IEC 61439-1: Answer to a NIAZ question in LinkedIn about Table 6 (Limits of temperature rise specified by manufacturer ?).

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Thanks, dear Niaz Hussain Panhwar. Your company should be proud to have you on the technical team.

I have been alerting to this critical point of the IEC61439-1 in the last 10 years. The question you did in my Linkedin post is a doubt of hundreds of users, certifiers, testing labs and manufacturers I met before. I hear this since the time I managed the big Brazilian testing labs.

I will write the answer in a way that may help experts of IEC MT 2 (Maintenance of IEC 61439-1, IEC 61439-2, IEC/TR 61439-0, IEC/TR 60890 and IEC/TR 61641), to understand the consequences of what they wrote in that table. Their link in IEC Web site is , by April 29, 2022: I hope someone from there reads this post and bring light on our doubt. https://www.iec.ch/dyn/www/f?p=103:14:23685049488833::::FSP_ORG_ID:10644

YOUR QUESTION ABOUT TABLE 6 OF IEC 61439-1 is:

> " Table 6 note g, states maximum temperature rise limit of 105K for copper busbars and conductors. Could you please refer / explain how it will be 75 ?K"

MY ANSWER IS: First of all, in IEC standards, a <u>temperature rise</u> of 105 K means that , in an ambient air temperature of 40°C , the <u>temperature</u> of 40 + 105 = 145°C . Also, as showed in the table of IEC62271-1 (high voltage switchgear) a <u>temperature rise</u> of 75K in the connections of the circuit breaker to the busbars, usually the hot-spot in low-voltage or high-voltage switchgear, means 40 + 75 = 115°C .

For those who don't realize the difference, temperature is one thing and temperature rise is quite another thing. The concept of aging materials is not to exceed the temperature limits of materials. This is well explained in IEC 60943 published originally by TC32 (Fuses) one year before the time I was the chair of TC32.

The values of the limits are expressed as temperature rise because the test can be done at any environment temperature of the laboratory. During the test, you measure the temperature of the points and subtract from the measured external air temperature getting the so called " ΔT = temperature rise". Then you compare the value of ΔT with the value of the limit in the table .

For example, in the well-done table of IEC 62271-1 the temperature rise limit of a silvered copper or aluminum bolted connection is 75 K. However , in the table of IEC61439-1 the word "connection " is not even mentioned. Only the words "busbars and conductors" are mentioned but no value is presented. If I read all the table 6 and notes I understand that <u>the only intention is to say,</u> **in Note F " the temperature-rise limits have to be specified by the original manufacturer".** This is not usual in IEC standards and is the reason why most test reports circulating in the market do not have a "passed / not passed" statement written by the lab. You don't need to be very smart to realize that it's an open door to deviations.

In Note G there is a mention to a 105 K for bare copper conductors but in the table, nothing is said about aluminum

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Table 14 – Limits of temperature and temperature rise for various parts, materials and dielectrics of high-voltage switchgear and controlgear

Nature of the part, of the material and of the dielectric (Refer to points 1, 2 and 3 in 7.5.6.2) (Refer to NOTE 1)	Maximum value	
	Temperature °C	Temperature rise at ambient air temperature not exceeding 40 °C (NOTE 2) K
1 Contacts (refer to point 4)		
2 Connection, bolted or the equivalent (refer to point 4)		
Bare-copper, bare-copper alloy or bare-aluminium alloy		
– in OG (refer to point 5)	100	60
– in NOG (refer to point 5)	115	75
– in oil	100	60
Silver-coated or nickel-coated (refer to point 6)		
– in OG (refer to point 5)	115	75
– in NOG (refer to point 5)	115	75
– in oil	100	60

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Table 6 – Temperature-rise limits (9.2)

Parts of assemblies	Temperature-rise K
Built-in components [a]	In accordance with the relevant product standard requirements for the individual components or, in accordance with the component manufacturer's instructions[f], taking into consideration the temperature in the assembly
Terminals for external insulated conductors	70[b]
Busbars and conductors	Limited by[f]: – mechanical strength of conducting material[g]; – possible effect on adjacent equipment; – permissible temperature limit of the insulating materials in contact with the conductor; – effect of the temperature of the conductor on the apparatus connected to it; – for plug-in contacts, nature and surface treatment of the contact material
Manual operating means:	

f For temperature-rise tests according to 10.10, the temperature-rise limits have to be specified by the original manufacturer taking. It is the responsibility of the original manufacturer to take into account any additional measuring points and limits imposed by the component manufacturer.

g Assuming all other criteria listed are met, a maximum temperature-rise of 105 K for bare copper busbars and

If , in real use an equipment is installed at an air ambient of 40°C (IEC reference for maximum air temperature) the temperature of the points will be $\Delta T + 40$. If you sum the temperature rise limit of standard, for example 75K, to 40°C you get 115°C.

So, using the 75K example, the concept in the standard is that if a silvered connection works at a temperature higher than 115°C a faster aging will happen. Just to fix the concept, if the equipment is supposed to be installed in a place where the air temperature is frequently 45°C (like in Mena region) the permitted temperature rise of the silver-plated connection should be de-rated to 70K = 115 – 45 instead of 75K, to avoid faster aging.

WHAT IS FASTER AGING ?: If, in the exemplified connection, you permanently work only 6.5K above standard limit temperature you have "loss of life" of the connection of more than 50%,. This is according to IEC60943 formulas (check my free book ´link at the end) . This means that a device designed to attend a 105K limit uses much less copper or aluminum than another designed to pass a 75K temperature rise test. So, a 105K equipment is cheaper and has a shorter time life of the connections. I explain the “market problem” below.

Even in the 2020 revision of IEC 61439-1 Table 6 remains with the same problem. Minor editorial changes were made without touching the real problem. Note 1 of the table and note G still show an unbelievable confusion of concepts. I don't know if there is any other non-technical purpose for not fixing this. I explain more technical details and the issue affecting the world market of low voltage switchgear in previous articles (link below).

ABOUT THE TABLE 14 of IEC 61439-1 , a very easy solution to correct the problem is simply to replace the bad table 6 by the phrase. "For the limits of temperature rise of IEC61439-1, Table 14 of IEC 62271-1 applies".

HV, MV, LV switchgear have the same functions and use the same materials. Each time you do a copy-paste of a same table , in different standards, you insert errors. I proposed the same change for the next revision of IEC 60282-2 (H.V. fuses), as we are already doing in the equivalent Brazilian standard I am convening.

THE TECHNICAL ERROR: It is completely unnecessary and inappropriate to set the temperature rise limits of busbars and conductors. IEC6043 explains the reasons. The hotspots and faster aging points in electrical equipment are the connections and contacts and , never, the busbars. As said, the table do not show values which can be used by testing labs, even for a silver-plated connection (75K). It inserts a very strange and dubious sentence inducing the readers, all over the world, to think that the manufacturer is whom define the temperature rise limit value. The correct way is to inform the lab , before the test, the material of the connections. Then, to state "passed or not passed" any lab can use an IEC table as the one in IEC 62271-1

Table 6 of IEC 61439-1is different from all the IEC standards I know. This is the reason why most of the reports I see in the market do not state if the equipment passed or not the test. Users have to pay attention to this. Maybe are buying something that did not pass the test. Many of the test reports I see in the market have, in the test reports, a temperature rises of the silvered connections in the range 80 to 95K. Much higher than 75K.

TEMPERATURE RISE OF BUSBARS AND CONDUCTORS ARE RELEVANT ? The ONLY temperature that cannot be exceeded on bare busbars is the annealing temperature of the material. According to IEC60943 the annealing temperature of copper is 190°C (better to say 200°C to 400°C). This means a temperature rise of 190-40 = 150K.

When the annealing temperature is exceeded , in the short time currents tests (short circuits like 65KA and not temperature rise as 3200A) the copper changes color, loses characteristics and begins to soften. That is why standards specifies a minimum cross section of earthing conductors. Above the annealing temperature but below melting point the busbar will be damaged but will not be broken. In future short circuits, if the earthing conductor, already in bad conditions, is broken , this can kill people in the neighborhood by electrocution.

THE MARKET PROBLEM: There are manufacturers that correctly use the value 75K for silver connections. There are others who, induced by Table 6 and Note F, use the value 105K. Using the correct value of 75K means using larger bars and a much more expensive product. The product for 105K will be cheaper and have a much faster aging. As said, for connections, in general the hot spots, , each 7 to 10 K above the 75K means a time life reduction of some 50%. So leaving a table with values undefined, you penalize the manufacturers who are doing the right thing and the users of the electricity. This is not a good thing for an IEC standard

LINK FOR THE PREVIOUS ARTICLE about Table 14 of IEC 62271-1 "IEC 61439: The Mystery of the Temperature Rise Limits" https://www.cognitor.com.br//TemperatureRise_IEC61439Mistery.pdf

This short article was posted in Linkedin by Sergio Feitoza Costa – www.cognitor.com.br sergiofeitozacosta@gmail.com

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REFERENCES:

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

My Free Book useful to understand the concepts explained in this article

"Switchgear, Busways, Isolators - Substations & Lines" (available also in Spanish and Portuguese)

https://www.cognitor.com.br/Book_SE_SW_2013_ENG.pdf (check from page 92 to 123)