FUSIVEIS EXPULSÃO da IEC 60282-2

Sugestões ao SC32A da IEC para próxima revisão baseadas na norma brasileira NBR7282

(DEC e o FEC mostram pouco onde impostos são excessivos e mal utilizados)

https://www.cognitor.com.br/IEC602822NBR7282POR.pdf

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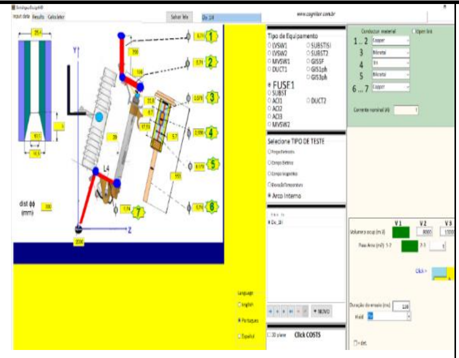
Tabela 1 – INDICADORES DE QUALIDADE E CUSTOS (ORDENS DE GRANDEZA)
Em caso de dúvidas leia o artigo original em inglês aqui https://www.cognitor.com.br/IEC602822sugestionstosc32afrombrazil.pdf

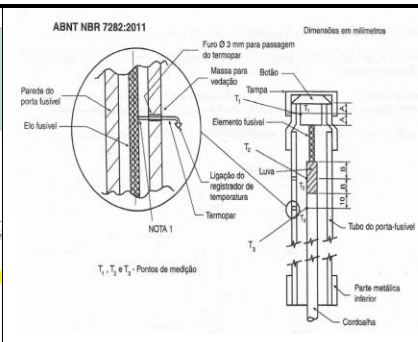
País	DEC SAIDI (minutos)		FEC SAIFI		Qualidade do fornecimento de eletricidade (Indice World Bank GovData360)	Preço ao consumidor residencial (*)(USD / MWh)	(USD / MWh) dividido por salário-mínimo mensal no país
EUA/Canada	> 92 (2019) IEA		1,25 (2016) IEA		6,2 -6,6	140 - 170	0,12
França	48,0 (2002) 70,0 (2016) CEER metodologia		0,11 (2002) 0,22 (2002) CEER metodologia		6,7	267	0,13
Holanda	31,5 (2012) 27,3 (2016) CEER metodologia		0,33 (2012) 0,32 (2016) CEER metodologia		6,8	259 - 316	0,14
Australia					5,7	176	0,14
Turquia					4,4	77	0,23
Filipinas					4,2	150	0,50
África do Sul					3,9	208-230	0,70
B R A S I L	26 (1996) 16 (2016) DEC - GESEL		22 (1996) 8 (2016) FEC - GESEL		4,5	280-314 (*)	0,85

1. INTRODUÇÃO

Nota do autor: Este artigo foi escrito e publicado originalmente em inglês, inclusive no LinkedIn. Esta versão em Portugues tem algumas opiniões na abordagem de problemas brasileiros escritas por mim Sergio Feitoza Costa. A coluna da direita na tabela 1 mostra a razão da frase, no título "DEC e o FEC mostram pouco onde impostos são extorsivos e mal utilizados". A tabela com as sugestões à IEC mostrada ao final não foi traduzida para o português.

A maioria das normas IEC está focada em países desenvolvidos e não considera as grandes diferenças de práticas e contexto de países em desenvolvimento e subdesenvolvidos. A foto no canto superior da figura a seguir dá uma ideia disso. Foi tirada em uma boa área residencial do Brasil, com altíssimo IPTU. O Brasil, rico em recursos e com bom clima, poderia estar no G7 se não fosse a baixa escolaridade média, os altos impostos e os maus políticos, que, por motivos óbvios, não têm interesse em avançar na educação. No entanto, o Brasil tem uma indústria elétrica no nível das melhores do mundo, pois nas décadas de 70 e 90 foram feitos bons investimentos em conhecimento, incluindo centros de pesquisa, boas universidades e formação de especialistas no exterior.





Em 2021, antes de começar a coordenar nova revisão da norma técnica brasileira para fusíveis de expulsão (NBR7282,) equivalente à IEC 60282-2, publicamos e enviamos à IEC um artigo apresentando sugestões ao SC32A (High Voltage Fuses) para o próxima revisão da IEC 60282-2. Recebemos, dias depois, os comentários do SC32A informando que as sugestões serão consideradas na próxima revisão. Este texto é uma atualização dessas sugestões, mas também contém informações sobre preços e qualidade dos serviços de distribuição de eletricidade em países desenvolvidos e em desenvolvimento. A coluna do lado direito da tabela 1 mostra por que não basta ter um melhor índice de qualidade do fornecimento. Importa muito mais o que se paga por isso, sistematicamente ocultado e mal percebido pela sociedade.

A NBR7282 anterior (1989 e 2011) foi baseada nos esforços de um bem-sucedido programa nacional realizado para melhorar a qualidade do fornecimento de energia elétrica reduzindo os índices de falhas no sistema de distribuição brasileiro. Este programa chamado PROQUIP trouxe resultados muito úteis e mensuráveis ao País. Centenas de testes foram feitos nos laboratórios do CEPEL, onde eu, Sérgio, trabalhei por 25 anos. O objetivo dos testes foi identificar o que deveria ser melhorado nas redes de distribuição. Participei de todas as fases desse trabalho.

As ações do Proquip para chaves e elos-fusíveis de distribuição se destacaram pela maior visibilidade de resultados como a redução da "falta de luz". O programa envolveu também pára-raios, relés e outros itens da rede. Os fusíveis expulsão são muito usados, mesmo no centro urbano das cidades brasileiras. Aqui, as preocupações com a estética das áreas públicas, ainda estão em baixo nível. Somente nas áreas mais ricas utilizam-se sistemas subterrâneos. No Brasil nunca houve discussão séria sobre o uso amplo dos sistemas subterrâneos. A primeira barreira é que prefeituras, concessionárias de energia elétrica, gás, internet e outros serviços não conseguem se organizar sobre o uso de dutos comuns a todos os serviços. O que antes se via apenas nas comunidades de baixa renda agora se vê em quase todos os lugares. Basta olhar os fios dos vários sistemas abandonados nas ruas e as reportagens das TVs sobre o assunto. Comece analisando pela cidade do Rio de Janeiro. Apenas investimentos muito grandes em Educação (p.ex. uns10% do PIB por cerca de uns 11 anos) poderiam, no futuro, vir a nos dar uma forma "desenvolvida" de olhar para problemas dos serviços públicos, saúde, corrupção e planejamento.

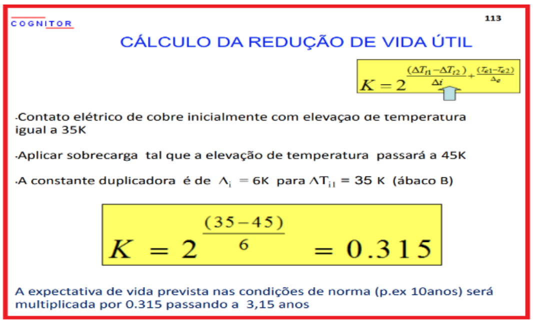
Apenas a título de curiosidade, há uns 20 anos atras eu fui chamado para dar um parecer técnico judicial em uma ação em que um contribuinte solicitava a remoção de um transformador de perto de sua janela em um bairro nobre do Rio de Janeiro. Era uma situação bem parecida com a foto do lado esquerdo logo abaixo. Na época recomendei , no processo judicial, que fosse feito um teste de curto-circuito em um transformador similar em que o fusivel falha-se. Falhas acontecem mesmo em equipamentos aprovados em testes. A ideia não era testar a chave fusivel e sim ver o alcance do óleo quente em caso de uma explosão. Eu assisti o teste e aconteceu exatamente o previsto por mim. O alcance era maior que a distância mostrada nesta foto. Portanto se a janela estivesse aberta e com uma cortina esta possivelmente pegaria fogo. Se houvesse alguém na janela nem é preciso explicar o que aconteceria.

O programa Proquip envolveu quase todas as concessionárias e fabricantes de chaves e elos-fusíveis de distribuição. A NBR7282 publicada em 1989, para consolidar o conhecimento adquirido, serviu de base para a revisão da IEC 60282-2 (1995). O Comitê Nacional Brasileiro sugeriu à IEC a revisão a ser feita e tive a honra de coordenar o grupo de trabalho do IEC. Naquela época, eu era Presidente do Comitê Técnico TC 32 (Fusíveis) da IEC.

Em 2011 uma nova revisão da NBR7282 foi publicada no Brasil. Agora, 2022, onze anos depois, estamos revisando novamente para melhorar alguns pontos, corrigir erros editoriais e incluir o novo conceito de extensão da validade dos relatórios de testes trazidos pela IEC 62271-307. Participei da elaboração deste documento IEC emitido em 2015. Ele visa evitar repetições desnecessárias de testes. A IEC62271-307 permite estender a validade dos resultados de testes feitos em um equipamento testado de tipo aprovado para outro não testado, da mesma família.

Penso que cerca de 70% do pessoal da indústria elétrica ainda está preso ao conceito antigo e ultrapassado de que tudo deve ser testado e retestado. Este é um conceito superado e basta ler as publicações do Cigrè e IEC dos últimos 10 anos. Portanto, para quem ainda tem esta visão, sugiro atualizar suas equipes com treinamentos específicos. Nos últimos 14 anos as concessionarias de energia, fabricantes, laboratorios de testes e outros que atuam na indústria elétrica praticamente abandonaram treinamentos e formação de pessoal. As equipes antigas aproveitaram os PDVs e saíram de circulação. Os novos que entraram têm pouquíssimo treinamento. O nível técnico das equipes de hoje é muito pior que nas décadas de 70 a 90 , quando parecia que o Brasil ia decolar. Entretanto ao invés disto, anda cada vez mais para trás.

<u>A NBR7282 contém testes que não fazem parte da IEC 60282-2.</u> A maioria está ligada ao envelhecimento prematuro dos elos-fusíveis. No Proquip, isto foi claramente identificado como o maior motivo dos frequentes desligamentos , antes da mudança da norma. Algumas propostas feitas pelo Brasil para a revisão da IEC de 1995 não foram aceitas pelos membros americanos e europeus, no grupo de trabalho IEC. O envelhecimento prematuro é uma questão fundamental e, naquela época, os fabricantes norte-americanos não estavam interessados em criar testes que pudessem fazê-los sair da zona de conforto. Para os europeus o uso de fusíveis de expulsão é muito pequeno. A Austrália também enviou propostas interessantes, inclusive sobre como evitar as “fagulhas” que provocam incêndios em zonas rurais. Este problema acontece muito por lá e há um teste específico na norma australiana. De acordo com a IEC60943, trabalhar apenas 10 K acima dos limites de elevação de temperatura de norma significa uma redução de vida útil de cerca de 66%, para conexões e contatos. Esta era a razão para a operação prematura dos elos-fusíveis. Por isso é fundamental durante os testes, medir as elevações de temperatura nos pontos certos. Os fusíveis que protegem um transformador de distribuição estão frequentemente nesta situação, nas goras de alta carga. É simples assim e bem coberto pela NBR7282, mas desconsiderado pela IEC60282-2



Aprendi, participando de muitas reuniões dos grupos de trabalho (GT) da IEC e Cigrè internacional, como é difícil aprovar modificações de normas IEC que são importantes para os países em desenvolvimento, mas não para os desenvolvidos. Nos GTs de IEC, salvo raras exceções, os especialistas de países desenvolvidos raramente têm a percepção do que acontece no mundo fora de seus países.

Por exemplo, eles não imaginam que em uma grande cidade como o Rio de Janeiro, o furto de energia e o furto de cabos do sistema de trens causem perdas, quase semanais, nas concessionárias de energia e interrupções nos serviços de trens. É rara a semana em que não vemos na TV uma notícia sobre isto. Basta dar uma busca na Web.

Portanto, quando solicitamos, na revisão da norma IEC, a inclusão de uma figura mostrando onde deve ser medida a elevação de temperatura, ou um teste para verificar a curva tempo X corrente após o envelhecimento, isso deveria ser analisado nos GTs da IEC, de uma perspectiva mais ampla.

Neste artigo apresentamos sugestões para a próxima revisão da IEC 60282-2. Na atual revisão da NBR 7282 brasileira, a intenção inicial era usar uma tradução completa da IEC60282-2. No entanto, uma análise detalhada nos mostrou que isso seria andar para trás. Então, em vez disso, decidimos manter os detalhes e testes extras atuais da NBR7282 e aprimorar o texto de norma.

Ao longo da minha vida, no ambiente da IEC, Cigrè e ABNT, defendi a ideia de que as normas nacionais devem ser idênticas às normas IEC. No entanto, hoje estou convencido de que certas normas técnicas nacionais são muito mais eficientes do que as correspondentes IEC. Este artigo tenta trazer evidências e ajudar a convencer a IEC SC32A de nossas sugestões.

Peço atenção aos conceitos de “extensão da validade dos relatórios de teste”. Mais do que isso, atentar para o fato de que, atualmente, temos recursos de simulação de testes que não existiam nos tempos de “tudo deve ser testado”. Eles são tecnicamente comprovados, confiáveis e validados para os testes de alta potência relevantes, incluindo os que envolvem arcos de alta corrente. É possível, por exemplo, esclarecer dúvidas quanto ao papel dos elos-fusíveis em cada uma das 5 sequencias de testes de interrupção de curto-circuito.

Nesse aspecto, até hoje, tenho dúvidas se os porta-fusíveis que são vendidos são os mesmos que são testados. Como saber, já que não é obrigatório informar, nos relatórios de ensaios a espessura da parte interna do porta-fusíveis? Com simulações de teste, poderíamos até definir um porta-fusíveis de teste padrão para elos-fusíveis.

2. ALGUNS INDICADORES DE QUALIDADE DOS SERVIÇOS DE ELETRICIDADE

Aqui estão alguns indicadores da qualidade dos serviços de distribuição de energia elétrica desde o final da década de 80 até os últimos anos. Busquei estes dados na web, só para apresentar ordens de grandeza. No caso do Brasil, eles dão uma ideia de como os sistemas de distribuição melhoraram após o programa Proquip e NBR7282. É uma pena que pagamos muito mais caro que outros países por isto. Usei como indicadores o DEC e o FEC aproximado pois as metodologias podem variar um pouco de pais para pais. Entretanto a ideia central pode ser percebida:

- DEC = duração total das interrupções/número de clientes
- FEC = quantidade total de interrupções/ número de clientes
- Preço da eletricidade (USD/KWh ou USD/MWh)
- Preço da eletricidade dividido pelo salário-mínimo do país, para entender a dificuldade do usuário em pagar a conta de eletricidade. Este é um índice importante que nunca aparece ao público.

Tabela 1 – INDICADORES DE QUALIDADE E CUSTOS (ORDENS DE GRANDEZA)

Em caso de dúvidas leia o artigo original em inglês aqui https://www.cognitor.com.br/IEC602822sugestionstosc32afrombrazil.pdf

País	DEC SAIDI (minutos)		FEC SAIFI		**Qualidade do fornecimento** de eletricidade (Indice World Bank GovData360)	**Preço ao consumidor residencial** (*)(USD / MWh)	**(USD / MWh) dividido por salário-mínimo** mensal no país
EUA/Canada	> 92 (2019) IEA		1,25 (2016) IEA		**6,2 -6,6**	140 - 170	**0,12**
França	48,0 (2002) 70,0 (2016) CEER metodologia		0,11 (2002) 0,22 (2002) CEER metodologia		**6,7**	267	**0,13**
Holanda	31,5 (2012) 27,3 (2016) CEER metodologia		0,33 (2012) 0,32 (2016) CEER metodologia		**6,8**	259 - 316	**0,14**
Australia					**5,7**	176	**0,14**
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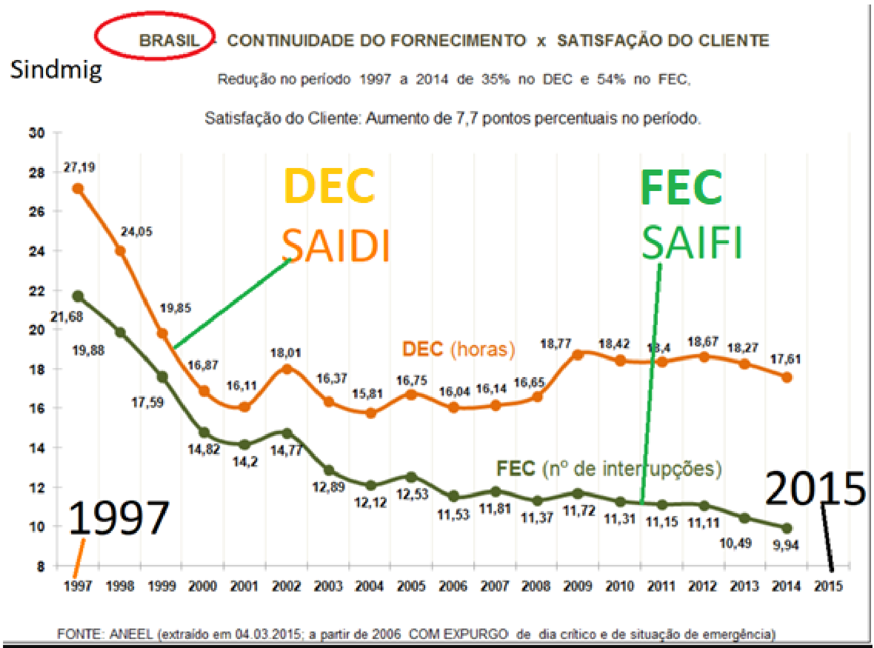
B R A S I L	**26 (1996)** **16 (2016)** DEC - GESEL		**22 (1996)** **8 (2016)** FEC - GESEL		**4,5**	280-314 (*)	**0,85**

(*) Ordem de grandeza dos valores. No Rio de Janeiro - Brasil paguei a conta de luz em abril de 2022 (apartamento para 3 pessoas) ~ USD 206,00 por 654 kWh (USD 314,00/MWh). Os impostos são 33% do total da conta.
(**) CEER -Tabela 9 - Eletricidade: DEC / SAIDI planejado e não planejado, incluindo eventos excepcionais (minutos por cliente)
(***) CEER - Tabela 17 – Eletricidade: FEC / SAIFI planejado e não, incluindo eventos excepcionais (interrupções por cliente

***Sua ajuda para atualizar/corrigir o DEC/FEC - SAIDI/SAIFI é muito bem-vinda (escreva para sergiofeitozacosta@gmail.com)



SINDIMIG: http://www.sindimig.com.br/wp-content/uploads/2016/04/dec-e-fec-aneel.bmp

FONTES DE INFORMAÇÃO INTERESSANTES:

Minimum Wage by Country 2022 (worldpopulationreview.com)	https://worldpopulationreview.com/country-rankings/minimum-wage-by-country OECD https://stats.oecd.org/Index.aspx?DataSetCode=RMW
Quality of electricity supply - GovData360 (worldbank.org)	https://govdata360.worldbank.org/indicators/heb130a3c?country=BRA&indicator=547&viz=line_chart&years=2007,2017
IEA - Statistics report - Key World Energy - Statistics 2021 - September 202 + EIA	https://iea.blob.core.windows.net/assets/52f66a88-0b63-4ad2-94a5-29d36e864b82/KeyWorldEnergyStatistics2021.pdf EIA methodology USA https://www.eia.gov/todayinenergy/detail.php?id=45796
MAIFI , SAID, SAIFI (Wikipedia)	https://en.wikipedia.org/wiki/MAIFI#:~:text=The%20Momentary%20Average%20Interruption%20Frequency,period%20(typically%20a%20year).
International electricity prices: How does Australia compare? (energycouncil.com.au)	https://www.energycouncil.com.au/analysis/international-electricity-prices-how-does-australia-compare/#:~:text=The%20average%20annual%20cost%20of,costs%20(down%20by%20%2467)
Energy Quality of Supply Work Stream (EQS WS) - **CEER** Benchmarking Report 6.1 on the Continuity of Electricity and Gas Supply - Data update 2015/2016	https://www.ceer.eu/documents/104400/-/-/963153e6-2f42-78eb-22a4-06f1552dd34c
ERIA Research project report 2017 Nr.12 Comparative Power Prices in the Philippines and selected Asian Countries	https://www.eria.org/research/comparative-analysis-of-power-prices-in-the-philippines-and-selected-asean-countries/
ANEEL – Indicadores coletivos de continuidade	https://www.eia.gov/todayinenergy/detail.php?id=45796
Dados Energéticos – São Paulo	https://dadosenergeticos.energia.sp.gov.br/portalcev2/intranet/Eletricidade/index.html
SINDMIG (chart above 1997 – 2015)	http://www.sindimig.com.br/wp-content/uploads/2016/04/dec-e-fec-aneel.bmp

3. SUGESTÕES PARA A PROXIMA REVISÃO DA NORMA IEC 60282-2

(PRÓXIMA PÁGINA)

A PARTIR DAQUI O TEXTO ESTÁ EM INGLÊS APENAS

SUGGESTIONS TO THE NEXT REVISION OF IEC 60282-2

BASED ON THE BRAZILIAN STANDARD

NBR7282

WHICH IS in 2022 UNDER REVISION

# 1	**Item1** **Add** **new** **paragraph** **after the 4th**	**Add this paragraph after the 4th paragraph** “It shall be recognized that the prevailing situation in the market is to find companies that manufacture (only) the fuse base and the fuse holder, but do not manufacture the fuse-links and vice versa. It should be noted that testing a homogeneous series of fuse-links (testing a large T link and a small K link as the maximum and minimum links to be tested) aims to cover everything in between, including different types of K or T such as the type H widely used in some countries ~~Brazil~~). When it is not clear where the role of the fuse link ends and that of the fuse holder begins, test simulation techniques and the principles of extending the validity of test reports defined in the (informative) Annex D, can be used. These principles are an adaptation of the ones presented in IEC62271-307.“ What is written in IEC 60282-2 (2008) to be improved 4th paragraph of 2008 version states: This standard covers only the performance of fuses, each one comprising a specified combination of fuse-base, fuse-carrier and fuse-link which have been tested in accordance with this standard; successful performance of other combinations cannot be implied from this standard	When the 4th paragraph says “ONLY” and “SUCCESSFUL PERFORMANCE OF OTHER COMBINATIONS CANNOT BE IMPLIED FROM THIS STANDARD” users and buyers are induced to ask manufacturers who produce fuse-links ONLY to do all breaking tests of sequence 1 to 5. It is similar to IEC62271-200 products, where there are manufacturers of metallic enclosures and manufacturers that assemble the complete panel (enclosure + internal components such as busbars, circuit breakers, etc.). However, in this case, there are separate prescriptions and tests to prevent enclosures-only manufacturers from having to do tests unrelated to their product. However, in IEC 60282-2 this separation is not defined, and this is what needs to be improved. Comparing the 1989 edition of IEC 60282-2 with the 2008 edition, we see that the SC32A tried to solve the problem of requiring an almost prohibitively large number of tests. Testing a homogeneous series of fuses has changed by adopting the IEEE C37.41 approach (essentially testing a large T link and a small K link as the maximum and minimum links to be tested, covering everything in between, including different types of K or T as the type H widely used in Brazil). However, the issue of different manufacturers supplying cut-out components to a customer was not addressed. Therefore, the current wording penalizes those who manufacture only fuse-links in favor of those who produce the complete set. A relevant fact to mention is that unlike in the past, there are now easy and cheap test simulation techniques and, after IEC 62271-307 (2015), the principles of extending the validity of test reports. When it is not clear where the role of the fuse link ends and that of the fuse holder begins, test simulation techniques and the principles of extending the validity of test reports can be used. These principles are taken up in the informative annex D. A real example, demonstrable with test reports, is when a manufacturer of – only – fuse-links invest thousands of dollars going to a neutral test laboratory and performing, in addition to sequences 4 and 5, test sequence 1. In the test of TD1 , the current is interrupted, but the fuse holder does not fall. The laboratory places a negative statement, on the basis that “Any failure to interrupt and, for self-opening fusible devices, any failure to move and remain in the correct opening position, during any test in test groups 1 to 5, is a failure of the device". There is evidence that the only influence the fuse link could have on not dropping the fuse holder is if the fuse link manufacturer's written instruction for cutting the cord is not followed by the user (see photo below). After this event, when the manufacturer went to sell the fuse-link to an electric power utility, they did not accept that fuse because they identified this statement in the test report. Thus, the standard text should be improved so as not to unduly eliminate fuse-links manufacturers from the market. Therefore, in addition to the warning phrase, openings must be created so that calculation methods or simulations or the rules of IEC 62271-307 can be used.

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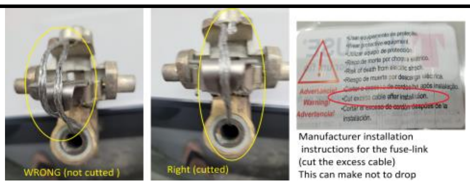
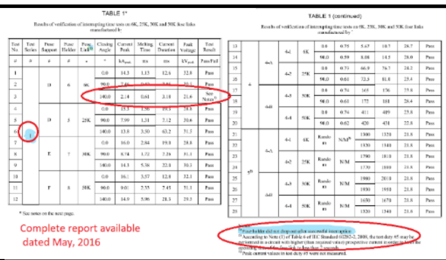
			
# 2	**Item1** **Add** **Note 5**	**Add the following Note 5:** NOTE 5 The best way to ensure that a fuse device with a base, a fuse holder and a fuse link performs well , in the real life, is to test the combination. Doing this with too many combinations is impractical. A complete technical identification of the set submitted to type tests, through drawings, photos and indication of materials, is the only way to assure that what was tested is what is regularly supplied. Extension of the validity of previous tests results performed on a certain device may be used to estimate the test result on an untested device. The principles for this are presented IEC 62271-307. These principles are detailed in Annex D, however, customized to IEC 60282-2.	Read the line above with the same reasoning Maybe the text of this note can be positioned in a part different of the “scope”, for example in the Notes of the Breaking Tests table. However, the alert about “what is tested should be equal to what is sold” is an important issue. The fact is that many IEC tests nowadays are not reproducible, at all, by lack of information in the test reports.
# 3	**Item** **3.3.6**	**Remove the Note or change it to:** Note: The protection performance provided by the selected fuse link and selected fuse holder combination can be verified by testing the specific fuse holder combination or using the principles of extending the validity of test reports of tested and approved products of the same. family (Annex D)	What is written in IEC 60282-2 (2008) to be improved **3.6 - interchangeability of fuse-links** compatibility of dimensions and pre-arcing time-current characteristics between different manufacturer's expulsion fuse-links, permitting use of such fuse-links in fuse-carriers of alternative manufacturers, without significant alteration of the pre-arcing time-current characteristics NOTE It should be noted that the protective and interrupting performance provided by the combination of the selected fuse-link and the selected fuse-carrier can only be assured by performance test on the specific combination. REASONING: Read lines above for the proposed changes in Section1
# 4	**Items** **6.3.5 / 7.3**	**Improve the text to clarify which manufacturer** is talking about (Fuse base and fuse holder OR fuse link ?) **Proposed texts:** 6.3.5 - The rated current assigned …… if applicable, within a fuse-carrier specified by the manufacturer of the fuse-link, at ambient temperature of ….. 7.3.1 General The time-current ….and unloaded fuse-link in a fuse-base specified by the manufacturer of the fuse-link	**REASONING:** 6.3.5 – This should be the manufacturer of the fuse-link. If a fuse-link that is made by someone other than the fuse-holder manufacturer does not meet the temperature rise requirements, it would not be suitable for use in the fuse-holder. 7.3.1 – again the fuse-link manufacturer, although the possible understanding is that the fuse-holder has very little influence on the time current characteristic the range specified in 8.7 (i.e., to 300/600 s).

<table>
<tr><td># 5</td><td>7.2. b</td><td><u>Improve the sentence</u> to clarify that the fuse holder (internal material to produce gasses) must withstand the “number of tests” (shots) interruption test.

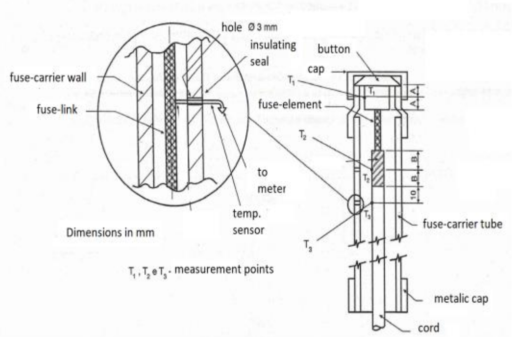
The proposed sentence is:
... After operation of the (complete) fuse device, its components, except those intended to be replaced after each operation, must be in substantially the same initial conditions, except for the internal erosion of the tube,, considering the number of tests before to replace the fuse holder, which it must support, according to Table 6. The identification of the material used, and its dimensions must be sufficiently presented in the test report, to enable reproducibility.</td><td><u>Editorial improvement</u></td></tr>
<tr><td># 6</td><td>7.4</td><td><u>Maintain only the 1st and 3rd sentences</u> and remove the 2nd that do not add useful information and may bring doubts.
Proposed text
7.4 - Temperature and temperature rise
The fuse-base, fuse-carrier and fuse-link shall carry their rated currents continuously without exceeding temperature and temperature-rise limits specified in Table 12. <s>These limits shall not be exceeded, even when the rated current of the fuse-link is equal to the rated current of the fuse-carrier intended to accommodate this fuse-link.</s> Fuse-link parts for which temperatures cannot be easily measured during tests (for example the small arc-quenching tube of distribution fuse-cutouts), shall be checked by visual examination for deterioration</td><td>REASONING

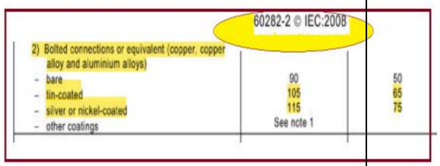
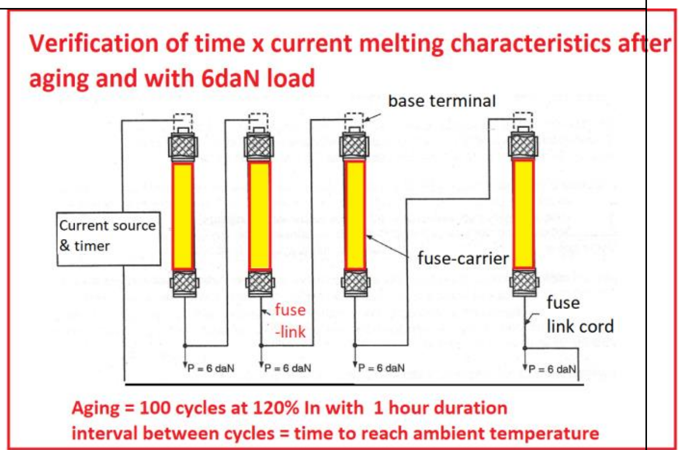
2nd sentence is superfluous</td></tr>
<tr><td># 7</td><td>8.2.2
Test Reports</td><td><u>Add the following sentence:</u>

“For a good identification of the tested product, it is recommended that the test reports include enough information to make the verifications of the relevant items of the tables in Annex D (informative).</td><td>REASONING
The principles of the extension of the validity of test reports (IEC 62271-307) are each time more used , as well as testing simulations for temperature rise tests, electrodynamic forces and even breaking tests The information of the tables can be used to do calculations, extrapolation of results and, for example, to identify where the role of the fuse link ends and that of the fuse holder begins (read the suggestion to Section 1). Testing laboratories usually include in the test report only what is required by the test payer. This sentence is to remind about registration of information that makes the test reproducible and <u>to verify if what as tested is the same that is sold.</u> For example, fuse holders of expulsion fuses shall support 3 shots before replacement. The thickness & material of the internal tube define the result but are not even mentioned in the standard.</td></tr>
<tr><td># 8</td><td>New
Section
8.2.3</td><td><u>Include Section 8.2.3</u>

8.2.3 - Extension of validity of type test reports
Information regarding the fundaments is given in the informative Annexe D.</td><td>This sentence is to call the new Annex D</td></tr>
<tr><td># 9</td><td>Section 8.5
Temperature rise</td><td>Insert a Figure for the temperature rise test clarifying where the temperatures shall be measured to avoid premature aging. This is not obvious for fuse-links

Reasoning: Aging is a key factor but is not addressed in this standard. Check explanations in this article

https://www.cognitor.com.br/IEC602822sugestionstosc32afrombrazil.pdf</td><td></td></tr>
</table>

# 1 0	**Table 12 for Temperature Rise**	**To avoid a duplicate source of information, maintain only the title of Table 12 and replace all its body by the single sentence:** **"The table 14 of IEC 62271-1 (2017) or the more recent edition applies to IEC 60282-2 .** **The publication "IEC TR 60943 - Guidance concerning the permissible temperature rise for parts of electrical equipment, in particular for terminals", provides relevant information about temperature rise limits and its relationship with the aging of fuse-links and other components"**	**REASONING** Temperature rises limits specified in all IEC standards have the same fundaments. Most IEC knowledge about temperature rise limits is explained in the IEC TR 60943 - Guidance concerning the permissible temperature rise for parts of electrical equipment, in particular for terminals. The first version was published in 1989 by TC32. I knew about its existence by chance because one year after I became Chairman of IEC TC32 (1990-1994). This document is fully applicable to fuses, switchgear, power transformers, etc. because the materials and principles are the same. However, because it was published by a fuses committee and is a T.R. , very few people, even within other IEC TC's know about its important contents. The fact is that standards of different TCs use the same table of IEC 60943 and the copy-pastes are a source of errors. For example, in the NBR 7282 there is a typing error – being corrected now – and the values for contacts tin-coated and silver-coated are changed in the last 11 years.   There are worst situations like in IEC 61439 series. When using this standard, it is impossible to a test lab to know what the temperature rise is permitted for connections and contacts. They are generally the hot spots. Most LV switchgear tests reports do not have a conclusion (passed / not passed) due to this. Possibly, in the past, someone modified the original table and did a gross mistake that directly affect the market. Check the article https://www.cognitor.com.br//TemperatureRise_IEC61439Mistery.pdf
# 1 1	**9.3**	**Insert a special test 9.3 named "Verification of time x current melting characteristics after aging"** As a preconditioning for the verification of the time x current melting characteristic curves, all sample units must be electrically connected in series and pulled by a load 6 daN, as shown in the Figure. The units, installed as indicated …, must be subjected to 100 cycles of current rating 20% higher than the nominal. Each cycle must consist of 1 h of current application and a shutdown period required for units to reach ambient temperature. This conditioning must be accompanied by current and/or temperature records to ensure that test conditions remain unchanged throughout the test. After conditioning, half of the samples must be submitted to verification of the curves of minimum melting characteristics time x current of 10 s, in accordance with ….. the other half of sample must be subjected to verification of the maximum melting characteristics time x current of 300 s. For the verifications of these tests, the mechanical load tension must be 6 daN Conditioned units must meet the requirements of B.7.9	

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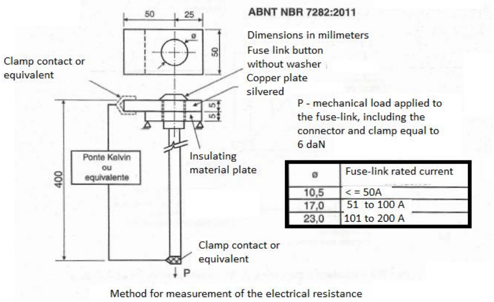
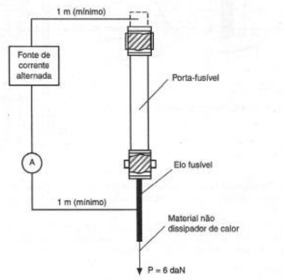
# 1 2	**9.4**	<u>**Insert a special test**</u> **Measurement of ohmic resistance of contacts** The resistance of the fuse switch contacts must be measured between each terminal on the base and the part metal of the nearest accessible fuse holder after contact. The resistance value must be the arithmetic mean of three independent measurements.....	This test creates a reference for the adjustments of the complete fuse. If the inclusion is accepted , we will provide the complete text of the method used in the Brazilian standard
# 1 3	**9.5**	<u>**Insert a special test**</u> **Measurement of electrical resistance of fuse links** The electrical resistance of the fuse link must not vary outside the limits of plus or minus 10% of the resistance of a standard comparator resistor to be prepared by the manufacturer for each rated current value and fuse link type.	 If the inclusion is accepted , we will provide the complete text of the method used in the Brazilian standard.
# 1 4	**9.i**	<u>**Insert a special test**</u> **Electromechanical test for H type fuse-links** Apply the rated current during 24 hours with a load of 6 daN Fuse-link is approved if supports the conditions for 24h	 If the inclusion is accepted , we will provide the complete text of the method used in the Brazilian standard.
1 3	**Include the new Annex D**	<u>**Include the new Annexe D**</u> ANNEXE D (informative) - EXTENSION OF THE VALIDITY OF TYPE TESTS ALREADY CARRIED OUT ON FUSE BASES, FUSE HOLDERS AND FUSE LINKS	**Read below the text proposed for the Annexe D in Section 4 of this article**

1. TEXT PROPOSED FOR A NEW ANNEXE D: "EXTENSION OF THE VALIDITY OF TYPE TESTS ALREADY CARRIED OUT ON EXPULSION FUSES, FUSE HOLDERS AND FUSE LINKS "

D.1 of Annexe D of the proposed revision - General

The principles of IEC 62271-307 (2015) show how to avoid unnecessary repetition of tests, which consume resources and increase the cost of equipment. This is done through the new concept of extending the validity of type test reports. The idea is to carefully select a certain product that will be tested like a "head of family". After approved in type tests this test report will be used to avoid testing other equipment which are of the same family, but with some differences. To be possible to do this a series of rules, described in tables, will be used. All these rules are related to well defined design parameters. The idea is to use in IEC 60282-2, the same approach of IEC 62271-307. Medium voltage fuses and switchgear have, within their functions, interrupting electrical circuits. There is a clear similarity of test principles and rules as in the tables presented below.

The aim of the extension of validity is not to repeat individual type tests in situations such as:
• for an alteration of constructive details, it can be demonstrated that this alteration does not influence the result of the individual type test.

• for a change to the installation instructions, provided that the test conditions are not invalidated by the new instructions.
• to cover other nominal values for the same equipment, if these new nominal values are covered by the tests already carried out.
• To demonstrate that a certain type of fuse link would perform satisfactorily if used in fuse-bases and fuse holders from different manufacturers and vice versa.

This Annex is used to extend the validity of type tests performed on a fuse with a defined set of ratings to another fuse of the same family with a different set of ratings or different component arrangements *(Comment: to list here some examples with extenders, links , buttons, etc...).* It concerns the selection of functionally representative test objects from a fuse family to optimize type testing using a consistent conformity assessment.

This Annex uses a combination of sound technical and physical principles, manufacturer and user experience, and test calculations /simulations to guide the extent of validity of type tests. It is applicable in different cases such as:
a) when the validity of a type test performed on a test object is extended to other functional units of the same fuse family.
b) when, for a fuse family, test objects are selected for each characteristic, whose results validate the complete family with a minimum number of test objects and type tests.
c) when for an untested test object, an analysis is performed using test reports of available types from the same fuse family to determine if the test results validate the test object for the specified characteristics.
d) when the validity of the type test of a previously tested item is extended to a design modification

The extension of validity is based on the use of parameters and design conditions clearly established in the specific tables below, for each type of test. To make it clear that the conditions are met, the use of calculations and simulations is allowed and widely used. This has become possible and validated over the last 20 years. The bibliographical references that are in { .... } cover these themes.

For the use of the tables, it should be considered that:
• Each design parameter to be evaluated must be compared with the design parameter already tested by applying the acceptance criteria in the table itself.
• The assertion of all extension criteria allows a test performed on a specific test object to be applied to another one of the same family, with different characteristics.
• If any of the extension criteria cannot be asserted, additional evidence is needed and can be demonstrated, for example, by technical arguments, calculations, testing simulations or special tests.

As for the use of calculations and simulations, they can only be applied in a comparative sense using calculation results available for a tested test object and results obtained for the other test object under investigation. The comparison is always based on the design parameters and acceptance criteria in the tables. For example, suppose you calculate a temperature rise in a tested equipment using a validated method (validated means equal test and simulation results within a known tolerance). If the results of the temperature rise, by the same method, applied to an untested object of the same family, are lower or equal, it is confirmed that the untested object would pass the test.

Validation of software tools and calculation methods are outside the scope of this standard. However, there are in Section D.2 some rules to serve as a reference for agreements between users and manufacturers, which aim to use a method or tool to assist in the extension of validity

<u>The tests for which the extension criteria can be used are:</u>
• Temperature rise test
• Short time withstand current test, where applicable.
• Ability to breaking and making
• Internal arc supportability (about operation during interruption and overpressure calculations inside fuse holders and fuse link tubes)
• Dielectric withstand tests

• Mechanical endurance tests

Tables D1 to D6 show the rules for extending the validity of each test. Each of them was based on the tables of IEC 62271-307. The modifications made to adapt them to this IEC 60282-2 are highlighted in each table.:

Table D-1 - Temperature Rise (Extension Criteria)

The temperature rises of the conductors, fuse-link and, where they touch, insulating materials, at the specific points measured are the parameters to be compared. If necessary, the temperature rise of the air inside the fuse holder may help in the assessment.

Item	Design parameter	Acceptance criterion	Condition
1	Centre distance between phases	≥	
2	Phase to earth distance	≥	
3	Dimensions and volume of the fuse holder and fuse link small tube	≥	The fuse holder and fuse link small tube have same construction
4	Materials	The same or that attend the Requirements in other parts of the standard	
5	Temperature class of insulating materials in contact with conductors	≥	

Table D-2 – Short-time and peak withstand current tests (extension criteria)

Item	Design parameter	Acceptance criterion	Condition
1	Centre distance between phases	≥	
2	Electro-dynamic forces due to current path	≤	The conductors have approximately the same physical arrangement and current path.
3	Mechanical strength of insulating conductor supports	≥	
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.
6	Material of conductors	Same	
7	Temperature class of insulating material in contact with conductors	≥	
8	Mechanical strength of the enclosure /partitions/ bushings	≥	
9	Contacts of removable part	Same	Consider complete design of contact sub-assembly and the fixing / mounting of the removable part.

Table D-3 – Breaking and making capacity (extension criteria)

The effects that influence the performance are the mechanical forces due to the short circuit, the overpressure inside the fuse holder and/or fuse link tube that gives rise to the blowing and expulsion of arc products, possibility of flashovers, speed with which the link – fuse is pulled due to the spring, after it breaks, and the thickness of the vulcanized fiber layer (which produces the gases in contact with the arc) .

Item	Design parameter	Acceptance criterion	Condition
1	Clearance between phases	≥	
2	Clearance to earth	≥	
3	Volume of fuse-holder and small tube of the fuse-link	≥	
4	~~Pressure of insulating gas~~	~~≥~~	
5	Cross-section of conductors	≥	
6	Electro-dynamic forces due to the current in the connection paths to the switching device	≤	
7	Mechanical strength of insulating supports	≥	
8	Mechanical strength of fuse-base, fuse-holder, fuse-link, extenders, buttons, and bushings	≥	
9	Length of unsupported section of conductors	≤	
10	Speed with which the fuse link is pulled after it breaks	≥	
11	Thickness of the vulcanized fiber layer (which produces gases in contact with the arc)	≥	

Table D-4 - Internal arc withstand - (regarding to performance during interruption and overpressure calculations inside fuse holders and fuse link tubes (extension criteria)

Item	Design parameter	Acceptance criterion	Condition
1	Clearance between phases	≤	
2	Clearance to earth	Same	
3	Net volume of fuse-holder and small tube of fuse-link	≥	
4	~~Rated Pressure of insulating gas~~	≤	
5	Cross-section of conductors	≥	Amount of vaporized material
6	Materials of conductor and fuse-link	Same	
7	Point of arc initiation (at the fuse link)	Same	
8	Insulating material exposed to arc	Same	
9	Exhaust opening pressure, if applicable	≥	The position of the exhaust gas outlet and the gas flow path are the same. Larger cross-sectional areas should be analyzed for gas escape velocity.
10	Mechanical strength of elements to let open the relief area, if applicable	≤	Relevant only if sealed
11	Mechanical strength of elements which may block the flux of hot gasses	≤	Relevant only if sealed
12	Mechanical strength of fuse base, fuse holder, fuse link	≥	
13	Thickness of the walls of the fuse holder and small tube of fuse-link including the thickness of the vulcanized fiber layer	≥	Same material

14	Mechanical strength of insulators , bushings, and related parts	≥	

Table D-5 – Dielectric tests performance (extension criteria)

Item	Design parameter	Acceptance criterion	Condition
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 fuse assembly
8	Isolating distance	≥	If influenced by the fuse assembly
9	Minimum functional pressure for insulation (if applicable)	≥	Same fluid

Tabela D-6 – Mechanical strength performance and tests (extension criteria)

Item	Design parameter	Acceptance criterion	Condition
1	To prepare based on IEC 62271-307 concepts	≥	

D.2 of Annexe D of the proposed revision - Reference rules for using calculations and test simulations, for agreements between users and manufacturers, to the extent of validity of type tests.,

Type tests made in testing laboratories, are the most used way to verify whether a given product meets the specification of the relevant technical standard. Tests of high electrical power such as internal arc, temperature rise, and short duration withstand currents and crest are costly and require long preparation time. There are few testing laboratories in the world capable of carrying them out.

Test calculation and simulation techniques are increasingly used to predict the results of some types of tests. Some recent Cigré brochures are the state of the art and give orientation in this theme. They are Brochure CIGRE 602 (2014) Simulation of Internal Arc Effects, Brochure Cigrè 740 (2018) - Low-Cost Substations in Developing Countries and Cigrè 830 (2021) Simulations for Calculating Temperature Rises "

Calculations and simulations allow obtaining more complete information than the information that could be obtained in laboratory testing. Simulations can be applied in situations, such as:

(a) to avoid tests on a certain equipment with characteristics close to another already tested
(b) to avoid the repetition of tests in product certification processes when modifications are made to an already certified product.
(c) to replace SF6 with air in internal arc tests with environmental benefits.

Calculations and simulations can be used to extrapolate the results of a laboratory test already carried out on certain equipment to other equipment, with similarities, which has not been tested. This can be done more easily or more complex depending on the type of test.
For temperature rise tests, the use of simulation to replace a real test is simpler to perform and to validate, being possible to obtain the values at the points of interest of the standards very close to the values obtained during the real tests.

For internal arc tests, like in IEC 62271-200, or even breaking tests, the task is more complex, but possible. What must be verified during the tests are things like the effects of the overpressures that occur in chambers, during the arc, and the possibility of people in the vicinity of the equipment being hit by hot gases or solid particles. The overpressure x time curve is the determining agent for the good or bad result. This type of calculation is of direct interest for expulsion-type fusible devices. In these, the interruption process inside the fuse holders and fuse links depend on calculations like those of internal arc tests.

In short time current and crest withstand current tests, the objective is to verify the withstandability of insulators and conductors to the effects of electrodynamic forces that occur during a short-circuit. Calculating mechanical forces and stresses is not such a complex task but measuring them is very difficult and costly. However, calculation methods have been used for many decades and are well accepted in the technical world. There are documents such as IEC 61117 – "A method for assessing the short circuit with stand strength of partially type-tested assemblies" that have several classic cases that allow validating calculations and simulations of real tests.

Difficulties in validating simulation methods occur when certain measurements of relevant parameters, during testing, are not specified in technical standards. The difficulty is just the lack of reliable information for comparison. However, the existence of IEC 62271-307 corrected these difficulties because, to use it and avoid testing, the mentioned measurements need to be made in the testing of the original equipment of a family.

The purpose of this Section D.2 is to provide guidelines for the systematization of the use of simulations and calculations, within the scope of IEC 60282-2, for the extension of the validity of tests. This may avoid test repetitions in situations where common sense shows it to be reasonable to do so. The main parameters to be recorded in the test reports, aiming at the extension of validity are in the Tables of this Annex . With them it is possible to validate calculations and simulations.

In the text below, typical values of acceptable tolerances are given for the calculated values when compared with the results of the laboratory test. The most frequent case of the use of simulations is the extrapolation of test results carried out in the laboratory, in a certain equipment, to predict the results of the same test in equipment with characteristics like the one already tested, but which has not been tested.

It is not the purpose of this Annex to present calculation methods for test simulations. A model or method is considered acceptable when it produces results that can be validated within acceptable tolerances and, in addition, validation can be demonstrated objectively and transparently to users.

D.2.1 - Definitions

D.2.1.1 – Simulation or calculation to replace a test and acceptable tolerances.
A calculation method used to predict, within a certain tolerance, the results of a laboratory test. In Table D.2.1 are presented typical values of acceptable tolerances of the results obtained in the simulations, when compared with the results of the laboratory test.

Table D.2.1 - Typical values of acceptable tolerances to validate calculations and test simulations

Type of test	Parameter to compare	Acceptable tolerances
Temperature rise test	Temperature rises in solids and fluids	1% to 5%
Internal arc tests and breaking tests	Overpressure within a defined compartment or chamber volume	5% to 10%
Short time current withstand tests	Electrodynamical forces in supports and mechanical stresses in spans of conductors	5% a 15%

D.2.1.2 - Product standard
Standard covering a specific product or a group of related products.

E.2.1.3 – Reproducibility of a simulation or calculation method or a test
The ability to obtain, for a given set of input data, the same test or simulation results on two different occasions or in two different laboratories.

E.2.1.4 – Validation of a simulation or calculation method.
A method of comparing the results shown in a well-documented test report issued by a testing laboratory and the results of the simulation method. A simulation method is generally acceptable, from the users' point of view, when it is reproducible and presents a difference from laboratory test results not exceeding a certain acceptable tolerance.

3.5 – Minimum input data to be recorded in temperature rise test reports.
These are the main values of the parameters needed to be registered in test reports to verify compliance with Table D.1:
- The circulating electric current,
- The total power dissipation within a fluid compartment
- The materials used in conductors and insulating parts
- Contact resistances (total per phase and those of individual parts, such as circuit breakers, fuses, insulators)
- The types of coatings for contacts, connections and conductors including paint.
- The fluid surrounding the components in a compartment and its temperature (at least at the bottom, at the top and at 50% of the height of the enclosure),
- The fluid circulation speed
- The position and spatial geometry of conductors
- The net volume of fluid inside the compartments
- The entrance and exit areas for ventilation as well as the existence of devices that close them during an internal arc
- The number of horizontal partitions inside the compartment, if applicable.
- The relative position of the equipment in relation to the walls, ceiling, and neighboring equipment (as in IEC 60890)

For reasons of test reproducibility, the measurement of the total resistance per phase and the main resistances that compose it, for example, those of circuit breakers and disconnectors contacts, must be measured, before and after the test, and recorded in the test report of laboratory.
Data values that affect the test result, such as those above, must be clearly recorded in the test report through photographs and/or drawings.

3.6 - Data to be recorded in internal arc test reports issued by laboratories
These are the parameter values which shall be registered to verify the compliance with Table D.4 with emphasis on the overpressure vs. time curve. Data affecting test and simulation results are

- Pressure vs. time curve with pressure transducers, when possible to measure them or values obtained by calculation. For fuses the second case apply
- The circulating electric current,
- The materials used in conductors and insulating parts
- The fluid that surrounds equipment within a compartment.
- The position and spatial geometry of conductors
- The volume of fluid inside the compartments
- The area of the overpressure relief devices and their opening speed.

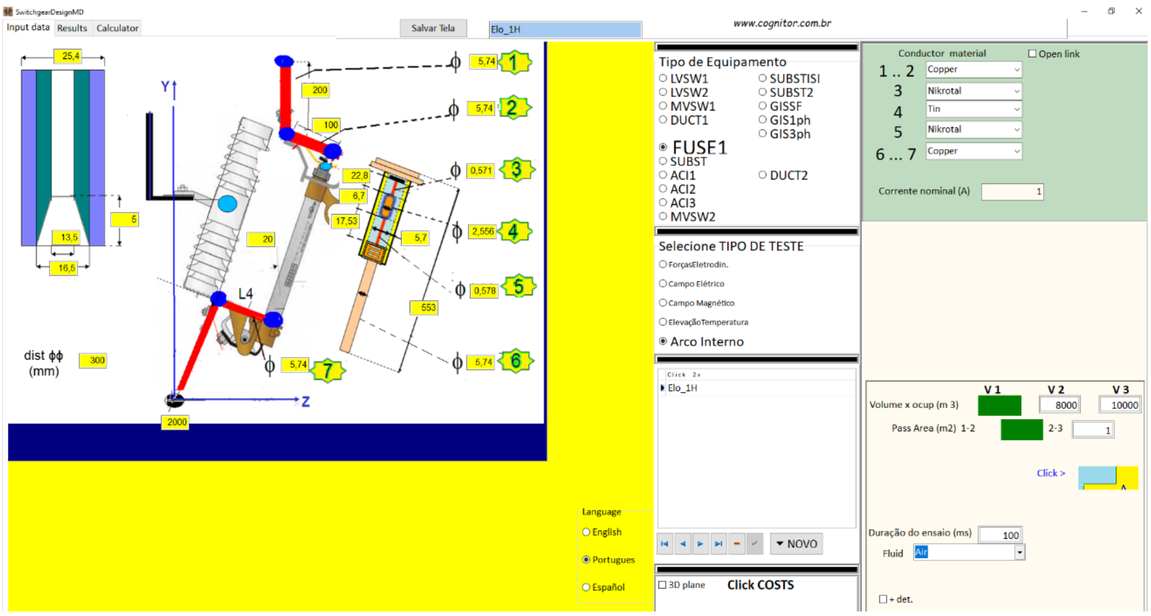
- The entrance and exit areas for ventilation as well as the existence of devices that close them during an internal arc
- The relative position of the equipment in relation to the walls and ceiling.

3.7 – Data to be recorded in short time current withstand current and crest test reports.
These are the parameter values from verifying compliance with Table D.2. The purpose of the test is to verify the withstandability to the effects of electrodynamic forces on insulators and conductors that occur during an arc-free short circuit. Verification is done by visual inspection and by measuring the electrical resistances per phase. Data affecting test and simulation results are

- The circulating electric current,
- The materials used in conductors and insulating parts
- Mechanical resistance to traction, compression and bending efforts of support insulators and the like
- The position and spatial geometry of conductors

For reasons of test reproducibility, the measurement of the total resistance per phase and the main resistances that compose it, for example, those of circuit breakers and disconnectors contacts, must be measured, before and after the test, and recorded in the test report of laboratory. If permanent deformations of dams and other parts are identified, these must be registered by photos and their estimated maximum dimensions and recorded in the test reports.

Figure D.1 – Input and geometry data for calculations and simulations of tests in a expulsion fuse.



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The main author of this article is Eng. Sergio Feitoza Costa. Sergio is an electrical engineer, M.Sc. in power systems and director of COGNITOR. It 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 and ABNT standards. Sergio is the author of SwitchgearDesign simulation software and DECIDIX.

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