SWITCHGEAR, SWITCHBOARDS & BUSWAYS IEC 62271 / IEC 61439

HOW TO BE APPROVED in SEISMIC TESTS ?

http://www.cognitor.com.br/seismicswitchgear.pdf

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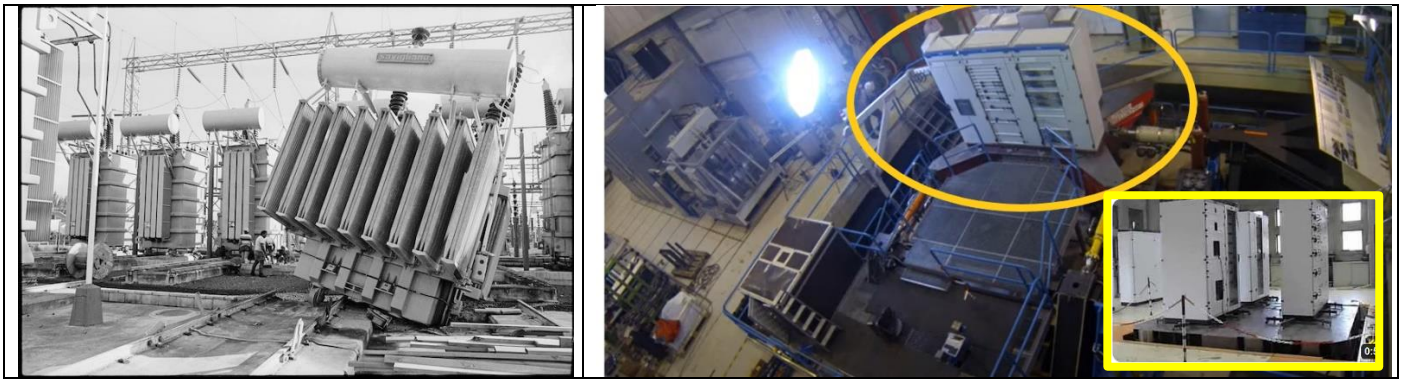


Video **https://youtu.be/wuOaVqOe5d4**

1. WHAT TO DO TO TEST A SWITCHGEAR PANEL TO BE APPROVED IN SEISMIC TESTS?

Some time ago, a client of my consultancy services for switchgear and switchboards design and testing (IEC 62271 and IEC 61439 series) asked me for an assessment about “how to pass in the seismic tests”.

I explained to the client that I never had specific experience with this because none of my clients had requested this before. In Brazil we don't have earthquakes and the most destructive actions are caused by high taxes, among the highest in the world, and by the low average level of Education. It is just this that prevents Brazil from quickly reaching the G7.

I remembered that some 25 years ago, when I was the general manager of CEPEL’s laboratories we had in the mechanics area labs a good shaking table to do seismic tests. It was rarely used, and I do not know if still exist. I lost completely the contact with the people there.

Also, few years ago a Brazilian client asked me about seismic tests because was going to sell switchgear panels to Chile, where earthquakes occur. In that times I refused the work and I think that they contracted some expert in calculations to replace the test. With my experience in lab tests, testing simulations and design I am sure that calculations are not enough for this kind of requirement.

Then I went through the strategy of reading the IEC and other technical standards trying to find some kind of guidance. I went also to the Web to identify if there also any “tricks and tips” for whom design an equipment “to be approved Seismic tests”.

In the next lines i resume what I found in this search. I did not find special measures used in this kind of equipment, but I imagine they exist. If they exist companies do not in the photos. As I am trying to learn the subject and I'm already too old to have vanities, any correction or criticism is very welcome.

2. WHAT IS THE TEST PRESCRIBED IN THE MAIN STANDARDS AND WHAT SHALL BE VERIFIED AFTER

First, this is not a test that can be simulated, and so, my analysis consists of understanding the IEC test requirements and identify literature about adaptations of the design to attend, for example, the 1.0 g class. Resuming, my objectives were:

(a) to understand the testing requirements of the standards and

(b) finding design tricks & tips used in equipment that will undergo seismic testing

Suppose that a manufacturer wants to do the test with acceleration 0.8g. The intensity expected on the countries, in the areas of higher seismic risk, reach different values. They are usually specified in local or national standards. The main titles of the technical standards are listed below.

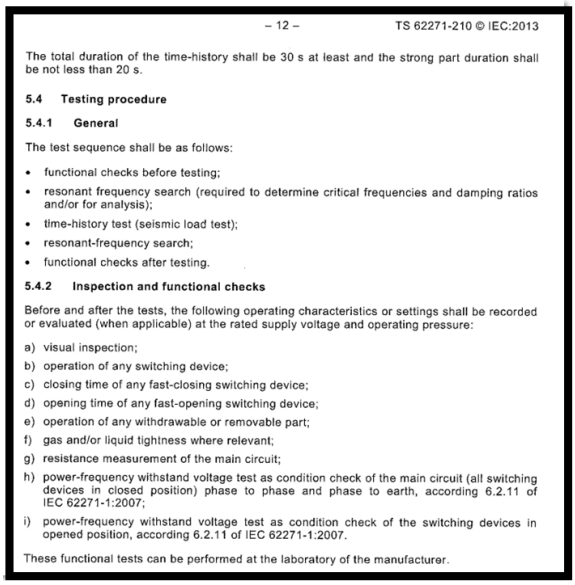
> THE TEST consists of fixing the panel to a shaking table that will produce specified lateral and vertical forces, as in an earthquake. The key aspect is "what will be verified after the tests", in relation to the panel functionalities. In this respect, the article: "Earthquakes and Seismic Compliance of LV Switchgear Assembly" (Dinesh Singh) is interesting and didactic.
> https://www.linkedin.com/pulse/earthquakes-seismic-compliance-lv-switchgear-assembly-dk-singh/

Also, principles of "inspection and functionality tests" after passing by the vibrations in the table are well detailed the section 5.4 of the IEC TS IEC 62271-210 (2013).

The observations after a successful seismic test, are verified by visual inspection. They are:

- No permanent deformation, dislocation, breakage, or cracks
- No loosening of components/equipment's from their original mounting and
- Doors to remain in closed position as was before test.
- Mounted equipment's should be in operational state in energized condition.
- A point to observe is that components as circuit-breakers, switches, relays TCs, TPs and busbars shall be in place during the test. I suppose that during the earthquake the complete set may be deenergized only momentarily.

An obvious point to mention is that the principles of "inspection and functionality tests" after the vibrations in the shaking table as well as section 5.4 of the IEC TS IEC 62271-210 (2013), for medium voltage switchgear, very possibly, are applicable to low voltage switchgear. The earthquake does not choose the voltage.



– 12 – TS 62271-210 © IEC:2013

The total duration of the time-history shall be 30 s at least and the strong part duration shall be not less than 20 s.

5.4 Testing procedure

5.4.1 General

The test sequence shall be as follows:

- functional checks before testing;
- resonant frequency search (required to determine critical frequencies and damping ratios and/or for analysis);
- time-history test (seismic load test);
- resonant-frequency search;
- functional checks after testing.

5.4.2 Inspection and functional checks

Before and after the tests, the following operating characteristics or settings shall be recorded or evaluated (when applicable) at the rated supply voltage and operating pressure:

a) visual inspection;
b) operation of any switching device;
c) closing time of any fast-closing switching device;
d) opening time of any fast-opening switching device;
e) operation of any withdrawable or removable part;
f) gas and/or liquid tightness where relevant;
g) resistance measurement of the main circuit;
h) power-frequency withstand voltage test as condition check of the main circuit (all switching devices in closed position) phase to phase and phase to earth, according 6.2.11 of IEC 62271-1:2007;
i) power-frequency withstand voltage test as condition check of the switching devices in opened position, according 6.2.11 of IEC 62271-1:2007.

These functional tests can be performed at the laboratory of the manufacturer.

3. LIST OF TECHNICAL STANDARDS and CONTENTS

IEC TS 62271-210 (013) : High-voltage switchgear and controlgear - Part 210: Seismic qualification for metal enclosed and solid-insulation enclosed switchgear and controlgear assemblies for rated voltages above 1 kV and up to and including 52 kV
Applies to assemblies of IEC 62271-200 and IEC 62271-201, intended to be used under seismic conditions. The seismic qualification considers any auxiliary and the control equipment mounted directly on the assembly. It specifies seismic severity levels, acceptance levels, and give methods to demonstrate the performance for which seismic qualification is required. https://www.sis.se/api/document/preview/571972/

IEC/IEEE 60980-344 (2020) - Nuclear facilities - Equipment important to safety - Seismic qualification https://webstore.iec.ch/publication/63550

Describes methods for establishing seismic qualification procedures that will yield quantitative data to demonstrate that the equipment can meet its performance requirements. This document is applicable to electrical, mechanical, instrumentation and control equipment/components that are used in nuclear facilities. Provides methods and documentation requirements for seismic qualification of equipment to verify the equipment's ability to perform its specified performance requirements during and/or after specified seismic demands. This document does not specify seismic demand or performance requirements. Other aspects, relating to quality assurance, selection of equipment, and design and modification of systems, are not part of this document. As seismic qualification is only a part of equipment qualification, this document is used in conjunction with IEC/IEEE 60780-323.
The seismic qualification demonstrates equipment's ability to perform its safety function(s) during and/or after the time it is subjected to the forces resulting from at least one safe shutdown earthquake (SSE/S2). This ability is demonstrated by considering, prior to the SSE/S2, the ageing of equipment and the postulated occurrences of a given number of lower intensity operating basis earthquake (OBE/S1). Ageing phenomena to be considered, if specified in the design specification, are those which could increase the vulnerability of equipment to vibrations caused by an SSE/S2

IEEE 693 (2018) - Recommended Practice for Seismic Design of Substations

Seismic design recommendations for substations, including qualification of different equipment types, are discussed. Design recommendations consist of seismic criteria, qualification methods and levels, structural capacities, performance requirements for equipment operation, installation methods, and documentation.

IEC 60068-2-57 (2013) - Environmental testing Tests. Test Ff: Vibration. Time-history and sine-beat method

Provides a procedure for determining, by the time-history and sine-beat methods, the ability of a specimen to withstand specified severities of transient vibration. To be read in conjunction with **IEC60068-**1 (1988).

4. ABOUT DESIGN TRICKS AND TIPS

After understanding the main testing requirements, specially about the state of equipment after the vibrations table, I went to search about design tricks & tips used in equipment that will undergo seismic testing.

> I found few technical details, explicitly mentioning seismic tests. It is not clear for me if they are not disclosed by the manufacturers or if they simply do not exist. I mean that a switchgear which will be subjected to seismic tests possibly is not significantly different from a switchgear which will not pass through the seismic tests.

Below is a list of documents I found in Web searches contain information. I did not read all of them.

1 SOME PARTS OF VIDEOS FOUND IN YOUTUBE

https://www.youtube.com/watch?v=_h1aB_Nk_W0

https://www.youtube.com/watch?v=cJVr94drRIs

https://www.youtube.com/watch?v=F4a_LqDao-8

2 **IEC/IEEE 60980-344 (2020) -** Nuclear facilities - Equipment important to safety - Seismic qualification
https://webstore.iec.ch/publication/63550

ARTICLE: "Earthquakes and Seismic Compliance of LV Switchgear Assembly" (Dinesh Singh)
https://www.linkedin.com/pulse/earthquakes-seismic-compliance-lv-switchgear-assembly-dk-singh/

Some highlights: Need of Testing a System for Seismic effect: During the seismic vibrations power contacts, cables & wire connections, internal components of switchgear & other devices may get misaligned. This could lead to malfunctioning of the equipment post-earthquake. A study of seismic effects on a structure, equipment or device will reveal its worthiness to withstand an earthquake without appreciable damage and perform satisfactorily during and after sudden shocks and vibrations. It is possible to study their performance through prescribed seismic withstand tests.
Assembly Testing for Seismic withstand : It is normal to test large complex assemblies by simulating the most critical in-service conditions. In such a case, the specimen is subjected to the required seismic input motion while the operating conditions are applied or simulated and while its performance is recorded during the tests.
After testing: , the assembly shall be inspected and the integrity of all the unmonitored devices, such as cabling, checked. The purpose of installing inoperative devices is to ensure that the specimen possesses the same dynamic characteristics as in normal operation. Seismic testing is a complex subject and providing details of testing procedures & acceptance criterion is not the objective of this paper. Though it can be referred from relevant standards. National & International Standards on switchgear assemblies normally not required such tests. They become vital when electrical equipment's are installed in Nuclear Power Plant (NPP) malfunctioning of equipment's proved to be catastrophic. ….

ARTICLE: Experimental Investigations of the Seismic Performance of a Base-Isolated Uninterruptible Power Supply (UPS) through Shaking Table Tests - Gia Toai Truong,1Seung-Jae Lee,1Ji-Eon Lee,1and Kyoung-Kyu Choi
https://www.hindawi.com/journals/sv/2022/2304290/

ARTICLE: EARTHQUAKE PROTECTION FOR SWITCHGEAR SYSTEMS (BY RITTAL)
https://www.rittal.com/imf/none/5_4394/Rittal_Whitepaper_Earthquake_protection_for_switchgear_sy_5_4394/

ARTICLE:: "Seismic Qualification of Electrical Cabinet Using High-Fidelity Simulation under High Frequency Earthquake"
https://www.mdpi.com/2071-1050/12/19/8048

ARTICLE: The seismic qualification of electrical equipment systems in loviisa npp automation renewal project Auth: Pentti Varpasuo - Fortum Nuclear Services, 00048 Fortum, Finland
https://www.iitk.ac.in/nicee/wcee/article/14_12-01-0137.pdf

ARTICLE: Seismic Qualification of an Electrical Cabinet: Comparison of Analysis and Test Results Marcus Ries1 , Tino Hahn2 , F.-O. Henkel
https://repository.lib.ncsu.edu/bitstream/handle/1840.20/35974/SMiRT-24_05-01-01.pdf?sequence=1&isAllowed=y

ARTICLE: Seismic White Paper SA12501SE Effective August 2009 Earthquake requirements and seismic capabilities for Eaton's electrical distribution and control equipment
https://www.eaton.com/content/dam/eaton/products/seismic-certificates/earthquake-requirements-and-seismic-capabilities-for-eaton-electrical-distribution-and-control-equipmen.pdf

WEB SEARCH: how to design electric panels to support earthquakes
https://www.google.com.br/search?as_q=how+to+design+electric+panels+to+support+earthquakes&as_epq=&as_oq=&as_eq=&as_nlo=&as_nhi=&lr=&cr=&as_qdr=all&as_sitesearch=&as_occt=any&safe=images&as_filetype=&tbs=

WEB SEARCH: condition after seismic test iec
https://www.google.com.br/search?as_q=CONDIITION+AFTER+SEISMIC++TEST+IEC++&as_epq=&as_oq=&as_eq=&as_nlo=&as_nhi=&lr=&cr=&as_qdr=all&as_sitesearch=&as_occt=any&safe=images&as_filetype=&tbs=

SEARCH: DESIGN OF ELECTRICAL PANELS FOR EARTHQUAKES

https://www.google.com.br/search?as_q=design+of+electrical+panels+for+earthquakes&as_epq=&as_oq=&as_eq=&as_nlo=&as_nhi=&lr=&cr=&as_qdr=all&as_sitesearch=&as_occt=any&safe=images&as_filetype=&tbs=

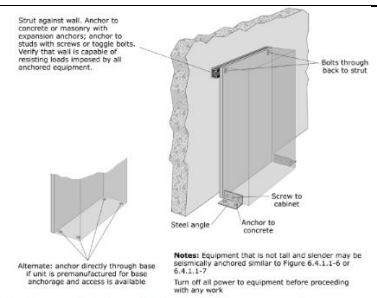
SEARCH: DESIGN OF ELECTRICAL PANELS FOR SEISMIC TESTS
https://www.google.com.br/search?q=design+of+electrical+panels+for+seismic+testsearthquakes&lr=&safe=images&as_qdr=all&ei=yPgVZMShH5KF0Aa2w6SwCQ&ved=0ahUKEwjEpYabhOb9AhWSAtQKHbYhCZYQ4dUDCA8&uact=5&oq=design+of+electrical+panels+for+seismic+testsearthquakes&gs_lcp=Cgxnd3Mtd2l6LXNIcnAQAzoICAAQogQQsAM6BQgAEKIEOgQIIRAKSgQIQRgBUMUmWPZPYK9aaANwAHgAgAGdAYgBzQ2SAQQwLjEzmAEAoAEByAEBwAEB&sclient=gws-wiz-serp

SEARCH: SEISMIC DESIGN SWITCHGEAR
https://www.bing.com/images/search?q=SEISMIC+DESIGN+SWITCHGEAR&qs=n&form=QBIDMH&sp=-1&ghc=1&lq=0&pq=seismic+design+switchgear&sc=0-25&cvid=A7F777D508664E94AA752E9B478BE3C7&ghsh=0&ghacc=0&first=1

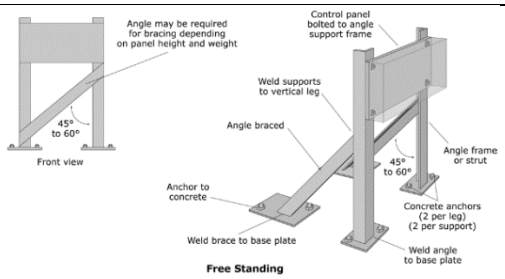
Found in the Web: Electrical control panels, motor control centers, switchgear and substations.
https://knowriskproject.com/electrical-panels-substations/?lang=pt

Equipment cabinets retrofitted with unidirectional snubbers at base (Photo courtesy of Mike Griffin).

Installation that performed well in the 2010 magnitude-8.8 Chile Earthquake; cabinets anchored at base. Some cabinets tied together side by side using existing lifting hooks at top of cabinets (Photos courtesy of Rodrigo Retamales, Ruben Boroschek & Associates).



igure 6.4.7.1-11 Electrical control panels, motor controls centers, or switchgear (ER).



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The author of this article is Eng. Sergio Feitoza Costa. Sergio is an electrical engineer, M.Sc. in power systems and director of COGNITOR. It has 40+ years of experience in the design, operation and management of high power, high voltage, and other testing laboratories. After leaving CEPEL's testing labs, Sergio gained considerable experience using lab experience + test simulations to support manufacturers and certification companies.
He is the author of SwitchgearDesign for testing simulations and DECIDIX for technical economical assessment of energy projects. Sergio was chairman of IEC Technical Committee 32 and is coauthor of IEC 62271-307 & IEC60282-2. In CIGRÈ is, coauthor of Cigrè brochures 602 (Internal Arc), 740 (Substations) and 830 (temperature rise). Sergio is also book writer, songs composer & musician.

More details, CV, free publications, training, and use of “SwitchgearDesign” in the site https://www.cognitor.com.br

CV here https://www.cognitor.com.br/Curriculum.html

Some things Sergio helped to do https://www.cognitor.com.br/HelpedToDo.pdf .

More https://www.cognitor.com.br/heritage.html

Books and articles free: https://www.cognitor.com.br/Downloads1.html

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Training: https://www.cognitor.com.br/trainingENG.pdf