

Rittal – The System.

Faster – better – everywhere.

► Earthquake protection for switchgear systems

White Paper IE 7

Date: November 2018

Author: Hartmut Paul

In order to avoid damage in the event of an earthquake, buildings and technical infrastructures need to be designed to be 'earthquake-proof' wherever possible. This means that switchgear manufacturers faced with the demands of earthquake safety are confronted with something that is not an everyday occurrence and which requires expert know-how. But what should be done if a switchgear unit needs to be earthquake-proof? This guide is intended to help the switchgear manufacturer gain a basic overview, precisely for this and similar cases.

ENCLOSURES

POWER DISTRIBUTION

CLIMATE CONTROL

IT INFRASTRUCTURE

SOFTWARE & SERVICES



Contents

1	Introduction	4
2	Is the switchgear system earthquake resistant?	6
2.1	What needs to be done?	6
2.2	What needs to be considered?	6
2.3	Which standards are applicable?	6
3	Intensities, magnitudes and earthquake zones	7
3.1	Subjective intensity scales	7
3.2	Measuring technology for earthquakes	8
3.3	The probability of an earthquake is important for risk assessment	8
4	Earthquake damage to the electrical infrastructure	10
5	Overview of current standards	11
6	Typical test methods	13
6.1	Different frequency spectra in the standards	13
6.2	Very similar test spectra	14
7	Earthquake-resistant enclosure	15
8	Specific approach	19
9	Summary	20
10	Table of figures, tables and references	21

1 Introduction

Natural forces have always posed a threat to humans and repeatedly cause numerous deaths and serious damage to property. Whilst extreme meteorological occurrences, such as storm surges, floods and heat waves, can be forecast relatively accurately these days, earthquakes remain relatively difficult to predict. This is one of the reasons that seven of the eleven natural disasters (see tab. 1) that caused the highest death tolls between 1980 and 2013 stemmed from earthquakes [Mun14].

Date	Incident	Magnitude	Region	Fatalities
12 Jan 2010	Earthquake	7.0	Haiti	222,570
26 Dec 2004	Earthquake, tsunami	9.1	Sri Lanka, Indonesia, Thailand, India, Bangladesh, Myanmar, Maldives, Malaysia	220,000
2-5 May 2008	Cyclone Nargis, storm tide	–	Myanmar	140,000
29-30 Apr 1991	Tropical cyclone, storm tide	–	Bangladesh	139,000
8 Oct 2005	Earthquake	7.8	Pakistan, India, Afghanistan	88,000
12 May 2008	Earthquake	5.8	China	84,000
Jul/Aug 2003	Heat wave	–	Europe	70,000
Jul/Sep 2010	Heat wave	–	Russia	56,000
20 Jun 1990	Earthquake	7.4	Iran	40,000
26 Dec 2003	Earthquake	6.6	Iran	26,200
11 Mar 2011	Seaquake, tsunami	9.0	Japan	18,537

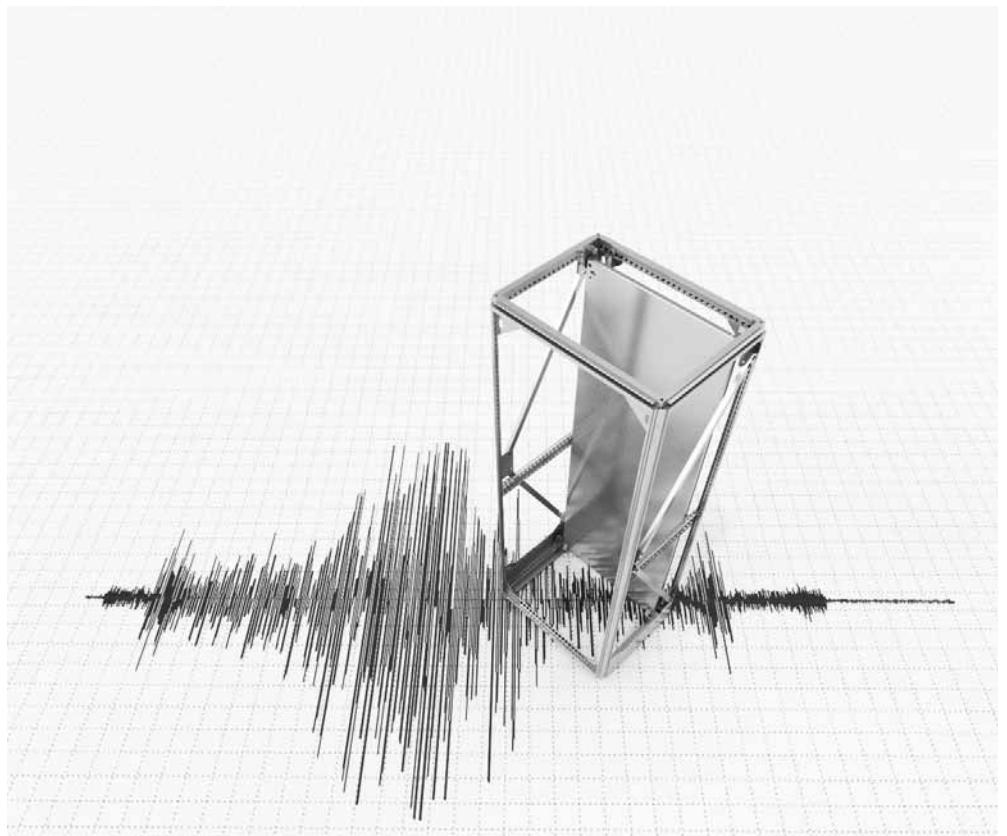
Table 1: Fatalities during natural disasters from 1980 till 2013

Earthquakes occur as the result of processes taking place below the surface of the Earth. The Earth's solid crust, which is made up of plates, moves over its liquid core – a process known as plate tectonics. These plates move toward, away from or along each other at their boundaries. As they catch on each other during these movements, immense pressure builds up. A sudden release of this energy is what results in an earthquake, which can cause great damage over considerable distances according to the magnitude of the force involved.

Earthquakes usually cause structural damage to buildings and the transportation infrastructure, which sometimes arises as a result of secondary events such as landslides or tsunamis. However, very serious damage can also occur to buildings' internal systems. Depending on the magnitude of the earthquake and the population of the affected region, this can certainly rival the severity of the afore-mentioned damage to buildings and transportation infrastructure. Damage to the technical infrastructure often also interrupts electricity, drinking water and gas supplies etc. in the aftermath of the actual earthquake. Immediately following an

earthquake, when aid is most urgently needed, damage to the transportation and technical infrastructure can hinder assistance efforts.

To avoid the kind of damage described above, buildings and the traffic and technical infrastructures in areas prone to earthquakes should be designed to be “earthquake-resistant”. However, the appropriate measures not only differ significantly depending on the area in question (buildings, technical infrastructure), but the risk of an earthquake happening also needs to be taken into account. In other words, a particularly earthquake-prone area will require correspondingly stricter measures. This white paper provides a broad outline of the meaning of “earthquake resistance” in specific relation to electrical infrastructure.



2 Is the switchgear system earthquake-resistant?

When it comes to earthquake protection, building safety is often the primary concern. This is certainly understandable, as primary earthquake damage to buildings generally causes the most fatalities, and the majority of damage to property also occurs this way. However, technical infrastructure installations such as electrical switchgear systems and data centres also require effective protection against earthquakes. This not only applies to critical systems, such as those in power plants or production facilities in the chemical industry, but may also be important for all systems of general supply.

2.1 What needs to be done?

Switchgear manufacturers called to consider earthquake-resistance requirements are confronted with issues beyond the scope of their regular business. What has to be done if a customer needs an earthquake-resistant switchgear system, for instance? This guide provides advice for this and similar scenarios to help switchgear manufacturers gain a general idea of the issues involved.

2.2 What needs to be considered?

What needs to be considered when constructing electrical switchgear systems in regions that are potentially earthquake-prone? This is the key question. To provide a clear insight into the problems involved, the paper starts by explaining a number of basic principles relating to earthquakes, their measurement and the different scales applied. The next section examines the effects an earthquake can have on electrical switchgear systems and the damage it can potentially cause.

2.3 Which standards are applicable?

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. This white paper provides an overview of the different standards relating to the electrical infrastructure.

3 Intensities, magnitudes and earthquake zones

In terms of physics, an earthquake is a shock wave that emanates from the epicentre of the earthquake. This shock wave causes the Earth’s crust to vibrate with a complex frequency spectrum, both horizontally and vertically. This is described in terms of the relating amplitudes and frequencies on the Earth’s surface. Because the energy released by an earthquake cannot be measured directly, we use various scales to describe the strength of an earthquake. This includes differentiating between scales of intensity and scales of magnitude.

3.1 Subjective intensity scales

Intensity scales are based on the macroscopic effects of an earthquake – such as the severity of damage to buildings – and the subjective impressions of the people who feel or hear the earthquake. A frequently used scale to indicate intensity is the **Mercalli scale**, which was developed in 1902 and is still in use today (see tab. 2). Scales of intensity can only be used to a limited extent in sparsely populated areas where there are few buildings where damage might occur and not many people to report their experiences.

JMA		Mercalli			
Category	Ground acceleration			Description	Category
	gal	gal	g (9.81 m/s ²)		
0	< 0.8				
		< 1.0	< 0.001	Not felt	I
1	0.8–2.5				
		1.0–2.1	0.001–0.002	Weak	II
2	2.5–8.0	2.1–5.0	0.002–0.005	Weak	III
		5.0–10	0.005–0.01	Light	IV
3	8.0–25	10–21	0.01–0.02	Moderate	V
		21–44	0.02–0.05	Strong	VI
4	25–80				
		44–94	0.05–0.1	Very strong	VII
5	80–250				
		94–202	0.1–0.2	Severe	VIII
6	250–400				
		202–432	0.2–0.5	Violent	IX
7	> 400				
		over 432	0.5–1	Extreme	X
			1–2	Extreme	XI
			> 2	Extreme	XII

Table 2: The Mercalli Scale compared to the Japanese JMA Scale

N.B.: Seismic intensity is not regulated based on ground acceleration only. This table is merely for reference.

3.2 Measuring technology for earthquakes

Scales of magnitude are based on measurements taken by seismometers, which measure the local vibrations in the Earth's surface in terms of speed, acceleration and displacements. Calculations using these measurements can indicate the strength of the earthquake. The best-known scale of magnitude is the Richter scale, which was developed in the 1930s and is still used today for this purpose. The magnitude according to the Richter scale is calculated using measurements taken near to the earthquake's epicentre, which is why it is also frequently called the 'local magnitude scale'. The measurements are taken by a special kind of seismometer at a distance of 100 km from the epicentre. Because of the specific type of seismometer its inventor Charles F. Richter used, the Richter scale has a maximum value of 6.5 and, strictly speaking, only applies to the U.S. federal state of California. Higher magnitudes, which the media often also cite as being measured on the open-ended Richter scale, are really moment-magnitude values along a modern extension of the Richter scale. The strongest ever recorded earthquake, with a magnitude of 9.5, occurred in Valdivia, Chile, in 1960. In comparison, the earthquake in Japan that caused the reactor disaster in Fukushima in 2011 had a magnitude of 9.0.

3.3 The probability of an earthquake is important for risk assessment

Besides categorising earthquakes according to strength, i.e. their intensity or magnitude, another important aspect is the probability that an earthquake of a given strength will occur. Earthquake risk zones are defined in order to facilitate a reasonable risk assessment. For instance, there are five earthquake zones in the United States. Zone 0 is where strong earthquakes can be practically ruled out, whereas earthquakes of quite a large magnitude are relatively probable in zone 4. Parts of the U.S. federal state of California are typical examples of earthquake zone 4. The requirements relating to earthquake protection for IT and telecommunications installations, and for electrical infrastructure installations, are often based on these earthquake zones.

However, zoning varies from country to country. In most countries in Europe (including Germany), the zones range from 0 to 3; but up to five zones might be categorised. This is further complicated by the lack of uniformity between the national standards that define the zones (see tab. 3). Thus it is not possible to draw a simple comparison between national standards. However, classifying earthquake zones is important when it comes to delivering earthquake-

resistant systems, as the appropriate measures – incurring additional costs – need only be taken in high-risk areas.

Country	AT	GER	CH	FR	IT*	GR	USA
Standard	ÖN 1998-1	DIN EN 1998-1	SIA 261	NF EN 1998-1	OPCM 28	Gna 1998-1	1997 UBC
Zone 0	$a < 0.035 \text{ g}$	0.0 g					0.0 g
Zone 1	$0.035 \text{ g} < a < 0.05 \text{ g}$	0.04 g	0.06 g	$a < 0.07 \text{ g}$	$a < 0.05 \text{ g}$	$a < 0.16 \text{ g}$	0.075 g
Zone 2	$0.05 \text{ g} < a < 0.075 \text{ g}$	0.06 g	0.1 g	$0.07 \text{ g} < a < 0.11 \text{ g}$	$0.05 \text{ g} < a < 0.15 \text{ g}$	$0.16 \text{ g} < a < 0.24 \text{ g}$	0.15 g
Zone 3	$0.075 \text{ g} < a < 0.1 \text{ g}$	0.08 g	0.13 g	$0.11 \text{ g} < a < 0.16 \text{ g}$	$0.15 \text{ g} < a < 0.25 \text{ g}$	$0.24 \text{ g} < a < 0.36 \text{ g}$	0.3 g
Zone 4	$0.1 \text{ g} < a$		0.16 g	$0.16 \text{ g} < a < 0.3 \text{ g}$	$0.25 \text{ g} < a < 0.3 \text{ g}$		0.4 g

Table 3: Ground acceleration in Europe and the USA

4 Earthquake damage to electrical infrastructure

In order to evaluate the relevance of earthquake resistance for electrical installations, an overview must first be established of the damage that can potentially occur in an earthquake, including any consequential damage that might arise if an electrical system fails. Damage to buildings is usually the focus of attention following an earthquake. Depending on the kind of building involved, the values for the systems installed in it are often higher than for the structural elements themselves. It makes sense, therefore, to look beyond the earthquake-resistance of the building alone and to also consider the potential requirements regarding its systems in the case of an earthquake.

It is particularly important that the installations of critical, safety-relevant infrastructures, such as in nuclear installations, remain operational even after high-magnitude earthquakes. This calls for a very extensive range of measures, which are beyond the scope of this white paper. A high level of systems availability, and thus robust protection against earthquakes, is also particularly vital for telecommunications and IT. At the same time, the ability of installations to remain operational for a given time or to resume service quickly are also important issues following an earthquake.

The frequency of the vibrations that occur during an earthquake generally ranges from 0.3 Hz to 50 Hz. The stresses these vibrations exert on a switchgear system can cause both malfunctions and structural damage to the entire system. Malfunctions can be remedied with little outlay, so a switchgear system can be put back into service relatively quickly following an earthquake. This might typically involve a loose contact or temporary short-circuit that is interrupted by the installation's safety systems.

More disruptive damage might include components breaking free from a support rail or mounting plate in an enclosure. Serious damage to the switchgear system generally causes a protracted interruption to the energy supply – say, if the earthquake were to move an enclosure, perhaps dislodging it from its anchoring or even tipping it over.

This category also includes any structural damage to the enclosure. Enclosures play an extremely important role because if they cannot withstand the earthquake, the entire system is going to fail. This makes earthquake protection for enclosures a key factor in all the relevant standards. However, this aspect can never be considered in isolation, but rather the surrounding building and all the installed components must also comply with the relevant requirements as well. Thus a suitable enclosure alone will not suffice if the system needs to remain operational after, or even during, an earthquake. In addition, the installed components must also meet the requirements of the appropriate standard and the functioning of the entire system must be proved under test conditions.

5 Overview of current standards

Earthquake protection is important from various points of view. Correspondingly, different standards are applied depending on the technical discipline concerned. These standards can be roughly divided into the categories civil engineering, IT and telecommunications, and electrical engineering. Furthermore, the applicable standards also differ according to the geographical location of the market. Building standards barely play any role in the construction of earthquake-resistant electrical switchgear systems, so they are not described in detail here. However, as electrical systems are predominantly installed in buildings, these standards do have a certain influence. The main focus in building standards is often on how the enclosure is fixed to the floor. However, verifying the floor fixing, requires certain knowledge of the circumstances in the installation site. Verification is therefore carried out by a building expert. Some of the standards that apply to electrical engineering and IT and telecommunications originate from a building standard, which they translate into specific requirements for the corresponding equipment. For instance, buildings can actually amplify the effect of an earthquake, potentially further increasing the amplitude and accelerations that are exerted on an electrical system.

Three specific sets of standards are particularly relevant to switchgear systems and other electrical engineering and information technology infrastructures – DIN EN/IEC 60068-3-3, IEEE 693 and Telcordia GR-63-CORE. Other standards, for example from the construction industry, are generally not relevant to switchgear production. It can be assumed that structural engineers will ensure compliance with these standards. Only the interface between construction and electrical engineering – where the building and enclosure meet – plays a certain role. This means that references to the respective building standards also appear in various standards.

DIN EN/IEC 60068-3-3

IEC 60068-3-3, identical to DIN EN 60068-3-3 [Beu93] in Germany and Europe, is primarily a guideline for checking electrical devices for seismic resistance. The standard distinguishes between a general and a specific seismic class. The specific seismic class should be used where knowledge of the seismic movement exists based on the local geographical situation or the building in which the device is to be installed.

IEEE 693

The 693 [IEE05] standard issued by the Institute of Electrical and Electronics Engineers (IEEE) specifies the parameters for earthquake-resistant switchgear. It defines the test methods for complete switchgear systems and for individual components such as power circuit-breakers. Besides test methods, the standard also contains guidelines for designing earthquake-proof switchgear. These guidelines relate, for example, to buildings, foundations and how

enclosures are anchored to the floor. Thus reference is also made to building standards in this document.

Telcordia GR-63-CORE

Although the GR-63-CORE [Tel02] generic requirements originally developed by Bellcore – now Telcordia – for telecommunications are not a formal standard as such, they form a very commonly stipulated requirement in contracts, especially in the United States. The basic premise is that systems – such as data centres – need to offer a high level of structural resilience under exposure to various influences such as moisture, fire, pollutants and earthquakes. 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 tab. 3). In order to ensure high system availability, the requirements in zone 4 are correspondingly higher than in zone 0. These requirements are very high and can therefore also be found in other standards (e.g. IEC 60068-3-3, DIN EN 61587-5 (RRS for uniaxial acceleration), ETSI EN 300019-1-3).

6 Typical test methods

There are in general two approaches to designing systems in earthquake-prone areas. The first is to test the complete switchgear system with the desired configuration – including all components installed in the enclosures – in a suitable laboratory. This approach is very expensive and time consuming and, in Rittal's experience, is only required by a small number of users. When adopting the second approach, the control or switchgear manufacturer uses components (incl. enclosures) that have been verified in principle as suitable for use in earthquake-prone areas. Rittal has had examples of its TS 8 and VX25 enclosures verified in approved laboratories for this purpose. To obtain this verification, the enclosures are tested according to a defined method to ascertain their suitability in principle for use in earthquake-prone areas. The following chapters describe a typical method used to test the earthquake resistance of enclosures. The vast majority of users choose this less costly approach.

All the applicable standards prescribe tests on a vibrating table to demonstrate an enclosure's earthquake resistance. The aim is to simulate the effects of an earthquake – i.e. vibrations and shock stresses – in the laboratory.

The test piece is mounted onto the vibrating table, where it is subjected to a pre-defined test program. The test piece must not incur any structural damage as a result, meaning that no load-bearing parts may be damaged, broken, etc. In addition, no important connections should separate. The same also generally applies for enclosure doors, hinges and locks. Functional tests are then performed – to ensure that the system still functions as required post-stress.

6.1 Different frequency spectra in the standards

The precise test requirements vary according to the standard in question, particularly regarding the exact frequency spectrum and related accelerations. The test method specified in Telcordia GR-63-CORE is outlined here as an example. First, the enclosure is mounted on a vibrating table and fitted with acceleration and path recorders in its centre and on top. During the test, the enclosure must be loaded to an extent that simulates a real installation. The tests are then conducted by running a specified movement program that must reach the stipulated acceleration values at frequencies of between 1 Hz and 50 Hz (the required response spectrum (RRS)). The spectrum that arrives at the test piece – the test response spectrum (TRS) – is key. This varies according to the test structure and the mass and geometry of the test piece. The displacements of the test piece, measured in its centre and at its top, must not be greater than 75 mm (3 inches) at any point during the test.

The vibration table tests described above are performed in all three dimensions. The RRS stipulated in GR-63-CORE results in a test duration of 31 seconds in each dimension. The loads exerted on the enclosure during these tests correspond approximately with those experienced during an earthquake with a strength of 8.3 on the moment-magnitude scale.

6.2 Very similar test spectra

To compare the requirements of the vibration table tests in all three relevant standards, the required RRS can be plotted in an acceleration-frequency diagram (see fig. 1). This reveals that the spectra applied in the individual standards are quite similar but have different acceleration values in the relevant areas. It also becomes apparent that zone-4 certification according to GR-63-CORE meets the requirements of the other two standards almost in full. The scope of examination was deliberately increased for the new VX25 to ensure that the RRS of IEEE 693 was also covered.

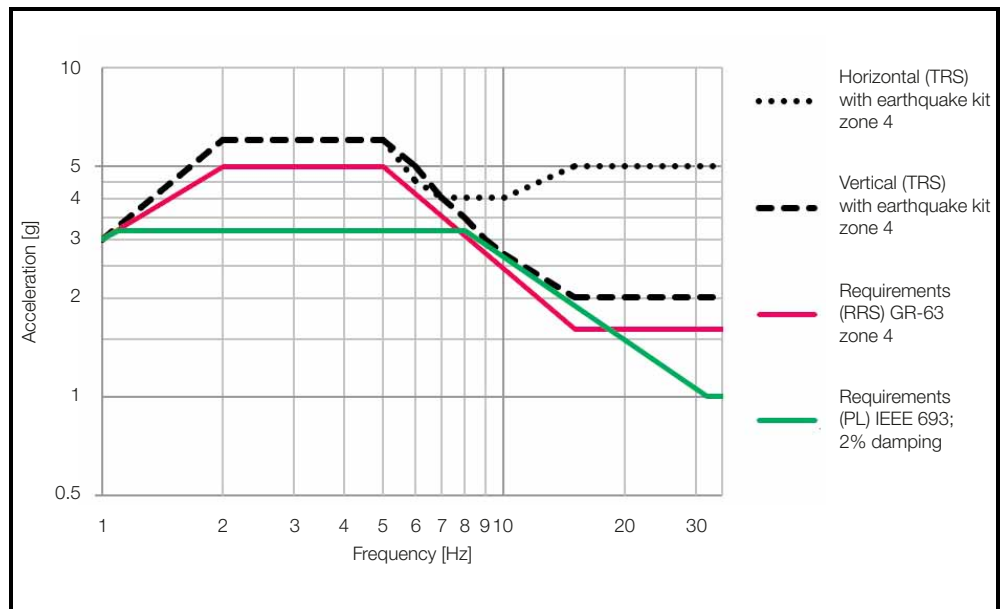


Figure 1: Acceleration-frequency diagram

7 Earthquake-resistant enclosure

One method of building stable mechanical constructions able to withstand tremors, which has continued to prove itself since ancient times, is a truss design. This design consists of individual members that are connected together at their ends to form triangles. As a result, the members are subjected almost exclusively to compressive or tensile forces, which makes the entire construction extremely sturdy and also reduces its weight. This technique is used to build houses, bridges and other load-bearing structures, with great success. These days, the norm is to provide buildings with as rigid a structure as possible, for example using solid concrete constructions. Another approach, which is particularly prevalent in high-rise buildings, is to use a tuned mass damper as an active element. An earthquake's movements make the damper move so that it absorbs almost all of the energy and thus prevents damage to the building's structures. A third option is to disconnect the object that is to be protected from the earthquake. This can be done, for example, by placing a building or item of equipment on oversized dampers that absorb and dampen the earthquake shockwaves. However, it is imperative to know exactly the weight that needs to be dampened and have adequate spring or damping path available.

Rittal also uses the truss technique to make its VX25 and TS 8 large enclosures (see fig. 2 and 3) earthquake-resistant. These robust enclosures are exceptionally flexible, efficient and high in quality. The optional earthquake extension accessories can be used to increase the rigidity of the enclosure frame to such an extent that both enclosure types satisfy the stringent requirements of zone 4 to GR-63-CORE. The earthquake kit consists of bracing struts that are screwed into the sides of the enclosure's frame to significantly enhance its rigidity. Gusset plates in the corners of the frame add extra stability. The mounting plate is additionally screwed to the bracing struts. While the rigidity of the mounting plate was increased by horizontal bars on the TS 8, this was not the case for the VX25. So the usable space of the VX25 mounting plate could be increased, since no screw heads have to be considered when planning the placing of the electrical components. A more stable base/plinth is also available that can be used to create an earthquake-resistant fixing between the enclosure and the floor.

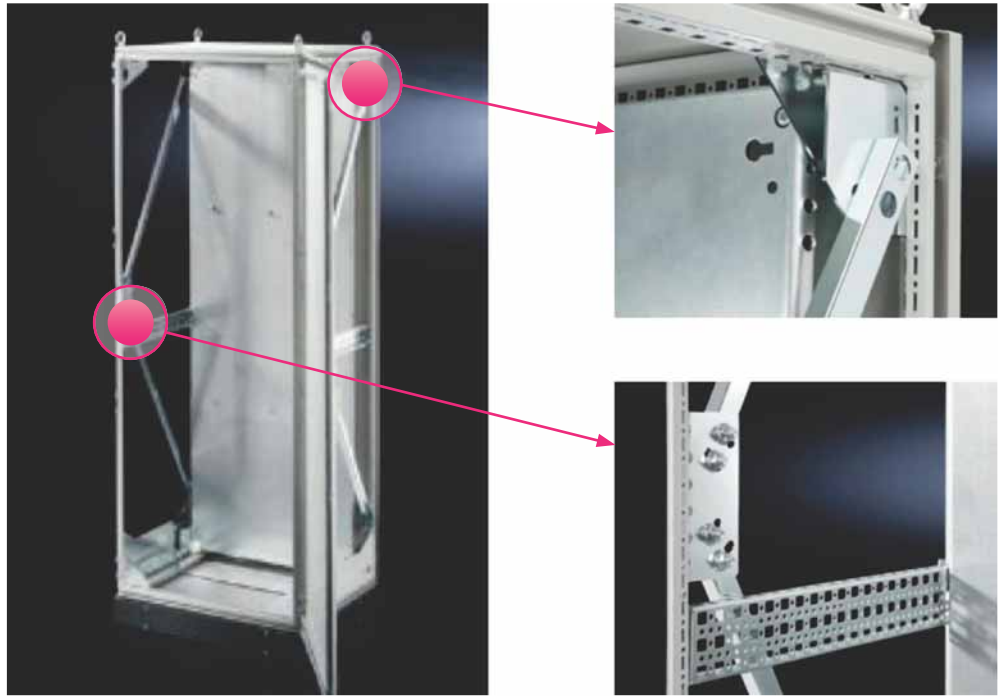


Figure 2: Earthquake extension accessories for the TS 8 large enclosure

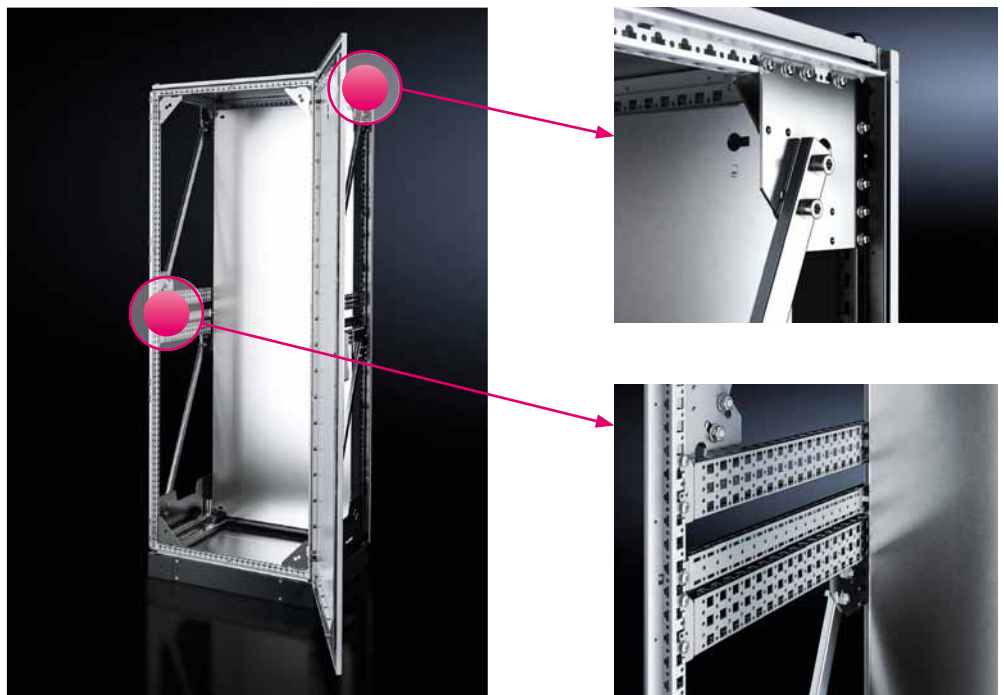


Figure 3: Earthquake extension accessories for the VX25 large enclosure

To demonstrate conformity with GR-63-CORE Zone 4, the TS 8 and VX25 large enclosures were tested by independent institutes. When fitted with the special earthquake accessories (consisting of earthquake kit, earthquake base/plinth and comfort handle), the enclosure achieved zone-4 certification with contents weighing 500 kg on its mounting plate and side walls. In addition, it was certified that configurations without any special accessories meet the requirements for lower zones with lower weights (see table below).

Due to its long heritage, the tests on the TS 8 were conducted with different dimensions. However, having tested these different variants – supported by tests on customer-specific variants – it is possible to assume that the design system is fit for purpose in principle. This means that TS 8 enclosures with other dimensions are also suitable for use in earthquake-prone areas and that the VX25 also exhibits similar suitability.

Peripheral conditions that need to be taken into account include the following:

- The standard / frequency spectrum must be comparable (see fig. 1)
- Even weight distribution
- The weight of installed components must be equal to, or less than, that of the tested variants
- The footprint must be equal to, or bigger than, the tested variants (bigger footprint improves lever ratio)
- Maximum height 2,000 mm (or centre of gravity no higher than 1000 mm, 750 mm in the case of the VX25 185 kg/zone 2)

Are bayed enclosures permitted? A stand-alone enclosure can be considered the worst-case scenario, so bayed enclosures are permitted. If anything, this arrangement improves the situation, since two interconnected vertical sections are more rigid than two separate vertical sections.

TS 8 variants tested

Model No.	Dimensions (W x H x D) mm	Measures	Tested installed weight kg	Standard, level
8806.500	800 x 2000 x 600	Standard	152	Telcordia GR-63-Core, Zone 3
8806.500	800 x 2000 x 600	Comfort handle, earthquake kit, earthquake plinth	500	Telcordia GR-63-Core, Zone 4
8604.500	600 x 2000 x 400	Comfort handle, earthquake kit, earthquake plinth	500	Telcordia GR-63-Core, Zone 4
8606.500	600 x 2000 x 600	Comfort handle, earthquake kit, earthquake plinth	500	Telcordia GR-63-Core, Zone 4

Table 4: Overview TS 8

VX25 variants tested

Model No.	Dimensions (W x H x D) mm	Measures	Tested installed weight kg	Standard, level
8806.000	800 x 2000 x 600	Side panels, base/plinth	185	Telcordia GR-63-Core, Zone 2 (2 g peak between 1 and 5Hz)
8806.000	800 x 2000 x 600	Side panels, comfort handle, earthquake plinth	150	Telcordia GR-63-Core, Zone 3 (3 g peak between 2 and 5Hz)
8806.000	800 x 2000 x 600	Side panels, comfort handle, earthquake plinth, earthquake kit	500	Telcordia GR-63-Core, Zone 4 (5 g peak between 2 and 5Hz)

Table 5: Overview VX25

Rittal can also assist here in an advisory capacity and, in borderline cases, work together with the customer to produce a qualified solution.

Additional note: Bolts for bases/plinth

Contrary to the values stated in the handbook for standard usage, the enclosure and base/plinth system are screwed together using 8 M12 screws (two at each corner) with a tightening torque of 45 Nm.

8 Specific approach

Even armed with this information about earthquakes, potential damage and the standards that exist, one question remains: How do you deal with a specific inquiry for earthquake-proof switchgear? The first step is to clarify the geographical location – for which country and which earthquake zone is the switchgear required? Then the standard underlying the requirement needs to be identified. All requirements relating to the building or how the switchgear is anchored within the building must be taken into consideration by the parties responsible for the construction and structural design. If there is no application standard for the enclosure, but just the construction standard or building code, then it can be helpful to compare the ground acceleration cited in the standard with the zone values for the United States in Table 3. If, for example, a ground acceleration of 0.1 g is required in the construction standard, this would lie within the requirements for Telcordia Zone 2. An enclosure configuration approved for this zone could also be classed as suitable for the requirement in question.

In respect of the above-cited examples of application standards, a distinction has to be made between structural integrity and functional integrity. If the sole concern is structural integrity, then a certified enclosure, such as the TS 8 enclosure fitted with the appropriate earthquake accessories, as described in the previous section, will generally suffice.

Of course, an enclosure cannot guarantee the functional integrity of a system, which is sometimes also required. Extensive tests need to be carried out for this purpose. Finite-element-method structural calculations can be performed in preparation. During this process, it is important to test the switchgear with the contents that are actually going to be fitted. Ultimately, the distribution and weight of the installed components can influence the vibration behaviour of the enclosure. The way the enclosure is installed – whether on mounting plates, top hat rails or busbar systems – can also affect its behaviour. For this requirement it is therefore advisable to test earthquake-resistant enclosures for each specific scenario, i.e. with the intended contents in place.

9 Summary

Earthquakes can represent a very serious danger to people and property in certain geographical locations. Electrical switchgear systems and data centres are not only very valuable property, but their key role in the technical infrastructure makes them particularly vital – hence the need to ensure their earthquake-resistance in regions where there is a risk of earthquakes. Enclosures – generally those containing switchgear and servers – play a key role in safeguarding the functional integrity of such a system in the event of an earthquake. After all, if these suffer serious structural damage, then this will undoubtedly disable the system.

Earthquake-resistant enclosures are thus extremely important. Various standards define the requirements such enclosures have to fulfil in order to qualify as earthquake-resistant. Different standards apply depending on the particular application and geographical market. Even though they adopt different approaches, they have one key aspect in common – the vibration test on a vibration table, which simulates the accelerations caused by an earthquake. The precise frequency and acceleration spectrum does vary to a certain extent from one vibration table test to another, however.

The VX25 and TS 8 large enclosure systems from Rittal are customised to satisfy the various earthquake standards up to the most stringent zone-4 requirement.

10 Table of figures, tables and sources

Table of figures

Figure 1: Acceleration-Frequency-Diagram.	14
Figure 2: Earthquake extension accessories for the TS 8	16
Figure 3: Earthquake extension accessories for the VX25 large enclosure	16

Tables

Table 1: Fatalities during natural disasters from 1980 to 2013	4
Table 2: The Mercalli Scale compared to the Japanese JMA Scale	7
Table 3: Ground acceleration in Europe and the USA	9
Table 4: Overview TS 8	18
Table 5: Overview VX25	18

Table of sources

[Mun14] Munich Re, NatCatSERVICE, 2014	4
[BEU93] DIN IEC 60068-3-3:1993-09 Environmental tests; seismic test methods for devices, Beuth-Verlag.	11
[IEE05] IEEE Standard 693 – IEEE Recommended Practice for Seismic Design of Substations, 2005	11
[TEL02] Telcordia GR-63-CORE Issue 2, 2002	12

Rittal – The System.

Faster – better – everywhere.

- Enclosures
- Power Distribution
- Climate Control
- IT Infrastructure
- Software & Services

You can find the contact details of all Rittal companies throughout the world here.



www.rittal.com/contact

RITTAL GmbH & Co. KG
Postfach 1662 · D-35726 Herborn
Phone +49(0)2772 505-0 · Fax +49(0)2772 505-2319
E-mail: info@rittal.de · www.rittal.com

11.2018

ENCLOSURES

POWER DISTRIBUTION

CLIMATE CONTROL

IT INFRASTRUCTURE

SOFTWARE & SERVICES

FRIEDHELM LOH GROUP

