# Deliverable 10.3: Acquisition of input data for characterization of stress withstand of breaker sub-components

PROMOTioN – Progress on Meshed HVDC Offshore Transmission Networks
Mail info@promotion-offshore.net
Web www.promotion-offshore.net

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**CONTACT**

# DOCUMENT INFO SHEET

**Document Name:** Acquisition of input data for characterization of stress withstand of breaker sub-components
**Responsible partner:** KEMA Laboratories
**Work Package**: WP 10
**Work Package leader:** Rene Smeets
**Task:** 10.3
**Task lead:** Nadew Belda

## DISTRIBUTION LIST

## APPROVALS

| | Name | Company |
|---|---|---|
| Validated by: | Poul Ejnar Sørensen | DTU |
| Validated by: | Geraint Chaffey | KU Leuven |
| | | |
| Task leader: | Nadew Belda | KEMA Laboratories |
| WP Leader: | Rene Smeets | KEMA Laboratories |

## DOCUMENT HISTORY

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| 1.0 | 22-02-2019 | First draft | Nadew Belda |
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# LIST OF CONTRIBUTORS

Work Package and deliverable involve a large number of partners and contributors. The names of the partners, who contributed to the present deliverable, are presented in the following table.

| PARTNER | NAME |
|---|---|
| KEMA Laboratories | Nadew Belda, Rene Smeets |
| DNV GL | Michalis Poikilidis, Massimiliano Longhin |
| | |
| | |

# CONTENT



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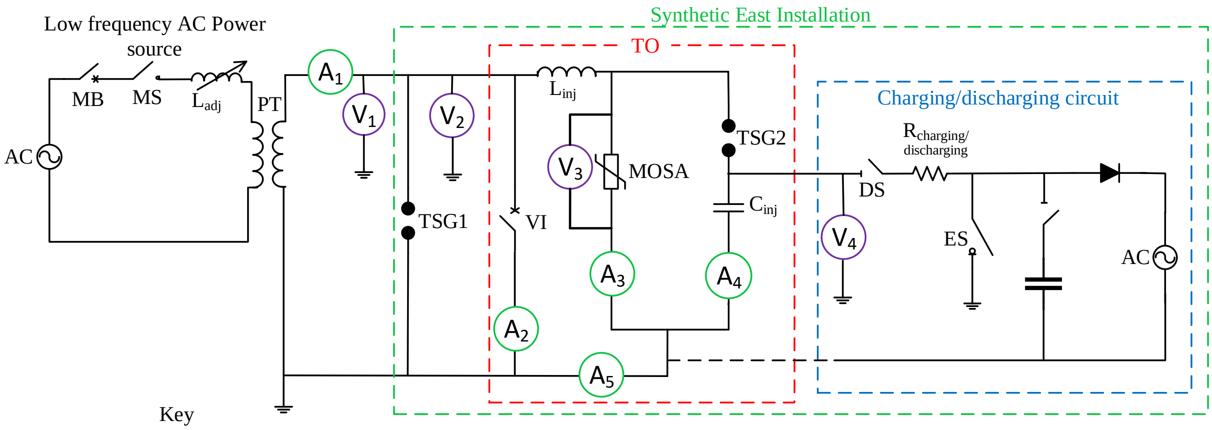
# 1 D10.3: ACQUISITION OF INPUT DATA FOR CHARACTERIZATION OF STRESS WITHSTAND OF BREAKER SUB-COMPONENTS

## 1.1 INTRODUCTION

This is a document accompanying the data supplied in excel sheet as well as . Besides, the actual test results as obtained in a test laboratory are supplied in a separate file. Therefore, this document is supplying descpription of the contents of those files.

## 1.2 TEST SET-UP




Key

MB= Master Breaker
MS= Making Switch
$L_{adj}$= adjustable reactor
PT= Power Transformer(s)
VI=Vacuum Interrupter
A = current measurement
V = voltage measurement

MOSA= Metal oxide surge arrester
$C_{inj}$=counter current injection capacitor
$L_{inj}$=counter current injection inductor
DS=Disconnector switch
ES=Earthing switch
TSG=Triggered Spark Gap (Triggered make gap)
$R_{charging/discharging}$ = charging and discharging resistor

Figure 1: Single line diagram of Experimental DC CB test set-up

## 1.3 DESCRIPTION OF THE CONTENT OF EXCEL SHEET

The information in the excel sheet is extracted from the test results obtained in the laboratory during an experimental test campaign. An active current injection type experimental DC CB is set up in a laboratory environment to investigate the stresses on the internal components. A single line diagram of overall test set-up is shown in Figure 1, with the experimental DC CB (TO) in the red dashed box. Several measurements have been recorded during the tests including,

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- $A_1$: Current supplied by the test circuit (here named as system current)
- $V_1$: Voltage across the entire test object
- $V_2$: Voltage across vacuum interrupter
- $A_2$: Current through vacuum interrupter
- $V_3$: Voltage across metal oxide surge arrester (MOSA)
- $A_3$: Current through MOSA
- $A_4$: Current through the injection branch
- $A_5$: Injection current + suppression

Although not included in the excel data, current through 8 columns of MOSA and temperature of 8 columns of MOSA have been recorded. Large number of tests have been conducted to investigate the impacts of various parameters of the test circuit as well as the parameters of the experimental DC CB on the performance of the main components, specifically, the vacuum interrupter and the MOSA. The detailed analysis of some peculiar test results as well as overall statistical behavior will be discussed in D10.4.

About 191 current interruption tests have been performed where about 836 current zeros are created, at some of which interruption occurred while in most cases reignition (failed to interrupt) occurred. In some cases, restrike occurred. That is, the vacuum interrupter dielectrically breaks down after current is commutated to MOSA or even later. The electrical parameters during each test and, at each current zero have been obtained from the measurements. These parameters are put in the excel database. Later, these parameters are used for statistical analysis if any trend can be deduced from these results. This will be presented in D10.4.

In the excel file, a row corresponds to a single current zero of a specific test result. This means a given test might have one or more rows depending at which current zero current interruption occurs. The experimental DC CB is designed in such a way that several current zeros are created in case the vacuum interrupter(s) fails to clear on first or second or further successive current zeros. The main parameters of interest related to a given current zero are provided in the columns of the excel sheet. The information common to all current zeros, such as test series number, test date, type of vacuum circuit breaker used (VCB), the number of interrupters used, current at the point of contact separation, arcing duration until counter current is injected, peak value of system current, etc. are duplicated for all current zeros of a given test. For the final current zero (at which current interruption occurs), the total duration of current suppression, the initial voltage at current final current zero, the peak value of the transient interruption voltage is provided. For all the test cases, the main parameters registered in the excel sheet are described below in reference to typical test result depicted in Figure 2.

1. **Test number:** Automatic number generated by system during a given test. This contains information about test hall and test sequence number during a test shift/session. This should not be confused as the same number is given to tests performed in the same test hall at another test session. This can only be seen after the test file is opened on the test result viewer software
2. **Data file number:** A unique number (sequential) given to a specific test data/result. If a number in the sequence is missing it means, it is a calibration shot which is not added in the database as it does not provide any information on the component stress


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3. **Test date:** the dates on which the test was performed
4. **VCB type:** Three different types of vacuum circuit breakers (VCBs) are investigated in the test campaign. Each VCB type are given code name type 1, 2, and 3.
5. **Number of interrupters:** Tests have been performed using only one vacuum interrupter (VI) or two vacuum interrupters in series. This are discussed as single break module and double break modules in D10.4. The number of VIs used are indicated in this column.
6. **System current at contact separation:** This gives the value of current at the moment the contacts of the VI(s) are separating. This is useful information regarding the formation of arc as well as the energy content of the arc. In Figure 2a, this is the value of current at time $T_1$. This is the same current as in Figure 2b at $T_1$.
7. **Arcing duration until current injection:** This column provides the time duration from contact separation until current is injected from pre-charged capacitor. This is the time from $T_1 - T_2$, in Figure 2b.
8. **System current at current injection (measured at $A_1$):** The value of current at the moment of counter current injection. This corresponds to current at $T_2$ on Figure 2b.
9. **Arcing duration until current interruption:** This provides time in milliseconds measured from the moment of contact separation till current is interrupted by the VI (local current interruption). If it is a failed interruption, this value is mentioned as inf (just to indicate that it was not cleared in the expected time). From Figure 2a and b, this is the time from $T_1$ till $T_3$.
10. **Peak value of system current (measured at $A_1$):** The peak value of current supplied by the test circuit that is measured during successful interruption as well as during failed interruption. If it is a failed interruption i.e. the VI failed to clear at any of the current zeros, this value corresponds to the peak value of the prospective current. In Figure 2a, it is shown as the value of current at $T_3$.
11. **Zero crossing number:** This counts the number of current zeros created through the vacuum interrupter until interruption or counts the total number of current zeros created in case it is a failed current interruption. In Figure 2b, the current oscillating through the vacuum interrupter is shown zoomed. The current zeros are counted from 1 till 8 (until interruption occurred).
12. **Odd/even current zero:** This is to check the current zero, if it is occurring on the even or odd number. It assigns a value 1 is it is odd numbered current zero or otherwise it assigns a value 0. This is just for statistical purpose to see if there is any tendency to clear at even numbered zeros or odd number zeros. If later restrike occur, i.e. if the vacuum interrupter dielectrically breaks down after MOSA starts conducting, this counting restart again. To show this zero counting is after re-strike, there restrike counter column described in number 14.
13. **Interruption/reignition:** This assigns a value 1 if interruption occurs at a given current zero (even if there is a restrike later) or otherwise a 0 is assigned. A value 0 means the interrupter(s) fail to clear at that particular zero. In other words, re-ignition occurred. For the test shown in Figure 2b, a value 0 is assigned to current zeros from 1-7 and a 1 at current zero number 8.


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14. **Restrike:** this is to indicate if the particular current zero is created after restrike occurred or not. A value 0 is assigned for the zeros created before any restrike occurs. If a restrike occurs after temporary current interruption, a value of 1 is assigned. For all zeros following this restrike a value 1 is assigned. After restrike zero crossing number (count) resets
15. **Peak current at VI before current zero (measured at $A_2$):** Because of superposition of counter injection current and the system current, the current through VI oscillates between high and low peak values until interruption occurs. The local peak value just before specific current zero is registered in this column. This is shown by blue circles on the magnified plot near current zero shown in Figure 2b. The peak value of current just before current zero contributes very much to the thermal reignition of the VI.
16. **Rate-of-change of current near current zero (di/dt) (measured at $A_2$)**: There are several reasons why reignition occurs at a given current zero. One of the several reasons is too high rate-of-change of current. The rate at which the current crosses zero is measured and provided in this column. This is provided for all current zeros created during the interruption process. The rate-of-change of current is provided as positive value although its sign alternates as the current is decreasing (negative) at odd current zero crossing and is increasing (positive) at even numbered current zero crossings. Only the magnitude of the rate-of-change of current matters.
17. **Initial Transient Interruption Voltage (ITIV) (measured at $V_2$):** At the moment of current zero, if the VI succeeds to clear, it must deal with the voltage across the injection capacitor due the remnant charge. The VI might fail because it may not be ready to withstand this voltage. Thus, it reignites. This is called dielectric reignition. The voltage at each re-ignition is registered in the re-ignition voltage column described below in number 20. The value of the initial TIV at current interruption is provided in this column. This value is provided only for the zeros at which interruption occurs as it can exist only in such a case
18. **Final Transient Interruption Voltage (FTIV) (measured at $V_2$):** the peak value of the TIV measured across the VI(s). This shows the peak value of voltage which the VI sustained during current suppression. This can be seen by a black circle in Figure 2c.
19. **Duration of current suppression:** If successful interruption, the duration of current suppression is measured and registered here. This duration corresponds to the time the MOSA conducts current.
20. **Reignition voltage (measured at $V_2$):** At current zero, the VI could fail to interrupt. It fails because it cannot sustain the instant voltage. If dielectric break down occurs because of the voltage, this is registered in this column. If there is no observable voltage at current zero (in which case the breakdown is caused by thermal effects), a value zero is given. In Figure 2c, the reignition voltages are shown by black circles shown by zoomed plot.


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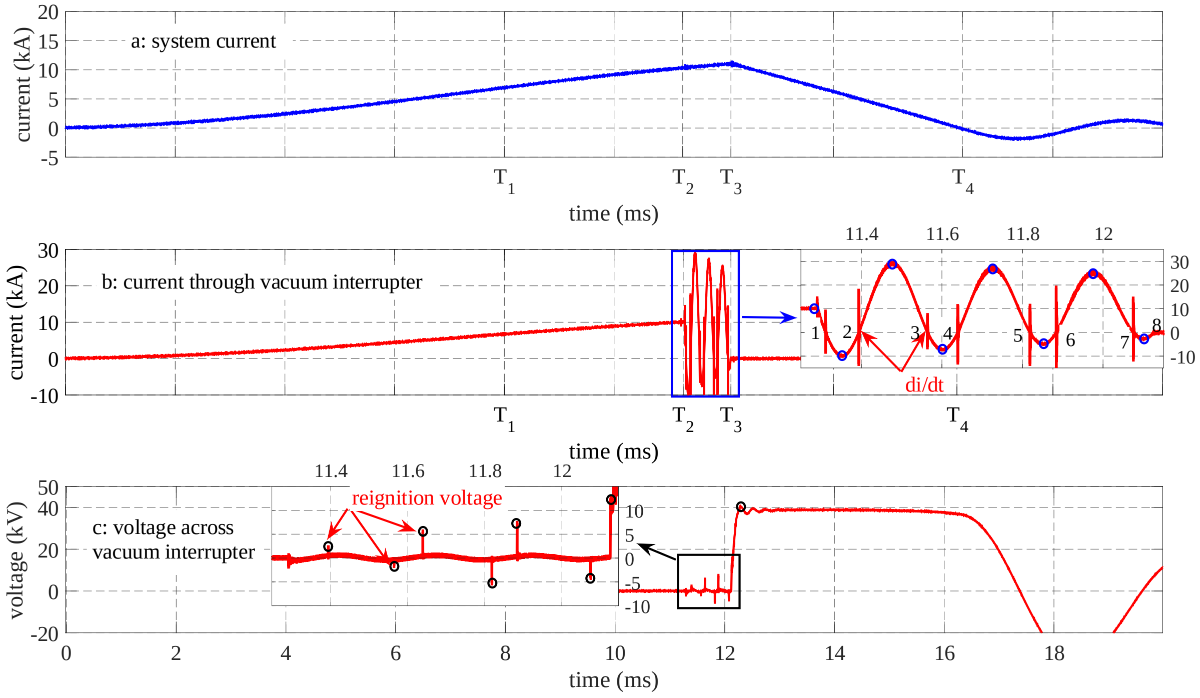


Figure 2: Example case test result of experimental DC CB

$T_1$ – contact separation
$T_2$ – counter current injection
$T_3$ – current interruption
$T_4$ – current suppression


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