COGNITOR Consultancy, R&D and Training Ltd

IEC61439-1: CYCLING TEST for INTERMITENT LOADS (CONVERTERS, ROLLING-MILLS, etc).

About overheating, vibrations, temperature rise limits & losses by interruptions.

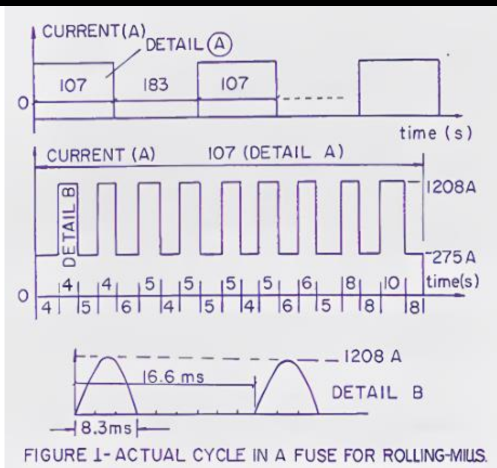

Figure 1 – Typical intermitent cycle

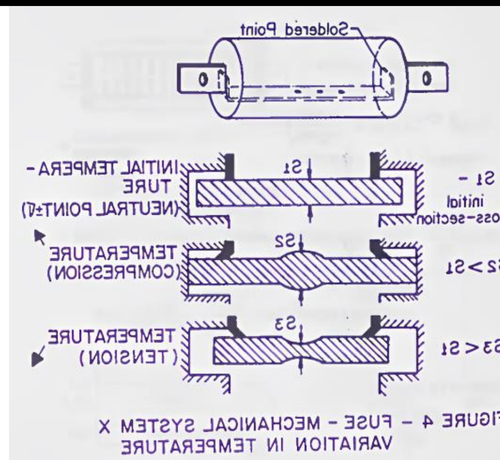

Figure 2 – Effects of "heating - cooling"

Link for the article: https://www.cognitor.com.br/OverloadTests.pdf

1. WHY CAN INTERMITENT CURRENT CYCLES BE HARNFUL AND ACCELERATE AGING

Recently I was asked to analyse a failure in a low voltage electrical panel. When I saw the information, I immediately remembered an article I wrote in 1991 for the “ICEFA - International Conference on Fuses and their Applications" in Nottingham-UK. At that time, I was chairing the Technical Committee 32 (Fuses) of the IEC – International Electrotechnical Commission. ICEFA is the best event about power fuses, and I was in the right place at the right time to learn from the world's leading fuse experts. The article title was “Overload Tests for Fuses in Rolling-Mills”. I wrote it with colleagues of an important Brazilian steel company. The article was about solving a real problem of frequent impacting failures that caused major losses by interrupting the operation of the steel mill. Such kind of intermittent current overloads are frequent in the oil & gas, mining, and steel industries. The link to the full article is at Reference [1] at the end.

Examples of intermittent loads are the activation of motors, compressors, systems of frequency converters In the Figures 1 and 2 we show the main effects. At that time, I did not yet have the experience I have today to realize that it was not just the fuses that were being subjected to cycles, vibrations, and overheating. All the components and their connections and contacts were also (Reference [3])

If contacts, connections, and conductors are not designed for repeated cycles, they weaken when exposed to extreme temperature changes. Additionally, there is the vibration effect, which has the potential to increase forces, cause immediate failures and even rupture the cable insulation, resulting in a short circuit and an internal arc.

It is not difficult to develop predictive maintenance rules, including thermography, to anticipate the emergence of more serious problems. However, most companies only start carrying out these procedures when the problem occurs once or twice, and financial losses occur.

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I also recalled a test that was conducted in a reputable testing facility. The equipment under test was connected to the laboratory circuit by a poorly tied cable, and the plastic insulation was severed as a result of short circuit forces that produced an arc process that was far larger than what was supposed to happen with the fine wires of the internal arc tests. The test was redone by the lab at no additional expense when they realized their mistake.

Even the most capable designs can have mistakes and failures, and they can teach us a lot. An IEC standard for low voltage fuses includes a test that assesses the effects of high intermittent loads. "Verification of non-deterioration of contacts" is the name given to it. However, this verification's reach is far broader. In the case of low voltage panels where fuses like these are installed in series, there are no special tests to consider the effects showed above for the fuses. This test could be there. They are quite different from the objectives of seismic tests.

Worse than this, the text of the temperature rise test of IEC 61439 series is very poorly written and leads to wrong interpretations as I explain in the article in Reference [2]. It is not reasonable creating more complicated than necessary tests that eliminate the possibility of many laboratories to perform them. This is a barrier to small manufacturers. The temperature rise limits in IEC61439-1 are not objectively defined on the contrary of most IEC product standards. It is also time to define the internal arc test as a type test.

2. SUGGESTION FOR A SPECIAL TEST TO ASSESS INTERMITENT LOADS EFFECTS

The aim of the test is to verify the performance under the thermal and dynamical effects of the variable current cycles. The idea is to identify sources of fast deterioration and bad performance of contacts, connections, and conductors. For facilitate the understanding it is valuable to resume some definitions used in previous IEC 60269-4:

a) Pulsed current - a unidirectional current the instantaneous value of which varies cyclically and includes intervals of small values of current as in Figure 1.

b) Rated-current - a value assigned by the manufacturer and verified by temperature rise and repetitive duty tests.

The usual test for the verification of rated normal current consist in applying a permanent current for some hours to verify if temperature rise of some specific parts are below the limits accepted by the materials. Values are universal and not "specified by the manufacturer" as can be understood in IEC61439-1. Looking the good table of IEC62271-1, the value for bare copper conductors is 60K and for silver plated connections is 75K. In IEC 61439 text you may understand that these limits reach values like 105K. If you have a connection between a silver-plated copper busbar (75K) and a special material of the circuit-breaker (e.g.85K) what prevails in the lowest value which will age first. An equipment designed for 85K will use much less copper than another one designed for 75K and will have an aging at least 30% higher.

<u>The test to verify the performance under cyclic, intermittent current</u>s could be something more or less like in the old IEC_60269-1 (1986 - section 10) where the focus was to verify if the contacts do not deteriorate when left undisturbed in service for a long period. However, the method is well applicable to verify the impacts of intermittent loads.

- Before the 3-phase test you measure the total electrical resistance, per phase, of the main relevant part of the main circuit containing at least one CB contact (or switch or fuse), their two connections to the busbar and 1 meter of busbar from each input / output connection. More relevant here means having higher resistance.

- Before starting to apply current measure, in each of the phases, the total resistance, Register the external air temperature.
- Then you apply the rated normal current during the time necessary for the stabilization of the temperature rise in the connections to the CB (or switch or fuse)
- Then you apply 250 cycles of load (1.2 x IN during 15s) + no-load (15s). This means a total time around 2 hours.
- At the end of the 250 cycles, you register the temperature rise in the same points and switch-of the circuit.
- Wait the temperatures to return to the ambient. A small fan to do faster is permitted.
- Measure again the total resistance correcting it to the same temperature of the beginning.

At the end of the 250 cycles, if the temperature rise of the connections is higher than 60+15 = 75K (bare connections) or 75+15= 90K (silver plated) it is an indication that the panel is susceptible to aging more quickly if subjected to intermittent loads.

For the same reason, if the final resistance, corrected for the temperature at the beginning of the test, is greater than 20% of the initial value, this is an indication of susceptibility to intermittent cycles.

3. FINAL COMMENTS

The well-known issues resulting from failures brought on by intermittent loads impact major industries such as mining, oil and gas, and steel, where service disruptions can result in significant losses.

This is made worse in the case of low voltage switchgear by the unclear and badly written text of the temperature rise test, where the permissible temperature rise limits values induce the reader to wrong interpretations and the usage of temperatures above those that are allowed by all other IEC standards .

Here we present a testing procedure that can be used as a starting point in situations like this. It is based on some principles found in low-voltage fuse standards, which are frequently seen in IEC61439 series circuits connected in series with the fuses.

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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. Read his CV and things he helped to do in the link below. Sergio 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 test simulations to support manufacturers and certification companies in substation equipment projects. He is co-author of several IEC standards and Cigrè brochures. Sergio is the author of SwitchgearDesign simulation software and DECIDIX. Sergio is also an inventor and author of a patent about use of metal foams in switchgear. More details, free publications, training, visiting researcher below .

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[2]_Article "TEMPERATURE RISE LIMITS OF IEC 61439-1: unclear values distort the LV switchgear market. (May,12, 2023) - http://www.cognitor.com.br/IEC614391Table6.pdf

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