TEMPERATURE RISE TESTS IN IEC 61439 x IEC 60439 (need to repeat tests?)

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A. DIFERENCES IN TEMPERATURE RISE TESTS BY IEC 60439 and IEC 61439 (need test repetitions?)

IEC technical standards are powerful documents providing directions for specifications, tests and types of equipment which will be commercialized in the Worldwide market. I learned this along my 40 years of activities in the electrical sector. Along this time, I had the satisfaction of collaborating in IEC working groups (WG) including coordinating a WG which prepared a revision of the IEC 60282-2 and, recently, a WG that prepared the new published IEC 62271-307.

What is written in IEC standards will influence what will happen all over the World in developed and developing countries. IEC standards are predominantly made by experts from the major international equipment manufacturers from developed countries. There are very few participants from small and medium size companies and from outside the group of developed countries.

This makes, even more important, to have clear texts and to avoid creating specifications and test conditions that will be more difficult to meet than the previous version of an existing standard. This is the central point of this article. IEC60439, for low voltage (LV) switchgear, from 2011, started to be replaced by the series IEC 61439 - Low-voltage switchgear and controlgear assemblies. It seems that there are significant differences on the temperature rise tests.

Some months ago a colleague from a big testing laboratory told me that the lab could do the tests in a LV switchboard according to IEC 60439 but could not do it according to IEC 61439. I told him immediately that he was wrong. However, when I went to read the details of the new IEC 61439 I simply did not understand the big and, at least for me, confusing text. Then I understood the doubt of my lab colleague. I am skilled in reading IEC standards and worked 25 years doing temperature rise tests inclusive by IEC 60439. If I have this doubt certainly many people have this doubt also. If I am right in my interpretation of the IEC 61439 text for temperature rise tests this affects everybody who already did these tests by IEC 60439.

My focus, in this article, is to compare the temperature rise tests specified in both standards. My doubt is if the IEC 61439 added a test requirement much more complicated than the previous IEC 60439. If I understood the writing of IEC 61439, the tests are now more difficult, more time consuming and expensive to do than before. Worse than this, most of the LV switchgear already tested in IEC 60439 would need to be tested again to attend IEC 61439. I would like to be wrong in my interpretation and, for this doubt, I ask for the clarifications from the IEC 61439 standard makers.

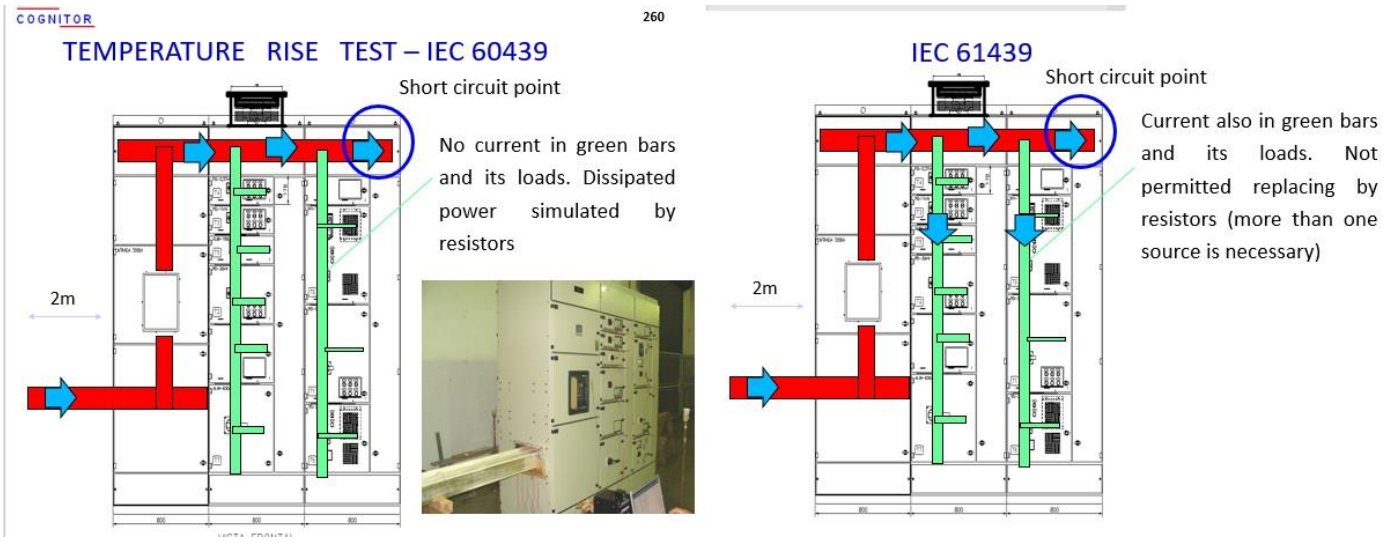
So, the objective of this article is to list doubts and get clarifications and not to explain something.

I am used to say to my colleagues in the IEC and CIGRE working groups on high-medium voltage (MV) equipment that the LV standards are more creative and have wider vision of practical aspects such as the difficulty of access to testing laboratories. They do not like when I say this but, it is a fact that LV systems appeared much before MV and HV ones. So there is much more experience hidden in the lines of the LV standards.

The previous IEC 60439 serious, started from 1999, brought the concept that many tests repetitions could be avoided if a certain equipment was derived from another one already tested. This was applicable to the most expensive laboratory tests (short circuit and temperature rise). The standard created a clear opening for the replacement of these tests by calculations. This is something intelligent and based on common sense. To repeat tests unnecessarily only serves to increase the price of electric products and this account will be paid by the final consumer.

IEC 61439 advanced even more with the concept of the "Design Rules" which permit that many tests and even calculations, as in IEC 60439, are avoided. IEC 62271-307 for MV switchgear in a certain way incorporated some of these concepts in a better writing and reasoning explanations.

My doubts for IEC 61439 are only about the temperature rise tests applicable to the original project (first of a family). The temperature rise test in a LV switchgear according to both standards is more or less like in Figure 1.



The main difference is the possibility of using or not some resistors to represent the effects of the power dissipation in the green bars and their associated loads as showed in the Figure 1. If you want to do a test more near the actual situation of use, as in IEC 61439, the onus of this sophistication, if compared with IEC 60439, is that it will be necessary to the laboratory to have several current sources to feed all bus bars. It is well-known that the critical point of temperature rises at LV switchgear are the connection points between the bus bar and the main resistance components (circuit breakers, switches and fuses).

When allowing the placement of resistors to simulate the above mentioned loads as in IEC 60439 this will cause the temperature rise of the internal fluid and by consequence the effect will be transmitted properly to the hottest spots as circuit breakers, where the current is really circulating. Is there any advantage?

Adding these extra requirements in IEC 61439 means to say indirectly that the previous tests were fundamentally wrong (but tested LV switchgear has been working well all over the World). Many people will interpret this to ask that the tests previously done by IEC 60439, should be repeated, to attend IEC 61439. Very possibly, this was not the purpose of the standard makers but is what is written there. Therefore, some revision needs to be done to clarify the purposes and to make clear that equipment already tested by IEC 60439 do not need not be re-tested.

An alternative for this is to write in IEC 61439 explicitly, the possibility of replacing complicated tests by a simulation that can be validated through objective comparisons with tests results registered in previous test reports In a simulation of a temperature rise test (see *** at the end) it is possible to represent – exactly - the actual use situation at a cost much-much lower than the laboratory test.

B. MAIN POINTS OF IEC 61439 RELATED TO DOUBTS OR EXCESSIVE COMPLEXITY OF THE TEST METHOD

We highlighted in **blue** the parts of the text *which cause confusion to the reader or are difficult to provide* in a laboratory tests. We did not include all the text of the section but instead, only some parts to identify them. The numbers are the sections or subsections of IEC 61439. The highlights in **green** are just questions or comments.

10.10 Verification of temperature rise
Verification shall be made by one or more of the following methods:
a) testing with current (10.10.2);

b) derivation (from a tested design) of ratings for similar variants (10.10.3); or
c) calculation (10.10.4).

10.10.2 Verification by testing with current
10.10.2.1 General
Verification by test comprises the following:
2) The ASSEMBLY shall be verified by one of the following methods …. considering individual units:
a) and the main and distribution busbars and the ASSEMBLY collectively according to 10.10.2.3.5;
b) separately and the complete ASSEMBLY including the main and distribution busbars according to 10.10.2.3.6;
c) and the main and distribution busbars separately as well as the complete ASSEMBLY according to 10.10.2.3.7.

10.10.2.2 Selection of the representative arrangement
10.10.2.2.1 General
The test shall be made on one or more representative arrangements loaded with one or more representative load combinations chosen to obtain with reasonable accuracy the highest possible temperature rise…

10.10.2.2.2 Busbars
For busbar systems consisting of single or multiple rectangular sections of conductor, the variants of which differ only in the reduction of height, or reduction of thickness or quantity of bars per conductor, but which have the same arrangement of bars, the same conductor spacing, the same enclosure and busbar compartment (if any), as a minimum for the test, the busbars with the greatest cross-sectional area shall be selected as the representative arrangement.

10.10.2.2.3 Functional units
{here there is a long text mentioning current and power losses very difficult to understand as a whole}

For functional units with currents up to and including 630 A, the critical unit in each range is the functional unit with the highest total power loss. For functional units with currents above 630A the critical unit in each range is that which has the highest rated current. This ensures that additional thermal effects relating to eddy currents and current displacement are taken into consideration.

The critical functional unit shall at least be tested inside the smallest compartment (if any) which is intended for this functional unit; and with the worst variant of internal separation (if any) with respect to size of ventilation openings; and the enclosure with the highest installed power loss per volume; and the worst variant of ventilation of the enclosure with respect to kind of ventilation (natural or forced convection) and size of ventilation openings …. If the functional unit can be arranged in different orientations (horizontal, vertical), then the most onerous arrangement shall be tested. *{ ??? how to which is know the most onerous ??? }*

10.10.2.3 Methods of test
10.10.2.3.1 General
….. Coils of relays, contactors, releases, etc., shall be supplied with rated operational voltage.
… If the ASSEMBLY includes fuses, these shall be fitted for the test with fuse-links as specified by the manufacturer…

When a control electro-magnet is energized during the test, the temperature is measured when thermal equilibrium is reached in both the main circuit and the control electro-magnet …. Tests on an individual section of the ASSEMBLY are acceptable provided the conditions of 10.10.2.2 are met. *{ ??? difficult to check and low impact ??? }*

When testing individual functional units within a section, the adjacent functional units can be replaced by heating resistors if the rating of each does not exceed 630 A and their temperature is not being measured. In ASSEMBLIES where there is a possibility that additional control circuits or devices may be incorporated, heating resistors shall simulate the power dissipation of these additional items.

10.10.2.3.5 Verification of the complete ASSEMBLY
Incoming and outgoing circuits of the ASSEMBLY shall be loaded with their rated currents (see 5.3.2) that result in the rated diversity factor being equal to 1 (see 5.3.3). If several or all circuits of an ASSEMBLY are loaded simultaneously then the same circuit is only able to carry its rated current multiplied with the rated diversity factor (see 5.3.3), due to

the thermal influence of the other circuits. Thus to verify the rated currents of all circuits a separate test for each type of circuit is necessary. To verify the rated diversity factor one additional test with simultaneous load on all circuits has to be done. *{ ??? doing several tests is expensive …. How many tests ? ??? }*

To avoid the large number of tests that may be necessary this clause describes a verification method where only one test is made with simultaneous load on all circuits. Because with only one test the rated currents and the rated diversity factor of the circuits cannot be verified separately, it is assumed that the diversity factor is one. In this case the load currents are equal to the rated currents. *{ ??? how can the reader understand what the standard want ??? }*

If the rated current of the incoming circuit or distribution busbar system (DBS) is less than the sum of the rated currents of all outgoing circuits, then the outgoing circuits shall be split into groups corresponding to the rated current of the incoming circuit or DBS. The groups as defined by the original manufacturer shall be formed in a manner so that the highest possible temperature rise is obtained. Sufficient groups shall be formed and tests undertaken so as to include all different variants of functional units in at least one group.

Where the fully loaded circuits do not distribute exactly the total incoming current, the remaining current shall be distributed via any other appropriate circuit. This test shall be repeated until all types of outgoing circuit have been verified at their rated current…. Change in the arrangement of functional units within a verified ASSEMBLY, or section of an ASSEMBLY may necessitate additional tests as the thermal influence of the adjacent units may differ significantly.

10.10.2.3.6 Verification considering individual functional units separately and the complete ASSEMBLY
{ the same complexity of text we see in the previous section 10.10.2.3.5 }

10.10.2.3.7 Verification considering individual functional units and the main and distribution busbars separately as well as the complete ASSEMBLY
{the same complexity of text we see in the previous section 10.10.2.3.5}

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The author of this paper is Mr. Sergio Feitoza Costa. Sergio is an electrical engineer, M.Sc in Power Systems and director of COGNITOR. Sergio has 25 years of experience in design, operation and management of high power, high voltage and other testing laboratories. After leaving the activities in testing labs Sergio acquired 16 years of experience in the use of testing simulations in support to manufacturers and certification companies. Sergio is the author of the simulations software SwitchgearDesign

In these links there are some videos and reference material, inclusive for validation of testing simulations:

Cognitor site and CV http://cognitor.com.br/en/site/index.php

*** Movies about temperature rise concepts and simulations in

YouTube Cognitor: https://www.youtube.com/channel/UCyQtdE7dQTvsZPHBw3ostMg/videos?view=0&sort=dd&shelf_id=0

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