# TEST SIMULATION REPORT 133/2023

http://www.cognitor.com.br/TR_133_ENG_AnswerIECaboutInternalArc.pdf

ftp://cognitorcom@177.39.156.174/public_html/TR_133_ENG_AnswerIECaboutInternalArc.pdf

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| ARTICLE | **IEC TR 61641 – Internal arc tests in LV switchgear:** some testing labs misinterpret shots. Read IEC explanation & avoid exaggerated tests. |
| REFERENCE STANDARDS | • **IEC 61439-1/2** - Low-voltage switchgear and controlgear assemblies<br>• **IEC TR61641:** "Enclosed low-voltage switchgear and controlgear assemblies - Guide for testing under conditions of arcing due to internal fault".<br>• **IEC 62271-200:** High-voltage switchgear and controlgear - Part 200: AC metal-enclosed switchgear &controlgear … > 1 kV & < 52 kV<br>• **IEC TR 62271-307**: …. Guidance for the extension of validity of type tests of AC metal-enclosed switchgear &controlgear … > 1 kV & < 52 kV |
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| Revisions | Date | Pages | Description |
|---|---|---|---|
| 0 | September 26, 2023 | - | First version |
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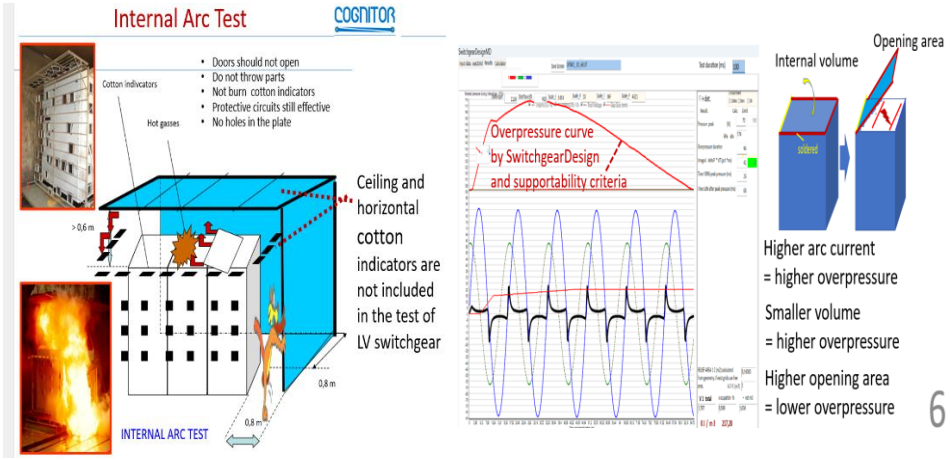
## ABBREVIATIONS:

**LV** = Low voltage (<= 1kVAC)
**MV/HV**: medium / high voltage (>1 kVAC)
**Switchgear:** electric panels, busways, busbar systems in general

## 1. ABOUT INTERNAL ARC and the IMPORTANCE OF THE TEST FOR LV SWITCHGEAR.

The test consists in creating an arc inside the switchgear through very thin wires. When you energize the equipment arcs will be created moving in the direction opposite to the source. They cause a big internal overpressure which will try to open doors and bend the walls. If the arc stop in a bolt of a bad finished busbar may burn-through creating a hole.
The cottons represent the skin of an operator outside. Some conditions shall be met during and after the test.




Internal arcs in MV switchgear above 15 kArms are extreme events that cause risks to life and installations. Deaths are not rare when an operator is in front of a door that opened by overpressures or an enclosure hole. Just look the videos at the end of this article to have an idea.

In LV systems the voltages are some 1/15 of the MV systems. However, currents higher than 40kA rms are each time more frequent. Short circuit levels like 85 to 100kArms are not anymore, an exception. So, the amount of energy involved in LV is not high as in HV systems but is very high. For LV, it is not difficult to avoid high power internal arcs. The easiest solutions is to make the phase to phase distances higher to provoke spontaneous self-extinction of the arc in the first milliseconds.
Another possibility is the well-planned placement of thermoplastics on the busbars. Increasingly smaller panels increase the risk to the lives of people close to them. An internal arc within a LV panel above some 30kA bring risks. It's not a rare event.

IEC TR 61641 (2014) is a guide for LV switchgear internal arc tests. It aims to assess the ability to limit the risk of personal injury, damages, and suitability for further service. It covers arcing classes related to (i) personnel protection, (ii) damage restricted to part of the assembly, and (iii) suitability for limited service after an internal arc. It specifies levels of personnel protection and differentiates areas restricted to skilled persons and others accessible to ordinary persons. It covers access from front, back and sides and – very important - requirements for arc ignition protected zone.

The concept of “arc ignition protected zone” is an advance. It is related to areas within an ASSEMBLY where measures are provided to ensure the initiation of an arcing fault is a remote possibility. The concept considers that insulation is an important means to reduce the probability of an arc ignition and the possibility of arc propagation.

The key conditions are like (a) all live parts of each main circuit are separately protected by solid insulation or insulating barriers, (b) the insulation meet a more severe dielectric test requirement

(c) the solid insulation provides ingress protection such that foreign bodies cannot contact the live conductors (IP4X)

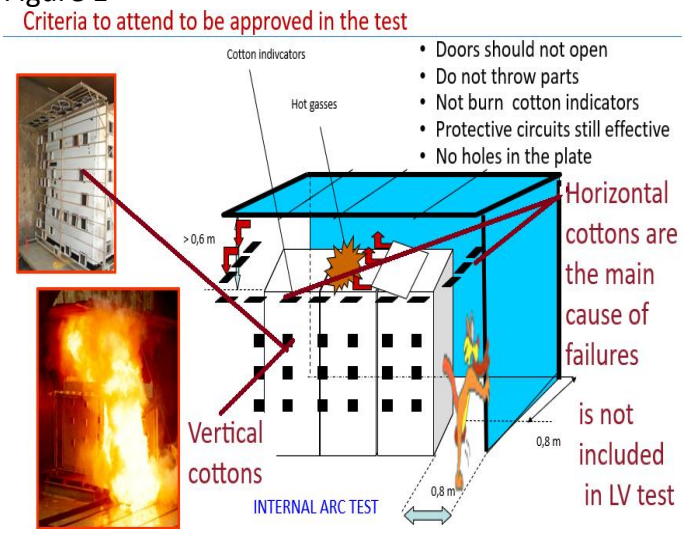
A very interesting aspect for a safer design, if you can use higher distances phase to phase is the arc auto-extinction following. If during the test, the arc extinguishes within the first half of the full intended test duration without being ignited again, the test shall be repeated using the same ignition point as used in the first test. A further repetition is not required because this would be the expected in real life. Auto-extinction bring lower overpressures and lower risks of burn-through.

**As written by IEC experts** in the answer from IEC below, IEC 61641 is not a Standard. It is a Technical Report. It states in the Scope; **'This test is subject to agreement between manufacturer and user. It is not considered to be a type test.' Accordingly, IEC 61641 has no definitive requirements and no specific pass criteria. It gives only guidance, and any interpretation can be agreed between the user and manufacturer.**

**Clause 7.2 lists areas of the assembly that should be considered, it does not state they shall be tested.** Clause 9 gives guidance on the details that should be included in the test report, and this includes the various locations where the arc is initiated.

**I think that this test should be a type test of IEC61439-1. More than this, I think the test method could be like the test for MV switchgear (IEC62271-200) but adding the concept of "arc ignition protected zone".** The main difference between the LV and MV tests is that the test in TR_61641 **do not require having the horizontal cotton indicators**, as in the MV standard.
The burning of the horizontal indicators is the main cause of failures in MV internal arc tests (Figure 1). This occurs because the hot gasses which goes out from depressurization openings reflect in the ceilings, returning down and burning indicators (Cigrè brochure 602/2014).

Figure 1



**What motivated me to write this article** is that some testing **laboratories interpretate wrongly that 6 shots are necessary while IEC says that is at least one**. More shots mean a longer and more expensive test and more risk to fail in the test.


**I wrote to IEC experts years ago to clarify this doubt on number of shots**. IEC gave me the same interpretation I defend - different from those labs.

**The complete IEC e-mail answer is in Section 2 below.** This first case where I had this doubt happened in a Brazilian testing lab in 2011. At that occasion I wrote to IEC and got the answer below.

I have seen testing laboratories giving wrong interpretations to standard texts because the standard texts are not clear enough. An example of a - difficult to understand text - is the Table 6 and temperature rise test method of IEC 61439. I explain why in the article at the end.
However, in this case of IEC TR61641, the text is well written and clear.

I do not understand how labs can understand that a test that is not even mandatory has so many shots. A third-party testing laboratory has no right to say that “if you do not the 6 shots we will write in the test report, that the test was not carried out within all the rules of IEC TR 61641”.

## 2. WHO SHALL DEFINE THE NUMBER OF SHOTS IN INTERNAL ARC TEST ?

**Read the answer from IEC in next page.**

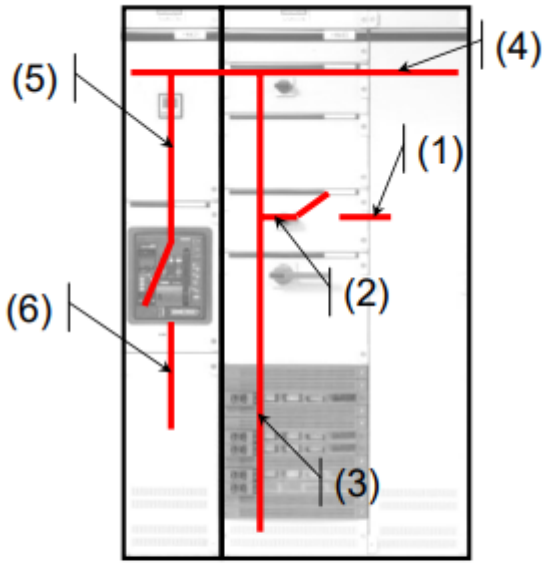
From the manufacturer's point of view, the objective is to carry out the internal arc test in the simplest and most economical way possible. If it is successful, they want to read in the test report a statement like "it was carried out in accordance with the document IEC / TR 61641".

Considering that the test is not a type test and is optional to the manufacturer, it is reasonable to try to do it with as few internal arc applications as possible, for example, 1 or 2. The text of the IEC TR clearly does not specify several applications. Therefore, it is not up to any laboratory to specify how many applications (shots) to perform.

### Test implementation – ignition points

The following ignition points have to be considered in the test:

- (1) Load side of a feeder
- (2) supply side of a feeder
- (3) Along distribution busbars
- (4) Along main busbars
- (5) Load side of an infeed
- (6) supply side of an incoming




No test is required if these ignition points fulfill the criteria of an arcing-free zone. Insulation material must not be destroyed, removed or punctured during attachment of the ignition wire.

Arcing test Industry Sector
Sven Obigt Slide 21/25

3. **THE QUESTION SENT TO IEC BY ME AND THE ANSWER RECEICED FROM IEC.**

## ANSWER from IEC from Mr. Thomas W. Mennel – Chairman of SC 17 D – Low voltage Switchgear and Controlgear Assemblies ( in 2011)

**From:** tom.mennell@schneider-electric.com
**Sent:** Monday, August 22, 2011 5:00 AM
**To:** sergiofeitoza@cognitor.com.br
**Cc:** Wolfgang Kluge ; Drebenstedt, Helmut
**Subject:** Re: Doubt on the interpretation of IEC TR 61641

Dear Sergio,

Thanks for your mail. My apologies for the slow response - unfortunately it slipped of the end of the 'to do' list.

IEC 61641 is not a Standard; it is Technical Report. As it states in the Scope; 'This test is subject to agreement between manufacturer and user. It is not considered to be a type test.'

Accordingly, IEC 61641 has no definitive requirements and no specific pass criteria. It gives only guidance, and any interpretation can be agreed between the user and manufacturer.

Clause 7.2 lists areas of the assembly that **should** be taken into account, it does not state they **shall** be tested. Clause 9 gives guidance on the details that should be included in the test report, and this includes the various locations where the arc is initiated.

I appreciate I may not have provided the precise answer you are seeking, but this is not possible due to the vagueness of a Technical Report. IEC 61641 is currently being revised by a Project Team led by Dr Helmut Drebenstedt.

By copy of this mail, I will make him aware of your concerns in order that they can be considered in the preparation of the next revision.

Please let me know if I can assist further.
Best Regards
Tom Mennell

## QUESTION SENT BY SERGIO FEITOZA COSTA TO IEC

**This email has been generated from IEC website**

SUBJECT Doubt about the interpretation of IEC TR 61641: Enclosed low-voltage switchgear and controlgear assemblies – Guide for testing under conditions of arcing due to internal fault
To Mr. Thomas W. Mennel – Chairman of SC 17 D – Low voltage Switchgear and ControlGear Assemblies

Copies to : Mr. Wolfgang Kluge - Secretary of SC 17 D and Mr. Damien Lee – Technical officer Dear Mr. Mennel

My name is Sergio Feitoza Costa, and I am a Brazilian consultant on switchgear, testing and standards. Many years ago, I had the honor of being Chairman of IEC TC 32 – Fuses.

**I would like to do clarify two doubts related to the interpretation of clauses of IEC TR 61641**

Question 1)
Frequently I find situations in which the intention of my clients (switchgear manufacturers) is to type test an equipment considering the classification "providing personal and assembly protection under arcing conditions " as described in Section 4 of TR 61641 (criteria 1 to 6). Suppose that the arc was ignited inside a box of a CCM (load or supply side of a feeder). The doubt is about what does it mean “defined area” in the term “capable of confining the arc to the defined area where it is ignited” (criteria 6 of Clause 8). Defined area is the box only or may be the complete column where the box is located?

Question 2)
As this test is expensive and time consuming, we try to do it with the minimum possible number of applications (ignition points) but which allows the laboratory doing the test to write in the test report, if attending the criteria, that "the test was made in accordance with the TR 61641 and met the requirements"
In sub-clause 7.2 are shown six possible points of ignition. There are laboratories that understand that the test applications must be made in all of them.

My interpretation about the intention of the standard is that the interested part in doing the test is who decides how many and where to do the applications. Even if the option is to do just one application (ignition point) and not the six, if successful, it can be written in the test report "the test was made in accordance with the TR 61641 and met the requirements."

Considering that these different interpretations can make the duration and cost of the test to be multiplied by 3 or 4 times, could you please inform the interpretation of SC 17D referring to this specific point?
Kind Regards
Sergio Feitoza Costa

## 4. FINAL COMMENTS.

Reading the IEC response, it is easy to see that if a laboratory tries to specify important test conditions such as the number of applications it is going beyond its scope and creating barriers and costs for manufacturers. I hope this answer helps whoever does this to correct their error.

## ANNEX – SOME IEC POSTS WITH INTERNAL ARC VIDEOS & RELATED INFORMATION

**LV INTERNAL ARC TEST by IEC_TR_61641 : Read the new article before quoting the test in the testing laboratory.**
https://www.linkedin.com/posts/sergiofeitozacosta_how-to-design-to-pass-the-test-and-to-have-activity-7112772896782991360-0FYI?utm_source=share&utm_medium=member_desktop

**INTERNAL ARC TEST 15kV 25kA WITHOUT RELIEF DUCT**
https://www.linkedin.com/posts/sergiofeitozacosta_internalarc-iec62271-iec61641-activity-7095124533128441857-YcUy?utm_source=share&utm_medium=member_desktop

**INTERNAL ARC TEST 15kV – 40kA WITH DUCT**
https://www.linkedin.com/posts/sergiofeitozacosta_internalarc-iec62271-iec61641-activity-7095123695370694656-mWf1?utm_source=share&utm_medium=member_desktop

**POWER TRANSFORMER INTERNAL ARC**
https://www.linkedin.com/posts/sergiofeitozacosta_electricalsafety-powertransformers-activity-7092957384012181504-KviE?utm_source=share&utm_medium=member_desktop

**MOVING ARC TRANSMISSION CABLE**
https://www.linkedin.com/posts/sergiofeitozacosta_arc-moving-along-conductors-activity-7105476678704898048--msV?utm_source=share&utm_medium=member_desktop

**TEST REPORT**
https://www.linkedin.com/posts/sergiofeitozacosta_iec62271-iec61439-iec61641-activity-7085987100621250560-moze?utm_source=share&utm_medium=member_desktop

**COPPER TO ALUMINUM**
https://www.linkedin.com/posts/sergiofeitozacosta_cigrea3-cigreb3-iec61439-activity-7084871676772950016-oXDm?utm_source=share&utm_medium=member_desktop

**METHOD OF TEMPERATURE RISE TEST IEC61439-1**
https://www.linkedin.com/posts/sergiofeitozacosta_iec61439-iec62271-cigre-activity-7083047364973797376-GpcP?utm_source=share&utm_medium=member_desktop

**CALCULATING LOSS OF LIFE IEC60943**
https://www.linkedin.com/posts/sergiofeitozacosta_iec61439-iec62271-cigre-activity-7082700902163226625-HhlS?utm_source=share&utm_medium=member_desktop

EM PORTUGUES --- **PAINEIS BT - NBR IEC61439-1 (novo artigo) – PERGUNTA AOS LABORATÓRIOS DE TESTES & CERTIFICADORAS. Que limites de elevação de temperatura nas conexões consideram na Tabela 6 para aprovar ou reprovar ?** Por que o teste de elevação de temperatura mudou para usar mais fontes de corrente, ficou mais caro e diminuiu o número de laboratórios que podem realizar ?
https://www.linkedin.com/posts/sergiofeitozacosta_nbriec61439-nbriec62271-iec61641-activity-7081978461338107905-ZG_T?utm_source=share&utm_medium=member_desktop

**EM PORTUGUES - TREINAMENTO**
https://www.linkedin.com/posts/sergiofeitozacosta_paineiseletricos-paineis-barramentos-activity-7110235935719497728-jOEk?utm_source=share&utm_medium=member_desktop

**WEB TRAINING TEMPERATURE RISE DESIGN**
https://www.linkedin.com/posts/sergiofeitozacosta_busway-switchgear-switchboard-activity-7085615715281477633-eGpn?utm_source=share&utm_medium=member_desktop

**HIGH POWER TESTS**
https://www.linkedin.com/posts/sergiofeitozacosta_temperaturerise-iec62271-iec61439-activity-7103722782714134529-ID7Z?utm_source=share&utm_medium=member_desktop

**INTERNAL ARC TEST SIMULATION**
https://www.linkedin.com/posts/sergiofeitozacosta_cigre-temperaturerise-iec62271-activity-7108431001999020032-9K_C?utm_source=share&utm_medium=member_desktop

**ELECTRIC PANELS**
https://www.linkedin.com/posts/sergiofeitozacosta_paineiseletricos-paineis-barramentos-activity-7110232186657619968-oMrF?utm_source=share&utm_medium=member_desktop

**CIGRÈ WORKING GROUP to study RAISING THE TEMPERATURE RISE LIMITS USED IN IEC STANDARDS** by 10 to 15K (time life 30 years). This would cause a considerable reduction of copper and aluminum use. In line with the goals for environment and reduction of wasting Earth resources. (read Section 3 of th article)
https://www.linkedin.com/posts/sergiofeitozacosta_cigre-iec-switchgear-activity-7082356756219072512-Wac5?utm_source=share&utm_medium=member_desktop

## ANNEX - IEC TECHNICAL REPORTS (TR) UNKNOWN BY PEPOLE TO WHOM COULD BE USEFUL.

IEC publishes documents like "Technical Standards" and "Technical Reports (TR)". Technical reports are usually very good documents that explain concepts behind the requirements of the technical standards. Due to a certain lac of view from IEC management some TRs which could be very useful to several Technical Committees (TCs) simply are unknown to other TCs because "it is not their area". When I was participating in the IEC WG activities for the preparation of TR IEC 62271-307 (extension of the validity of test reports – HV switchgear), we included in the bibliography many of these documents like

- [1] IEC/TR 60890, A method of temperature-rise verification of low-voltage switchgear and
- controlgear assemblies by calculation
- [3] IEC 61117, Method for assessing the short-circuit withstand strength of partially type tested assemblies (PTTA)2
- [4] IEC TR 60865-1, Short-circuit currents – Calculation of effects – Part 1: Definitions and
- calculation methods
- [5] IEC TR 60865-2, Short-circuit currents – Calculation of effects – Part 2: Examples of
- calculation
- [6] CIGRE Brochure 601 (2014), "Tools for the simulation of the effects of the
- internal arc in transmission and distribution switchgear"
- [8] IEC TR 60943, Guidance concerning the permissible temperature rise for parts of
- electrical equipment, in particular for terminals