IEC 62271-307 – Extension of the validity of type tests to avoid tests repetitions.

https://www.cognitor.com.br/IEC62271307ENG.pdf

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1. INTRODUCTION

The document IEC TR 62271-307 began to be prepared in 2011 and was published in 2015. Its title is High-voltage Switchgear and Controlgear – Part 307: Guidance for the extension of validity of type tests of AC metal and solid-insulation enclosed switchgear and controlgear for rated voltages above 1 kV and up to and including 52 kV. Sergio Feitoza Costa is coauthor and was a member of the IEC working group that prepared it along several international meetings.

This IEC Report (TR) focuses on medium/high voltage switchgear of the IEC 62271-200 and 62271-201 standards and provides a method to avoid unnecessary repetition of costly tests. These opportunities can only be taken advantage of by manufacturers who have test reports on hand that transparently describe the details of the equipment that was actually tested. For reference, the information that must be included in a complete test report for this purpose is like in the document http://www.cognitor.com.br/TR_071_ENG_ValidationSwitchgear.pdf . The more relevant information is presented in the tables of next pages. The manufacturer going to test the "original" equipment must be careful to alert the testing laboratory the information to include in the test reports.

To help understand the concepts involved in replacing laboratory tests with rules and/or calculations, it is also worth mentioning the standards for low voltage switchgear. The ways to avoid tests in the IEC 60439 series (TTA / PTTA) were only for temperature rise and short circuit tests (electrodynamic forces only). Repetition of tests is replaced by comparing a tested design with the untested derived design. In the series of IEC 61439 standards that replaced 60439, the so-called "Design Rules" were added. These "Rules" allow even to avoid tests and calculations. Table 1 below shows the fundamentals of the design rules. There are more details on this topic in the book "Switchgear, Busways and other Substation Equipment" (free download at: http://www.cognitor.com.br/Book_SE_SW_2013_ENG.pdf)

Table 1 – Design rules for LV switchgear

	Rule (T = temperature F = force P = pressure)	T	F	P
1	Short time current lower or equal to the tested one ?		x	x
2	Bus bar cross section lower or equal to the tested one ?	x		
3	Distance between phases greater or equal to the tested one ?	x	x	
4	Bus bar supports of same type and distance between insulators of same phase lower or equal ... ?		x	
5	Materials, mounting ... equal?	x	x	x
6	Short circuit devices are equivalent / same type and manufacturer ?			
7	Length of live conductor lower or equal ...?			
8	Compartments were included in the original tests ?	x	x	x
9	Compartments are of the same type and dimensions higher or equal ?	x		x
10	Compartments have the same mechanical conception ?	x		x
" YES : to all items NO TEST and NO CALCULATION "NO to some of the rules then additional verification by calculations				

2. USE OF IEC 62271-307 TO AVOID TESTS ON MEDIUM VOLTAGE SWITCHGEAR.

This TR allows, if certain rules are met, a report of tests carried out on a certain panel representative of a family of panels, to be used as the basis for a study that demonstrates that if the tested one passed the tests, the non-tested one would also pass.

The extension of the validity of test reports seeks to avoid unnecessary repetition of tests of IEC 62271-200 and 62271-201 standards. It can be used to extend type tests performed on one sample with a defined set of ratings for another switchgear of the same family with a different set of ratings or different arrangements. The IEC TR62271-307 describes:

• The use, parameters and application of extension criteria and the use of calculations
• The information necessary to extend the validity (which must be included in the test reports)
• Specific aspects to extend the validity of, one by one, dielectric tests, temperature rise tests, mechanical tests, short-duration and crest withstand current tests, interruption and internal arc tests.
• The extension of validity of a test report to other functional units (situation a)
• Validation of a family by selecting test objects (situation b)
• Validation of a set of existing test reports (situation c)
• Validation of a project modification (situation d)
• Justification for extension criteria
• Examples of extending the validity of type tests such as:
    o Design modification of a cable terminal in an air-insulated switchgear (AIS)
    o Modification of the design of a functional unit by adding current transformers
    o Modification of the design of a key-lock on the door of an AIS functional unit
    o Extension of reports from a" ring main unit GIS" to functional units with greater width
    o Extension of a family of gas insulated assemblies (GIS) to a functional unit

The section "Use of Extension Criteria" explains that due to the wide variety of functional unit types and possible component combinations, it is not practical to perform type tests with all possible switchgears. Therefore, the performance of a particular assembly can be evaluated against reports of type testing done on other assemblies in the same assembly family. For each type of test type, a non-exhaustive list of design parameters is shown, which must be analysed for the extension of validity. The analysis must be based on solid technical principles, physics, experience, and calculations.

Each design parameter listed in Tables 2 to 6 must be compared between tested and untested designs under the criteria provided in the tables. A simple example to visualize is that in the temperature rise test (line 5 of table 2) , if the current density of the conductors of the untested equipment is lower than that of the one tested, the criterion is accepted as it will heat up less. If any of the criteria is not clearly met, it is necessary to use other arguments such as calculations, explanations and simulations or even additional tests.

Calculations and simulations can only be applied in a comparative sense based on the design parameters and acceptance criteria. The tools must be previously validated and the simulation reproducible. Validation of software tools and calculation methods are outside the scope of the TR IEC.

2.1) CRITERIA FOR TEMPERTURE RISE TESTS

The IEC TR 60890 document provides calculation procedures that can be applied to compare fluid temperatures inside enclosures. The calculation is made based on the Watts dissipated, the area of the compartment walls, the number of horizontal partitions, and the area of the ventilation openings. Simulations are generally carried using tools like the SwitchgearDesign software whose validation is at http://www.cognitor.com.br/TR_071_ENG_ValidationSwitchgear.pdf

Table 2 – Extension criteria for temperature rise performance.

Item	Design parameter	Acceptance criterion	Condition	Criteria was attended?
(1)	(2)	(3)	(4)	

1	Centre distance between phases	≥	Only to be validated for rated normal currents above 1 250 A (see IEC 62271-1:2007, 6.5.2)	
2	Phase to earth distance	≥	Only to validate if an influence on the surrounding elements due to currents cannot be excluded, e.g., eddy currents and magnetising currents.	
3	Enclosure/compartment dimensions (L,H,W) and volume	≥	The enclosure and compartments are of the same construction.	
4	Minimum pressure of insulating gas	≥	Same gas; for gas insulated switchgear	
5	Current density of conductors	≤	The conductors have the same physical arrangement	
6	Resistance per unit length of conductors	≤	Compare conductor material and cross-section	
7	Contact surface area of connections / joints	≥	Same or better contact material	
8	Contact force of connections / joints	≥	Same or better contact material	
9	Permissible temperature of contact materials of connections / joints	≥	Including metallic coatings having the same or lower resistivity	
10	Effective ventilation area of partitions and enclosure	≥	Note 3	
11	Power dissipation of components	≤	Here the main switching devices, fuses and current transformers are considered.	
12	Area of insulating barriers	≤	Barriers have the same physical arrangement	
13	Thickness of insulating coating of conductors	≤	Thermal resistivity and emission coefficient of the coating should be the same.	
14	Total coated surface area of enclosure for heat transfer	≥	The emission coefficient of the coating should be the same.	
15	Temperature class of insulating material in contact with conductors	≥		

2.2) CRITERIA FOR DIELECTRIC TESTS (electric fields)

The dielectric performance of two switchgears may, if necessary, involve simulating and comparing the strength of electric fields using software tools.

Table 3 – Extension criteria for dielectric withstand performance.

Item	Design Parameter	Acceptance Criterion	Condition	Criteria was attended?
(1)	(2)	(3)	(4)	

1	Clearance between phases	≥		
2	Clearance to earth	≥		
3	Creepage distance	≥		
4	Electrical properties of Insulating material	≥	A comparative result between two materials might be required (e.g. Comparative Tracking Index according to IEC 60112 [7])	
5	Surface roughness of live parts	≤		
6	Radius of conductive parts	≥	Not only the radius of live parts, but also the radius of all other conductive parts facing live parts (e.g., earthing devices, enclosure, LV wiring, supporting structures) shall be considered	
7	Open contact gap	≥	If influenced by the switchgear assembly	
8	Isolating distance	≥	If influenced by the switchgear assembly	
9	Minimum functional pressure for insulation	≥	Same fluid; for fluid insulated switchgear	

2.3) CRITERIA FOR MECHANICAL TESTS

The use of simulations and calculations to extend the validity of mechanical type tests is not recommended, mainly due to the difficulty or impossibility of validating their results.

Table 4 – Extension criteria for performance regarding mechanical supportability

Item	Part	Design parameter	Acceptance criterion	Condition	Criteria attended?
(1)	(2)	(3)	(4)	**(5)**	
1	shutter systems	Strength of locked mechanical linkage, including shutter	≥	The principal design of the shutter system is the same, but dimensions may be different. See Note	
		mass of shutter	≤		
2	contacts of removable part	number of contact points	≤	The designs of contacts, including base and coating material, and supports of movable and fixed contacts are the same	
		contact force per contact	≤		
		roughness of contact surface	≤		
3	interlocking-system directly operated on the mechanical chain	Strength of locked mechanical linkage	≥	The principle design of the interlocking system is the same, but dimensions may be different. Note	
		torque applied during operation attempt	≤		
4	interlocking- system preventing access to the operating devices	Strength of locked mechanical linkage	≥	The principle design of the interlocking system is the same, but dimensions may be different.	
		normal operating force	≤		

2.4) CRITERIA FOR THERMAL AND ELECTRODYNAMIC STRESSES DURING SHORT CIRCUIT

Calculations include determining electromagnetic forces between conductors and the mechanical stress that can bend bars and cause damage to insulators. The calculation methods used in the SwitchgearDesign software in:

- IEC 61117, Method for assessing the short-circuit withstand strength of partially type-tested assemblies (PTTA)
- IEC 60865-1, Short-circuit currents – Calculation of effects – Part 1: Definitions and calculation methods.

- IEC TR 60865-2, Short-circuit currents – Calculation of effects – Part 2: Examples of calculation.

Table 5 – Extension criteria for performance regarding thermal and electrodynamic short-circuit stresses.

Item	Design parameter	Acceptance criterion	Condition	Criteria attended?
(1)	(2)	(3)	(4)	
1	Centre distance between phases	≥		
2	Electro-dynamic forces due to current path	≤	The conductors have the same physical arrangement. Note 1	
3	Mechanical strength of insulating conductor supports	≥	Notes 2 and 3	
4	Length of unsupported sections of conductors	≤		
5	Cross-section of conductors	≥	Connections of the conductors are scaled and have the same or greater clamping force and contact area. Notes 4 and 5	
6	Material of conductors	same	Notes 4 and 5	
7	Temperature class of insulating material in contact with conductors	≥		
8	Mechanical strength of the enclosure /partitions/ bushings	≥	Notes 2 and 3	
9	Contacts of removable part	same	Consider complete design of contact sub-assembly and the fixing / mounting of the removable part.	

NOTE 1 The effect of different paths can be assessed by calculation of electro-dynamic forces
NOTE 2 Strength includes mechanical resistance to compression, traction, and bending loads.
NOTE 3 The enclosure can provide the base for the mechanical supports.
NOTE 4 In case of earthing circuits: in some designs, conductors can include parts of the metallic enclosure being used as earthing circuit.
NOTE 5 Conductors include connections in the main circuit and in the earthing circuit up to the earthing terminal.

2.5) CRITERIA FOR OVERPRESSURE CAUSED BY INTERNAL ARC

Comparing the performance of electric panels in withstanding overpressure in the compartments is the analysis to be carried out. Overpressure is a function of arc currents, areas of depressurization openings and internal volumes. The evaluation of the force on the switchgear walls can be done for simple geometries using a calculation formula, otherwise using finite element analysis for mechanical stress.

The flow of hot gases expelled can be simulated by CFD programs and the burning of indicators can be simulated, but no one to date has validated this type of calculation. It would be very expensive to do as it would require a lot of testing. The basis for the assessment are the values obtained for the overpressure's curves. These concepts are well detailed in the pages 177 to 191 of this book authored by Sergio http://www.cognitor.com.br/Book_SE_SW_2013_ENG.pdf
The worldwide reference for this theme is the brochure CIGRÈ 602 / 2014 Tools for the Simulation of The Effects of the Internal Arc in T&D Switchgear. Sergio is coauthor of this Cigrè document and was member of CIGRE working group that prepared it. https://www.e-cigre.org/publications/detail/602-tools-for-simulation-of-the-internal-arc-effects-in-hv-and-mv-switchgear.html

Table 7 – Extension criteria for internal arc tests (equipment)

Item	Design parameter	Acceptance criterion	Condition	The criteria were attended?

1	Clearance between phases	≤		
2	Clearance to earth	same	This concerns the region where the arc is initiated.	
3	Net compartment volume	≥		
4	Rated pressure of insulating gas, if applicable; see Note 1	≤		
5	Cross-section of conductors	≥	This concerns the region where the arc is initiated.	
6	Raw material of conductors (Al or Cu or their alloys)	same	This concerns the region where the arc is initiated.	
7	Location of the point of arc initiation	same	Applying the rules of IEC 62271-200 or IEC 62271-201	
8	Insulating material exposed to the arc	same		
9	Exhaust cross sectional area	≥	The position of the exhaust in the compartment and the gas flow path are the same. Larger cross-sectional areas are only acceptable if an exhaust duct is used	
10	Exhaust opening pressure	≤	Applicable to fluid tight compartments	
11	Mechanical strength of elements to let open the relief device (flap)	≤	Applicable to non-tight compartments. The relief device and its retaining elements have the same design.	
12	Mechanical strength of the enclosure and compartment	≥	This also includes the strength of partitions and bushings Note 2	
13	Thickness of the enclosure walls	≥	Same material Note 2	
14	Mechanical strength of the doors and covers	≥	Note 2	
15	Degree of protection (IP-code) of enclosure	≥	Where relevant for indicator ignition criterion	

2.6) CRITERIA FOR INTERRUPTION AND BREAKING TESTS

Table 7 – Extension criteria for interruption and establishment of short-circuit currents.

Item	Design parameter	Acceptance criterion	Condition	The criteria were attended?

(1)	(2)	(3)	(4)	
1	Clearance between phases	≥	Note 1	
2	Clearance to earth	≥		
3	Enclosure/compartment volume	≥	Only to be validated, if the fluid (gas or liquid) in the volume is involved in the making and breaking process.	
4	Pressure of insulating gas	≥	The travel characteristic is within the permissible tolerances.	
5	Cross-section of conductors	≥	Note 2	
6	Electro-dynamic forces due to the current in the connection paths to the switching device	≤	Only to be validated, if there is an impact of the current path on the making and breaking performance	
7	Mechanical strength of insulating supports	≥	Here, the supports of the phase conductors should be considered Note 3	
8	Mechanical strength of the enclosure/ partitions / bushings	≥	Note 3	
9	Length of unsupported section of conductors	≤	Note 3	
NOTE 1 Extensions of type test validity with respect to the centre distance between phases inside the switching device should be dealt with in accordance with the relevant component standard. NOTE 2 The contacts of a removable part do not affect the making and breaking capacity of the associated switching device and therefore need not be considered. NOTE 3 It is assumed that the mechanical strength is already validated by a short time and peak withstand current test. Not applicable for capacitive or any other load switching currents.				

2.5) INFORMATION REQUIRED TO EXTEND THE VALIDITY OF TYPE TESTS

Information from the switchgear that is required in type tests in accordance with IEC 62271 1 and IEC 62271-200 must be collected. Furthermore, the relevant parameters information is that shown in Tables 2 to 7 for each specific test and functional unit under evaluation. Applicable type test reports of the tested switchgear shall be provided for comparison of “tested” and “untested” assemblies.
For this reason, it is recommended that the manufacturer inform clearly the testing laboratory that need that the relevant information on the design parameters listed in tables 2 to 7 be included in the test reports (even if the product standard does not request it). Relevant and detailed drawings are essential as part of this information. It is recommended to use testing laboratories that have technical resources to obtain essential information, e.g. measuring overpressures in internal arc tests.

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ABOUT THE AUTHOR OF THE ARTICLE

The author of this article is Eng. Sérgio Feitoza Costa. Sergio is an electrical engineer, M.Sc. in power systems and director of COGNITOR. He has more than 40 years of experience in the design, operation and management of high power, high voltage, and other testing laboratories. After leaving CEPEL, Sergio gained considerable experience in using test simulations to support manufacturers and certification companies in substation equipment design. He is co-author of several IEC standards and Cigrè brochures. Sergio is the author of the SwitchgearDesign simulation software, and a patent related to electrical panels.

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