

Examination Procedure <small>Title</small> Seismic Qualification	Document KBE EP-147
	Issue 8
	Date 2024-05-07
	Supersedes 7

1 Scope

This examination procedure is applicable to all types of electrical equipment and shall be performed as type inspection.

2 Objective

To demonstrate the ability of devices and equipment to perform their required function during and after the design basis earthquake.

The design basis earthquake is the SSE /S2, Safe Shutdown Earthquake according to IEC/IEEE 60980-344.

3 Method

3.1 General Requirements

Equipment may be qualified for seismic requirements by testing, analysis, experience or a combination of these.

Normally verification by testing is required. Static or dynamic analysis or combined tests and analysis may be adequate for the verification of structurally simple and/or rigid equipment and shall be performed in accordance with IEC/IEEE 60980-344. Qualification method shall be specified by the Manufacturer/Supplier and approved by the Purchaser.

Test methods other than those stated in this Examination Procedure that are found in IEC/IEEE 60980-344, may be applied after approval by the Purchaser e.g. continuous sinus or sine-beat.

Electrical equipment, such as control panels, densely packed racks, modules, transducers, relays and other types of functionally and structurally complex equipment, are not suitable for qualification by analysis and shall therefore be qualified by testing as specified in this Examination Procedure.

Complex assemblies consisting of several devices may be tested without being in operation, provided that enough vibration monitoring equipment is used to determine vibration levels and natural frequencies. The maximum acceleration level at the locations of inoperative devices shall then be used for testing the devices individually. When these tests are performed the devices shall be in operation.

All variants or sizes within a group of the same type of equipment are not required to be tested. A representative selection of equipment to be tested shall be made by the Manufacturer/Supplier for approval by the Purchaser. The selection shall be based on similarity in form, function and structural dynamics so that the qualification is representative for all units included in the delivery.

Generally the device or assembly shall be tested in a manner that simulates the intended operation and way of mounting/installation.

Tested items may not be a part of the delivery unless otherwise agreed upon.

If the equipment to be tested has significant ageing mechanisms, the equipment shall prior to the seismic testing, be subjected to simulated ageing of these mechanisms (thermal and/or mechanical ageing). Simulated ageing is described in KBE EP-154.

3.2 Test plan

A detailed test plan shall be worked out by the Manufacturer/Supplier and be approved by the Purchaser prior to any testing. The test plan shall fulfil the test and documentation requirements specified in this Examination Procedure and in the Technical Specification.

4 Test Requirements

4.1 Seismic simulation test

4.1.1 General

The equipment or separately tested device shall be subjected to vibratory motion along each of the three major perpendicular axes (horizontal x/y, vertical z).

Vibration/fatigue testing according to KBE EP-154 is preferably coordinated with the testing described in this Examination Procedure.

4.1.2 Test method

Preferably the equipment should be subjected triaxial independent multifrequency test, biaxial can be accepted in agreement with Purchaser (Time History Test according to IEC/IEEE 60980-344).

The choice of test method shall be made such that operational performance could be verified during the test. Use of sinusoidal waves, continuous or sine-beat, is not considered suitable for seismic testing of “Hard mounted” equipment. Sine wave motion may result in uncontrolled resonances damaging the equipment.

Line mounted equipment shall be tested for a series of single-frequency tests according to IEC/IEEE 60980-344. Requirement levels are given in TS.

The test specimen shall be fastened by means of its normal mounting devices. If additional fastening devices are necessary, this shall be specified in the test plan and noted in the test report. The test specimen should also, if applicable, be completely assembled and provided with all protective and mounting devices, cables, connectors and other interfaces, as required for the operation when installed in a system.

4.2 Functional monitoring during the test

4.2.1 General

As a general rule, the equipment shall be in operation during the test and shall be electrically energized prior to the test sequence for a time sufficient to reach thermal equilibrium.

Sufficient monitoring equipment shall be used to evaluate the performance of the equipment prior to, during and after the test. A specification of the functional conditions, requirements and malfunction criteria as well as typical loads and operational settings of adjustable devices, shall be made up by the Manufacturer/Supplier in cooperation with the Purchaser.

4.2.2 Active device testing

Devices such as sensors, actuators, controllers, amplifiers, relays, contactors, etc., shall be electrically energized during the test, and the performance of relevant operational modes shall be verified. Requirement for operation during testing is specified in technical specification.

4.2.3 Passive device testing

Devices such as terminal blocks, connectors, manually operated switches, wiring, cabling and other electromechanical components, shall be monitored during the test in such a way that breaks or shorts and other malfunctions are detected.

4.3 Test sequence

4.3.1 Testing of complete assemblies

Testing of complete assemblies consisting of several devices, such as cabinets, panels etc.

General

The test sequence in this section shall apply to complete assemblies or units which with regard to weight and size can be mounted on the vibration table, and can be adequately operated and monitored during the test.

If all devices in the assembly are not in operation during testing, these devices shall be tested separately according to section 4.3.2 Device testing.

Resonance search

A resonance search at low excitation (approx. 0,2 g) in each direction shall be conducted to determine the natural frequencies of the equipment within the specified frequency range and also to establish the damping of the tested equipment.

The excitation is done in the frequency range 2 – 50 Hz while the resonance monitoring is done in an expanded range with max 100 Hz in order to detect vibration caused by mechanical impact and rattling.

Frequency range, excitation: 2 – 50 Hz

Frequency range, resonance monitoring: 2 – 100 Hz

Seismic simulation test

A seismic simulation test shall be conducted to ensure that maximum acceleration is applied with simultaneous excitation in at least two directions within the entire seismic frequency band. All combination of the x-, y- and z-directions shall be tested. Triaxial excitation is preferred.

Acceleration: Response spectrum according to the Technical Specification. Preferably one of the Seismic Environmental Classes SL1 – SL6 should be selected.
See Figure 1, 2 and 3.

Frequency range: 2 – 50 Hz

Test duration: minimum 15 seconds

Test cycles: 1

If the vibration generator cannot generate the acceleration stated at low frequencies, the test may be performed excluding the lower frequency range, provided that the following condition is met: If the lowest natural frequency of the test specimen is F_{01} , the lower frequency limit for the test spectrum shall be $\leq F_{01} / \sqrt{2}$. Particulars concerning such test limitations shall be described in the test procedure.

4.3.2 Device testing

General

The test sequence below applies to devices intended for mounting in cabinets, panels or similar structures.

It is assumed that the cabinets, etc., have been previously analysed or tested with inoperative devices installed, in order to determine natural frequencies and accelerations at the device locations.

Resonance search

A resonance search in each direction shall be conducted to determine the natural frequencies of the equipment within the specified seismic frequency range. If certain types of (closely located) devices will cause mechanical impacts or rattling the frequency range shall be expanded to 100 Hz.

Frequency range: 2 – 50 Hz, max 100 Hz

Seismic simulation test

A seismic simulation test shall be conducted to ensure that maximum acceleration is applied with simultaneous excitation in at least two directions within the entire seismic frequency band. All directions x, y and z shall be tested. Triaxial excitation is preferred.

Acceleration: Response spectrum according to analysis or tests performed for relevant device locations.

Frequency range: 2 – min 50 Hz, max 100 Hz

The test spectrum shall include frequencies shown to have significant resonance levels at the test according to section 4.3.1 in the range 50 – 100 Hz.

Test duration: minimum 15 seconds

Test cycles: 1

If the vibration generator cannot generate the acceleration stated at low frequencies, the test may be performed excluding the lower frequency range provided that the following condition is met: If the lowest natural frequency of the test specimen is F_{01} , the lower frequency limit for the test spectrum shall be $\leq F_{01} / \sqrt{2}$. Particulars concerning such test limitations shall be described in the test procedure.

5 Acceptance Criteria

The functional requirements are specified in the Technical Specification and supplementary documents.

The delivered equipment shall meet all requirements regarding functional performance and structural integrity (e.g. requirements on degree of protection provided by enclosure, isolation distance, protection against electrical shock, etc.) during and after the test sequence.

For Swedish conditions where SSE/S2 only needs to be considered certain structural deformations may be accepted, e.g. it is acceptable that cabinet doors are difficult to open or to reclose. Even minor deformations on fasteners can be accepted provided that equipment or cables are not damaged.

6 Documentation

Performed verification/qualification of seismic capability shall be documented in a technical report.

6.1 Qualification by analysis

The analytical calculations shall be presented in a clear and systematic manner and be easily auditable. Maximum displacements and stresses should be computed, and the values should not exceed documented allowable limits for safe operation. A summary of the results from the calculations performed, including applicability limitations and concise statement of the conclusions drawn, shall be provided.

6.2 Qualification by testing

The report shall as a minimum include the following:

- Product identification

Product type, designation, version, quantity and serial number as well as reference to relevant specifications. In addition, it shall be specified which variants and versions of the product the testing is applicable for.

- Test specimens, identity, traceability

The identity of the test specimens in comparison with the Manufacturer/Supplier specification and/or the Technical Specification shall be clearly verified according to KBE EP-180.

- Test plan

It shall be clearly stated whether the test and inspection have been carried out according to this document or according to any other specification or procedure agreed upon.

- Test set-up

Detailed description of the test set-up including electrical and mechanical connections.

- Test and monitoring equipment

Manufacturer/Supplier, type, identification, accuracy and calibration status for monitoring and recording equipment shall be stated. In addition, mounting to the shake table and location of monitoring accelerometers shall be specified.

- Acceptance criteria

Performance requirements before, during and after specified tests.

- Test response spectra

Test response spectra obtained shall be shown to meet acceptable requirement of compliance with the required response spectra. Preferably, this shall be presented as response curve diagrams.

- Test results

Results and conclusions, particularly functional performance, natural frequencies, and maximum acceleration shall be reported. Measured values that shall be documented according to the test plan, as well as any deviations from requirements in applicable specifications or test procedures, shall be included in the report. Date of testing and name of responsible inspectors shall be included.

- Summary and conclusion

The approved test report shall include a summary clearly stating the extent to which the product has fulfilled specified requirements and acceptance criteria.

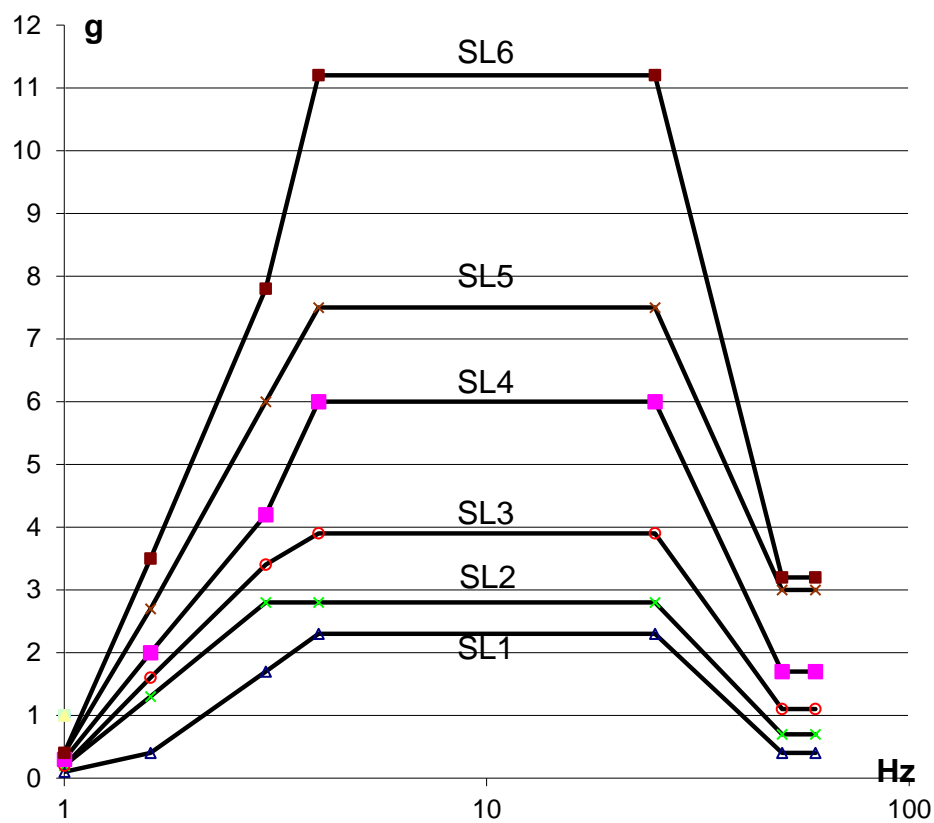
- Approval

The report shall be reviewed and approved in accordance with the Manufacturers/Supplier and/or the Test Laboratories internal QA/QC-routines.

6.3 Experience-based seismic qualification

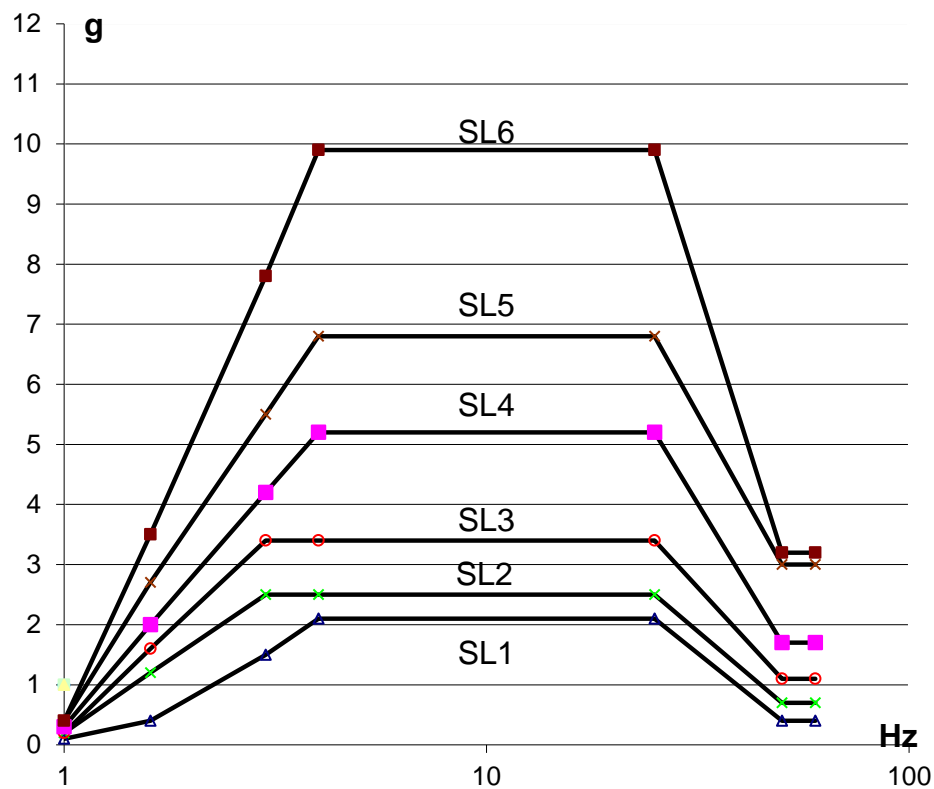
Experience-based seismic qualification shall be made in accordance with IEC/IEEE 60980-344

Figure 1
Seismic environmental classes - 4 % damping



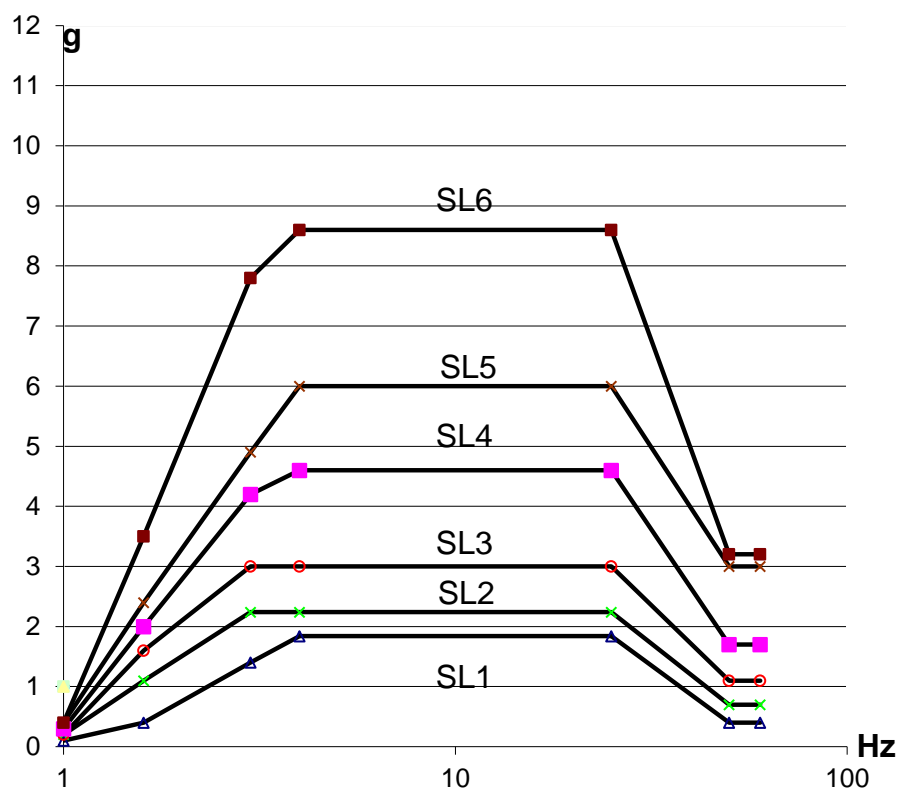
Hz	SL1 g	SL2 g	SL3 g	SL4 g	SL5 g	SL6 g
1	0,1	0,2	0,2	0,3	0,4	0,4
1,6	0,4	1,3	1,6	2,0	2,7	3,5
3	1,7	2,8	3,4	4,2	6,0	7,8
4	2,3	2,8	3,9	6,0	7,5	11,2
25	2,3	2,8	3,9	6,0	7,5	11,2
50	0,4	0,7	1,1	1,7	3,0	3,2
60	0,4	0,7	1,1	1,7	3,0	3,2

Figure 2
Seismic environmental classes - 5 % damping



Hz	SL1 g	SL2 g	SL3 g	SL4 g	SL5 g	SL6 g
1	0,1	0,2	0,2	0,3	0,4	0,4
1,6	0,4	1,2	1,6	2,0	2,7	3,5
3	1,5	2,5	3,4	4,2	5,5	7,8
4	2,1	2,5	3,4	5,2	6,8	9,9
25	2,1	2,5	3,4	5,2	6,8	9,9
50	0,4	0,7	1,1	1,7	3,0	3,2
60	0,4	0,7	1,1	1,7	3,0	3,2

Figure 3
Seismic environmental classes - 7 % damping



Hz	SL1 g	SL2 g	SL3 g	SL4 g	SL5 g	SL6 g
1	0,1	0,2	0,2	0,3	0,4	0,4
1,6	0,4	1,1	1,6	2,0	2,4	3,5
3	1,4	2,24	3,0	4,2	4,9	7,8
4	1,84	2,24	3,0	4,6	6,0	8,6
25	1,84	2,24	3,0	4,6	6,0	8,6
50	0,4	0,7	1,1	1,7	3,0	3,2
60	0,4	0,7	1,1	1,7	3,0	3,2