**INTERNATIONAL ELECTROTECHNICAL COMMISSION (IEC) SYSTEM FOR CERTIFICATION TO STANDARDS RELATING TO EQUIPMENT FOR USE IN EXPLOSIVE ATMOSPHERES (IECEx SYSTEM)**

**Title: Discussion paper regarding dielectric strength test**

**Circulated to: ExTAG – IECEx Testing and Assessment Group**

**INTRODUCTION**

In response to Decision 2020/33 - ExTAG 2020 Annual Meeting held remotely,

**2020/33**

Members supported the proposal from Prof Xu Jianping for a topic on leakage current rating. ACTION: NEPSI and PTB will prepare a discussion paper on this matter. If available in time, this discussion paper may serve as input to the next IEC TC31 CAG meeting.

The attached Discussion Paper, Version A, has been prepared to take into account an additional Section 2 prepared by PTB and is issued for discussion/noting during the next ExTAG meeting, 2021.

On behalf

***Dr Lienisch***

**ExTAG Chair**

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| **Address:****IECEx Secretariat****Level 33 Australia Square****264 George Street****Sydney NSW 2000****Australia****Web:** [**www.iecex.com**](file://C:\Users\christine.kane\AppData\Local\Microsoft\Windows\Temporary%20Internet%20Files\christine.kane\AppData\Local\Microsoft\Windows\Temporary%20Internet%20Files\christine.kane\AppData\Local\Microsoft\Windows\christine.kane\AppData\Local\Microsoft\Windows\Temporary%20Internet%20Files\Content.Outlook\AppData\Local\Users\horn02\AppData\Local\christine.kane\AppData\Local\Microsoft\christine.kane\AppData\Local\Microsoft\Windows\Temporary%20Internet%20Files\Christine.Kane\AppData\Local\Microsoft\Windows\Temporary%20Internet%20Files\AppData\Local\jugauthier\AppData\Local\Temp\notesC9812B\www.iecex.com) |

**Section 1**

**Discussion paper prepared by Professor Xu Jianping (ExTAG Chair) regarding Decision 2020/33 (ExTAG/631/DL)**

**To: IEC TC31 CAG meeting**

Discussion paper regarding dielectric strength test

# Introduction

With regard to the dielectric strength test indicated in IEC 60079 series standards, some of the standards specify the leakage current while others not. It is necessary for ExCBs and ExTLs to have a better understanding about how much the leakage current rating will influence the test results of dielectric strength test.

# Background

It is found that there are varying understandings by test laboratories, when setting the leakage current during the dielectric strength test to an identical increased safety equipment. Different laboratories do set different leakage currents on the test apparatus: 5 mA, 50 mA, or even 200 mA, while the test results are always just PASS or FAIL.

The following are the relevant parts of IEC 60079 series standards regarding dielectric strength test.

* **IEC60079-11:2011**

***10.3 Dielectric strength tests***

*The applied voltage shall remain constant during the test. The current flowing during the test shall not exceed 5 mA r.m.s. at any time.*

* **IEC60079-18:2014**

***8.2.4 Dielectric strength test***

***8.2.4.2 Acceptance criteria***

*The test shall be deemed as passed if no breakdown or arcing occurs during testing.*

*NOTE Typically the current flowing during the test will not exceed 5 mA r.m.s.*

* **IEC60079-5:2015**

***5.1.3 Dielectric strength test for filling material***

*The filling material complies with the requirements if the leakage current does not exceed 10-6 A. If the material fails to comply, further conditioning and retesting are not permitted.*

However, we are NOT able to find such kind of requirement for the leakage current in clause 6.1 of IEC 60079-7:2015, and in clause 5.1.2 of IEC/IEEE 60079-30-1:2015, as follows:

* **IEC60079-7:2015**
	1. ***Dielectric strength***

*Dielectric strength shall be verified by test:*

*a) either as given in a relevant industrial standard for the individual items of electrical equipment; or*

*b) if no such test requirement exists, at the test voltage according to 1), 2) or 3) below, and maintained for at least 1 min without dielectric breakdown occurring.*

*1) for electrical equipment and Ex Components with rated voltages not exceeding 90V peak or in which working voltages not exceeding 90V peak are present: 500Vr.m.s.+5/0%.*

*2) for resistance heating devices and resistance heating units to which additional requirements of 5.8 apply : (1000+2Un) V r.m.s. +5/0%, where Un is the rated voltage.*

*3) for other electrical equipment and Ex Components, where working voltages exceeding 90V peak are present: (1000+2U) V r.m.s. +5/0% or 1500 V r.m.s. +5/0%, whichever is greater, where U is the working voltage.*

*D.C. test voltages are permitted as an alternative to the specified a.c. test voltage and shall be 170% of the specified a.c., r.m.s. test voltage for insulated windings, or 140% of the specified a.c., r.m.s. test voltage for situations where air or creepage distance is the insulating medium.*

*For equipment or Ex Components with galvanically isolated parts, the test shall be applied separately, at the appropriate voltage, to each part.*

* **IEC/IEEE 60079-30-1:2015**
	1. ***5.1.2 Dielectric test***

*The dielectric test shall be performed on trace heaters in accordance with Table 4 on test sample(s) prepared as described in 5.1.1.*

*Table 4 – Test voltages for the dielectric test*

|  |  |
| --- | --- |
| *Rated voltage* | *Test voltage**V a.c.(r.m.s.)* |
| *<30 V a.c. (r.m.s.)* | *500* |
| *<60 V d.c.* | *500* |
| *≥30 V a.c. (r.m.s.)* | *2 U + 1 000* |
| *≥60 V d.c.* | $$\sqrt{2} U+1 000$$ |

*The test voltage, where U is the rated voltage, shall be applied between the conductors and the electrically conductive covering at a rate of rise of neither less than 100 V/s nor more than 200 V/s and maintained for (60*$\frac{-0}{+5}$*)s without dielectric breakdown. The test voltage waveform shall be essentially sinusoidal, with a frequency of 45 Hz to 65 Hz. Alternatively the dielectric test may be conducted by submerging the trace heater in tap water at room temperature (resistivity typically 500Ω•m). The ground braid or sheath shall be bonded to the water and the voltage shall be applied between the conductors and the water.*

*When determining U, the correct use of Phase to Phase or Phase to Neutral voltage levels shall be considered.*

# Discussion and decision of 2020 ExTAG Webinar meeting

During the 2020 ExTAG Webinar meeting, this topic was raised by Prof Xu Jianping, NEPSI CN. Members expressed different opinions on this issue:

**Opinion 1:** Leakage current should not be taken into consideration for some cases such as an equipment with large distributed capacitances, due to that capacitance coupling current instead of leakage current may lead the test to a misleading way for AC dielectric test. The test results should lie chiefly in the phenomenon of breakdown by visual check.

**Opinion 2:** Rather than set a limit value of leakage current, we should record the leakage current every time during the test, because the situation will vary from product to product.

**Opinion 3:** It depends on the level of rated voltage, it will be totally different for high-voltage equipment and low-voltage equipment.

**Opinion 4:** The leakage current may vary from environment to environment, such as temperature, humidity.

As a conclusion from the discussion during the ExTAG Webinar meeting, a decision was made as follows:

***Decision 2020/33***

*Members supported the proposal from Prof Xu Jianping for a topic on leakage current rating.*

***ACTION:*** *NEPSI and PTB will prepare a discussion paper on this matter. If available in time, this discussion paper may serve as input to the next IEC TC31 CAG meeting.*

# Outcomes expected

It seems there are three aspects to consider:

* In case that the leakage current rating may influence the test result of dielectric strength test, it should be stipulated in IEC60079-7.
* In case that the leakage current rating does not influence the test result of dielectric strength test, it should be removed from IEC60079-11, IEC60079-5, IEC60079-18 and other standards, to minimize the misunderstanding.
* To bridge a gap between the above mentioned 2 solutions, in case that this will vary from product to product, rated voltage to rated voltage, environment to environment, then it is better to give more details in some specific standards.

To achieve a consistent testing and certification practice according to these IEC standards mentioned above, it is likely an ExTAG decision sheet, as an interim solution, will need to be generated to clarify and unify this issue, based on discussion and clarifications from IEC TC 31 CAG meeting.

Prof Xu Jianping

Managing Director of NEPSI/SITIIAS

ExTAG Chair of IECEx System

22 October 2020

**Section 2**

**Discussion paper from PTB regarding Decision 2020/33 (ExTAG/631/DL)**

**Topic: Dielectric strength test (60079 series)**

**Preface:**

The focus of this discussion is on the dielectric strength tests indicated in IEC 60079 series standards. The question is about how much the leakage current rating will influence the test results of dielectric strength test.

**Physical background:**

The dielectric strength tests of the different standards cannot be directly compared with each other. Different setups and testing procedures lead to the investigation of different physical conditions. Also, the behaviour of leakage currents can be different depending on e.g. the material, the geometry of the electrodes, the geometry of the insulation material or specimen, the humidity, temperature, and the pollution.

When a dielectric strength test is performed, various physical causes can lead to a failing test with a high current (if not limited by the source):

* At first the intended **breakdown** of the primary insulation (mostly solid medium) which is the object of these test. These can often be detected by a high current (much more than leakage currents and often just depending on the limitation of the source). Sometimes visual inspections are also possible depending on the material, geometry, and other aspects.
* Another possibility which can also be an object of investigation is the **flashover** over the solid surface. This can also be interpretated as a breakdown of the surrounding medium (mostly gaseous secondary insulation). Here, usually also a high current can be detected which is limited trough the source.

Other possibilities, which are typically not object of dielectric strength tests occur also. These are regarding to the level of leakage current may be misinterpreted as a breakdown/flashover. These other physical phenomena are:

* **Surface discharges** (or **partial discharges**) which are depending e.g. on the electrodes, the material, the surface structure, the pollution, and humidity. These lead to mostly small leakage currents on the surface of the insulation. Partial discharges can also occur e.g. on sharp conductive edges of conductive parts as the electrodes.
* **Capacitive currents** through the insulation (at AC sinusoidal) occur inside the insulation and depend e.g. on the material properties (polarization, permittivity, capacitance), the voltage (level and frequency) and on the material geometry. These also lead to mostly small currents inside the insulation.
* **Resistive currents** through the insulation (at DC) occur inside the insulation at DC voltage and depend e.g. on the voltage level and the material properties (resistivity, resistance). Also, these lead to mostly small currents inside the insulation. The resistance (insulation resistance or impedance) of the material is depending additionally on voltage level and thus electrical field strength. Here is humidity, temperature, electrode configuration, material, possible pollution etc. also important.

**Explosion protection**

For explosion protection there are sometimes other aspects important. No effective ignition source should be available. Most important potential ignition sources for this topic are electrical discharges and high temperature.

The forementioned physical phenomena can be discussed with respect to the occurrence as potential ignition sources:

* Discharges as **electric arcs** are electric discharges and cause heating (high temperature). These arcs occur at dielectric breakdown and flashover and are very **critical** regarding explosion protection.
* **Surface discharges** and **partial discharges (PD)** cause no immediate breakdown of the insulation but are a source of aging (heating, electrical discharge, chemical decomposition). Here, electric currents in the milliampere and sub-milliampere range flow over the insulation surface and cause heating and are also electric discharges which **can be relevant** for explosion protection regarding the corresponding level.
* **Capacitive currents** through the insulation in the case of AC or **resistive currents** in the case of DC lead normally only to a small heating of the material if small enough but can also be in the milliampere range. These are tested with e.g. insulation resistance measurements. These currents are **typically uncritical** regarding explosion protection if the level doesn’t get too high.

**Conclusion:**

Dielectric Strength tests are tests for determination mainly regarding the electrical breakdown/flashover. Many factors influence the outcome and cannot be generalised. It depends on the level of rated voltage; it will be totally different for high-voltage equipment and low-voltage equipment. The leakage current may vary from environment to environment, such as temperature, humidity. Different test objects have different behaviour due to different material and system properties.

Thus, the level of leakage current must be defined separate for each test with respect to the test conditions. For some tests it is necessary and for other not. This depends on many factors and cannot be generalised.