Ave N.W.
Rochester, MN 55901
507-287-3535
www.crenlo.com/enclosures

Media inquiries

Two Rivers Marketing
John Krantz
jkrantz@2rm.com
515-557-2072