

KEMA TYPE TEST CERTIFICATE OF SHORT-CIRCUIT PERFORMANCE

Object	A three-pole SF ₆ live-tank circuit-breaker, single-pole enclosure, common operated		2181-17
Type	LW30-145	Serial No.	17101 and 17102
Rated voltage	145 kV	Rated normal current	3150 A
Rated short-circuit current	40 kA	Rated frequency	50 Hz
Manufacturer	Shangdong Taikai High Voltage Switchgear Co., Ltd., Tai'an, China *)		
Client	Shangdong Taikai High Voltage Switchgear Co., Ltd., Tai'an, China		
Tested by	DNV GL Netherlands B.V., Arnhem, the Netherlands		
Date of tests	4, 5, 8, 12, 16, 18, 19 and 30 May and 9 June 2017		

The object, constructed in accordance with the description, drawings and photographs incorporated in this Certificate, has been subjected to the series of proving tests in accordance with

IEC 62271-100 (2012) subclauses 6.6 (STC), 6.102 to 6.106 (T10, T30, T60, T100), 6.108 (DEF), 6.109 (SLF) and 6.110 (Out-of-phase)

This Certificate has been issued by DNV GL following exclusively the STL Guides.

The results are shown in the record of proving tests and the oscillograms attached hereto. The values obtained and the general performance are considered to comply with the above standard and to justify the ratings assigned by the manufacturer as listed on page 7.

This Certificate applies only to the object tested. The responsibility for conformity of any object having the same type references as that tested rests with the Manufacturer.

*) as declared by the manufacturer

This Certificate consists of 389 pages in total.

DNV GL Netherlands B.V.



J.P. Fonteijne
Executive Vice President
KEMA Laboratories



Laboratories Arnhem, 5 December 2017

INFORMATION SHEET

1 KEMA Type Test Certificate

A KEMA Type Test Certificate contains a record of a series of (type) tests carried out in accordance with a recognized standard. The object tested has fulfilled the requirements of this standard and the relevant ratings assigned by the manufacturer are endorsed by DNV GL. In addition, the object's technical drawings have been verified and the condition of the object after the tests is assessed and recorded. The Certificate contains the essential drawings and a description of the object tested. A KEMA Type Test Certificate signifies that the object meets all the requirements of the named subclauses of the standard. It can be identified by gold-embossed lettering on the cover and a gold seal on its front sheet.

The Certificate is applicable to the object tested only. DNV GL is responsible for the validity and the contents of the Certificate. The responsibility for conformity of any object having the same type references as the one tested rests with the manufacturer.

Detailed rules on types of certification are given in DNV GL's Certification procedure applicable to KEMA Laboratories.

2 KEMA Report of Performance

A KEMA Report of Performance is issued when an object has successfully completed and passed a subset (but not all) of test programmes in accordance with a recognized standard. In addition, the object's technical drawings have been verified and the condition of the object after the tests is assessed and recorded. The report is applicable to the object tested only. A KEMA Report of Performance signifies that the object meets the requirements of the named subclauses of the standard. It can be identified by silver-embossed lettering on the cover and a silver seal on its front sheet.

The sentence on the front sheet of a KEMA Report of Performance will state that the tests have been carried out in accordance with The object has complied with the relevant requirements.

3 KEMA Test Report

A KEMA Test Report is issued in all other cases. Reasons for issuing a KEMA Test Report could be:

- Tests were performed according to the client's instructions.
- Tests were performed only partially according to the standard.
- No technical drawings were submitted for verification and/or no assessment of the condition of the object after the tests was performed.
- The object failed one or more of the performed tests.

The KEMA Test Report can be identified by the grey-embossed lettering on the cover and grey seal on its front sheet.

In case the number of tests, the test procedure and the test parameters are based on a recognized standard and related to the ratings assigned by the manufacturer, the following sentence will appear on the front sheet. The tests have been carried out in accordance with the client's instructions. Test procedure and test parameters were based on If the object does not pass the tests such behaviour will be mentioned on the front sheet. Verification of the drawings (if submitted) and assessment of the condition after the tests is only done on client's request.

When the tests, test procedure and/or test parameters are not in accordance with a recognized standard, the front sheet will state the tests have been carried out in accordance with client's instructions.

4 Official and uncontrolled test documents

The official test documents of DNV GL are issued in bound form. Uncontrolled copies may be provided as a digital file for convenience of reproduction by the client. The copyright has to be respected at all times.

5 Accreditation of KEMA Laboratories

The KEMA Laboratories of DNV GL are accredited in accordance with ISO/IEC 17025 by the respective national accreditation bodies. KEMA Laboratories Arnhem, the Netherlands, is accredited by RvA under nos. L020, L218, K006 and K009. KEMA Laboratories Chalfont, United States, is accredited by A2LA under no. 0553.01. KEMA Laboratories Prague, the Czech Republic, is accredited by CAI as testing laboratory no. 1035.

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1 IDENTIFICATION OF THE OBJECT TESTED

1.1 Ratings/characteristics of the object tested

Voltage	145 kV	X
Lightning impulse withstand voltage	650 kV	
Power-frequency withstand voltage	315 kV	
Normal current	3150 A	
Number of poles	3	
Frequency	50 Hz	X
Short-circuit making current / peak withstand current	100 kA _{peak}	X
Short-circuit breaking current / short-time withstand current	40 kA	X
• d.c. time constant	45 ms	X
• minimum opening time	26,6 ms	
• d.c. component	44 %	X
Duration of short-circuit	3 s	X
Transient recovery voltage		
• first-pole-to-clear factor	1,5	X
Operating sequence	O-0,3 s-CO-3 min-CO	X
Short-line fault surge impedance	450 Ω	X
Out-of-phase making and breaking current	10 kA	X
• out-of-phase voltage factor	2,5	X
Line-charging breaking current	50 A	
Cable-charging breaking current	160 A	
Supply voltage of closing and opening devices and auxiliary circuits		
• closing device	220 Vd.c.	
• opening device	220 Vd.c.	
• motor	220 Va.c.	
Filling pressure for interruption SF ₆ at 20 °C	0,70 MPa	
Class	E1	X
Class	C2, M2	

X = This rating has been proved by the tests of this Certificate.

1.2 Description of the object tested

A three-pole SF₆ live-tank circuit-breaker, single-pole enclosure, common operated

Minimum functional pressure for interruption SF₆ at 20 °C 0,60 MPa

Mechanism:

Stored energy closing (springs, charged by motor).

Stored energy opening (springs, charged at closing).

1.3 Travel recorder

Travel recorder attached to main contact shaft. Non-linear with contact travel.

1.4 List of drawings

The manufacturer has guaranteed that the object submitted for tests has been manufactured in accordance with the following drawings and/or documents. KEMA Laboratories has verified that these drawings and/or documents adequately represent the object tested. The manufacturer is responsible for the correctness of these drawings and/or documents and the technical data presented.

The following drawings and/or documents have been included in this Certificate:

Drawing no./document no.	Revision
T40290366	1

The following drawings and/or documents are only listed for reference and are kept in KEMA Laboratories' files:

Drawing no./document no.	Revision
T47430122	1
T52600256	1
T52600258	1
T52820323	1
T54020038	1
T54020039	1
T54020040	1
T55500429	1
T42320250	1
T45500132	1
T45500170	1
T47220023	1
T47220024	1
T50120522	1
T50140056	1
T51140052	1
T51770871	1
T51770872	1
T51800957	1
T52820274	1
T52820298	1
T52850043	1
T53650253	1
T54510086	1
T54540072	1
T54540076	1
T55100969	1
T55500431	1
T55690435	1
T55690579	1

2 GENERAL INFORMATION

2.1 The tests were witnessed by

Name	Company
Chong, W.	Shangdong Taikai High Voltage Switchgear Co., Ltd.,
Peiqing, L.	Tai'an, China
Zhi Yuan, Z.	
Kejia, X.	
Li Wen, Z.	
Zhonghua, L.	

2.2 The tests were carried out by

Name	Company
Dekker, M. (12, 30 May 2017)	DNV GL Netherlands B.V.,
Minkhorst, D. (18, 19 May 2017)	Arnhem, the Netherlands
Nijman, R.M. (16, 18 May 2017)	
Aditya, J. (4, 5, 8 May and 9 June 2017)	

2.3 Accuracy of measurement

The guaranteed uncertainty for the measured voltages and currents taking into account the total measuring system, is less than 5%, unless mentioned otherwise.

3 LEGEND

Phase indications

If more than one phase is recorded on oscillogram, the phases are indicated by the digits 1, 2 and 3. These phases 1, 2 and 3 correspond to the phase values in the columns of the accompanying table, respectively from left to right.

Explanation of the letter symbols and abbreviations on the oscillograms

pu	Per unit (the reference length of one unit is represented by the black bar on the oscillogram)
CS1	Timing signal contact separation
CS2	Timing signal contact separation
CS3	Timing signal contact separation
I1cs	Current of current circuit, synthetic tests
I1TO	Current through test object
I1TOa	Current through test object
I2cs	Current of current circuit, synthetic tests
I2TO	Current through test object
I2TOa	Current through test object
I3cs	Current of current circuit, synthetic tests
I3TO	Current through test object
I3TOa	Current through test object
IABcl	Current closing coil auxiliary breaker
IABop	Current opening coil auxiliary breaker
Ics	Current of current circuit, synthetic tests
Ireig	Current reignition circuit, synthetic tests
Isyn	Current synthetic circuit
Isyn1	Current synthetic circuit
Isyn2	Current synthetic circuit
Itank	Tank current test object
ITO	Current through test object
ITO/A	Current through test object, amplified
ITOcl	Current closing coil test object
ITOop	Current opening coil test object
TR	Travel recorder
U1cs	Voltage current circuit
U1S	Supply voltage
U1TO	Voltage across test object
U2cs	Voltage current circuit
U2S	Supply voltage (2nd transformer winding, one phase test)
U2TO	Voltage across test object
U3cs	Voltage current circuit
U3TO	Voltage across test object
Ucs	Voltage current circuit
UTO	Voltage across test object
UTO/A	Voltage across test object, amplified



4 REPEATED TEST DUTIES

During the complete test series forming this Certificate the following initial test-duties have been repeated because of errors in assembly or maintenance. According to subclause 4.9 of the general STL-Guide, written, convincing and detailed explanations have been given by the manufacturer for the root cause of the failures. The received explanations are kept in KEMA Laboratories archive.

Repeated test-duties
T100s (a) and T100s(b)

5 SUMMARY OF TESTS

No-load tests								
Test no.		170504 5017	170504 5018	170504 5019	170504 5020	170504 5023	170504 5024	
Time interval between operations	s	-	0,300	-	0,299	-	0,293	
Operation		O	CO	O	CO	O	CO	
Current closing coil	A	-	2,62	-	2,35	-	1,97	
	A	ms	-	75,7	-	77,0	-	82,7
Closing time	B	ms	-	75,7	-	76,8	-	82,6
	C	ms	-	76,1	-	77,1	-	82,6
Current opening coil	A	-2,40	-2,40	-2,19	-2,16	-1,59	-1,57	
	A	ms	26,4	26,6	28,0	27,4	40,4	38,6
Opening time	B	ms	26,2	26,3	27,8	27,0	40,1	38,4
	C	ms	26,3	26,5	28,0	27,3	40,3	38,6
Voltage closing coil	Vd.c.	-	242	-	220	-	187	
Voltage opening coil	Vd.c.	242	242	220	220	154	154	
Gas pressure at 20 °C	MPa	0,60	0,60	0,60	0,60	0,60	0,60	
Operating pressure	MPa	-	-	-	-	-	-	

Remarks	
170504-5017	-
170504-5018	-
170504-5019	-
170504-5020	-
170504-5023	-
170504-5024	-

L90							
Test no.		170504 5029	170504 5030	170504 5033	170504 5034	170504 5035	
Time interval between operations	s	-	-	-	0,314	-	
Operation		O _S	O _S	O _D	C _D O _S	(C)O _S	
Phase		A	A	A	A	A	
Applied voltage, current source, phase value	kV	34,0	34,0	-	34,7	-	
Charging voltage capacitor bank, DC value	kVd.c.	140	142	-	140	140	
Making current, peak	kA	-	-	-	79,8	-	
Breaking current, symmetrical, phase value	kA	36,2	36,3	37,0	36,3	36,4	
Breaking current, DC-component	%	1	1	2	9	3	
di/dt at last current zero	A/μs	16,0	16,4	-	16,2	16,1	
TRV, first line-side peak (u _T), across breaker	kV	-20,4	-	-	-19,0	-19,9	
TRV, peak u _M	kV	-163	-	-	-165	-168	
Recovery voltage, phase value	kV	89,2	-	33,6	88,7	89,3	
Make time	ms	-	-	-	75,5	-	
Arc duration	ms	12,9	(1)	13,4	22,8	16,9	
Opening time	ms	26,6	26,6	26,5	26,3	26,5	
Break time	ms	39,5	-	39,9	49,1	43,4	
t _h	μs	346	380	-	359	344	
Current last loop, peak	kA	49,8	49,1	-	54,2	48,8	
Time interval since previous test	min	-	-	-	-	9	
Voltage closing coil	Vd.c.	-	-	-	242	242	
Voltage opening coil	Vd.c.	242	242	242	242	242	
Gas pressure at 20 °C	MPa	0,60	0,60	0,60	0,60	0,60	
Operating pressure	MPa	-	-	-	-	-	

Remarks	
170504-5029	Breaker cleared. O _S = Operation in a synthetic circuit.
170504-5030	Test to verify the correct reignition behaviour of the breaker (subclause 6.102.10 of IEC 62271-101). (1) Arcing time set for 11,9 ms. O _S = Operation in a synthetic circuit.
170504-5033	Breaker cleared. O _D = Operation with current source only.
170504-5034	Breaker closed and cleared. Voltage measurement out of range. C _D = Operation with current source only. O _S = Operation in a synthetic circuit.
170504-5035	Breaker closed in no-load and cleared. O _S = Operation in a synthetic circuit.

Voltage tests as a condition check							
Test no.		170505 5003	170505 5004	170505 5005	170505 5006	170505 5007	170505 5010
Phase		A	A	A	A	A	A
Charging voltage capacitor bank	kVd.c.	248	251	251	250	251	-251
Peak voltage, test object	kV	386	390	391	389	390	-388
Gas pressure at 20 °C	MPa	0,60	0,60	0,60	0,60	0,60	0,60

Remarks	
170505-5003	Breaker withstood the test voltage.
170505-5004	Breaker withstood the test voltage.
170505-5005	Breaker withstood the test voltage.
170505-5006	Breaker withstood the test voltage.
170505-5007	Breaker withstood the test voltage.
170505-5010	Breaker withstood the test voltage.

Voltage tests as a condition check (continued)							
Test no.		170505 5011	170505 5012	170505 5013	170505 5014	170505 5016	170505 5017
Phase		A	A	A	A	A	A
Charging voltage capacitor bank	kVd.c.	-251	-252	-252	-252	-249	-251
Peak voltage, test object	kV	-390	-391	-389	-388	-386	-388
Gas pressure at 20 °C	MPa	0,60	0,60	0,60	0,60	0,60	0,60

Remarks	
170505-5011	Breaker withstood the test voltage.
170505-5012	Breaker withstood the test voltage.
170505-5013	Breaker withstood the test voltage.
170505-5014	Breaker withstood the test voltage.
170505-5016	Breaker withstood the test voltage.
170505-5017	Breaker withstood the test voltage.

Voltage tests as a condition check (continued)							
Test no.		170505 5018	170505 5019	170505 5020	170505 5023	170505 5024	170505 5025
Phase		A	A	A	A	A	A
Charging voltage capacitor bank	kVd.c.	-251	-252	-252	250	251	250
Peak voltage, test object	kV	-389	-390	-390	388	389	388
Gas pressure at 20 °C	MPa	0,60	0,60	0,60	0,60	0,60	0,60

Remarks	
170505-5018	Breaker withstood the test voltage.
170505-5019	Breaker withstood the test voltage.
170505-5020	Breaker withstood the test voltage.
170505-5023	Breaker withstood the test voltage.
170505-5024	Breaker withstood the test voltage.
170505-5025	Breaker withstood the test voltage.

Voltage tests as a condition check (continued)							
Test no.		170505 5026	170505 5027				
Phase		A	A				
Charging voltage capacitor bank	kVd.c.	251	251				
Peak voltage, test object	kV	390	390				
Gas pressure at 20 °C	MPa	0,60	0,60				

Remarks	
170505-5026	Breaker withstood the test voltage.
170505-5027	Breaker withstood the test voltage.

L75							
Test no.		170505 5031	170505 5032	170505 5033	170505 5036	170505 5037	170505 5038
Time interval between operations	s	-	-	-	-	0,312	-
Operation		O _S	O _S	O _S	O _D	C _D O _S	(C)O _S
Phase		C	C	C	C	C	C
Applied voltage, current source, phase value	kV	37,2	37,2	37,2	-	35,8	-
Charging voltage capacitor bank, DC value	kVd.c.	133	132	131	-	131	133
Making current, peak	kA	-	-	-	-	74,9	-
Breaking current, symmetrical, phase value	kA	30,3	30,3	30,3	30,8	30,1	30,4
Breaking current, DC-component	%	1	2	1	1	17	1
di/dt at last current zero	A/μs	13,6	13,5	13,5	-	13,5	13,6
TRV, first line-side peak (u _T), across breaker	kV	-60,0	-59,7	-	-	-58,6	-59,7
TRV, peak u _M	kV	-157	-155	-	-	-152	-156
Recovery voltage, phase value	kV	81,7	81,0	-	34,9	80,3	87,2
Make time	ms	-	-	-	-	75,4	-
Arc duration	ms	12,0	11,1	(1)	11,6	19,8	14,7
Opening time	ms	26,3	26,3	26,1	26,5	26,8	27,1
Break time	ms	38,3	37,4	-	38,1	46,6	41,8
t _h	μs	367	359	390	-	360	362
Current last loop, peak	kA	41,2	42,3	42,3	-	46,5	41,2
Time interval since previous test	min	-	-	-	-	-	7
Voltage closing coil	Vd.c.	-	-	-	-	242	242
Voltage opening coil	Vd.c.	242	242	242	242	242	242
Gas pressure at 20 °C	MPa	0,60	0,60	0,60	0,60	0,60	0,60
Operating pressure	MPa	-	-	-	-	-	-

Remarks	
170505-5031	Breaker cleared. O _S = Operation in a synthetic circuit.
170505-5032	Breaker cleared. O _S = Operation in a synthetic circuit.
170505-5033	Test to verify the correct reignition behaviour of the breaker (subclause 6.102.10 of IEC 62271-101). (1) Arcing time set for 10,4 ms. O _S = Operation in a synthetic circuit.
170505-5036	Breaker cleared. O _D = Operation with current source only.
170505-5037	Breaker closed and cleared. C _D = Operation with current source only. O _S = Operation in a synthetic circuit.
170505-5038	Breaker closed in no-load and cleared. O _S = Operation in a synthetic circuit.

No-load tests							
Test no.		170505 5039	170505 5040	170505 5041	170505 5042	170505 5043	170505 5044
Time interval between operations	s	-	0,302	-	0,302	-	0,294
Operation		O	CO	O	CO	O	CO
Current closing coil	A	-	2,63	-	2,36	-	1,98
	A	ms	-	78,2	-	79,5	-
Closing time	B	ms	-	76,6	-	77,6	-
	C	ms	-	77,9	-	78,9	-
Current opening coil	A	-2,45	-2,42	-2,20	-2,16	-1,61	-1,61
	A	ms	26,2	25,9	27,0	26,9	40,8
Opening time	B	ms	26,5	26,3	27,8	27,2	41,2
	C	ms	26,8	26,4	28,0	27,2	41,3
Voltage opening coil	Vd.c.	242	242	220	220	154	154
Gas pressure at 20 °C	MPa	0,60	0,60	0,60	0,60	0,60	0,60
Operating pressure	MPa	-	-	-	-	-	-
Voltage closing coil	Vd.c.	-	242	-	220	-	187

Remarks	
170505-5039	-
170505-5040	-
170505-5041	-
170505-5042	-
170505-5043	-
170505-5044	-

T60							
Test no.		170505 5048	170505 5049	170505 5050	170505 5053	170505 5054	170505 5055
Time interval since previous test	min	-	-	-	-	-	8
Time interval between operations	s	-	-	-	-	0,312	-
Operation		O _S	O _S	O _S	O _D	C _D O _S	(C)O _S
Phase		B	B	B	B	B	B
Applied voltage, current source, phase value	kV	29,0	28,6	28,5	-	29,7	-
Charging voltage capacitor bank, DC value	kVd.c.	216	218	217	-	217	218
Making current, peak	kA	-	-	-	-	40,7	-
Breaking current, symmetrical, phase value	kA	24,2	24,1	24,1	24,2	24,0	24,2
Breaking current, DC-component	%	3	3	3	3	4	2
di/dt at last current zero	A/μs	10,7	10,7	10,7	-	10,7	10,7
TRV, peak	kV	-	-271	-	-	-272	-274
Recovery voltage, phase value	kV	-	142	-	29,0	141	142
Make time	ms	-	-	-	-	76,0	-
Arc duration	ms	(1)	13,2	(1)	13,5	20,1	16,3
Opening time	ms	27,2	26,2	26,5	26,4	26,4	26,8
Break time	ms	-	39,4	-	39,9	46,5	43,1
t _h	μs	362	365	358	-	371	362
Current last loop, peak	kA	33,5	33,3	33,6	-	31,4	33,5
Voltage closing coil	Vd.c.	-	-	-	-	242	242
Voltage opening coil	Vd.c.	242	242	242	242	242	242
Gas pressure at 20 °C	MPa	0,60	0,60	0,60	0,60	0,60	0,60
Operating pressure	MPa	-	-	-	-	-	-

Remarks	
170505-5048	(1) Arcing time of 11,4 ms is too short for test breaker to clear. O _S = Operation in a synthetic circuit.
170505-5049	Breaker cleared. O _S = Operation in a synthetic circuit.
170505-5050	Test to verify the correct reignition behaviour of the breaker (subclause 6.102.10 of IEC 62271-101). (1) Arcing time set for 12,1 ms. O _S = Operation in a synthetic circuit.
170505-5053	Breaker cleared. O _D = Operation with current source only.
170505-5054	Breaker closed and cleared. C _D = Operation with current source only. O _S = Operation in a synthetic circuit.
170505-5055	Breaker closed in no-load and cleared. O _S = Operation in a synthetic circuit.

No-load tests							
Test no.		170508 5001	170508 5002	170508 5003	170508 5004	170508 5005	170508 5006
Time interval between operations	s	-	0,304	-	0,303	-	0,300
Operation		O	CO	O	CO	O	CO
Current closing coil	A	-	2,63	-	2,36	-	1,96
	A	ms	-	79,7	-	81,2	-
	B	ms	-	78,4	-	79,4	-
	C	ms	-	79,4	-	80,5	-
Current opening coil	A	-2,45	-2,42	-2,22	-2,18	-1,51	-1,54
	A	ms	26,2	26,3	27,9	27,6	34,9
	B	ms	26,4	26,3	28,1	27,6	35,1
	C	ms	26,5	26,5	28,4	27,8	35,3
Voltage closing coil	Vd.c.	-	242	-	220	-	187
Voltage opening coil	Vd.c.	242	242	220	220	154	154
Gas pressure at 20 °C	MPa	0,60	0,60	0,60	0,60	0,60	0,60
Operating pressure	MPa	-	-	-	-	-	-

Remarks	
170508-5001	-
170508-5002	-
170508-5003	-
170508-5004	-
170508-5005	-
170508-5006	-

No-load tests							
Test no.		170512 5001	170512 5002	170512 5003	170512 5004	170512 5005	170512 5006
Time interval between operations	s	-	0,284	-	0,286	-	0,286
Operation		O	CO	O	CO	O	CO
Current closing coil	A	-	1,91	-	2,28	-	2,54
	A	ms	-	73,3	-	71,5	-
Closing time	B	ms	-	73,9	-	71,6	-
	C	ms	-	73,9	-	71,8	-
Current opening coil	A	-1,40	-1,40	-2,10	-2,10	-2,31	-2,31
	A	ms	30,0	31,1	25,7	25,6	25,0
Opening time	B	ms	30,0	31,0	25,8	25,5	24,9
	C	ms	29,9	30,9	25,7	25,6	24,9
Voltage closing coil	Vd.c.	-	187	-	220	-	242
Voltage opening coil	Vd.c.	154	154	220	220	242	242
Gas pressure at 20 °C	MPa	0,60	0,60	0,60	0,60	0,60	0,60
Operating pressure	MPa	-	-	-	-	-	-

Remarks	
170512-5001	-
170512-5002	-
170512-5003	-
170512-5004	-
170512-5005	-
170512-5006	-

T100a							
Test no.		170512 5018	170512 5020	170512 5022	170512 5024		
Time interval since previous test	min	-	-	-	-		
Operation		O _s	O _s	O _s	O _s		
	A	kV	21,3	21,5	21,5	21,5	
Applied voltage, current source, phase value	B	kV	21,3	21,5	21,5	21,5	
	C	kV	21,3	21,5	21,5	21,5	
	A	kVd.c.	198	196	195	196	
Charging voltage capacitor bank, DC value	B	kVd.c.	122	121	124	123	
	C	kVd.c.	122	121	124	123	
	A	kA	40,7	41,0	41,0	40,9	
Breaking current, symmetrical, phase value	B	kA	40,2	40,7	40,6	40,5	
	C	kA	40,0	40,4	40,4	40,2	
	A	kA	67,7	67,1	66,6	71,1	
Current last loop, peak	B	kA	55,4	56,9	56,5	43,8	
	C	kA	-69,8	-70,2	-69,5	-59,1	
	A	ms	12,3	11,6	11,6	12,1	
Duration last loop	B	ms	9,43	9,49	9,49	8,09	
	C	ms	13,6	13,6	13,6	12,1	
	A	%	22	21	21	29	
Breaking current, DC-component	B	%	9	10	10	20	
	C	%	32	30	31	9	
	A	A/μs	18,5	18,2	18,2	18,4	
di/dt at last current zero	B	A/μs	15,4	15,4	15,5	15,4	
	C	A/μs	15,4	15,4	15,6	15,5	
	A	kV	-	-256	-254	-256	
TRV, peak	B	kV	-	-146	-148	-148	
	C	kV	-	146	145	150	
	A	kV	-	125	124	125	
Recovery voltage, phase value	B	kV	-	79,0	80,2	80,2	
	C	kV	-	80,9	82,5	82,0	
	A	ms	(1)	12,4	15,4	15,6	
Arc duration	B	ms	16,3	17,6	20,5	19,9	
	C	ms	16,3	17,6	20,5	19,7	
Opening time		ms	25,2	25,0	25,2	25,2	
	A	ms	-	37,4	40,6	40,8	
Break time	B	ms	41,5	42,6	45,7	45,1	
	C	ms	41,5	42,6	45,7	44,9	
	A	μs	364	368	362	367	
t _n	B	μs	440	429	426	438	
	C	μs	444	426	424	434	
Voltage opening coil		Vd.c.	242	242	242	242	
Gas pressure at 20 °C		MPa	0,60	0,60	0,60	0,60	
Operating pressure		MPa	-	-	-	-	

Remarks	
170512-5018	Test to verify the correct reignition behaviour of the breaker (subclause 6.102.10 of IEC 62271-101). (1) Arcing time set for 11,3 ms. O _S = Operation in a synthetic circuit.
170512-5020	Breaker cleared. O _S = Operation in a synthetic circuit.
170512-5022	Breaker cleared. O _S = Operation in a synthetic circuit.
170512-5024	Breaker cleared. O _S = Operation in a synthetic circuit.

No-load tests								
Test no.		170512 5026	170512 5027	170512 5028	170512 5029	170512 5030	170512 5031	
Time interval between operations	s	-	0,292	-	0,293	-	0,289	
Operation		O	CO	O	CO	O	CO	
Current closing coil	A	-	2,56	-	2,29	-	1,91	
	A	ms	-	75,9	-	77,9	-	79,3
Closing time	B	ms	-	75,5	-	77,2	-	78,8
	C	ms	-	76,7	-	78,6	-	79,9
Current opening coil	A	-2,30	-2,30	-2,07	-2,07	-1,42	-1,42	
	A	ms	24,8	24,6	25,6	25,5	31,3	30,8
Opening time	B	ms	24,4	24,2	25,3	25,1	30,7	30,3
	C	ms	24,5	24,3	25,3	24,9	30,8	29,7
Voltage closing coil	Vd.c.	-	242	-	220	-	187	
Voltage opening coil	Vd.c.	242	242	220	220	154	154	
Gas pressure at 20 °C	MPa	0,60	0,60	0,60	0,60	0,60	0,60	
Operating pressure	MPa	-	-	-	-	-	-	

Remarks	
170512-5026	-
170512-5027	-
170512-5028	-
170512-5029	-
170512-5030	-
170512-5031	-

No-load tests							
Test no.		170516 5001	170516 5002	170516 5003	170516 5004	170516 5005	170516 5006
Time interval between operations	s	-	0,299	-	0,299	-	0,296
Operation		O	CO	O	CO	O	CO
Current closing coil	A	-	2,50	-	2,24	-	1,87
	A	ms	-	69,5	-	70,6	-
	B	ms	-	70,6	-	71,8	-
	C	ms	-	69,7	-	70,9	-
Current opening coil	A	-2,34	-2,31	-2,09	-2,06	-1,41	-1,36
	A	ms	25,5	25,1	26,4	25,8	31,6
	B	ms	25,1	24,5	26,0	25,2	31,1
	C	ms	25,6	25,1	26,4	25,8	31,6
Voltage closing coil	Vd.c.	-	-	-	220	-	187
Voltage opening coil	Vd.c.	242	242	220	220	154	154
Gas pressure at 20 °C	MPa	0,60	0,60	0,60	0,60	0,60	0,60
Operating pressure	MPa	-	-	-	-	-	-

Remarks	
170516-5001	-
170516-5002	-
170516-5003	-
170516-5004	-
170516-5005	-
170516-5006	-

T10							
Test no.		170516 5010	170516 5011	170516 5014	170516 5015	170516 5016	
Time interval since previous test	min	-	-	-	-	9	
Operation		O _s	O _s	O _D	(C)O _s	(C)O _s	
Phase		A	A	A	A	A	
Applied voltage, current source, phase value	kV	46,2	46,2	-	-	-	
Charging voltage capacitor bank, DC value	kVd.c.	181	182	-	187	187	
Breaking current, symmetrical, phase value	kA	4,03	4,03	4,02	4,08	4,05	
Breaking current, DC-component	%	2	4	1	1	2	
di/dt at last current zero	A/μs	1,79	1,80	-	1,87	1,84	
TRV, peak	kV	-	-272	-	-276	-275	
Recovery voltage, phase value	kV	-	122	46,6	126	125	
Arc duration	ms	(1)	11,6	11,2	20,6	15,9	
Opening time	ms	25,4	25,4	25,5	25,7	25,6	
Break time	ms	-	37,0	36,7	46,3	41,5	
t _h	μs	400	360	-	351	361	
Current last loop, peak	kA	5,64	5,74	-	5,58	5,69	
Time interval between operations	s	-	-	-	0,291	-	
Voltage closing coil	Vd.c.	-	-	-	242	242	
Voltage opening coil	Vd.c.	242	242	242	242	242	
Gas pressure at 20 °C	MPa	0,60	0,60	0,60	0,60	0,60	
Operating pressure	MPa	-	-	-	-	-	

Remarks	
170516-5010	Test to verify the correct reignition behaviour of the breaker (subclause 6.102.10 of IEC 62271-101). (1) Arcing time set for 10,7 ms. O _s = Operation in a synthetic circuit.
170516-5011	Breaker cleared. O _s = Operation in a synthetic circuit.
170516-5014	Breaker cleared. O _D = Operation with current source only.
170516-5015	Breaker closed in no-load and cleared. O _s = Operation in a synthetic circuit.
170516-5016	Breaker closed in no-load and cleared. O _s = Operation in a synthetic circuit.

T30							
Test no.		170516 5019	170516 5020	170516 5023	170516 5024	170516 5025	
Time interval since previous test	min	-	-	-	-	8	
Operation		O _s	O _s	O _D	(C)O _s	(C)O _s	
Phase		B	B	B	B	B	
Applied voltage, current source, phase value	kV	34,7	33,2	-	-	-	
Charging voltage capacitor bank, DC value	kVd.c.	187	187	-	186	186	
Breaking current, symmetrical, phase value	kA	12,1	12,1	12,0	12,1	12,1	
Breaking current, DC-component	%	1	3	5	2	0	
di/dt at last current zero	A/μs	5,41	5,40	-	5,40	5,40	
TRV, peak	kV	-280	-	-	-277	-278	
Recovery voltage, phase value	kV	129	-	33,1	128	116	
Arc duration	ms	11,6	(1)	11,3	18,6	15,6	
Opening time	ms	25,1	25,0	25,0	24,9	24,7	
Break time	ms	36,7	-	36,3	43,5	40,3	
t _h	μs	406	418	-	402	411	
Current last loop, peak	kA	16,7	17,0	-	16,4	16,7	
Time interval between operations	s	-	-	-	0,293	-	
Voltage closing coil	Vd.c.	-	-	-	242	242	
Voltage opening coil	Vd.c.	242	242	242	242	242	
Gas pressure at 20 °C	MPa	0,60	0,60	0,60	0,60	0,60	
Operating pressure	MPa	-	-	-	-	-	

Remarks	
170516-5019	Breaker cleared. O _s = Operation in a synthetic circuit.
170516-5020	Test to verify the correct reignition behaviour of the breaker (subclause 6.102.10 of IEC 62271-101). (1) Arcing time set for 10,6 ms. O _s = Operation in a synthetic circuit.
170516-5023	Breaker cleared. O _D = Operation with current source only.
170516-5024	Breaker closed in no-load and cleared. O _s = Operation in a synthetic circuit.
170516-5025	Breaker closed in no-load and cleared. O _s = Operation in a synthetic circuit.

Double-earth fault test							
Test no.		170516 5028					
Time interval since previous test	min	-					
Operation		O _s					
Phase		C					
Applied voltage, current source, phase value	kV	33,9					
Charging voltage capacitor bank, DC value	kVd.c.	227					
Breaking current, symmetrical, phase value	kA	35,0					
Breaking current, DC-component	%	5					
di/dt at last current zero	A/μs	12,4					
TRV, peak	kV	-297					
Recovery voltage, phase value	kV	147					
Arc duration	ms	18,8					
Opening time	ms	25,3					
Break time	ms	44,1					
t _h	μs	388					
Current last loop, peak	kA	50,4					
Voltage opening coil	Vd.c.	242					
Gas pressure at 20 °C	MPa	0,60					
Operating pressure	MPa	-					

Remarks	
170516-5028	Breaker cleared. O _s = Operation in a synthetic circuit.

No-load tests							
Test no.		170516 5029	170516 5030	170516 5031	170516 5032	170516 5033	170516 5034
Time interval between operations	s	-	0,299	-	0,299	-	0,297
Operation		O	CO	O	CO	O	CO
Current closing coil	A	-	2,52	-	2,25	-	1,87
	A	ms	-	69,5	-	70,6	-
	B	ms	-	71,0	-	72,2	-
	C	ms	-	68,1	-	69,3	-
Current opening coil	A	-2,33	-5,00	-2,09	-5,00	-1,37	-5,00
	A	ms	25,6	25,7	26,6	26,4	31,0
	B	ms	25,2	25,3	26,2	25,9	30,5
	C	ms	25,6	25,7	26,3	26,0	30,8
Voltage closing coil	Vd.c.	-	242	-	220	-	187
Voltage opening coil	Vd.c.	242	242	220	220	154	154
Gas pressure at 20 °C	MPa	0,60	0,60	0,60	0,60	0,60	0,60
Operating pressure	MPa	-	-	-	-	-	-

Remarks	
170516-5029	-
170516-5030	-
170516-5031	-
170516-5032	-
170516-5033	-
170516-5034	-

No-load tests								
Test no.		170518 4011	170518 4012	170518 4013	170518 4014	170518 4015	170518 4016	
Time interval between operations	s	-	0,302	-	0,300	-	0,301	
Operation		O	CO	O	CO	O	CO	
Current closing coil	A	-	2,27	-	1,89	-	2,54	
	A	ms	-	73,4	-	75,9	-	72,3
Closing time	B	ms	-	74,5	-	77,1	-	73,3
	C	ms	-	73,6	-	76,2	-	72,4
Current opening coil	A	-2,03	-2,02	-1,34	-1,36	-2,29	-2,27	
	A	ms	26,4	26,3	30,9	31,2	25,7	25,5
Opening time	B	ms	25,9	25,9	30,4	30,7	25,2	25,0
	C	ms	26,5	26,4	31,0	31,2	25,7	25,6
Voltage closing coil	Vd.c.	-	220	-	187	-	242	
Voltage opening coil	Vd.c.	220	220	154	154	242	242	
Gas pressure at 20 °C	MPa	0,60	0,60	0,60	0,60	0,60	0,60	
Operating pressure	MPa	-	-	-	-	-	-	

Remarks	
170518-4011	-
170518-4012	-
170518-4013	-
170518-4014	-
170518-4015	-
170518-4016	-

OP2 (make)							
Test no.		170518 4053	170518 4054				
Time interval since previous test	min	-	-				
Operation		C	C				
Phase		B	B				
Applied voltage, phase value	kV	168	168				
Applied voltage, between phases	kV	-	-				
Making current, peak	kA	20,1	16,0				
Symmetrical current, end	kA	9,84	9,70				
Average curr. end, three phase	kA	-	-				
Make time	ms	66,9	47,2				
Pre-arcing time	ms	9,5	28,4				
Current duration	ms	225	244				
Voltage closing coil	Vd.c.	242	242				
Gas pressure at 20 °C	MPa	0,60	0,60				
Operating pressure	MPa	-	-				

Remarks	
170518-4053	Breaker closed.
170518-4054	Breaker closed.

OP2 (break)							
Test no.		170519 4002	170519 4003	170519 4004	170519 4005	170519 4006	
Time interval since previous test	min	-	6	6	9	13	
Operation		(C)O	(C)O	O	O	O	
Phase		B	B	B	B	B	
Breaking current, phase value	kA	10,2	10,2	10,2	10,2	10,2	
Average current, three phase	kA	-	-	-	-	-	
Breaking current, DC-component	%	4	4	5	5	5	
Recovery voltage, phase value	kV	208	-	207	207	209	
Recovery voltage, between phases	kV	-	-	-	-	-	
TRV, peak	kV	-373	-	372	371	371	
Arc duration	ms	12,4	(1)	30,3 (1)	26,5 (1)	13,0 (1)	
Opening time	ms	24,6	25,1	25,0	25,1	25,0	
Break time	ms	37,0	-	55,3	51,6	38,0	
Voltage opening coil	Vd.c.	242	242	242	242	242	
Gas pressure at 20 °C	MPa	0,60	0,60	0,60	0,60	0,60	
Operating pressure	MPa	-	-	-	-	-	

Remarks	
170519-4002	Breaker closed in no-load and cleared.
170519-4003	Test to verify the correct reignition behaviour of the breaker (subclause 6.102.10 of IEC 62271-101). (1) Arcing time set for 11,2 ms.
170519-4004	Breaker cleared. (1) Arcing time set for 19,7 ms.
170519-4005	Breaker cleared. (1) Arcing time set for 16,0 ms.
170519-4006	Breaker cleared. (1) Arcing time set for 22,9 ms.

No-load tests								
Test no.		170519 4008	170519 4009	170519 4010	170519 4011	170519 4012	170519 4013	
Time interval between operations	s	-	0,299	-	0,299	-	0,296	
Operation		O	CO	O	CO	O	CO	
Current closing coil	A	-	2,57	-	2,31	-	1,93	
	A	ms	-	73,8	-	75,1	-	77,0
Closing time	B	ms	-	75,4	-	76,8	-	78,7
	C	ms	-	74,3	-	75,8	-	77,7
Current opening coil	A	-2,30	-2,25	-2,06	-2,01	-1,33	-1,33	
	A	ms	26,1	25,6	26,9	26,4	31,2	30,8
Opening time	B	ms	25,3	24,7	26,0	25,3	30,4	29,8
	C	ms	25,7	25,2	26,6	26,0	30,9	30,5
Voltage closing coil	Vd.c.	-	242	-	220	-	187	
Voltage opening coil	Vd.c.	242	242	220	220	154	154	
Gas pressure at 20 °C	MPa	0,60	0,60	0,60	0,60	0,60	0,60	
Operating pressure	MPa	-	-	-	-	-	-	

Remarks	
170519-4008	-
170519-4009	-
170519-4010	-
170519-4011	-
170519-4012	-
170519-4013	-

Short-time withstand current and peak withstand current test							
Test no.			170530 5003				
	A	kA	101				
Peak value of current	B	kA	-85,5				
	C	kA	-72,8				
	A	kA	38,4				
Symmetrical current, beginning	B	kA	39,4				
	C	kA	38,1				
	A	kA	38,2				
Symmetrical current, middle	B	kA	39,4				
	C	kA	38,1				
	A	kA	38,3				
Symmetrical current, end	B	kA	39,6				
	C	kA	38,3				
	A	kA	38,3				
Symmetrical current, average	B	kA	39,5				
	C	kA	38,2				
		kA	38,7				
Average current, three phase		kA	38,7				
Current duration	A	s	3,28				
	B	s	3,28				
	C	s	3,28				
Thermal equivalent			40 kA during 3,06 s				
Gas pressure at 20 °C		MPa	-				

Remarks	
170530-5003	No visible disturbance.

No-load test							
Test no.		170530 5004					
Operation		O					
Current opening coil	A	-1,31					
Opening time	A	ms	31,7				
	B	ms	31,8				
	C	ms	31,5				
Voltage opening coil	Vd.c.	154					
Gas pressure at 20 °C	MPa	-					
Operating pressure	MPa	-					

Remarks	
170530-5004	-

No-load tests								
Test no.		170609 5001	170609 5002	170609 5003	170609 5004	170609 5005	170609 5006	
Time interval between operations	s	-	0,295	-	0,295	-	0,293	
Operation		O	CO	O	CO	O	CO	
Current closing coil	A	-	2,53	-	2,26	-	1,89	
	A	ms	-	69,9	-	70,9	-	73,9
Closing time	B	ms	-	70,8	-	71,7	-	74,6
	C	ms	-	69,8	-	70,7	-	73,8
Current opening coil	A	-2,34	-2,30	-2,08	-2,05	-1,38	-1,39	
	A	ms	25,3	25,0	26,0	25,8	30,9	30,9
Opening time	B	ms	25,0	24,6	25,6	25,3	30,5	30,4
	C	ms	25,5	25,2	26,2	26,0	31,1	31,0
Voltage closing coil	Vd.c.	-	242	-	220	-	187	
Voltage opening coil	Vd.c.	242	242	220	220	154	154	
Gas pressure at 20 °C	MPa	0,60	0,60	0,60	0,60	0,60	0,60	
Operating pressure	MPa	-	-	-	-	-	-	

Remarks	
170609-5001	-
170609-5002	-
170609-5003	-
170609-5004	-
170609-5005	-
170609-5006	-

Determination of pre-arcing time							
Test no.			170609 5011	170609 5012	170609 5013		
Time interval since previous test	min		-	-	-		
Operation			C	C	C		
Applied voltage, phase value	A	kV	84,8	84,8	84,8		
	B	kV	84,6	84,6	84,5		
	C	kV	84,2	84,2	84,1		
Applied voltage, between phases	kV	146	146	146			
Peak value of current	A	kA	2,72	-4,24	-4,09		
	B	kA	-4,44	-2,38	4,37		
	C	kA	4,10	4,30	-2,56		
Symmetrical current, end	A	kA	1,51	1,51	1,50		
	B	kA	1,49	1,49	1,48		
	C	kA	1,50	1,50	1,49		
Average curr. end, three phase	kA	1,50	1,50	1,49			
Make time	A	ms	67,2	66,7	66,3		
	B	ms	68,1	66,7	66,3		
	C	ms	67,3	69,6	66,4		
Pre-arcing time	A	ms	3,9	3,9	4,2		
	B	ms	2,4	4,0	4,2		
	C	ms	3,2	1,0	4,1		
Current duration	ms	280	282	286			
Voltage closing coil	Vd.c.	242	242	242			
Gas pressure at 20 °C	MPa	0,60	0,60	0,60			
Operating pressure	MPa	-	-	-			

Remarks	
170609-5011	Breaker closed.
170609-5012	Breaker closed.
170609-5013	Breaker closed.

T100s(a)							
Test no.			170609 5020				
Time interval since previous test		min	-				
Operation			C				
	A	kV	18,0				
Applied voltage, current source, phase value	B	kV	18,0				
	C	kV	18,0				
	A	kVd.c.	107				
Charging voltage capacitor bank, DC value	B	kVd.c.	100				
	C	kVd.c.	100				
	A	kV	208				
Applied voltage test object, phase value	B	kV	119				
	C	kV	-158				
	A	kA	-101				
Making current, peak	B	kA	108				
	C	kA	-66,0				
Symmetrical current, begin		kA	-				
	A	ms	69,0				
Make time	B	ms	65,5				
	C	ms	65,6				
	A	µs	63,0				
Transfer time	B	µs	66,0				
	C	µs	60,0				
	A	ms	4,6				
Pre-arcing time	B	ms	4,5				
	C	ms	4,4				
	A	ms	260				
Current duration	B	ms	263				
	C	ms	259				
Voltage closing coil		Vd.c.	242				
Gas pressure at 20 °C		MPa	0,60				
Operating pressure		MPa	-				

Remarks	
170609-5020	Breaker closed.

T100s(b)							
Test no.		170609 5025	170609 5026	170609 5029	170609 5030	170609 5031	
Time interval since previous test	min	-	-	-	-	19	
Time interval between operations	s	-	-	-	0,316	-	
Operation		O _s	O _s	O _D	C _D O _s	C _D O _s	
	A	kV	19,3	19,4	-	22,8	23,1
Applied voltage, current source, phase value	B	kV	20,7	20,3	-	20,5	21,3
	C	kV	19,5	19,7	-	21,5	21,9
	A	kVd.c.	191	194	-	193	194
Charging voltage capacitor bank, DC value	B	kVd.c.	130	129	-	129	129
	C	kVd.c.	130	128	-	130	129
	A	kA	-	-	-	92,8	102
Making current, peak	B	kA	-	-	-	-94,1	-87,5
	C	kA	-	-	-	61,2	-74,9
	A	kA	40,0	40,3	41,3	40,2	40,7
Breaking current, symmetrical, phase value	B	kA	40,2	40,5	41,6	40,1	40,9
	C	kA	40,0	40,3	41,4	40,0	40,6
	A	%	7	2	7	10	11
Breaking current, DC-component	B	%	14	1	15	9	7
	C	%	6	2	9	1	4
	A	A/μs	17,8	17,8	-	17,8	17,8
di/dt at last current zero	B	A/μs	15,7	15,6	-	15,6	15,5
	C	A/μs	15,4	15,4	-	15,4	15,0
	A	kV	-	-261	-	-252	-267
TRV, peak	B	kV	-144	-144	-	-138	-144
	C	kV	152	143	-	164	153
	A	kV	-	126	22,0	124	125
Recovery voltage, phase value	B	kV	84,0	84,0	19,7	84,3	84,0
	C	kV	87,0	86,8	20,9	87,1	86,8
	A	ms	-	-	-	69,7	75,4
Make time	B	ms	-	-	-	70,3	74,1
	C	ms	-	-	-	69,8	74,1
	A	ms	(1)	12,6	13,1	15,7	14,6
Arc duration	B	ms	17,1	17,6	17,7	20,7	19,6
	C	ms	16,9	17,6	17,7	20,7	19,6
Opening time		ms	24,7	24,6	24,8	24,7	30,2
	A	ms	-	37,2	37,9	40,4	44,8
Break time	B	ms	41,8	42,2	42,5	45,4	49,8
	C	ms	41,6	42,2	42,5	45,4	49,8
	A	μs	398	391	-	406	393
t _h	B	μs	426	407	-	418	418
	C	μs	427	403	-	415	411
	A	kA	50,4	55,8	-	58,7	61,4
Current last loop, peak	B	kA	51,6	48,1	-	44,6	47,3
	C	kA	-56,5	-55,0	-	-52,8	-56,4
Voltage closing coil		Vd.c.	-	-	-	242	187

Voltage opening coil	Vd.c.	242	242	242	242	154	
Gas pressure at 20 °C	MPa	0,60	0,60	0,60	0,60	0,60	
Operating pressure	MPa	-	-	-	-	-	

Remarks	
170609-5025	Test to verify the correct reignition behaviour of the breaker (subclause 6.102.10 of IEC 62271-101). (1) Arcing time set for 11,6 ms. O _S = Operation in a synthetic circuit.
170609-5026	Breaker cleared. O _S = Operation in a synthetic circuit.
170609-5029	Breaker cleared. O _D = Operation with current source only.
170609-5030	Breaker closed and cleared. C _D = Operation with current source only. O _S = Operation in a synthetic circuit.
170609-5031	Breaker closed and cleared. C _D = Operation with current source only. O _S = Operation in a synthetic circuit.

No-load tests							
Test no.		170609 5032	170609 5033	170609 5034	170609 5035	170609 5036	170609 5037
Time interval between operations	s	-	0,300	-	0,300	-	0,296
Operation		O	CO	O	CO	O	CO
Current closing coil	A	-	2,53	-	2,27	-	1,90
	A	ms	-	72,6	-	73,8	-
Closing time	B	ms	-	75,1	-	76,2	-
	C	ms	-	73,2	-	74,4	-
Current opening coil	A	-2,31	-2,30	-2,08	-2,06	-1,37	-1,35
	A	ms	25,0	25,0	25,6	25,4	30,2
Opening time	B	ms	23,1	23,1	23,9	23,7	28,4
	C	ms	24,5	24,6	25,1	25,2	29,8
Voltage opening coil	Vd.c.	242	242	220	220	154	154
Gas pressure at 20 °C	MPa	0,60	0,60	0,60	0,60	0,60	0,60
Operating pressure	MPa	-	-	-	-	-	-
Voltage closing coil	Vd.c.	-	242	-	220	-	187

Remarks	
170609-5032	-
170609-5033	-
170609-5034	-
170609-5035	-
170609-5036	-
170609-5037	-

6 NO-LOAD TESTS

Standard and date

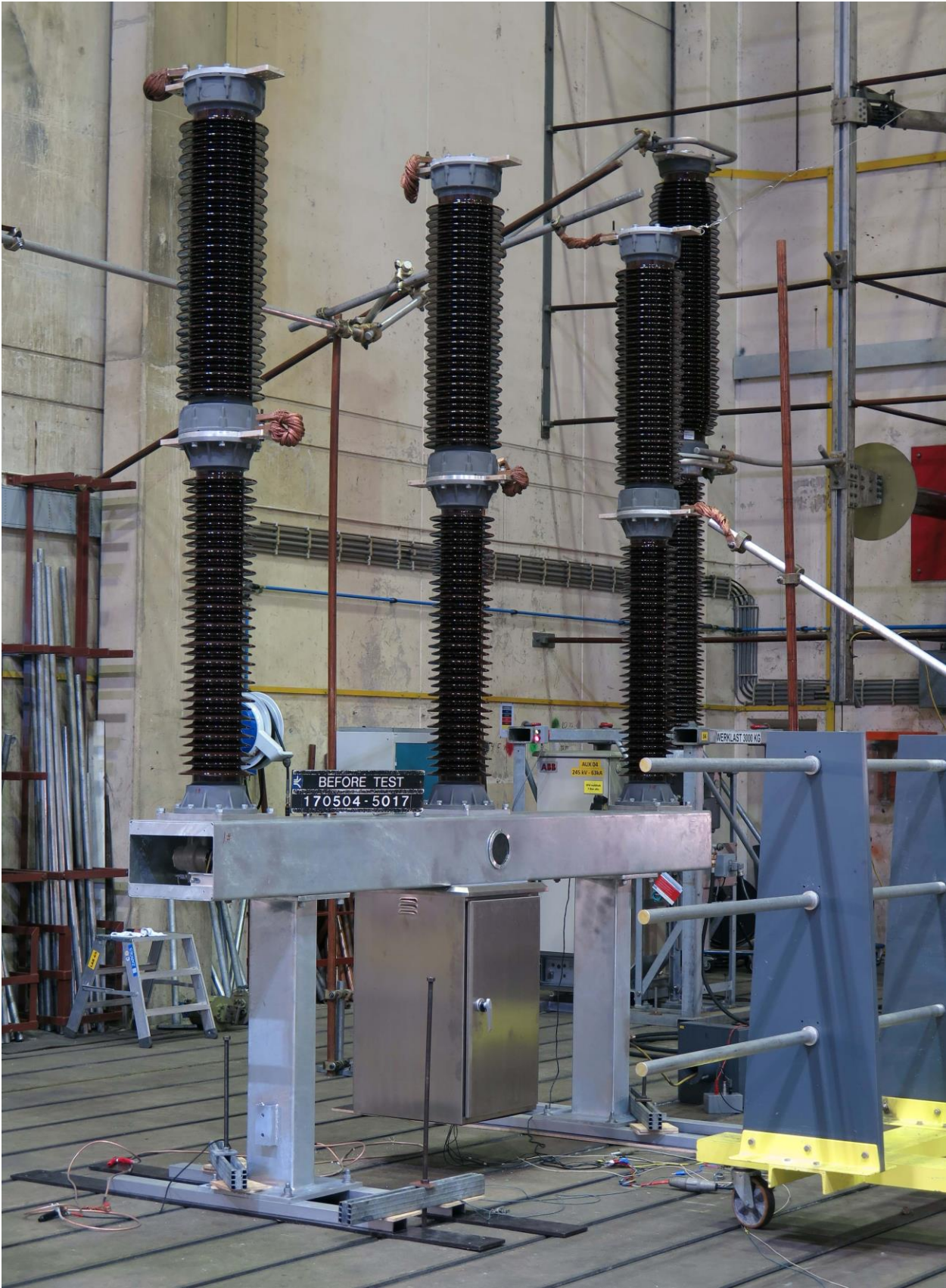
Standard IEC 62271-100

Test date 4 May 2017

6.1 Condition before test

Breaker (Serial No. 17101) new.

6.2 Photograph before test



6.3 Test results and oscillograms

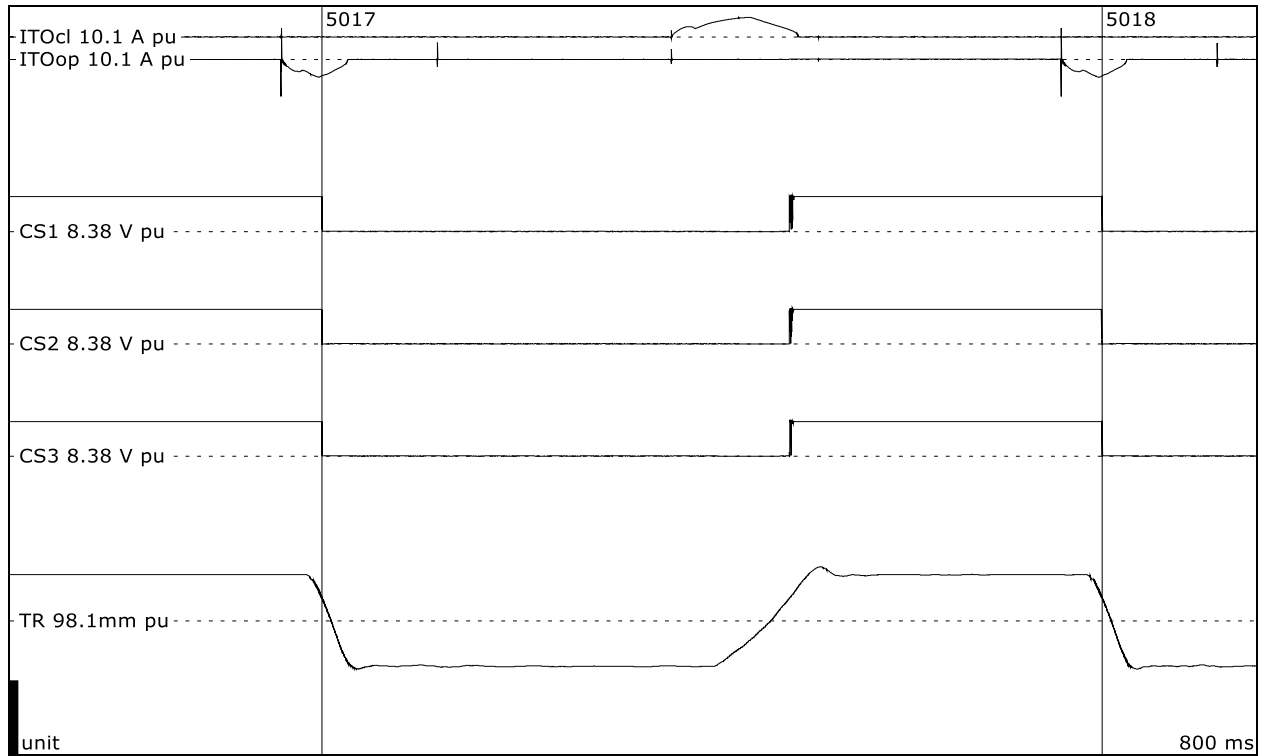
Overview of test numbers

170504-5017 to 5024

Remarks

-

No-load test



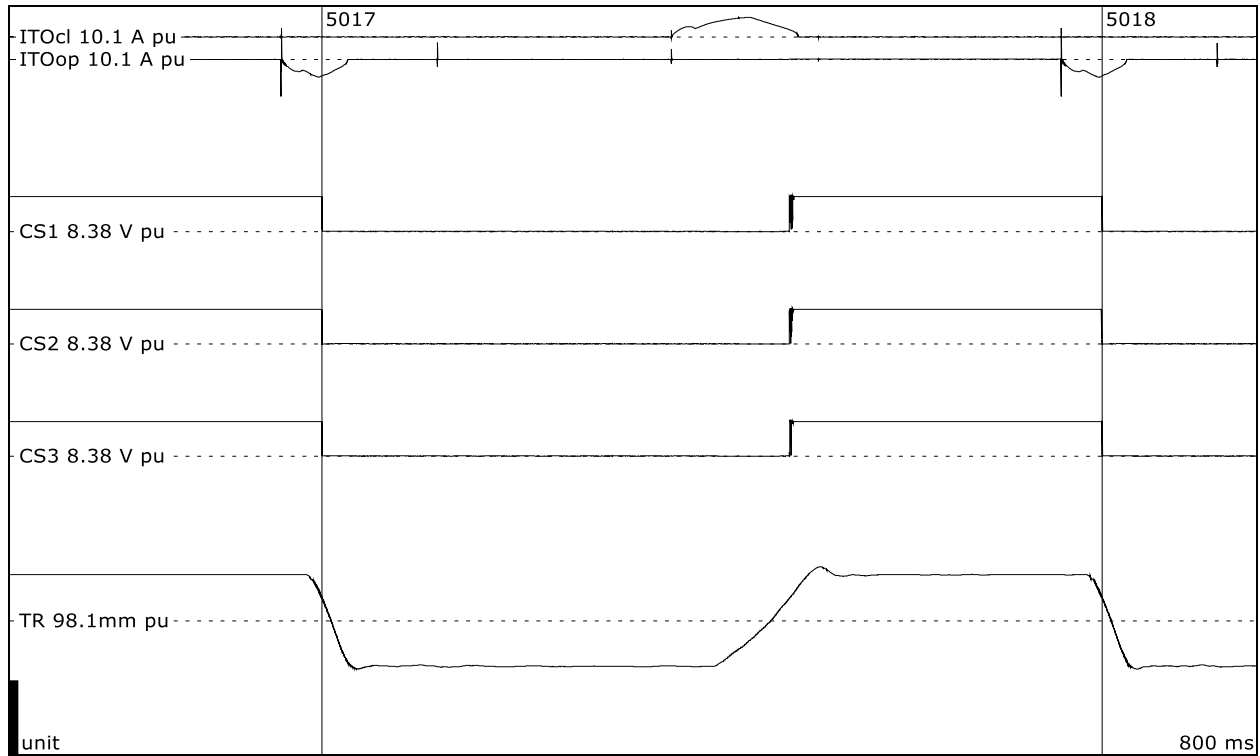
Test number: 170504-5017

Operation		O		
Phase		A	B	C
Current opening coil	A	-2,40		
Opening time	ms	26,4	26,2	26,3

Voltage opening coil	242 Vd.c.	Gas pressure at 20 °C	0,60 MPa
		Operating pressure	- MPa

Remarks: -

No-load test



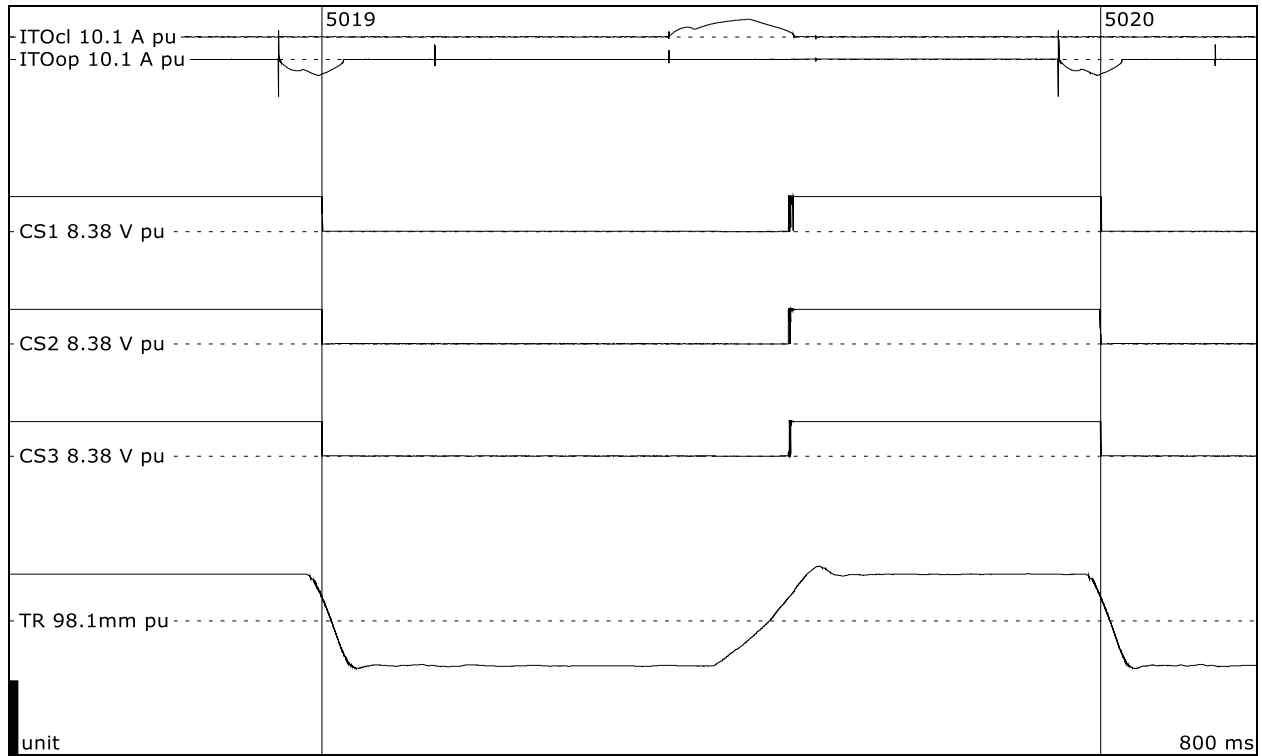
Test number: 170504-5018

Time interval between operations	s	0,300		
Operation	CO			
Phase		A	B	C
Current closing coil	A	2,62		
Closing time	ms	75,7	75,7	76,1
Current opening coil	A	-2,40		
Opening time	ms	26,6	26,3	26,5

Voltage closing coil	242 Vd.c.	Gas pressure at 20 °C	0,60 MPa
Voltage opening coil	242 Vd.c.	Operating pressure	- MPa

Remarks: -

No-load test



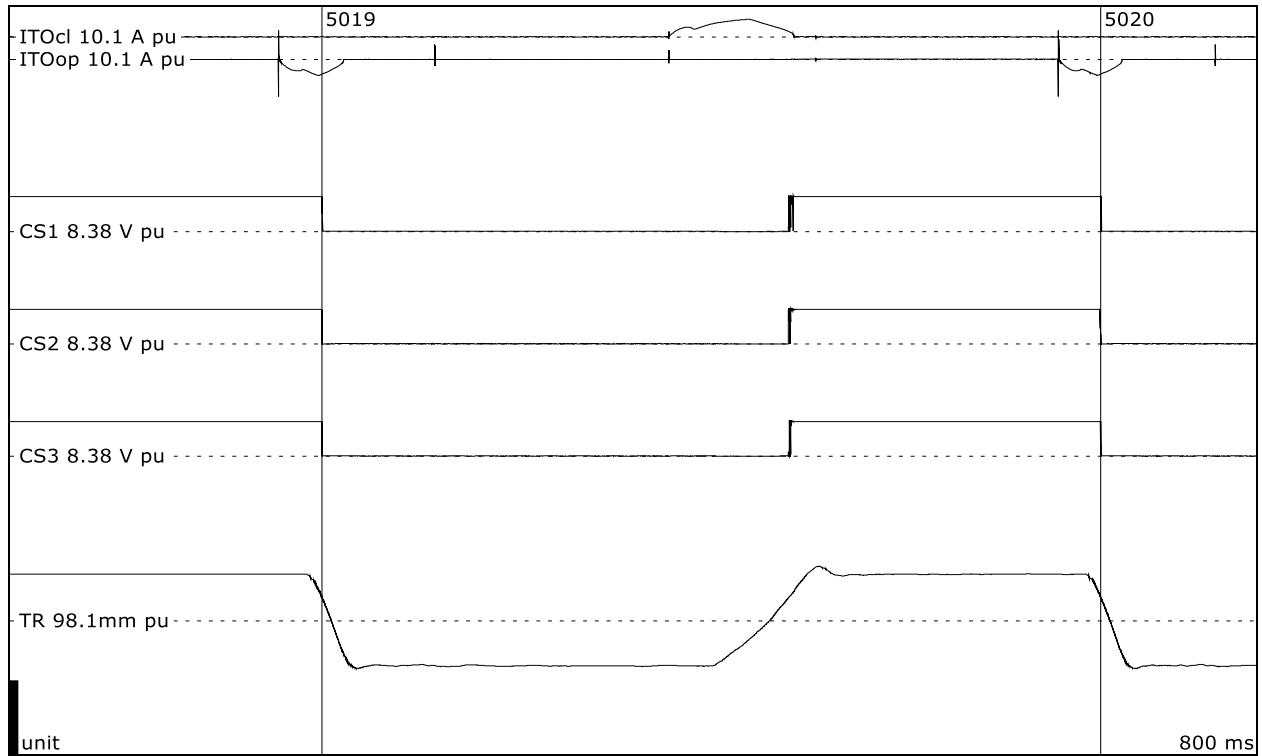
Test number: 170504-5019

Operation		O		
Phase		A	B	C
Current opening coil	A	-2,19		
Opening time	ms	28,0	27,8	28,0

Voltage opening coil	220 Vd.c.	Gas pressure at 20 °C	0,60 MPa
		Operating pressure	- MPa

Remarks: -

No-load test



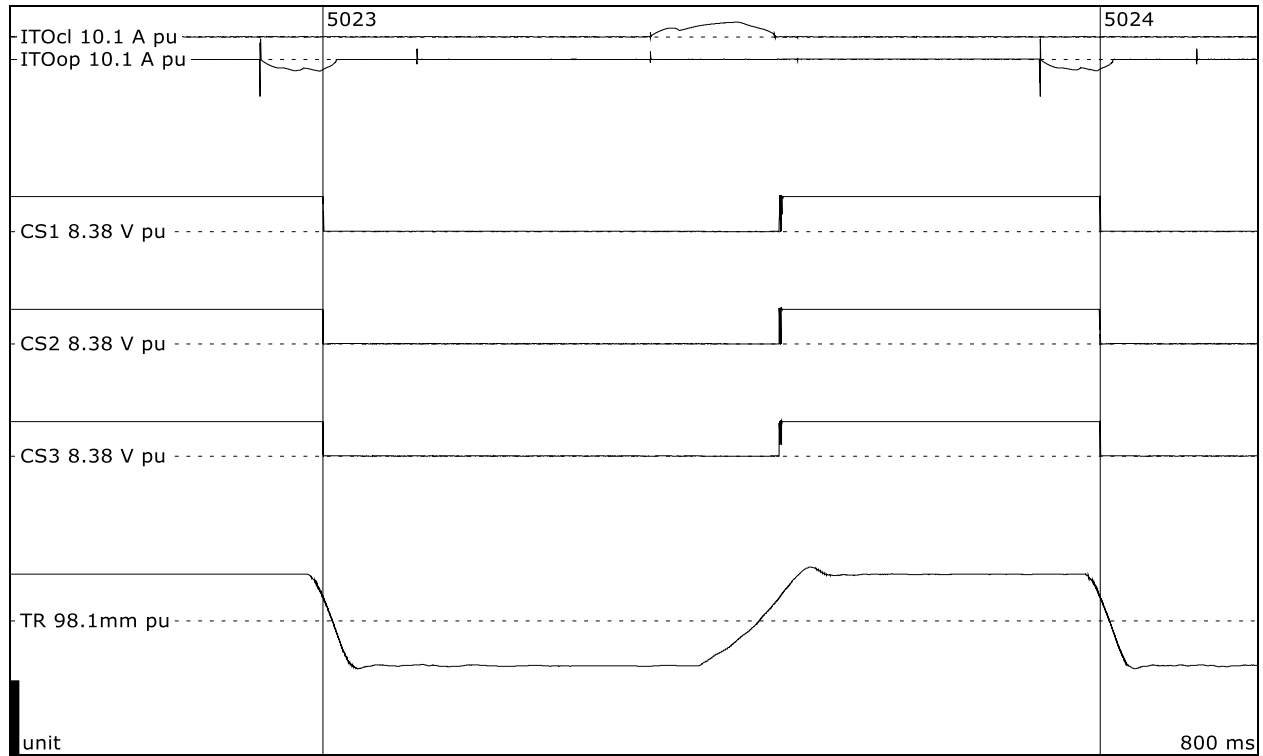
Test number: 170504-5020

Time interval between operations	s	0,299		
Operation	CO			
Phase		A	B	C
Current closing coil	A	2,35		
Closing time	ms	77,0	76,8	77,1
Current opening coil	A	-2,16		
Opening time	ms	27,4	27,0	27,3

Voltage closing coil	220 Vd.c.	Gas pressure at 20 °C	0,60 MPa
Voltage opening coil	220 Vd.c.	Operating pressure	- MPa

Remarks: -

No-load test



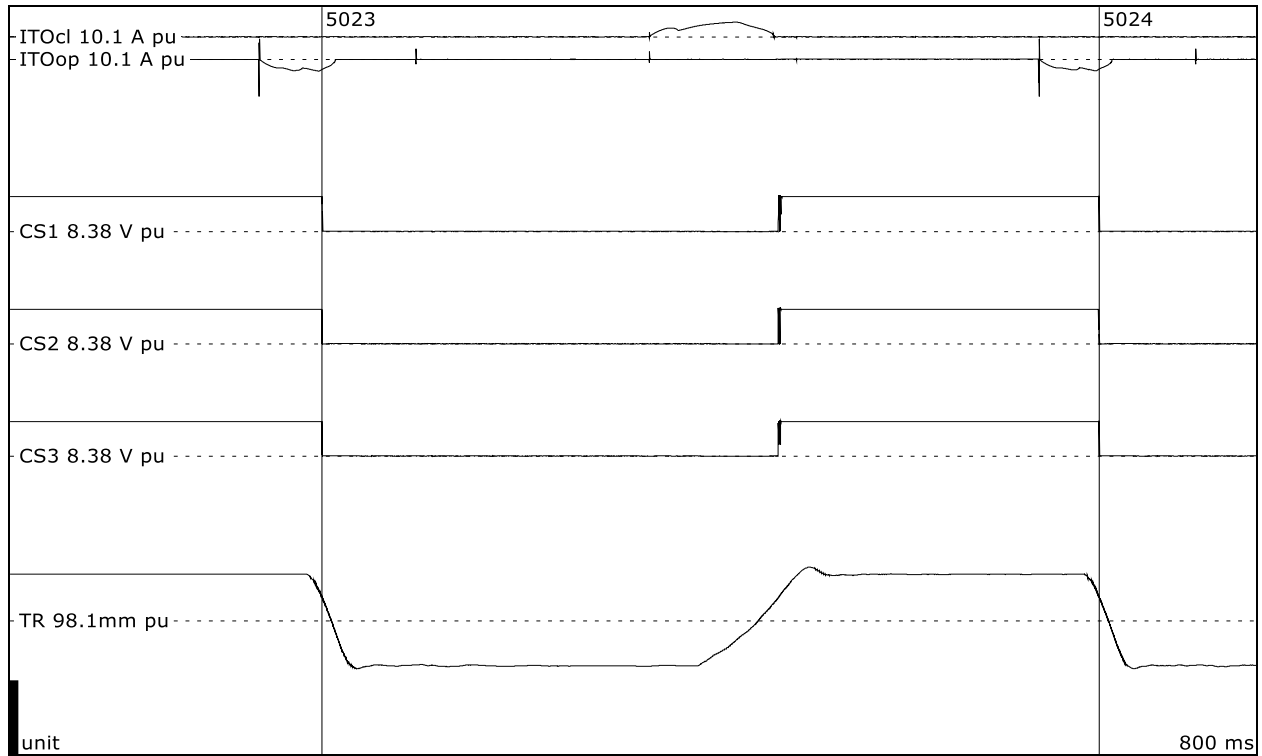
Test number: 170504-5023

Operation		O		
Phase		A	B	C
Current opening coil	A	-1,59		
Opening time	ms	40,4	40,1	40,3

Voltage opening coil	154 Vd.c.	Gas pressure at 20 °C	0,60 MPa
		Operating pressure	- MPa

Remarks: -

No-load test



Test number: 170504-5024

Time interval between operations	s	0,293		
Operation	CO			
Phase		A	B	C
Current closing coil	A	1,97		
Closing time	ms	82,7	82,6	82,6
Current opening coil	A	-1,57		
Opening time	ms	38,6	38,4	38,6

Voltage closing coil	187 Vd.c.	Gas pressure at 20 °C	0,60 MPa
Voltage opening coil	154 Vd.c.	Operating pressure	- MPa

Remarks: -

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Standard and date

Standard IEC 62271-100

Test date 4 May 2017

7.1 Condition before test

Breaker (Serial No 17101) in same condition.

Pole A under test.

Supply to fixed contact.

Moving contact earthed.

Frame earthed via a CT.

Auxiliary breaker:

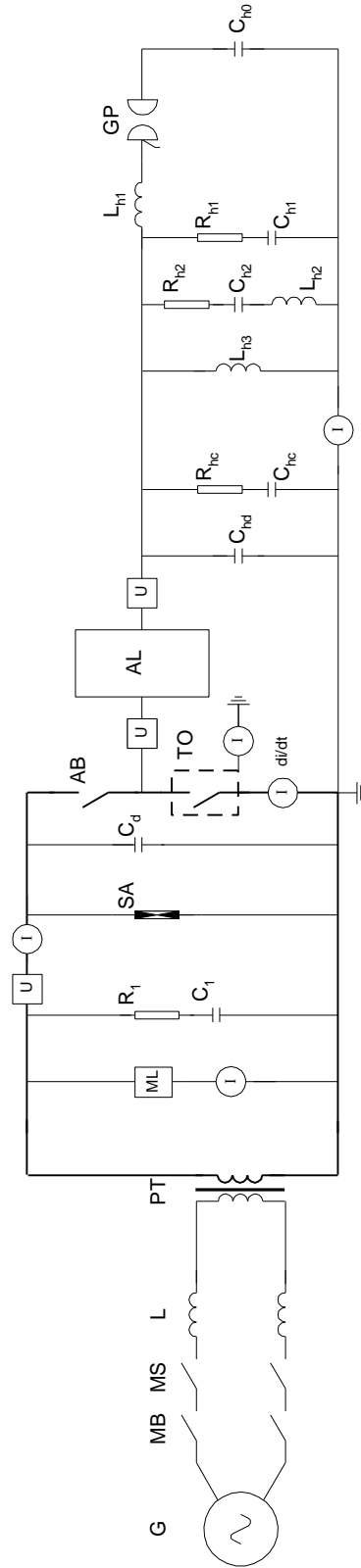
An SF₆ breaker, provided by KEMA Laboratories.

Number of elements: 1 per breaker.

7.2 Test circuit S05

Diagram

Current injection



G = Generator	L = Reactor	U = Voltage Measurement to earth	SA = Surge Arrester
MB = Master Breaker	TO = Test Object	I = Current Measurement	AB = Auxiliary Breaker
MS = Make Switch	R = Resistor	AL = Artificial line	GP = Gap
PT = Power Transformer	C = Capacitor	ML = Multi-loop device	

Values

Supply		
Power	MVA	1296
Frequency	Hz	50
Phase(s)		1
Voltage	kV	36,0
Current	kA	36,0
Impedance	Ω	1
Power factor		< 0,1
Neutral		not earthed

Injection circuit		
C_{h0}	μF	8,00
U_{h0}	kVd.c.	140
L_{h1}	mH	7,04
f_{h1} (including AL)	Hz	613
R_{h1}	Ω	111
C_{h1}	μF	0,10
C_{hd}	nF	15,0
R_{hc}	Ω	117
C_{hc}	nF	20,0
R_{h2}	Ω	80,0
C_{h2}	μF	0,50
L_{h2}	mH	3,75
R_{hp}	k Ω	-
L_{h3}	H	1,20
f_{RV}	Hz	48

Prospective TRV		
$U_{recovery}$	kVa.c.	83,7
u_1	kV	89,0
u_c	kV	166
t_d	μs	2,00
t_1	μs	44,0
t_2	μs	178
t_3	μs	-
Rate of rise	kV/ μs	2,00

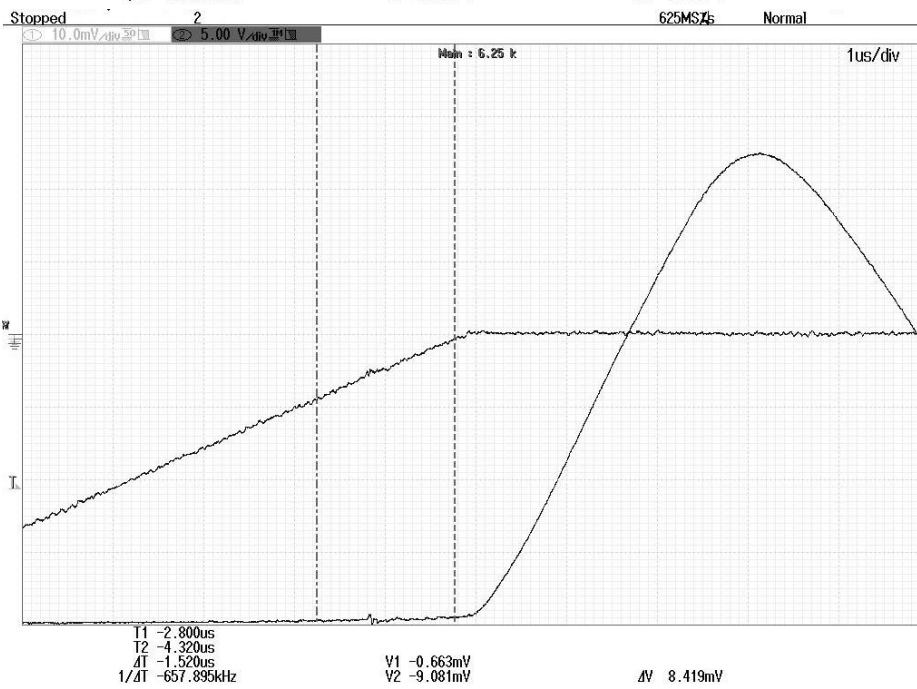
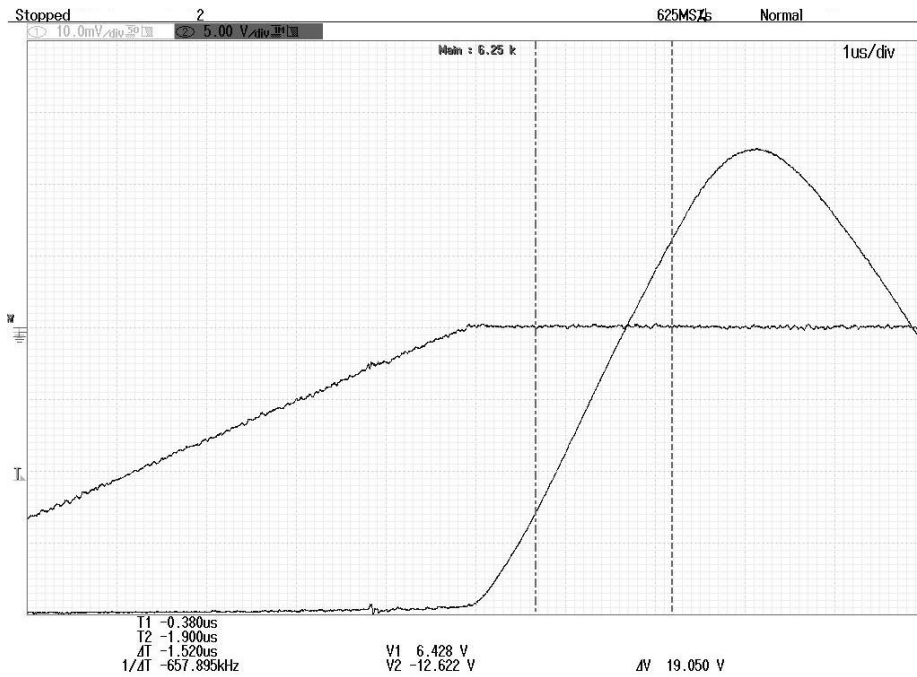
Load	
Short-circuit point	earthed

Artificial line		
I_L / I		0,91
I_L	kA	36,4
L_L	μH	724
Z	Ω	453
di/dt	A/ μs	16,2
du/dt	kV/ μs	7,34
u_L^*	kV	19,8
t_L	μs	2,70
t_{dL}	μs	< 0,1
C_{dL}	pF	-

TRV control elements added (supply)		
C_1	μF	0,66
R_1	Ω	60,0
C_d	nF	15,0

Remarks: -

7.3 Inherent transient voltage record of artificial line



Shunt = 4,82 A/V

k = 1,67

t_{dL} = < 0,1 μs

7.4 Test results and oscillograms

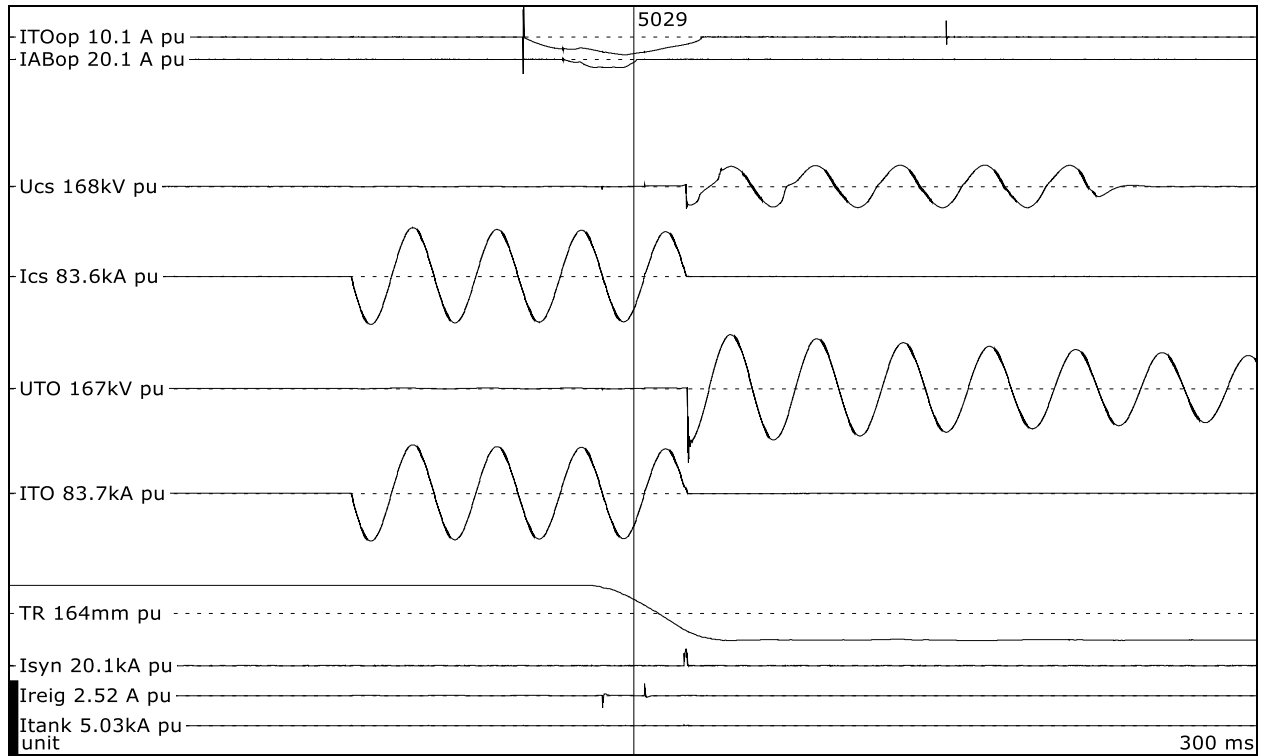
Overview of test numbers

170504-5029, 5030, 5033 to 5035

Remarks

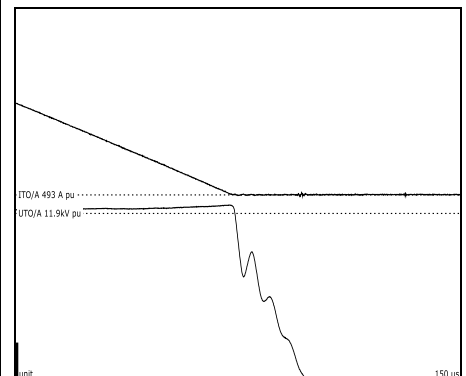
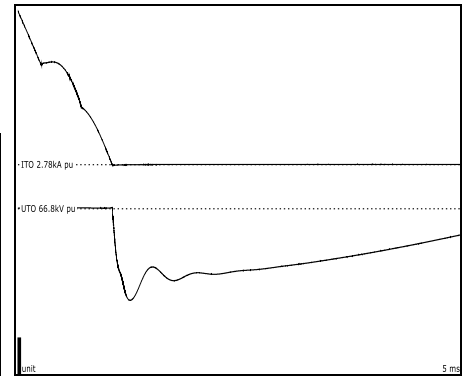
-

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Test number: 170504-5029

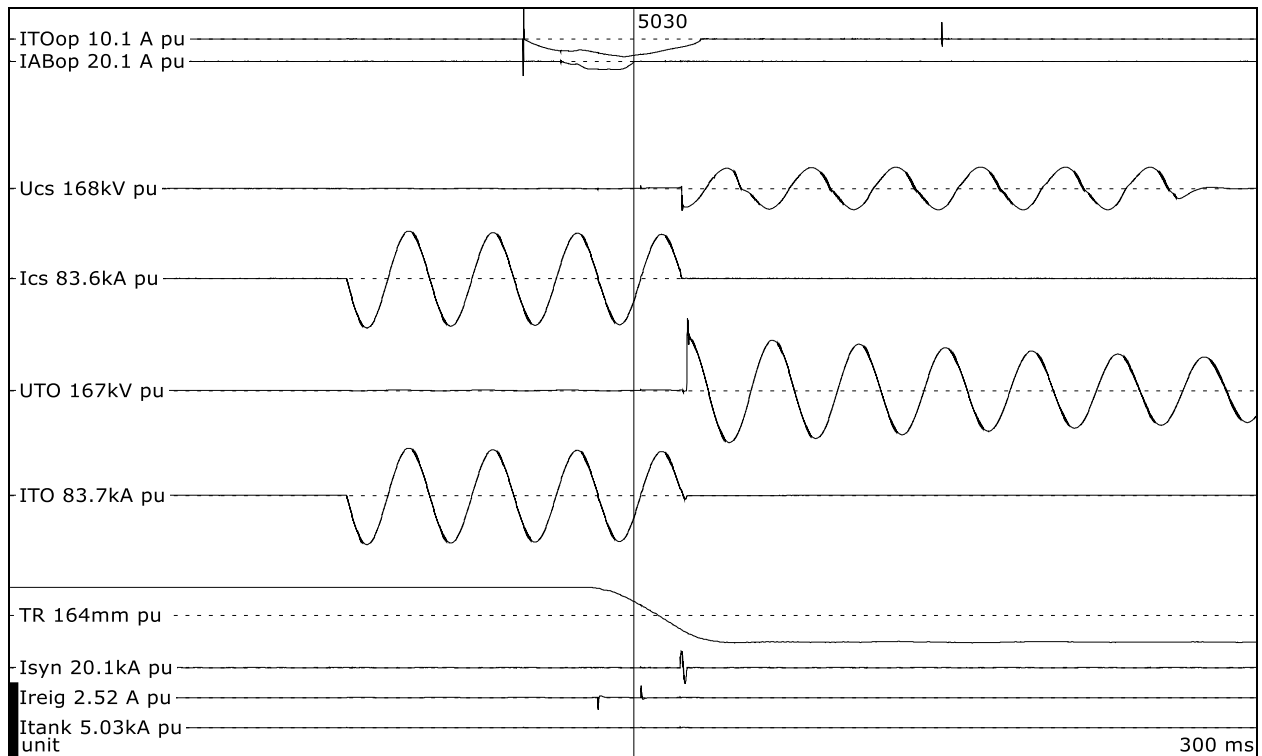
Time interval since previous test	min	-
Operation		O _s
Phase		A
Applied voltage, current source, phase value	kV	34,0
Charging voltage capacitor bank, DC value	kVd.c.	140
Breaking current, symmetrical, phase value	kA	36,2
Breaking current, DC-component	%	1
di/dt at last current zero	A/μs	16,0
TRV, first line-side peak (u _T), across breaker	kV	-20,4
TRV, peak u _M	kV	-163
Recovery voltage, phase value	kV	89,2
Arc duration	ms	12,9
Opening time	ms	26,6
Break time	ms	39,5
t _h	μs	346
Current last loop, peak	kA	49,8



Voltage opening coil	242 Vd.c.	Gas pressure at 20 °C	0,60 MPa
		Operating pressure	- MPa

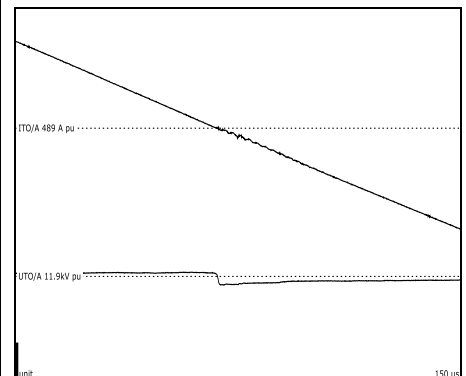
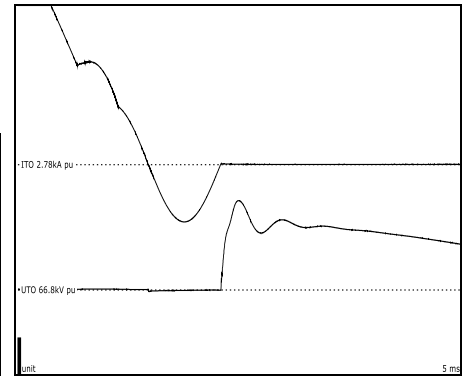
Remarks: Breaker cleared.
O_s = Operation in a synthetic circuit.

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Test number: 170504-5030

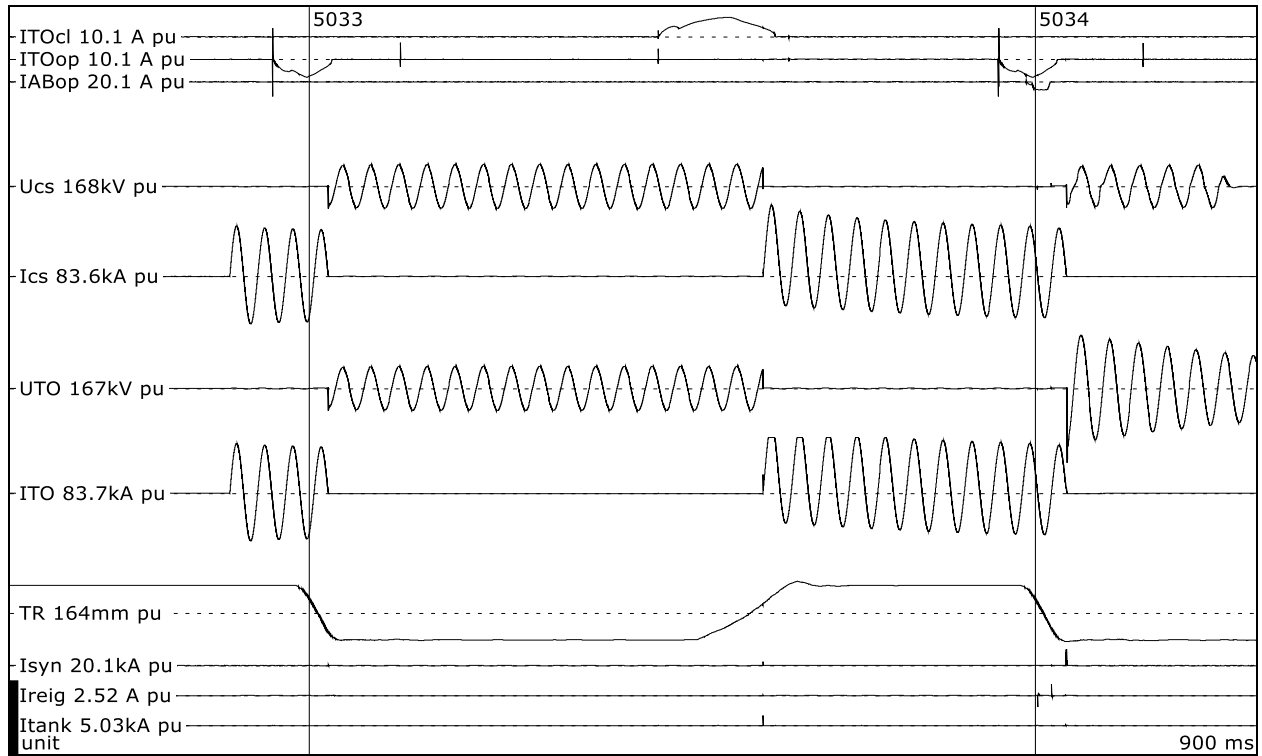
Time interval since previous test	min	-
Operation		O _S
Phase		A
Applied voltage, current source, phase value	kV	34,0
Charging voltage capacitor bank, DC value	kVd.c.	142
Breaking current, symmetrical, phase value	kA	36,3
Breaking current, DC-component	%	1
di/dt at last current zero	A/μs	16,4
TRV, first line-side peak (u _T), across breaker	kV	-
TRV, peak u _M	kV	-
Recovery voltage, phase value	kV	-
Arc duration	ms	(1)
Opening time	ms	26,6
Break time	ms	-
t _h	μs	380
Current last loop, peak	kA	49,1



Voltage opening coil	242 Vd.c.	Gas pressure at 20 °C	0,60 MPa
		Operating pressure	- MPa

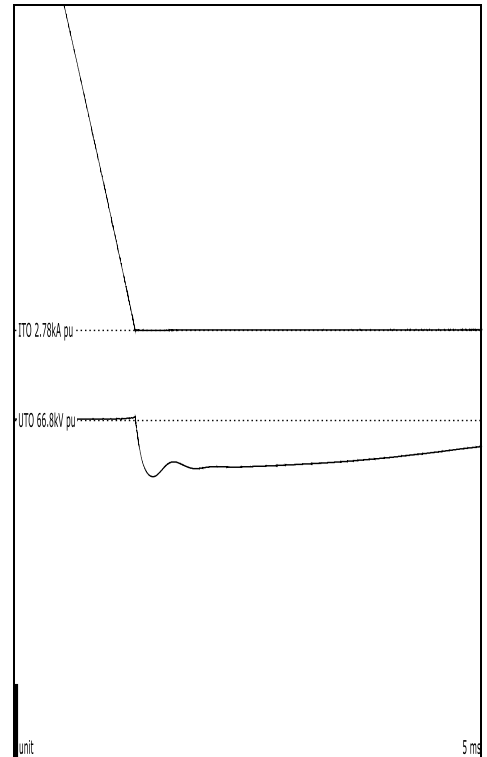
Remarks: Test to verify the correct reignition behaviour of the breaker (subclause 6.102.10 of IEC 62271-101).
 (1) Arcing time set for 11,9 ms.
 O_S = Operation in a synthetic circuit.

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Test number: 170504-5033

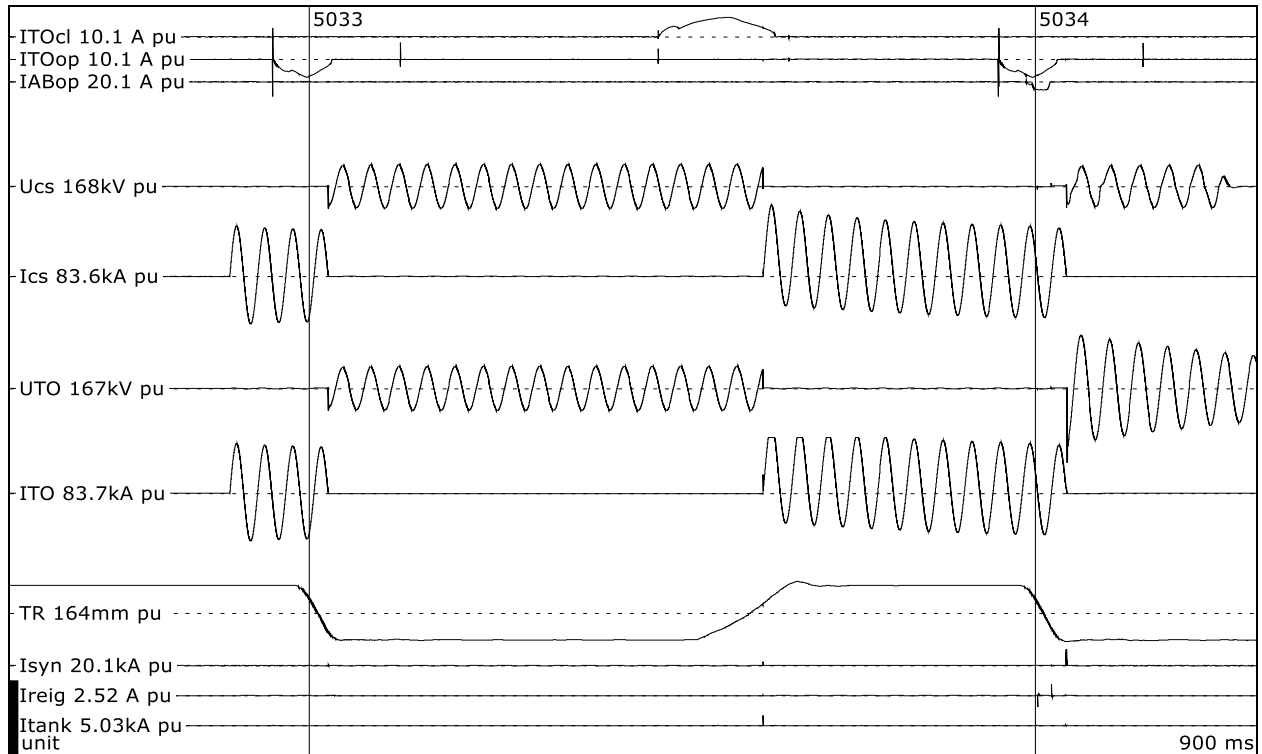
Time interval since previous test	min	-
Operation		O _D
Phase		A
Breaking current, symmetrical, phase value	kA	37,0
Breaking current, DC-component	%	2
Recovery voltage, phase value	kV	33,6
Arc duration	ms	13,4
Opening time	ms	26,5
Break time	ms	39,9



Voltage opening coil	242 Vd.c.	Gas pressure at 20 °C	0,60 MPa
		Operating pressure	- MPa

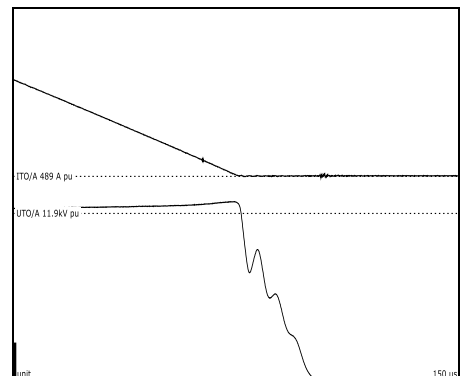
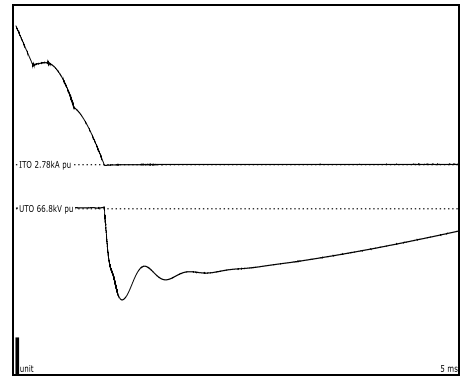
Remarks: Breaker cleared.
O_D = Operation with current source only.

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Test number: 170504-5034

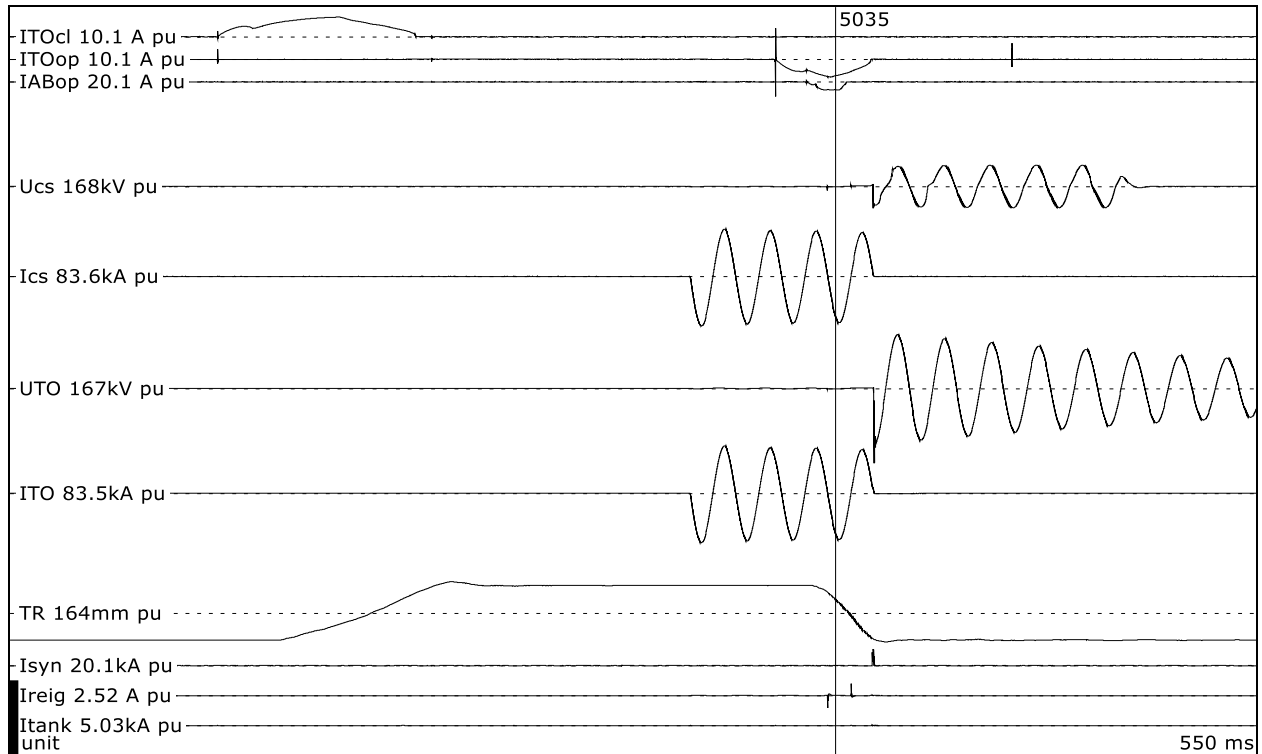
Time interval between operations	s	0,314
Operation		C _D O _S
Phase		A
Applied voltage, current source, phase value	kV	34,7
Charging voltage capacitor bank, DC value	kVd.c.	140
Making current, peak	kA	79,8
Breaking current, symmetrical, phase value	kA	36,3
Breaking current, DC-component	%	9
di/dt at last current zero	A/μs	16,2
TRV, first line-side peak (u _T), across breaker	kV	-19,0
TRV, peak u _M	kV	-165
Recovery voltage, phase value	kV	88,7
Make time	ms	75,5
Arc duration	ms	22,8
Opening time	ms	26,3
Break time	ms	49,1
t _h	μs	359
Current last loop, peak	kA	54,2



Voltage closing coil	242 Vd.c.	Gas pressure at 20 °C	0,60 MPa
Voltage opening coil	242 Vd.c.	Operating pressure	- MPa

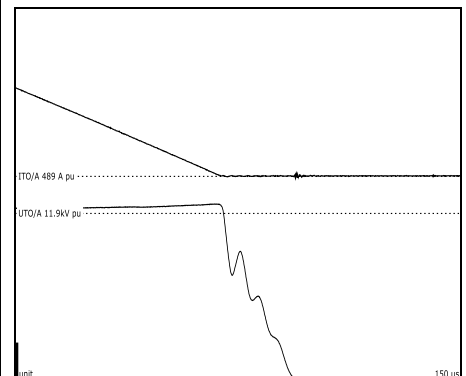
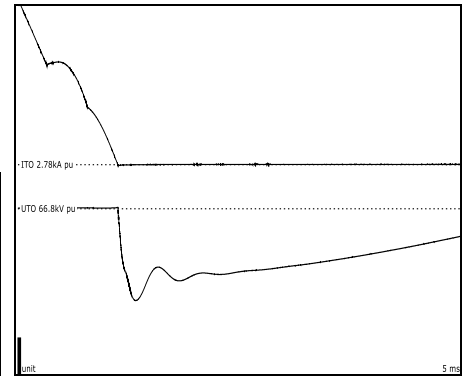
Remarks: Breaker closed and cleared.
 Voltage measurement out of range.
 C_D = Operation with current source only. O_S = Operation in a synthetic circuit.

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Test number: 170504-5035

Time interval since previous test	min	9
Operation		(C)Os
Phase		A
Charging voltage capacitor bank, DC value	kVd.c.	140
Breaking current, symmetrical, phase value	kA	36,4
Breaking current, DC-component	%	3
di/dt at last current zero	A/μs	16,1
TRV, first line-side peak (u _T), across breaker	kV	-19,9
TRV, peak u _M	kV	-168
Recovery voltage, phase value	kV	89,3
Arc duration	ms	16,9
Opening time	ms	26,5
Break time	ms	43,4
t _h	μs	344
Current last loop, peak	kA	48,8



Voltage closing coil	242 Vd.c.	Gas pressure at 20 °C	0,60 MPa
Voltage opening coil	242 Vd.c.	Operating pressure	- MPa

Remarks: Breaker closed in no-load and cleared.
Os = Operation in a synthetic circuit.

8 VOLTAGE TESTS AS A CONDITION CHECK

Standard and date

Standard	IEC 62271-100
Test date	5 May 2017

8.1 Condition before test

Breaker (Serial No 17101) in same condition.

Pole A under test.

Enclosure earthed via a CT.

Tests 170505-5003 to 5016:

Voltage applied to moving contact of pole A.

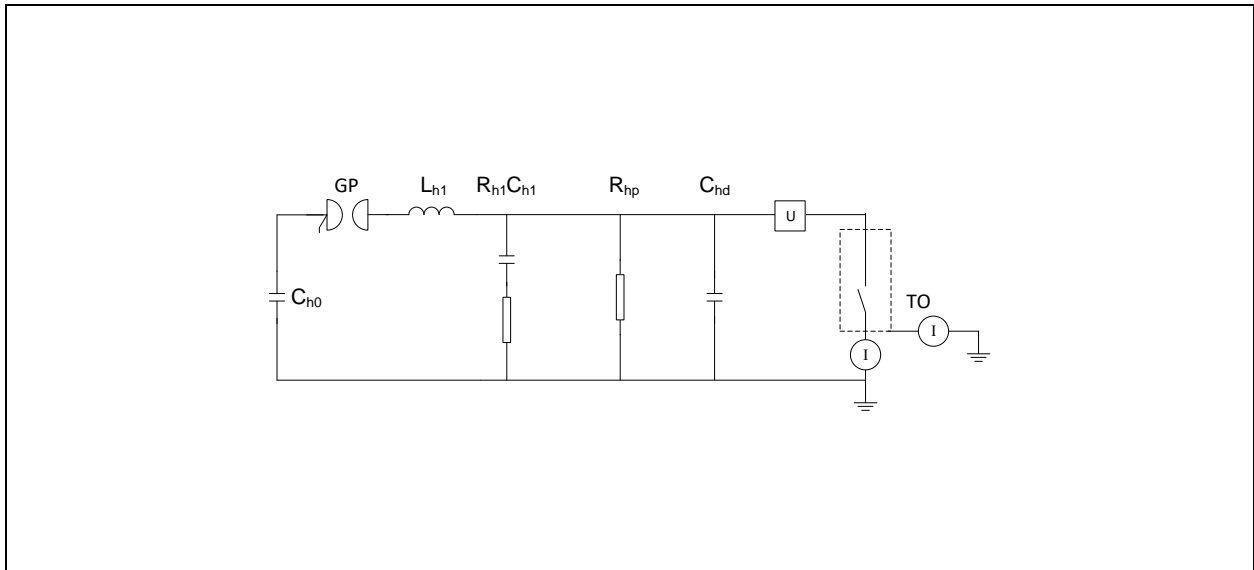
Fixed contact earthed via a CT.

Tests 170505-5017 to 5027:

Voltage applied to fixed contact of pole A.

Moving contact earthed via a CT.

8.2 Test circuit S06



GP = Gap U = Voltage Measurement to earth
 L = Reactor I = Current Measurement
 R = Resistor TO = Test Object
 C = Capacitor GP = Gap

Voltage source		
C _{h0}	μF	2,70
U _{h0}	kVd.c.	253
L _{h1}	mH	16,0
f _h	Hz	732
R _{h1}	kΩ	3,20
C _{h1}	μF	0,50
C _{hd}	nF	12,9
R _{hc}	Ω	-
C _{hc}	nF	-
R _{hp}	kΩ	12,0

Prospective TRV		
u ₁	kV	-
u _c	kV	390
t _d	μs	6,00
t ₁	μs	-
t ₃	μs	39,0
Rate of rise	kV/μs	10,0

Remarks: -

8.3 Test results and oscillograms

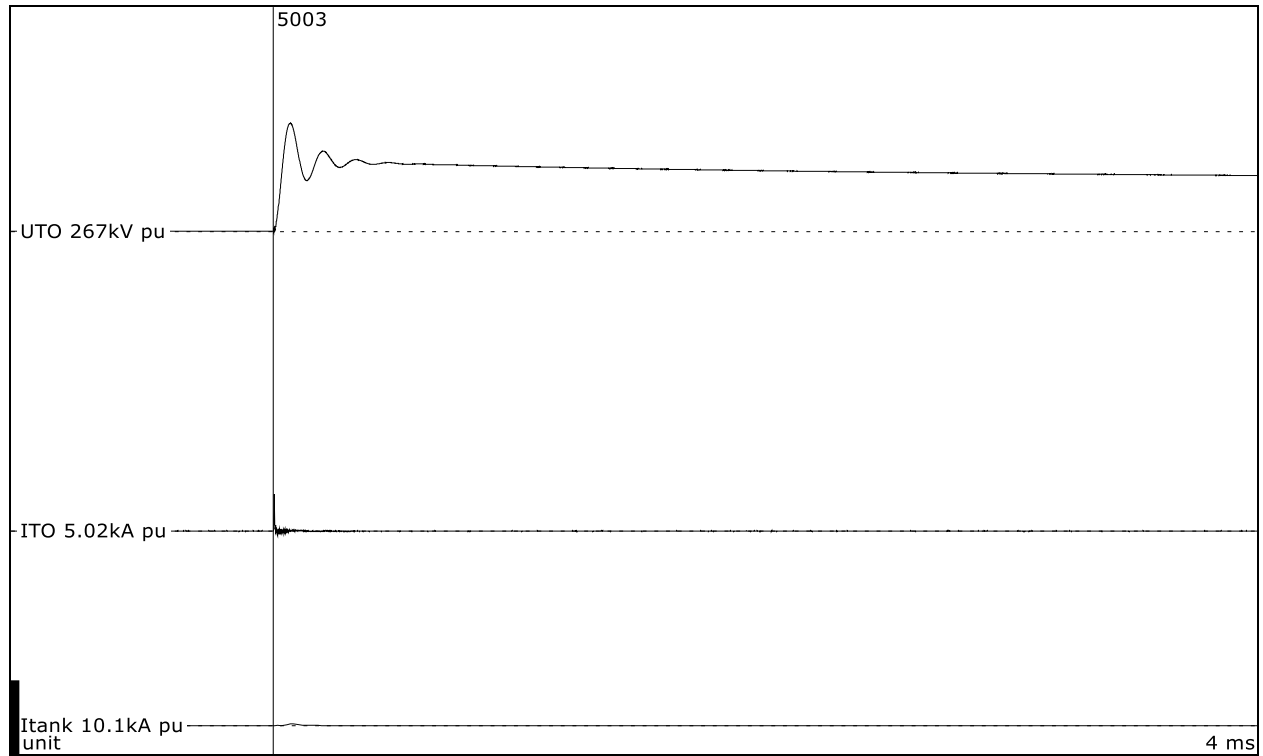
Overview of test numbers

170505-5003 to 5007, 5010 to 5014, 5016 to 5020, 5023 to 5027

Remarks

-

Voltage test as a condition check



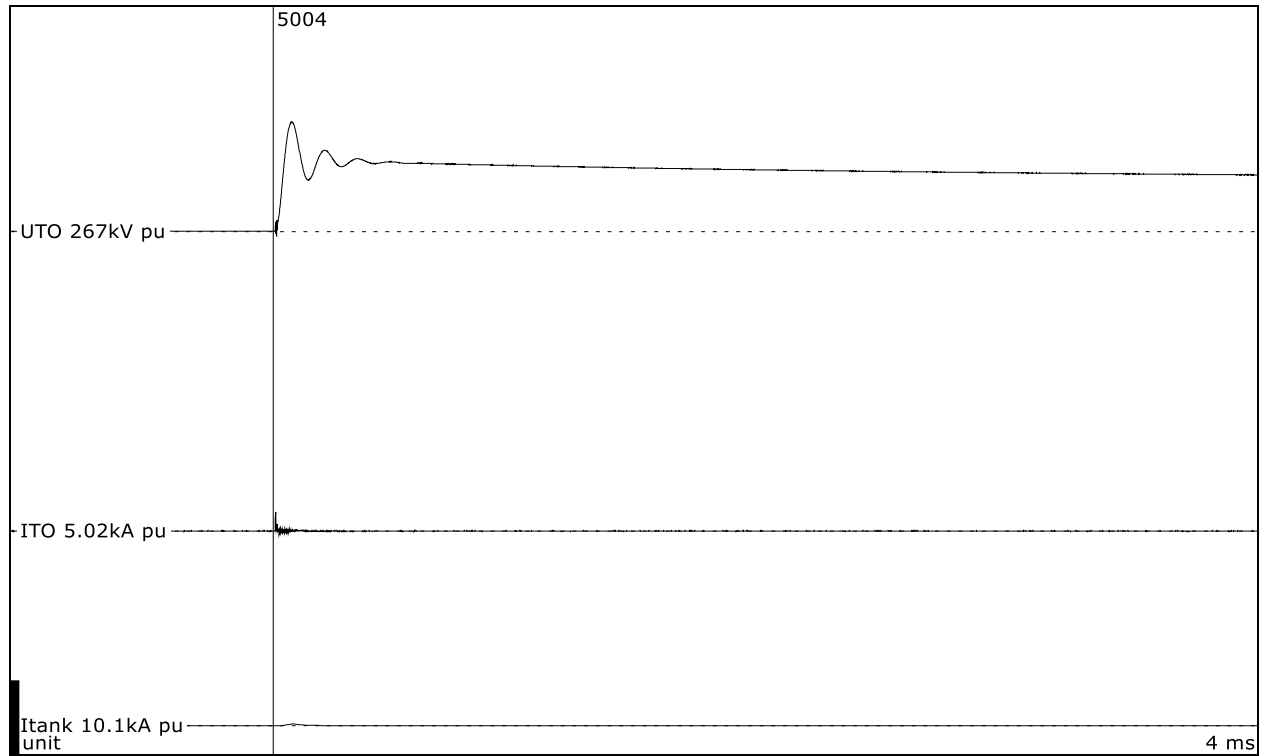
Test number: 170505-5003

Phase		A
Charging voltage capacitor bank	kVd.c.	248
Peak voltage, test object	kV	386

Gas pressure at 20 °C 0,60 MPa

Remarks: Breaker withstood the test voltage.

Voltage test as a condition check



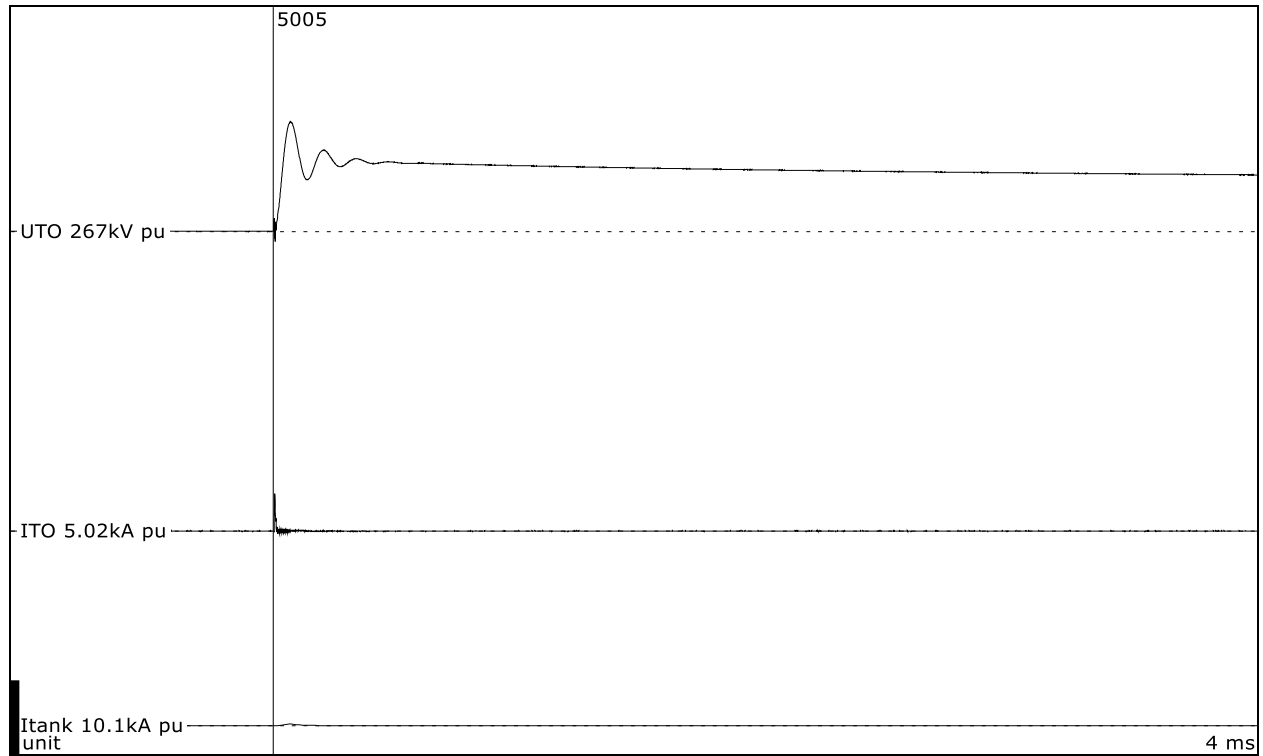
Test number: 170505-5004

Phase	A	
Charging voltage capacitor bank	kVd.c.	251
Peak voltage, test object	kV	390

Gas pressure at 20 °C 0,60 MPa

Remarks: Breaker withstood the test voltage.

Voltage test as a condition check



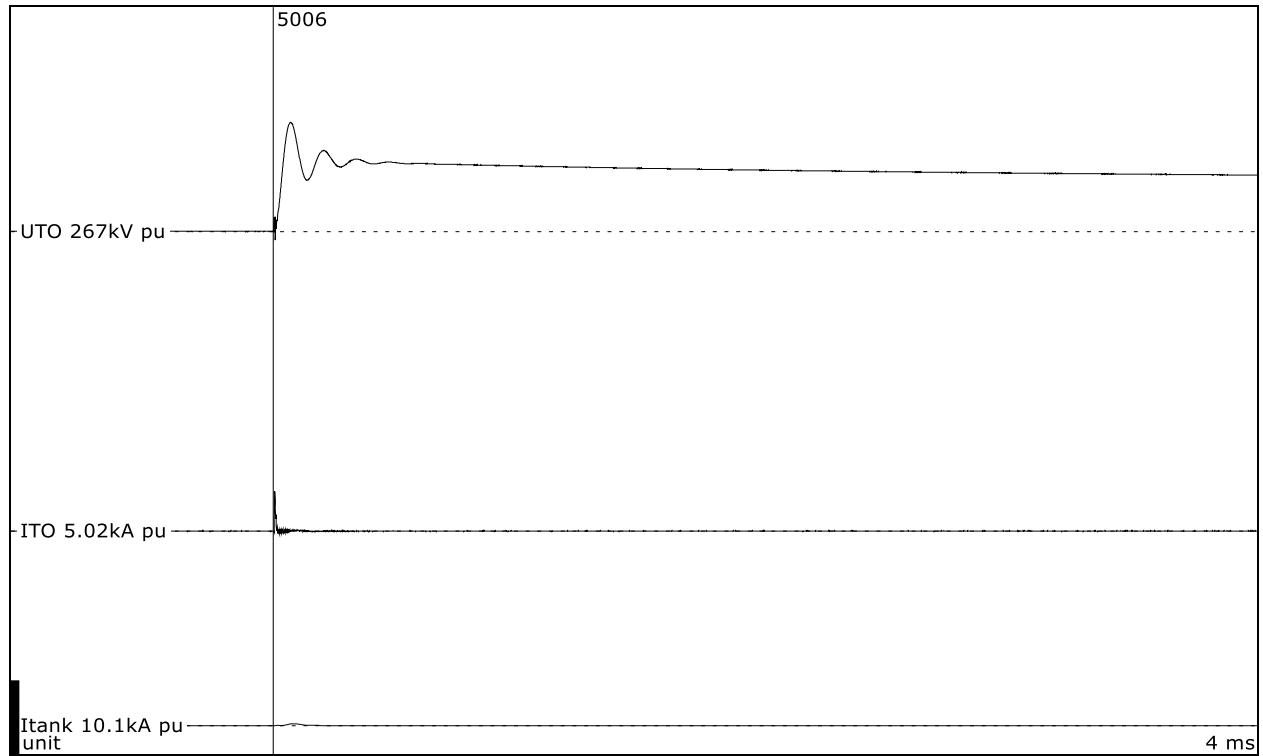
Test number: 170505-5005

Phase		A
Charging voltage capacitor bank	kVd.c.	251
Peak voltage, test object	kV	391

Gas pressure at 20 °C 0,60 MPa

Remarks: Breaker withstood the test voltage.

Voltage test as a condition check



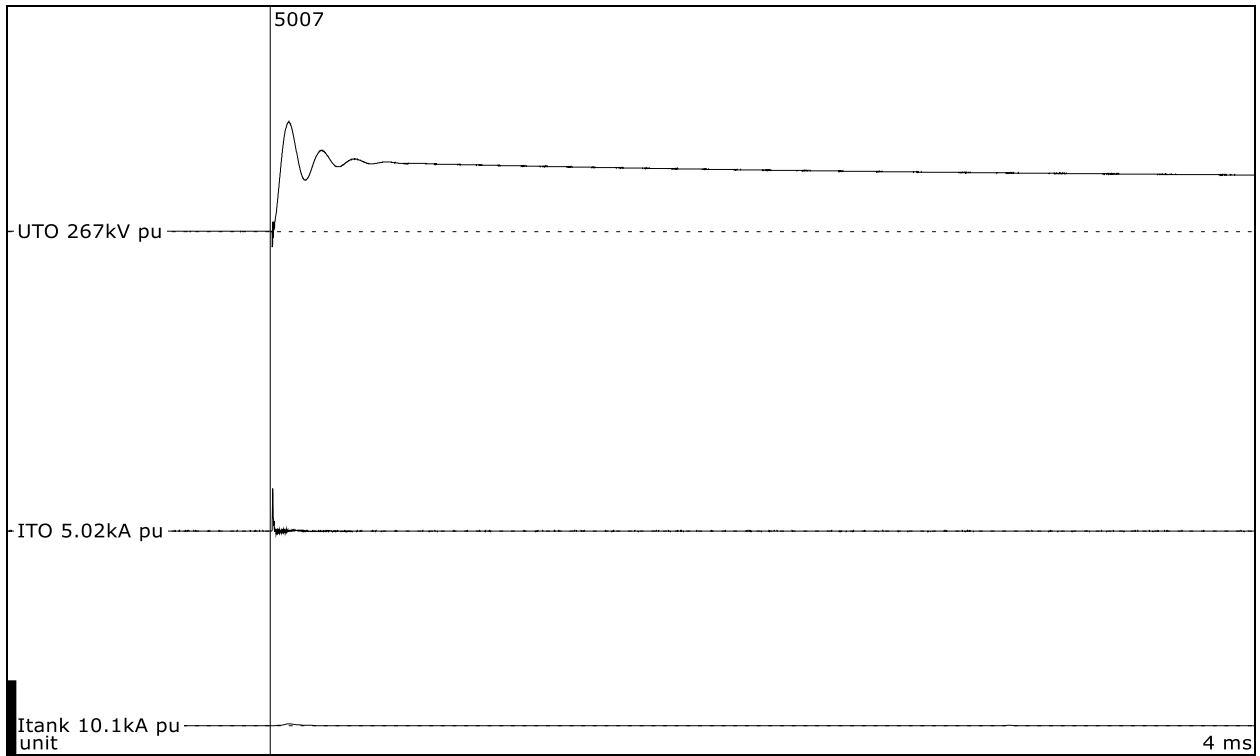
Test number: 170505-5006

Phase		A
Charging voltage capacitor bank	kVd.c.	250
Peak voltage, test object	kV	389

Gas pressure at 20 °C 0,60 MPa

Remarks: Breaker withstood the test voltage.

Voltage test as a condition check



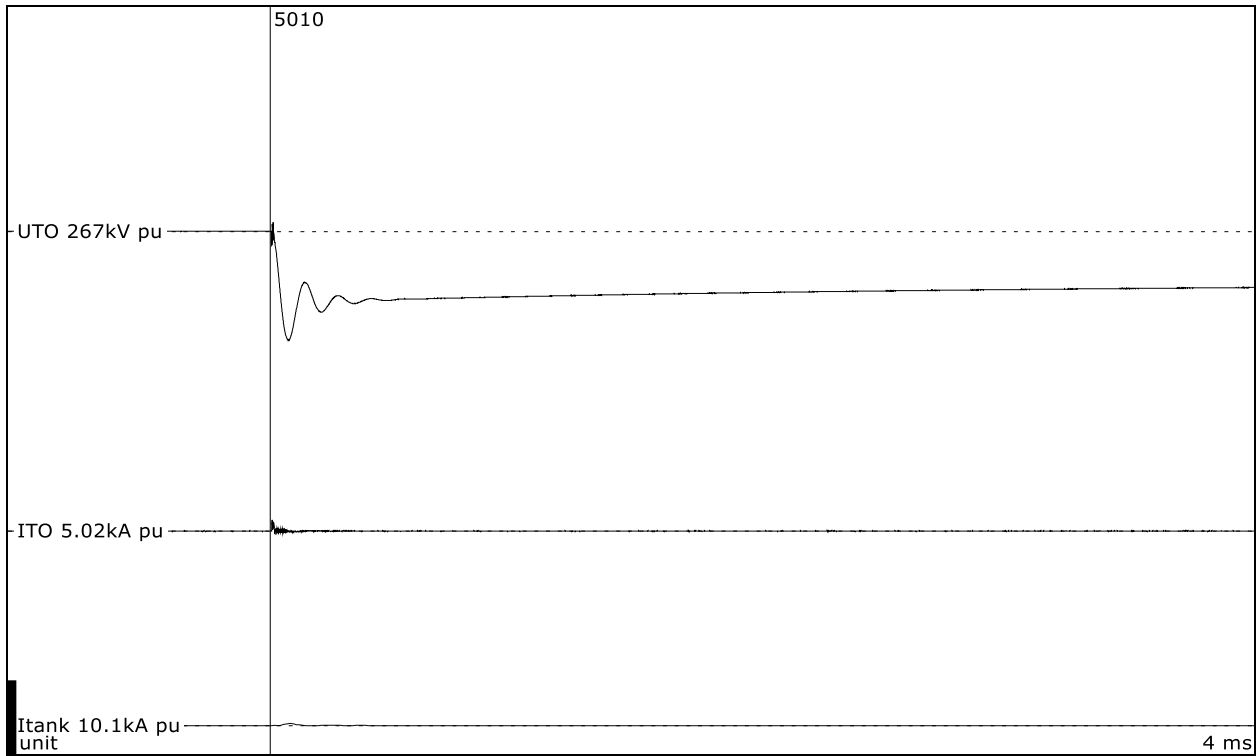
Test number: 170505-5007

Phase	A	
Charging voltage capacitor bank	kVd.c.	251
Peak voltage, test object	kV	390

Gas pressure at 20 °C 0,60 MPa

Remarks: Breaker withstood the test voltage.

Voltage test as a condition check



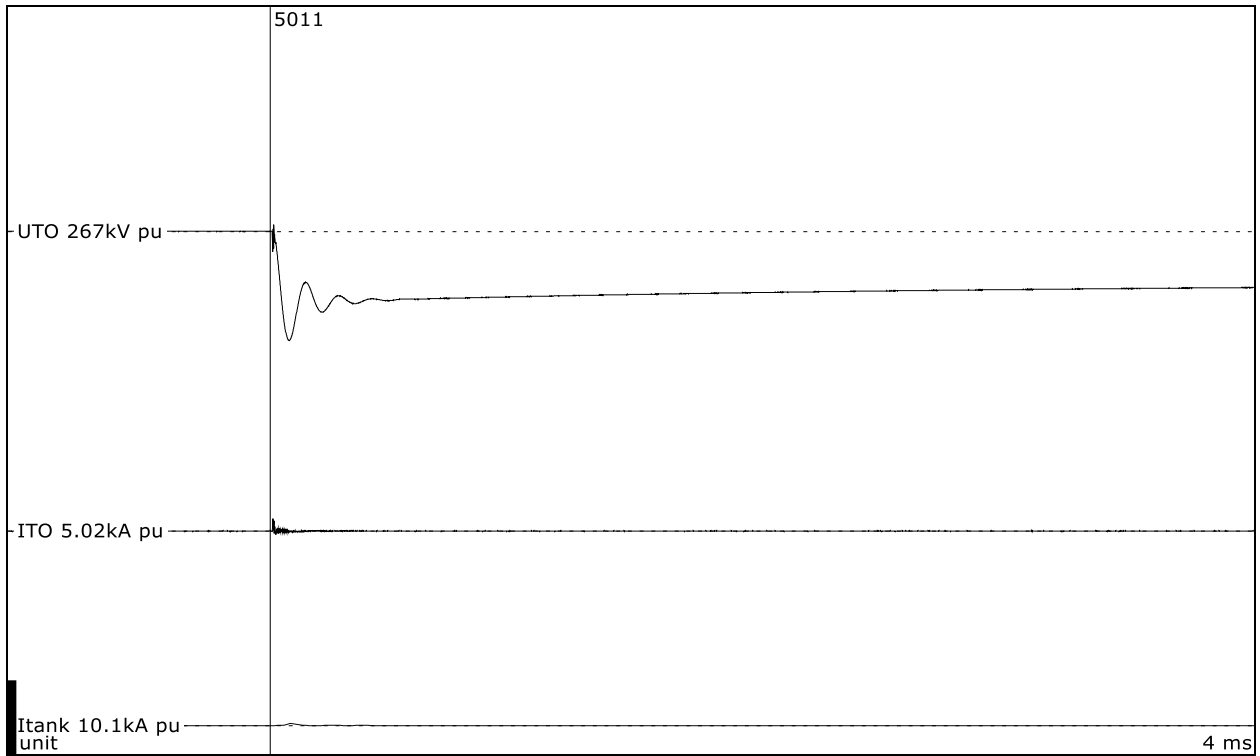
Test number: 170505-5010

Phase		A
Charging voltage capacitor bank	kVd.c.	-251
Peak voltage, test object	kV	-388

Gas pressure at 20 °C 0,60 MPa

Remarks: Breaker withstood the test voltage.

Voltage test as a condition check



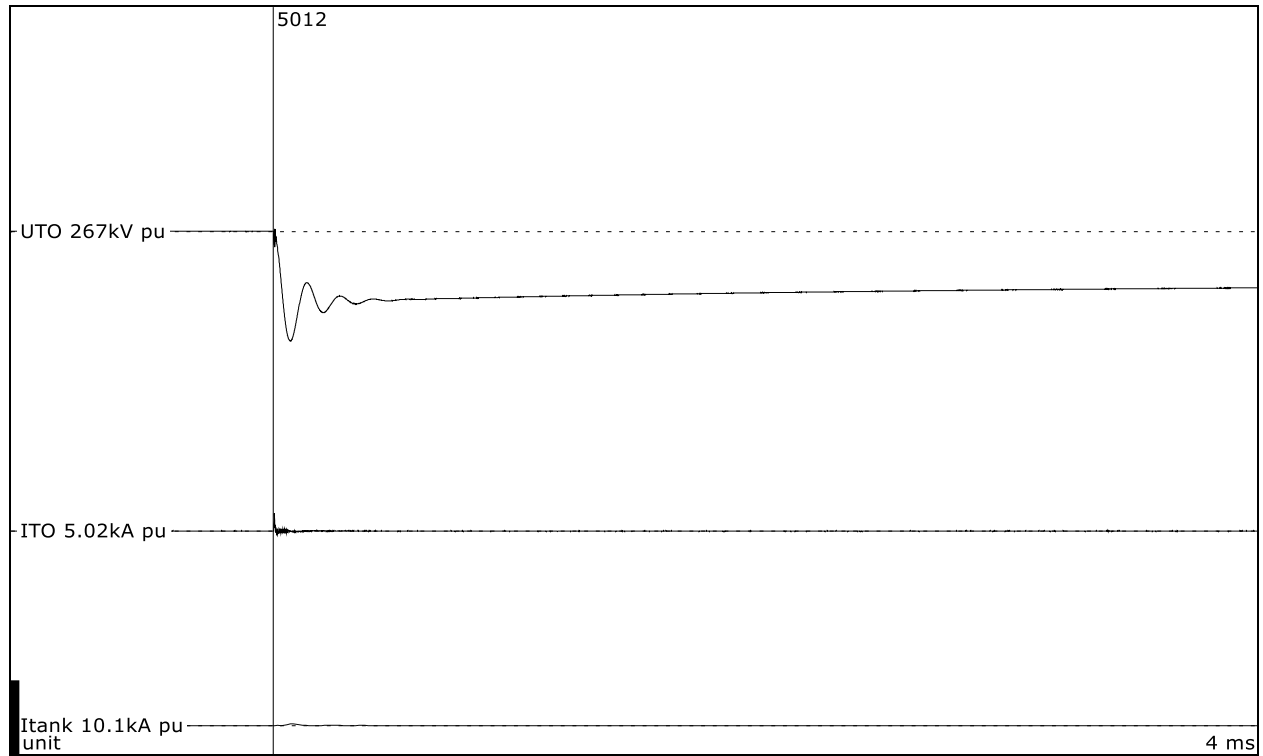
Test number: 170505-5011

Phase		A
Charging voltage capacitor bank	kVd.c.	-251
Peak voltage, test object	kV	-390

Gas pressure at 20 °C 0,60 MPa

Remarks: Breaker withstood the test voltage.

Voltage test as a condition check



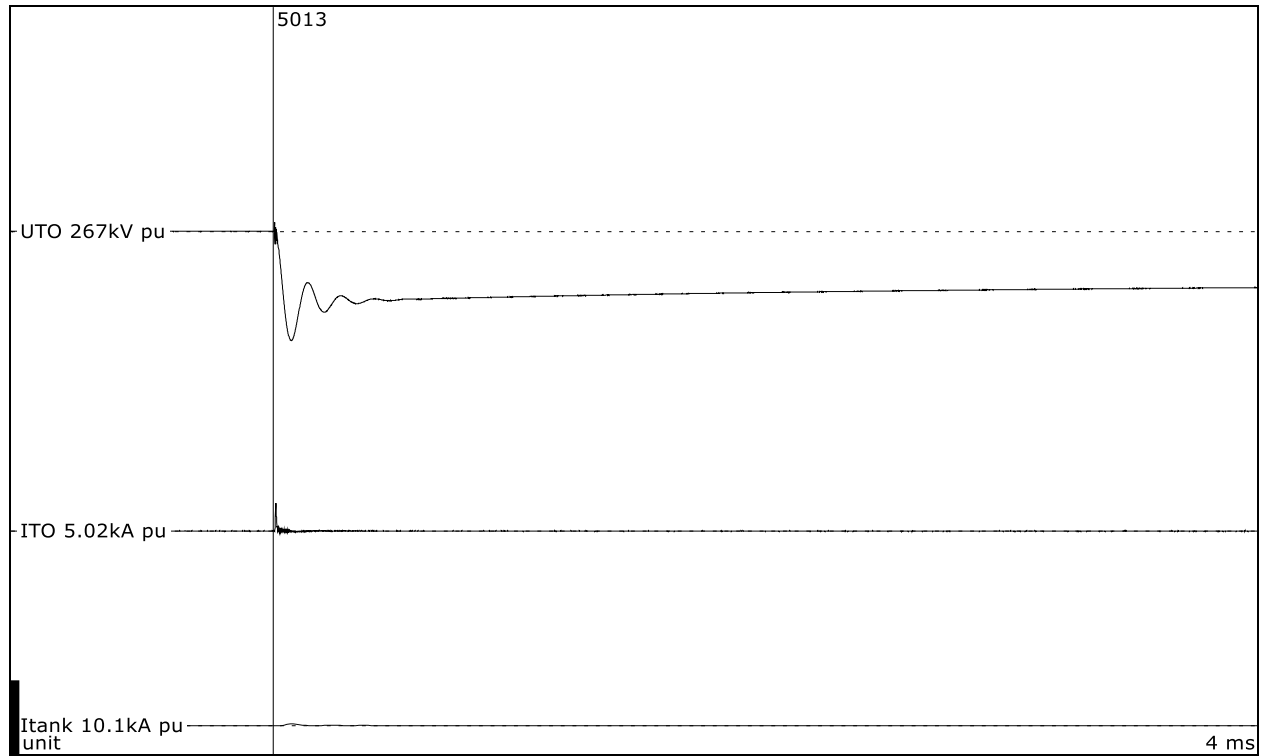
Test number: 170505-5012

Phase		A
Charging voltage capacitor bank	kVd.c.	-252
Peak voltage, test object	kV	-391

Gas pressure at 20 °C 0,60 MPa

Remarks: Breaker withstood the test voltage.

Voltage test as a condition check



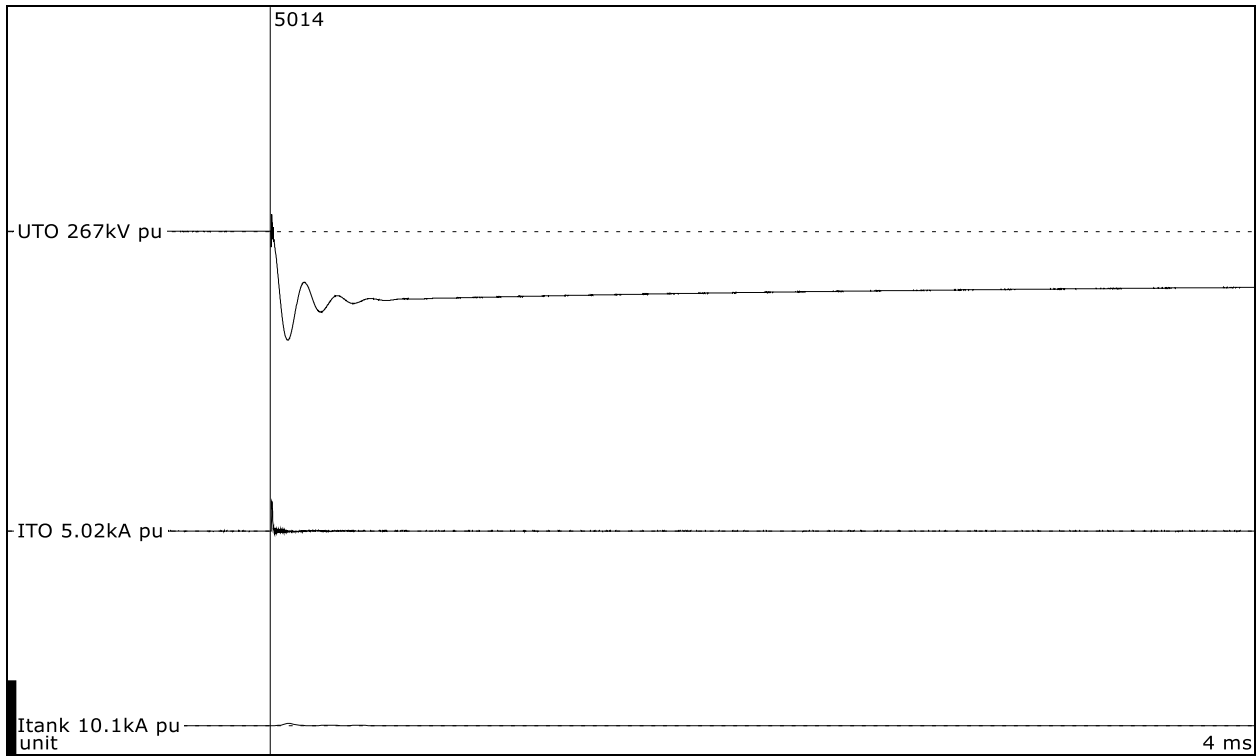
Test number: 170505-5013

Phase		A
Charging voltage capacitor bank	kVd.c.	-252
Peak voltage, test object	kV	-389

Gas pressure at 20 °C 0,60 MPa

Remarks: Breaker withstood the test voltage.

Voltage test as a condition check



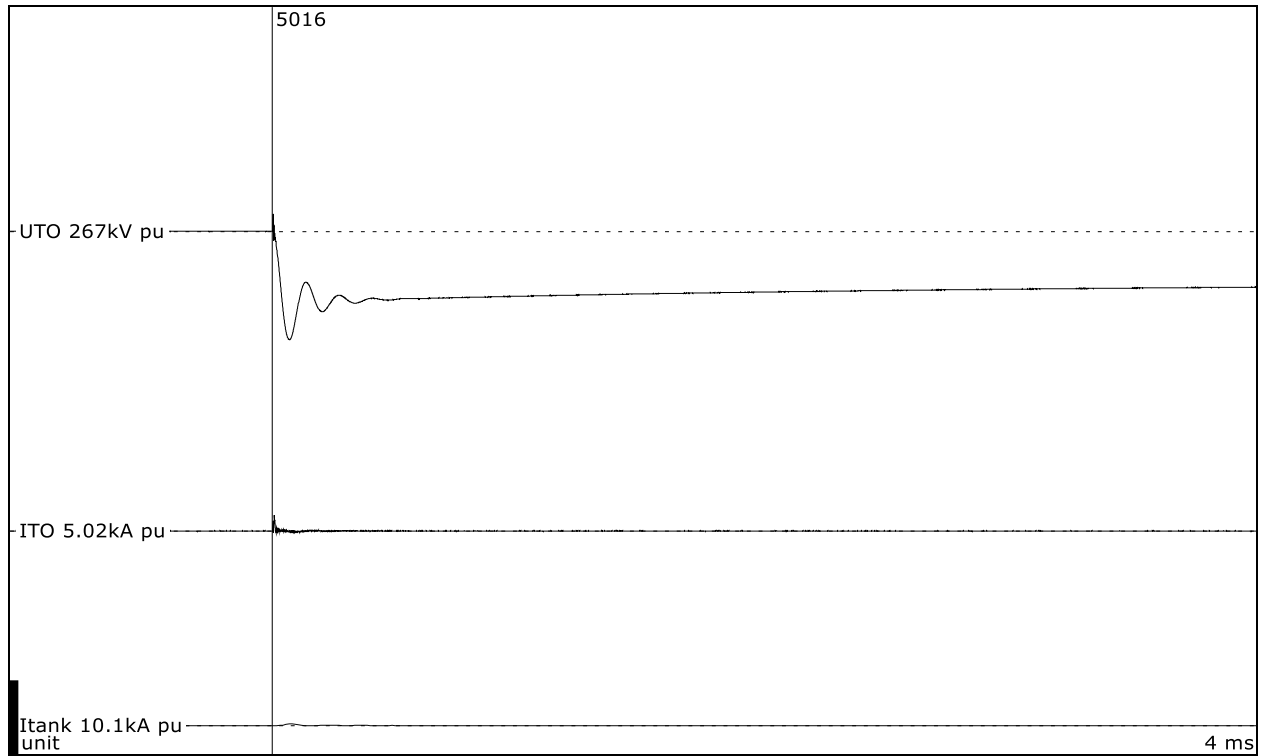
Test number: 170505-5014

Phase		A
Charging voltage capacitor bank	kVd.c.	-252
Peak voltage, test object	kV	-388

Gas pressure at 20 °C 0,60 MPa

Remarks: Breaker withstood the test voltage.

Voltage test as a condition check



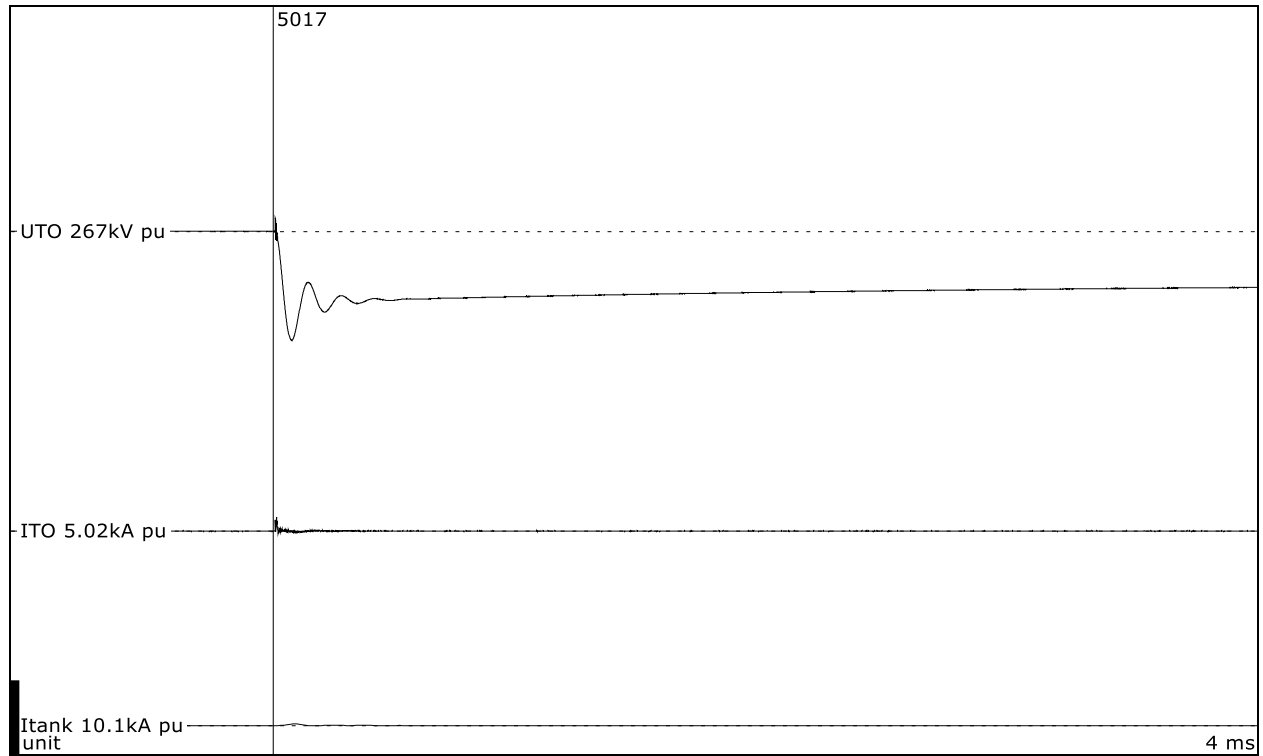
Test number: 170505-5016

Phase		A
Charging voltage capacitor bank	kVd.c.	-249
Peak voltage, test object	kV	-386

Gas pressure at 20 °C 0,60 MPa

Remarks: Breaker withstood the test voltage.

Voltage test as a condition check



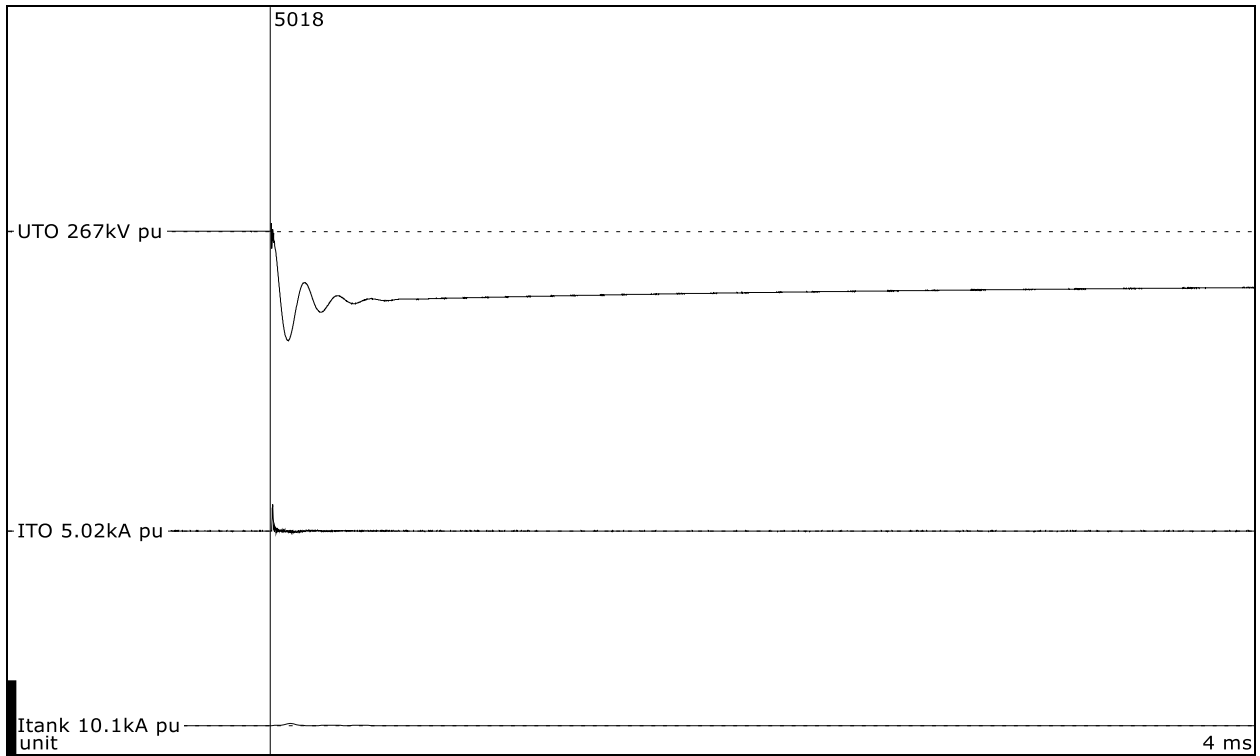
Test number: 170505-5017

Phase		A
Charging voltage capacitor bank	kVd.c.	-251
Peak voltage, test object	kV	-388

Gas pressure at 20 °C 0,60 MPa

Remarks: Breaker withstood the test voltage.

Voltage test as a condition check



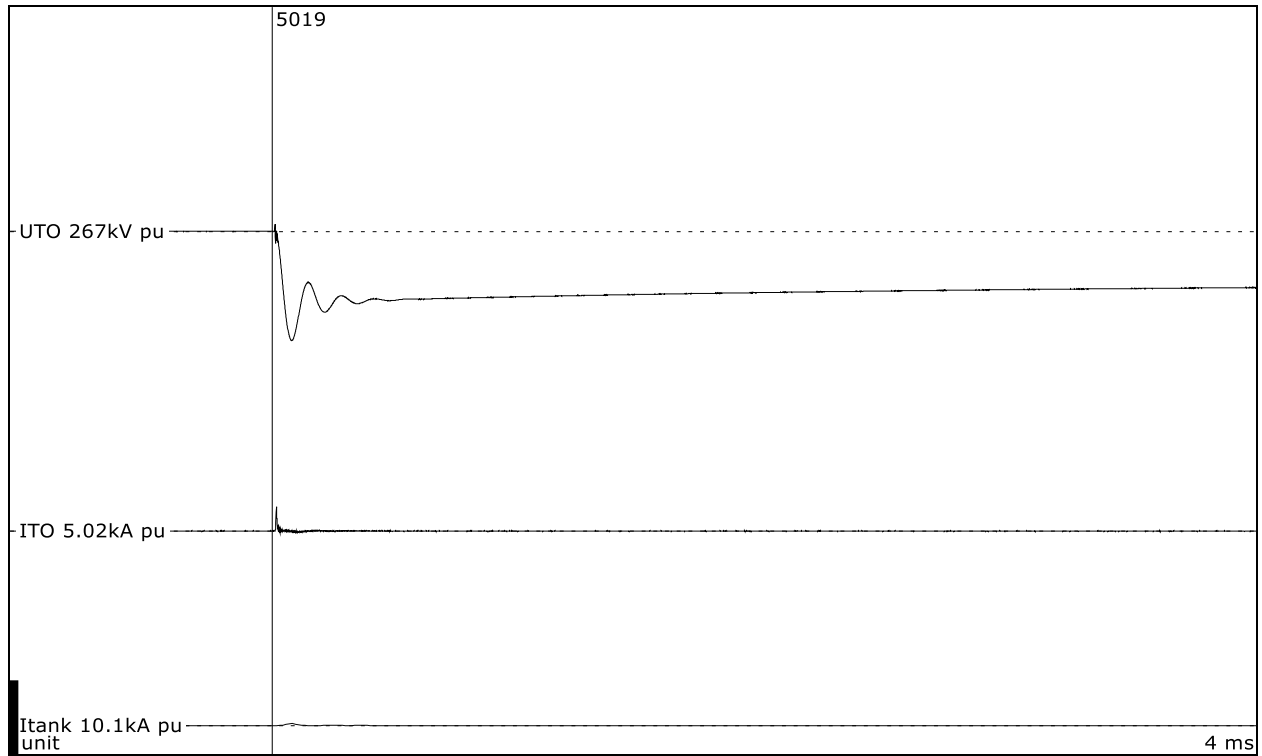
Test number: 170505-5018

Phase		A
Charging voltage capacitor bank	kVd.c.	-251
Peak voltage, test object	kV	-389

Gas pressure at 20 °C 0,60 MPa

Remarks: Breaker withstood the test voltage.

Voltage test as a condition check



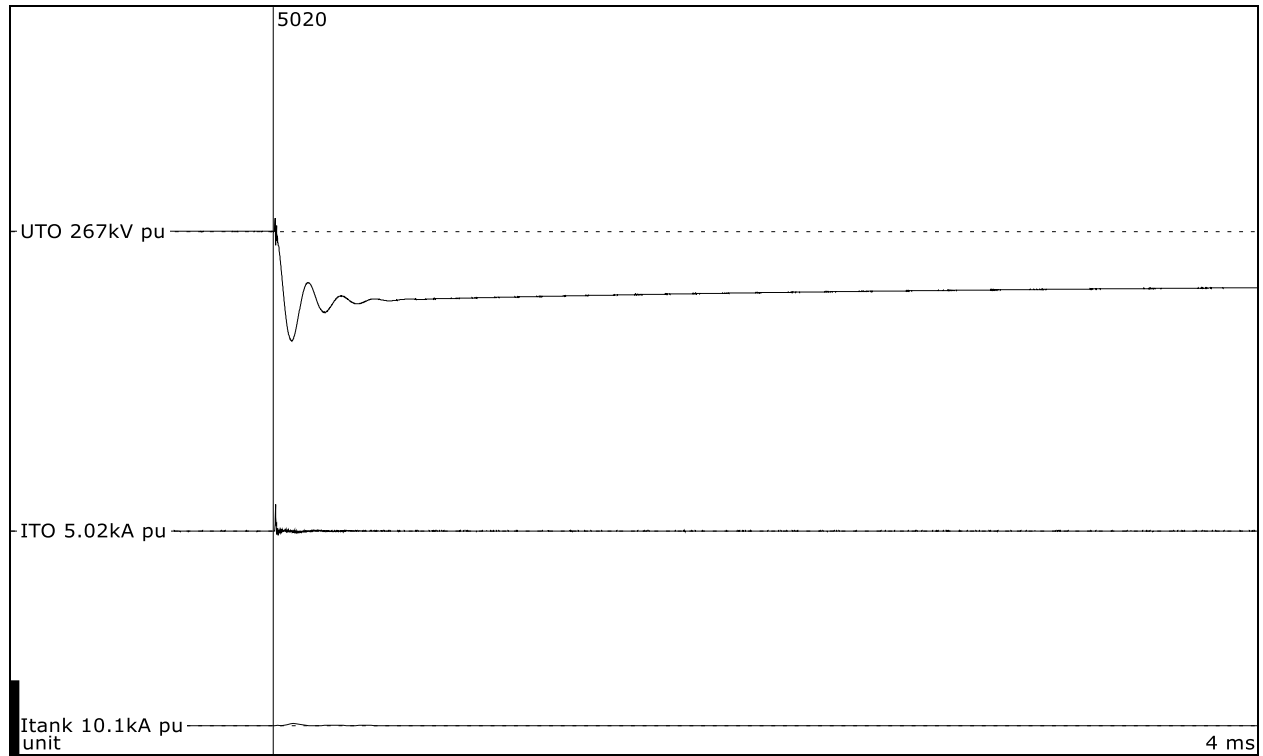
Test number: 170505-5019

Phase		A
Charging voltage capacitor bank	kVd.c.	-252
Peak voltage, test object	kV	-390

Gas pressure at 20 °C 0,60 MPa

Remarks: Breaker withstood the test voltage.

Voltage test as a condition check



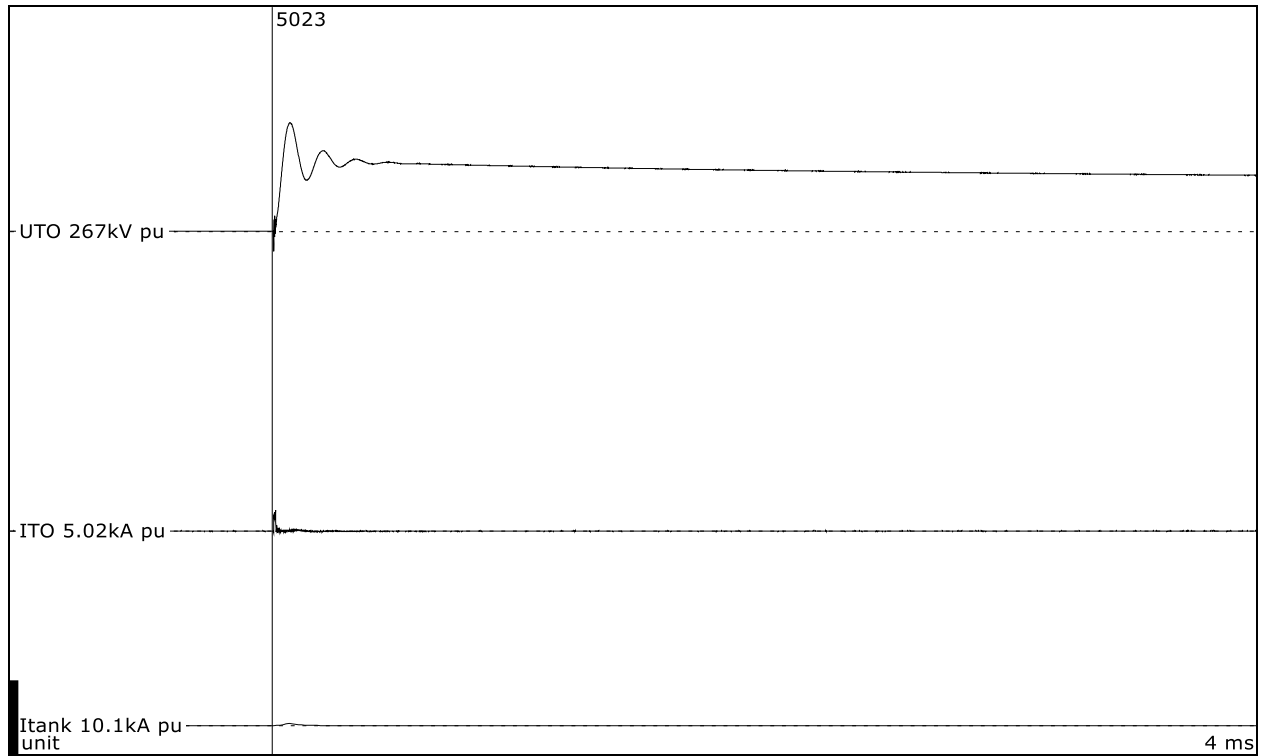
Test number: 170505-5020

Phase		A
Charging voltage capacitor bank	kVd.c.	-252
Peak voltage, test object	kV	-390

Gas pressure at 20 °C 0,60 MPa

Remarks: Breaker withstood the test voltage.

Voltage test as a condition check



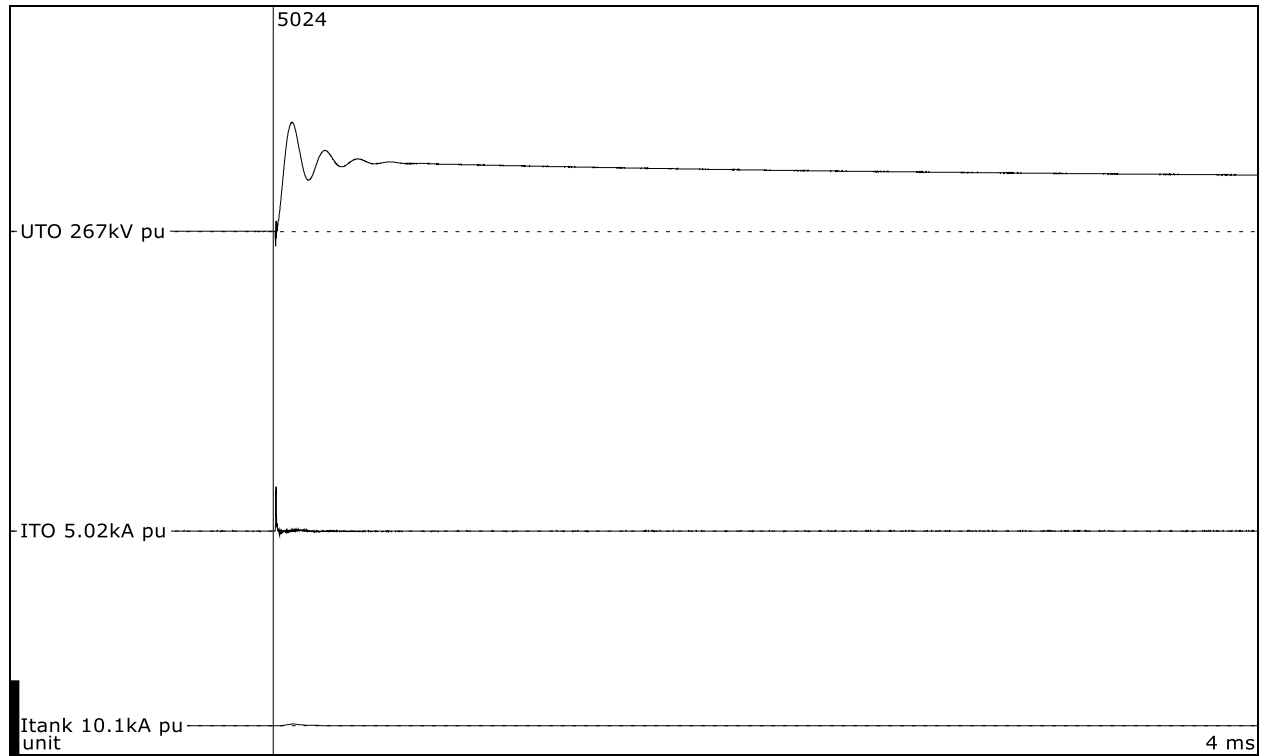
Test number: 170505-5023

Phase		A
Charging voltage capacitor bank	kVd.c.	250
Peak voltage, test object	kV	388

Gas pressure at 20 °C 0,60 MPa

Remarks: Breaker withstood the test voltage.

Voltage test as a condition check



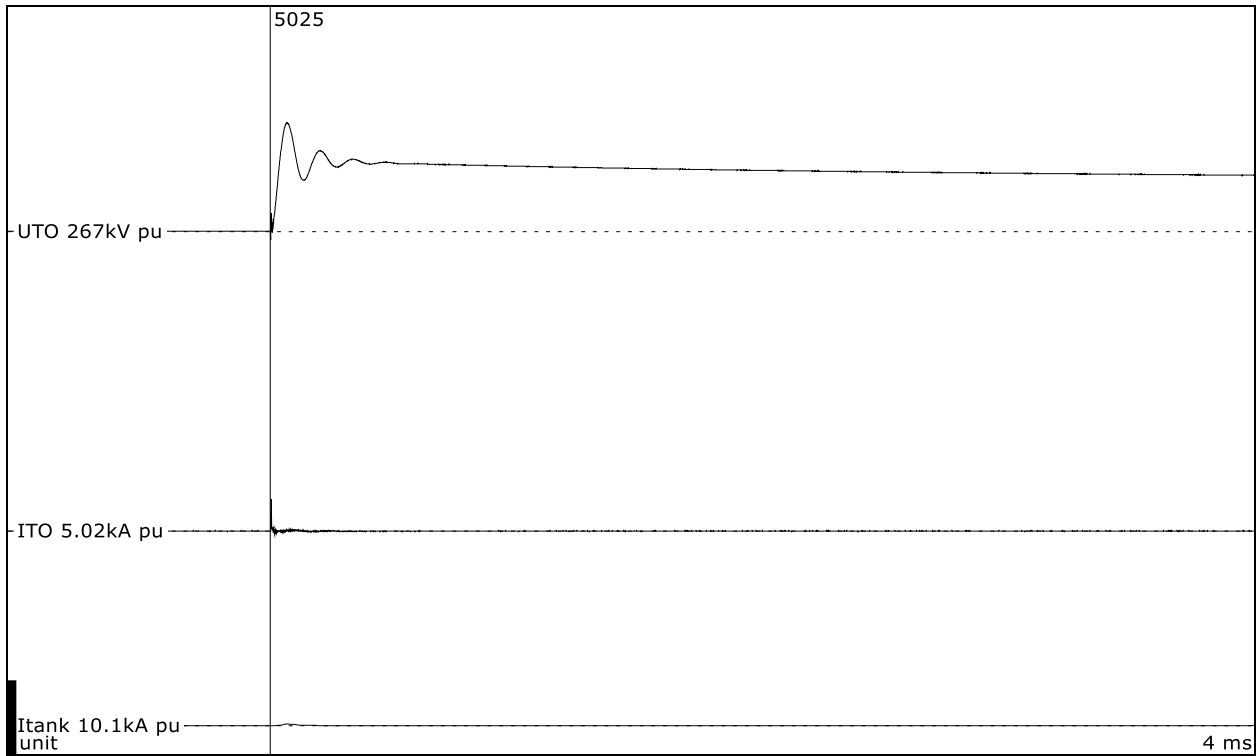
Test number: 170505-5024

Phase		A
Charging voltage capacitor bank	kVd.c.	251
Peak voltage, test object	kV	389

Gas pressure at 20 °C 0,60 MPa

Remarks: Breaker withstood the test voltage.

Voltage test as a condition check



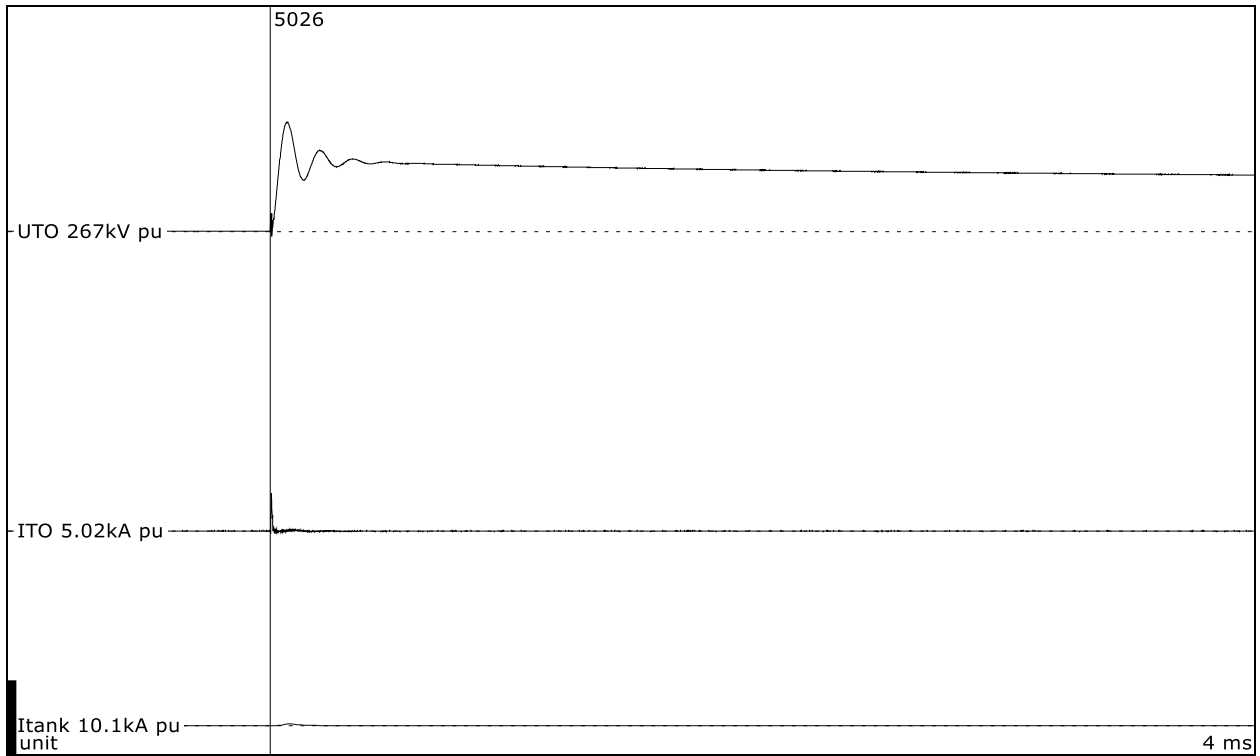
Test number: 170505-5025

Phase		A
Charging voltage capacitor bank	kVd.c.	250
Peak voltage, test object	kV	388

Gas pressure at 20 °C 0,60 MPa

Remarks: Breaker withstood the test voltage.

Voltage test as a condition check



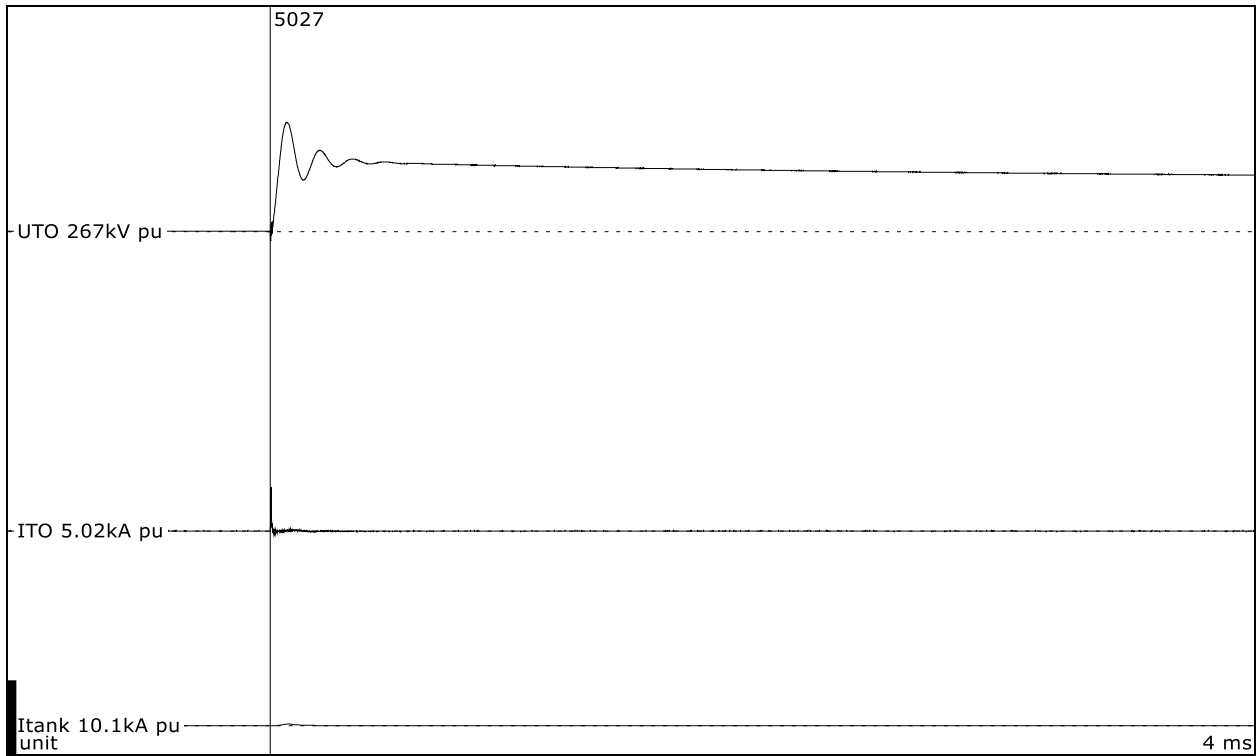
Test number: 170505-5026

Phase		A
Charging voltage capacitor bank	kVd.c.	251
Peak voltage, test object	kV	390

Gas pressure at 20 °C 0,60 MPa

Remarks: Breaker withstood the test voltage.

Voltage test as a condition check



Test number: 170505-5027

Phase		A
Charging voltage capacitor bank	kVd.c.	251
Peak voltage, test object	kV	390

Gas pressure at 20 °C 0,60 MPa

Remarks: Breaker withstood the test voltage.

8.4 Condition / inspection after test

Externally no visible change.

Inspection of contacts:

Fixed arcing contact moderately burnt.

Moving arcing contact moderately burnt.

Fixed main contact finger tips showed locally moderate commutation marks. Silver layer on main contact area intact.

Moving main contact rim showed locally moderate commutation marks. Silver layer on main contact area intact.

Nozzle moderately eroded.

Auxiliary nozzle moderately eroded.

8.5 Photographs after test















9 L75

Standard and date

Standard	IEC 62271-100
Test date	5 May 2017

9.1 Condition before test

Breaker (Serial No 17101) in same condition.

Pole C under test.

Supply to fixed contact.

Moving contact earthed.

Frame earthed via a CT.

Auxiliary breaker:

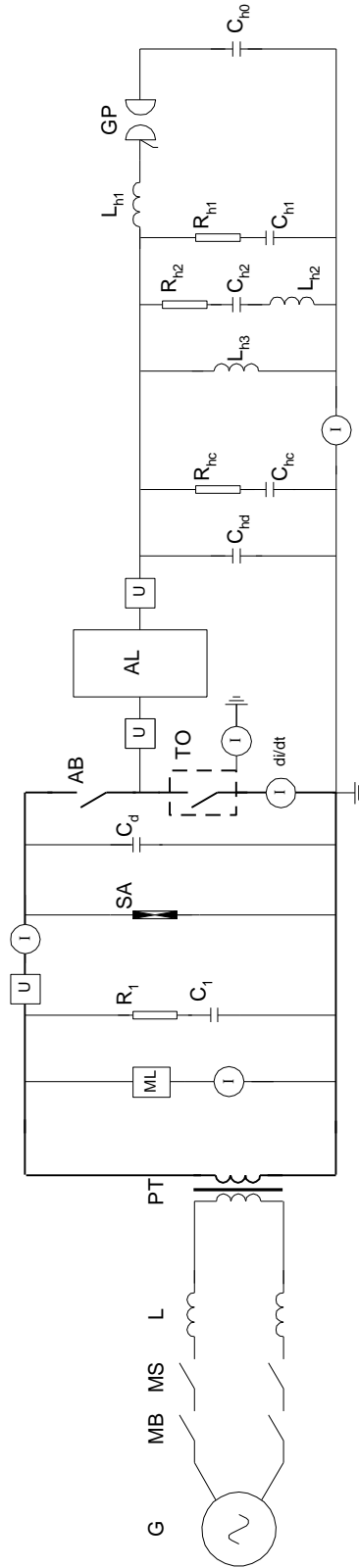
An SF₆ breaker, provided by KEMA Laboratories.

Number of elements: 1 per breaker.

9.2 Test circuit S07

Diagram

Current injection



G = Generator	L = Reactor	U = Voltage Measurement to earth	SA = Surge Arrester
MB = Master Breaker	TO = Test Object	I = Current Measurement	AB = Auxiliary Breaker
MS = Make Switch	R = Resistor	AL = Artificial line	GP = Gap
PT = Power Transformer	C = Capacitor	ML = Multi-loop device	

Values

Supply		
Power	MVA	1080
Frequency	Hz	50
Phase(s)		1
Voltage	kV	36,0
Current	kA	30,0
Impedance	Ω	1,20
Power factor		< 0,1
Neutral		not earthed

Injection circuit		
C_{h0}	μF	8,00
U_{h0}	kVd.c.	132
L_{h1}	mH	6,79
f_{h1} (including AL)	Hz	571
R_{h1}	Ω	100
C_{h1}	μF	0,1
C_{hd}	nF	15
R_{hc}	Ω	111
C_{hc}	nF	25
R_{h2}	Ω	87
C_{h2}	μF	0,44
L_{h2}	mH	3,75
R_{hp}	k Ω	-
L_{h3}	H	1,20
f_{RV}	Hz	48,3

Prospective TRV		
$U_{recovery}$	kVa.c.	83,7
u_1	kV	89,0
u_c	kV	166
t_d	μs	2,00
t_1	μs	44,0
t_2	μs	178
t_3	μs	-
Rate of rise	kV/ μs	2,00

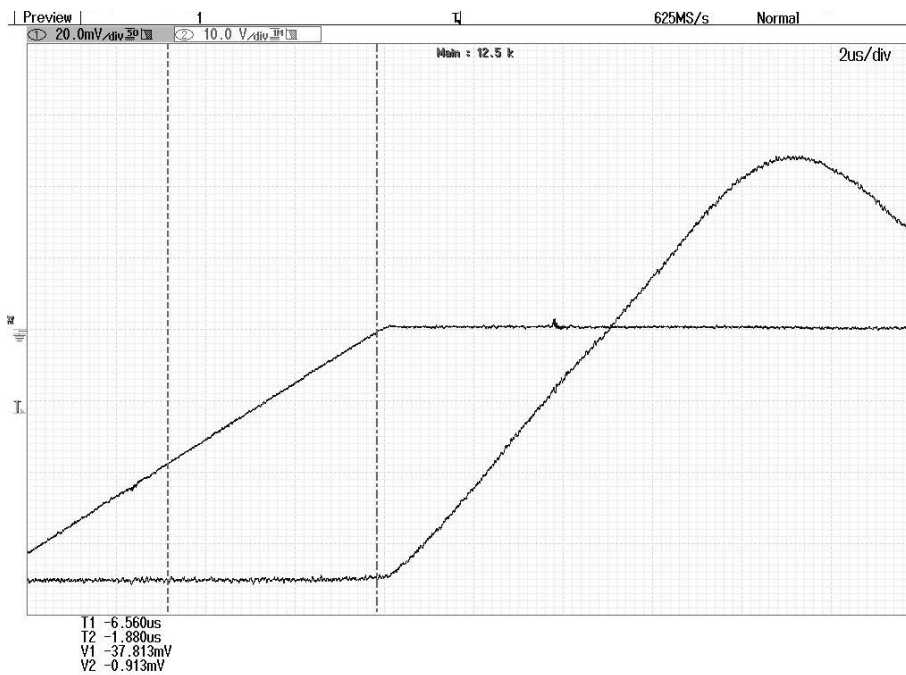
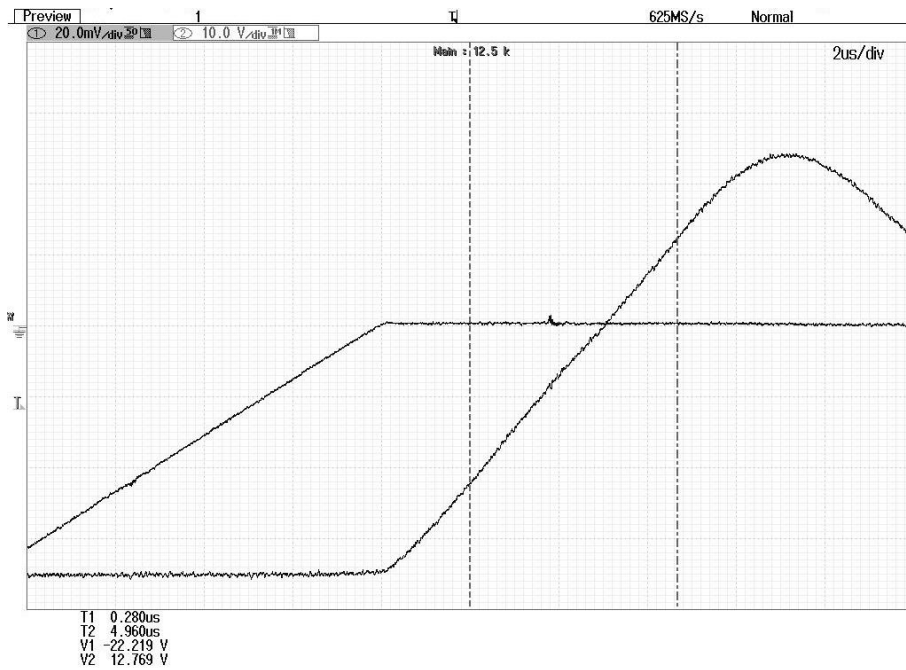
Load	
Short-circuit point	earthed

Artificial line		
I_L / I		0,76
I_L	kA	30,3
L_L	mH	2,16
Z	Ω	450
di/dt	A/ μs	13,5
du/dt	kV/ μs	6,11
u_L^*	kV	48,7
t_L	μs	7,96
t_{dL}	μs	< 0,1
C_{dL}	pF	-

TRV control elements added (supply)		
C_1	μF	0,55
R_1	Ω	72
C_d	nF	15

Remarks:

9.3 Inherent transient voltage record of artificial line



Shunt = 2,03 A/V
k = 1,70
 $t_{dL} = < 0,1 \mu s$

9.4 Test results and oscillograms

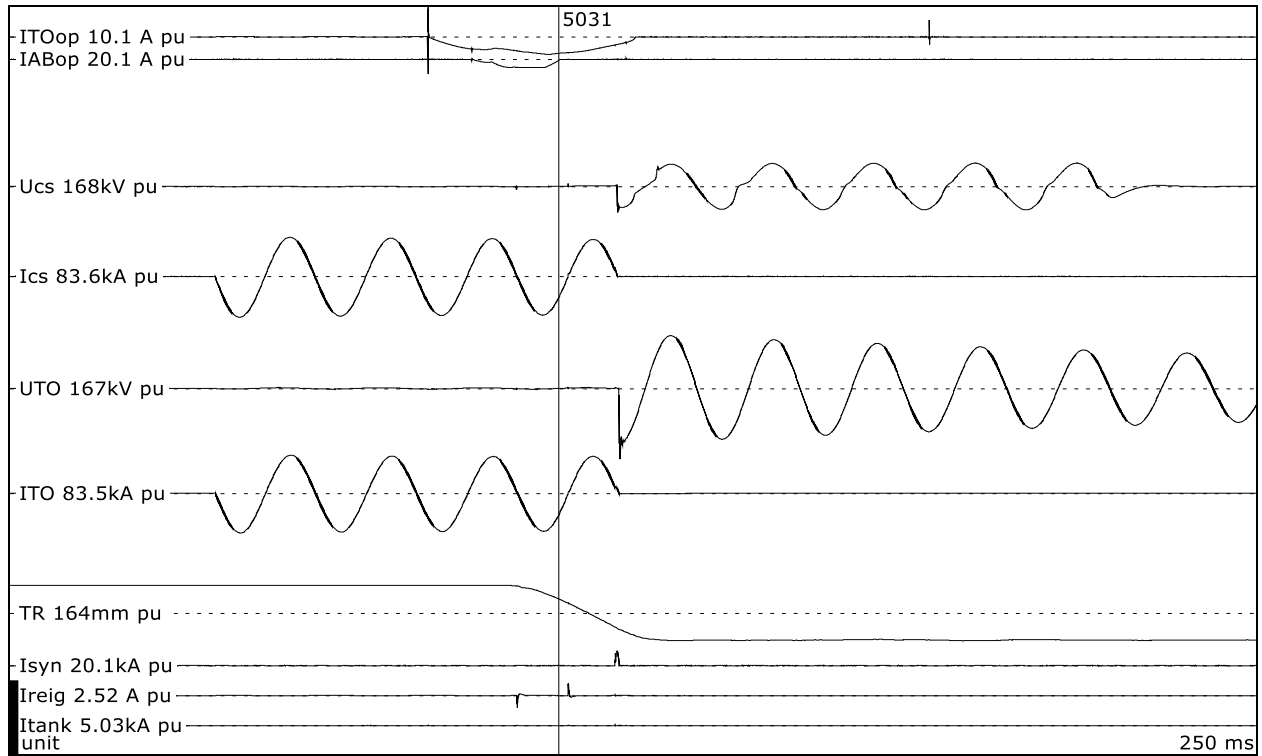
Overview of test numbers

170505-5031 to 5033, 5036 to 5038

Remarks

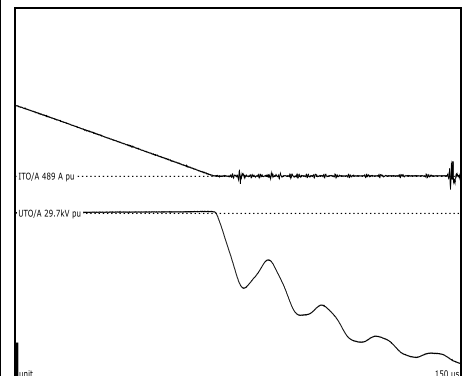
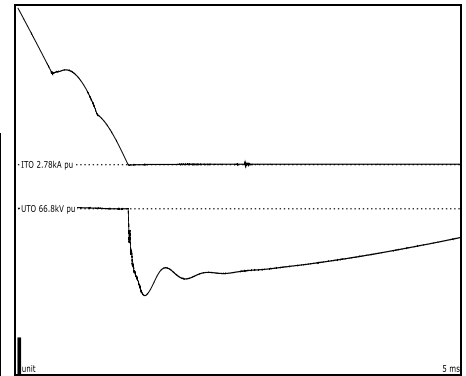
-

L75



Test number: 170505-5031

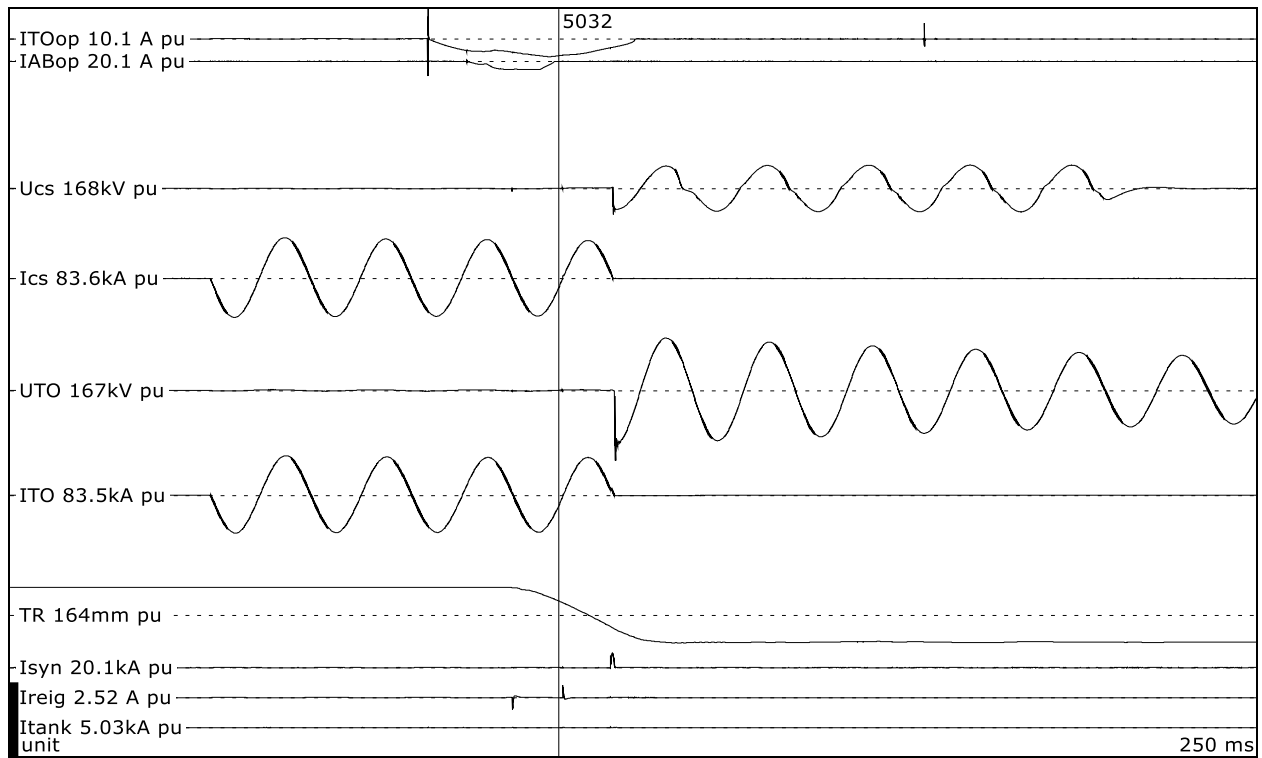
Time interval since previous test	min	-
Operation		O _s
Phase		C
Applied voltage, current source, phase value	kV	37,2
Charging voltage capacitor bank, DC value	kVd.c.	133
Breaking current, symmetrical, phase value	kA	30,3
Breaking current, DC-component	%	1
di/dt at last current zero	A/μs	13,6
TRV, first line-side peak (u _T), across breaker	kV	-60,0
TRV, peak u _M	kV	-157
Recovery voltage, phase value	kV	81,7
Arc duration	ms	12,0
Opening time	ms	26,3
Break time	ms	38,3
t _h	μs	367
Current last loop, peak	kA	41,2



Voltage opening coil	242 Vd.c.	Gas pressure at 20 °C	0,60 MPa
		Operating pressure	- MPa

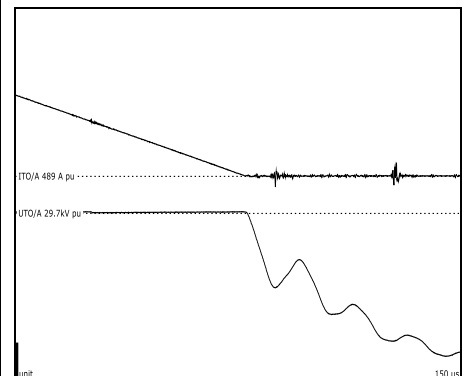
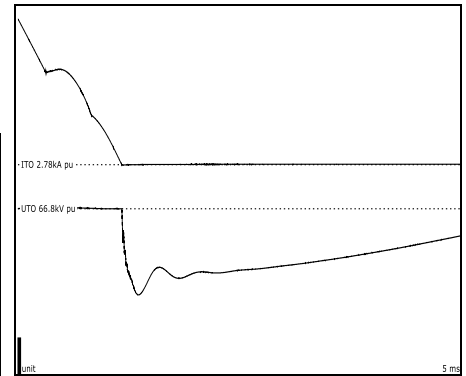
Remarks: Breaker cleared.
O_s = Operation in a synthetic circuit.

L75



Test number: 170505-5032

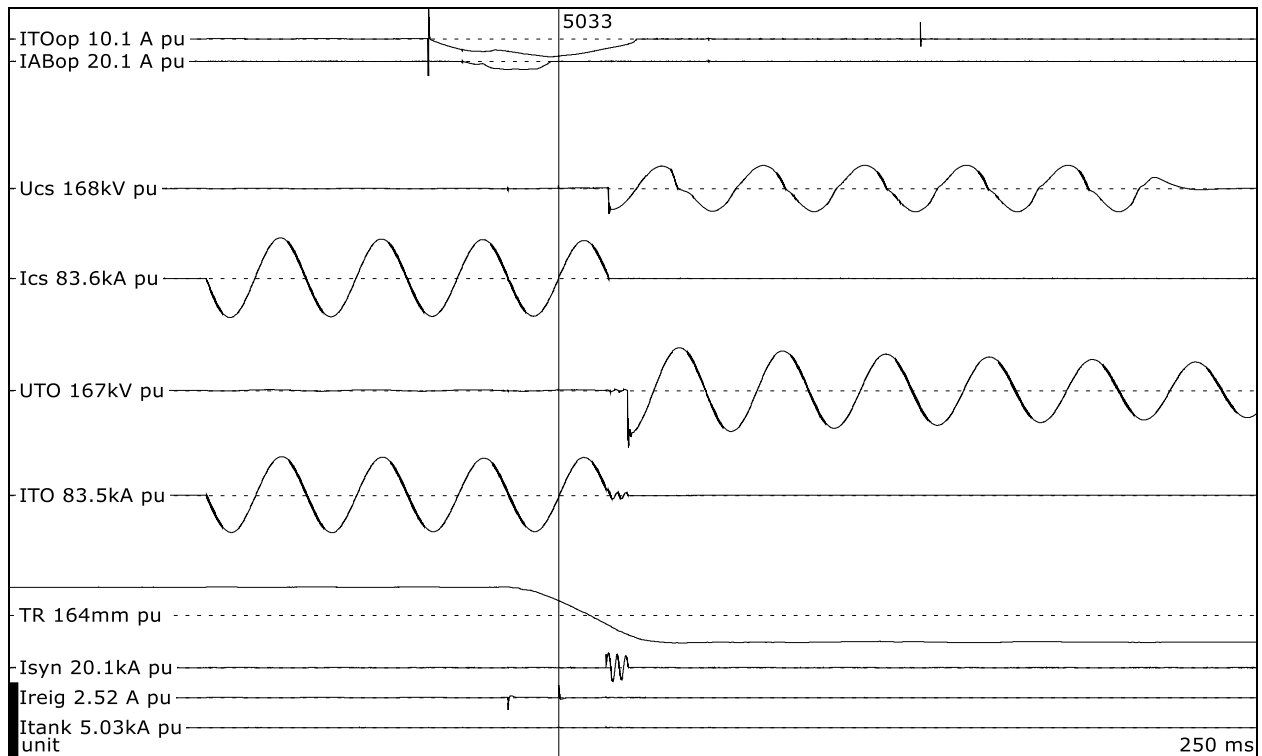
Time interval since previous test	min	-
Operation		O _s
Phase		C
Applied voltage, current source, phase value	kV	37,2
Charging voltage capacitor bank, DC value	kVd.c.	132
Breaking current, symmetrical, phase value	kA	30,3
Breaking current, DC-component	%	2
di/dt at last current zero	A/μs	13,5
TRV, first line-side peak (u _T), across breaker	kV	-59,7
TRV, peak u _M	kV	-155
Recovery voltage, phase value	kV	81,0
Arc duration	ms	11,1
Opening time	ms	26,3
Break time	ms	37,4
t _h	μs	359
Current last loop, peak	kA	42,3



Voltage opening coil	242 Vd.c.	Gas pressure at 20 °C	0,60 MPa
		Operating pressure	- MPa

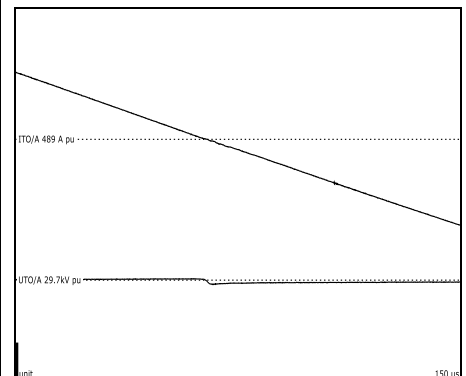
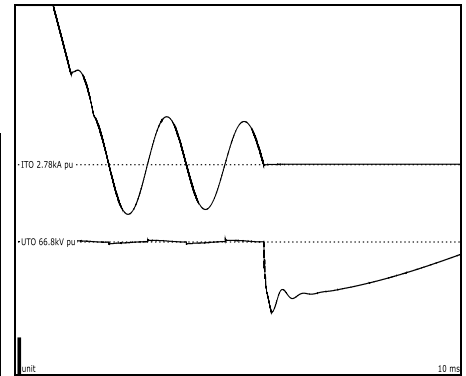
Remarks: Breaker cleared.
O_s = Operation in a synthetic circuit.

L75



Test number: 170505-5033

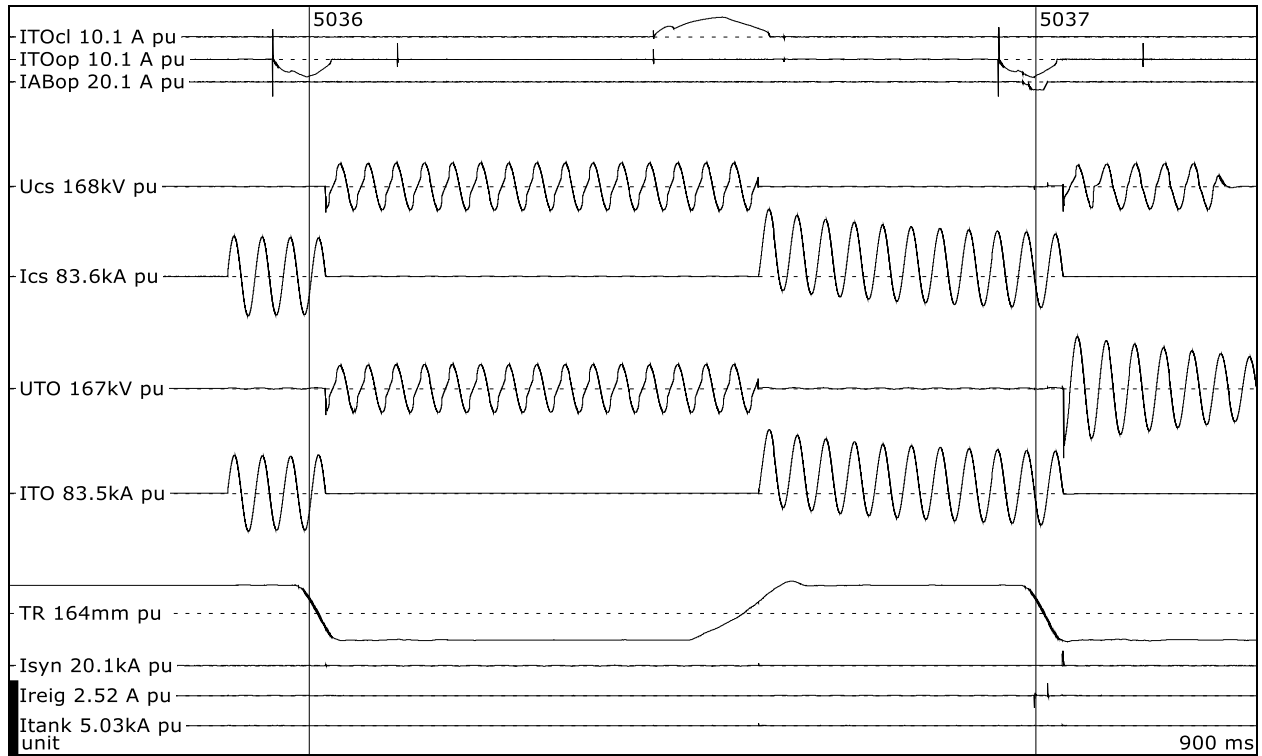
Time interval since previous test	min	-
Operation		O _s
Phase		C
Applied voltage, current source, phase value	kV	37,2
Charging voltage capacitor bank, DC value	kVd.c.	131
Breaking current, symmetrical, phase value	kA	30,3
Breaking current, DC-component	%	1
di/dt at last current zero	A/μs	13,5
TRV, first line-side peak (u _T), across breaker	kV	-
TRV, peak u _M	kV	-
Recovery voltage, phase value	kV	-
Arc duration	ms	(1)
Opening time	ms	26,1
Break time	ms	-
t _h	μs	390
Current last loop, peak	kA	42,3



Voltage opening coil	242 Vd.c.	Gas pressure at 20 °C	0,60 MPa
		Operating pressure	- MPa

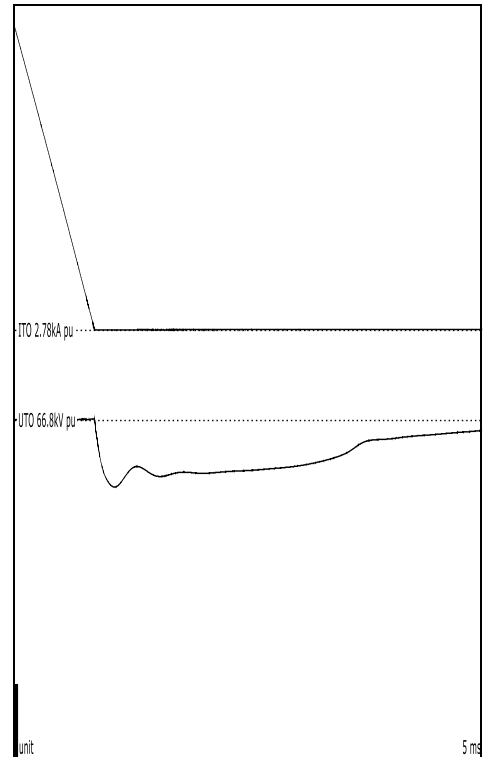
Remarks: Test to verify the correct reignition behaviour of the breaker (subclause 6.102.10 of IEC 62271-101).
 (1) Arcing time set for 10,4 ms.
 O_s = Operation in a synthetic circuit.

L75



Test number: 170505-5036

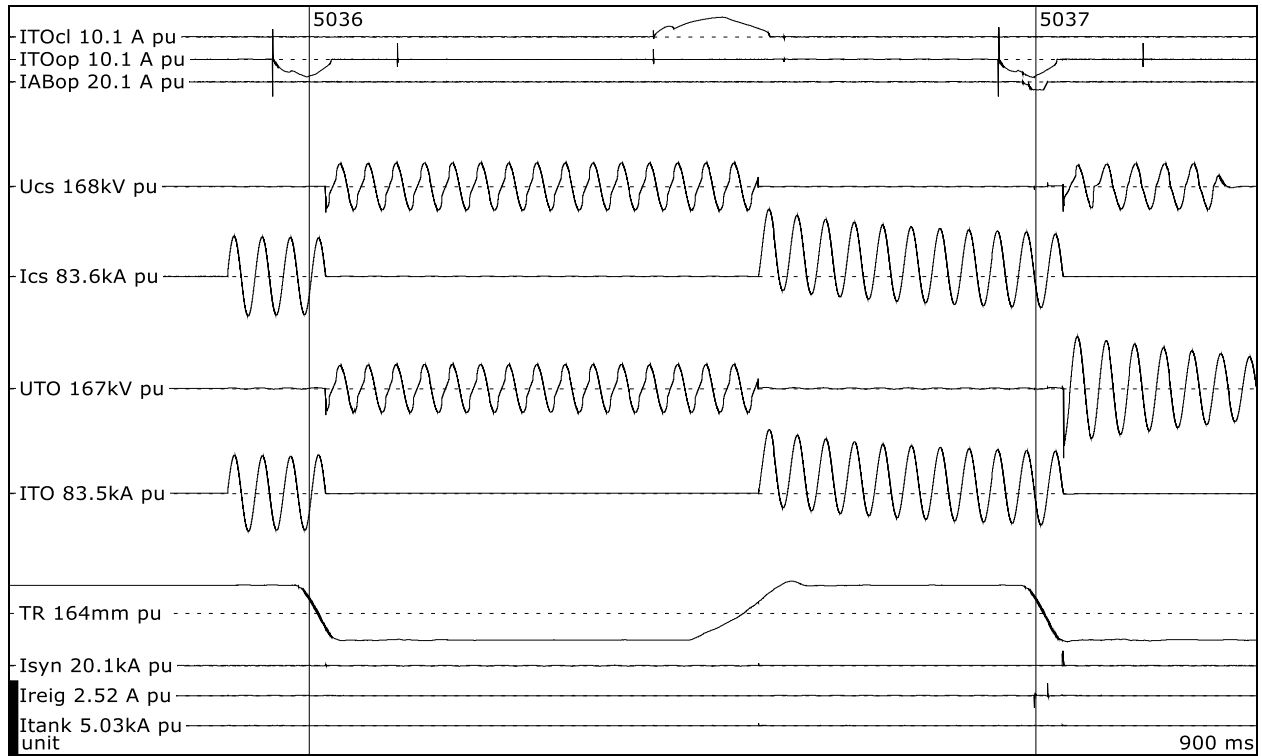
Time interval since previous test	min	-
Operation		O _D
Phase		C
Breaking current, symmetrical, phase value	kA	30,8
Breaking current, DC-component	%	1
Recovery voltage, phase value	kV	34,9
Arc duration	ms	11,6
Opening time	ms	26,5
Break time	ms	38,1



Voltage opening coil	242 Vd.c.	Gas pressure at 20 °C	0,60 MPa
		Operating pressure	- MPa

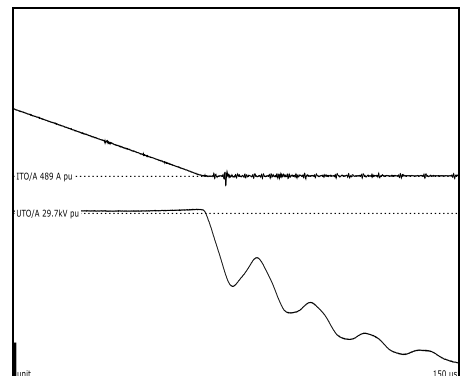
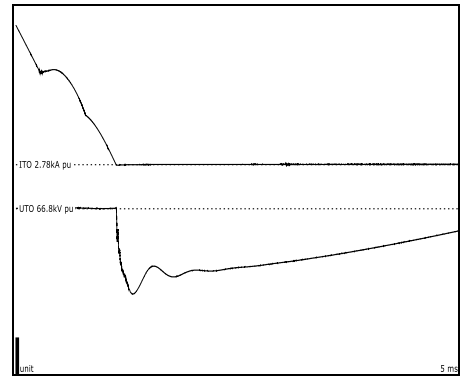
Remarks: Breaker cleared.
O_D = Operation with current source only.

L75



Test number: 170505-5037

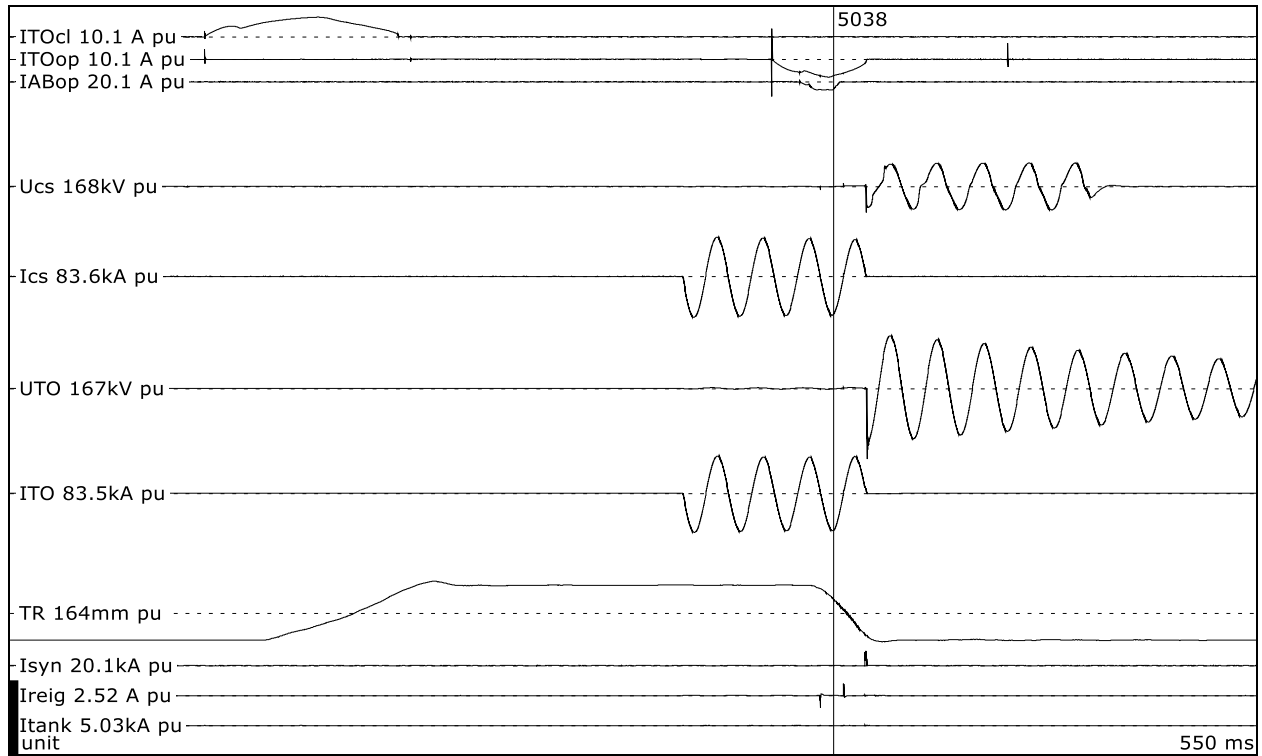
Time interval between operations	s	0,312
Operation		C _D O _S
Phase		C
Applied voltage, current source, phase value	kV	35,8
Charging voltage capacitor bank, DC value	kVd.c.	131
Making current, peak	kA	74,9
Breaking current, symmetrical, phase value	kA	30,1
Breaking current, DC-component	%	17
di/dt at last current zero	A/μs	13,5
TRV, first line-side peak (u _T), across breaker	kV	-58,6
TRV, peak u _M	kV	-152
Recovery voltage, phase value	kV	80,3
Make time	ms	75,4
Arc duration	ms	19,8
Opening time	ms	26,8
Break time	ms	46,6
t _h	μs	360
Current last loop, peak	kA	46,5



Voltage closing coil	242 Vd.c.	Gas pressure at 20 °C	0,60 MPa
Voltage opening coil	242 Vd.c.	Operating pressure	- MPa

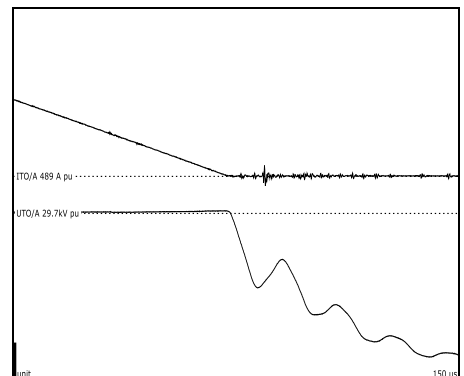
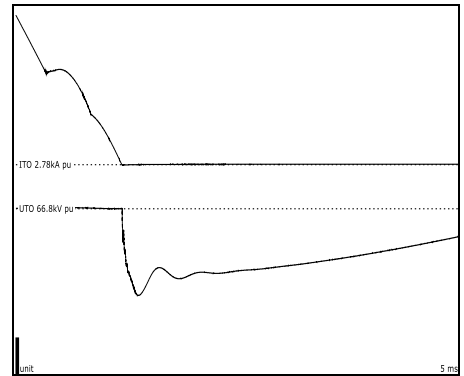
Remarks: Breaker closed and cleared.
 C_D = Operation with current source only. O_S = Operation in a synthetic circuit.

L75



Test number: 170505-5038

Time interval since previous test	min	7
Operation		(C)Os
Phase		C
Charging voltage capacitor bank, DC value	kVd.c.	133
Breaking current, symmetrical, phase value	kA	30,4
Breaking current, DC-component	%	1
di/dt at last current zero	A/μs	13,6
TRV, first line-side peak (u _T), across breaker	kV	-59,7
TRV, peak u _M	kV	-156
Recovery voltage, phase value	kV	87,2
Arc duration	ms	14,7
Opening time	ms	27,1
Break time	ms	41,8
t _h	μs	362
Current last loop, peak	kA	41,2



Voltage closing coil	242 Vd.c.	Gas pressure at 20 °C	0,60 MPa
Voltage opening coil	242 Vd.c.	Operating pressure	- MPa

Remarks: Breaker closed in no-load and cleared.
Os = Operation in a synthetic circuit.

10 NO-LOAD TESTS

Standard and date

Standard IEC 62271-100

Test date 5 May 2017

10.1 Condition before test

Breaker (Serial No 17101) in same condition.

10.2 Test results and oscillograms

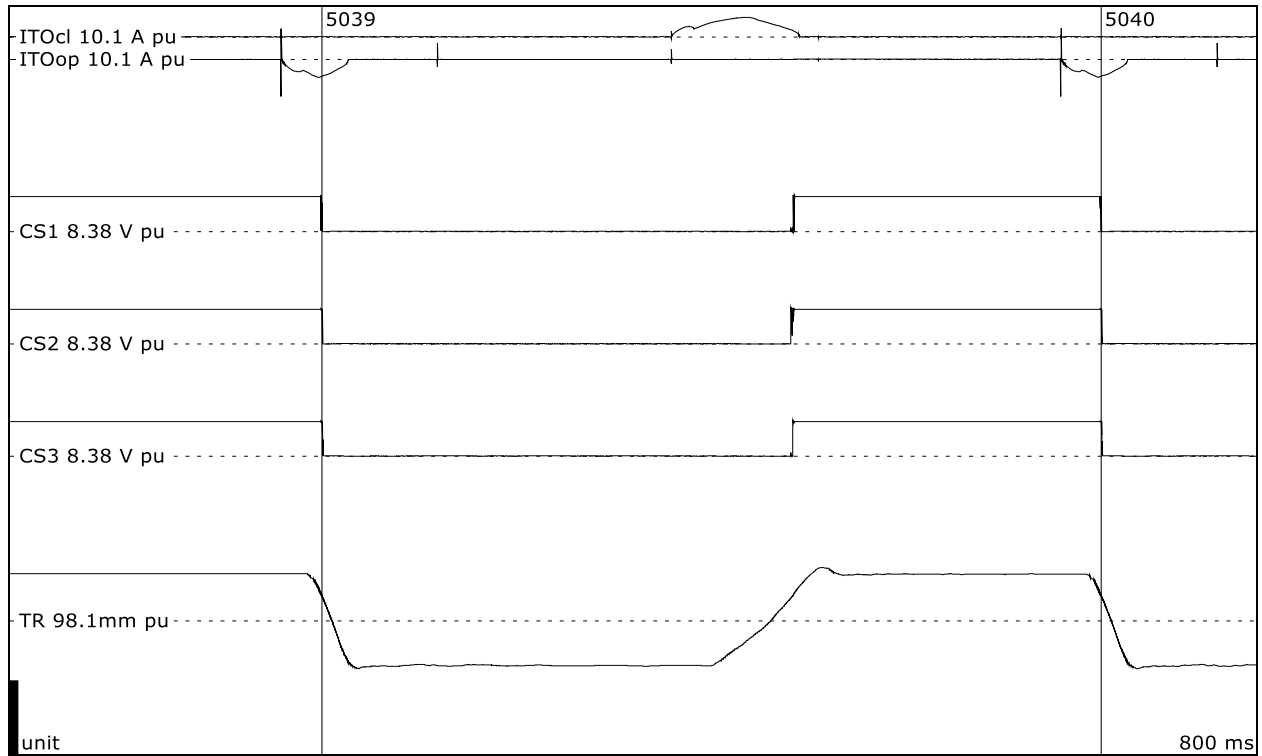
Overview of test numbers

170505-5039 to 5044

Remarks

-

No-load test



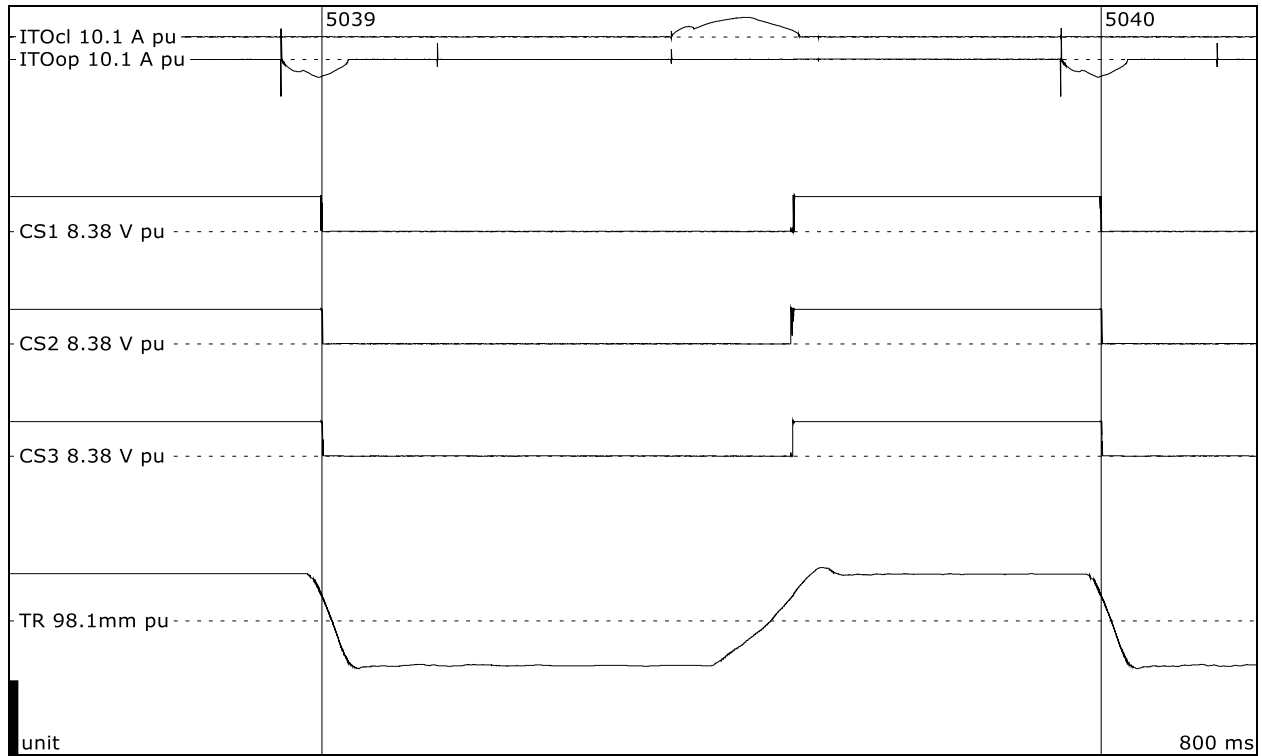
Test number: 170505-5039

Operation		O		
Phase		A	B	C
Current opening coil	A	-2,45		
Opening time	ms	26,2	26,5	26,8

Voltage opening coil	242 Vd.c.	Gas pressure at 20 °C	0,60 MPa
		Operating pressure	- MPa

Remarks: -

No-load test



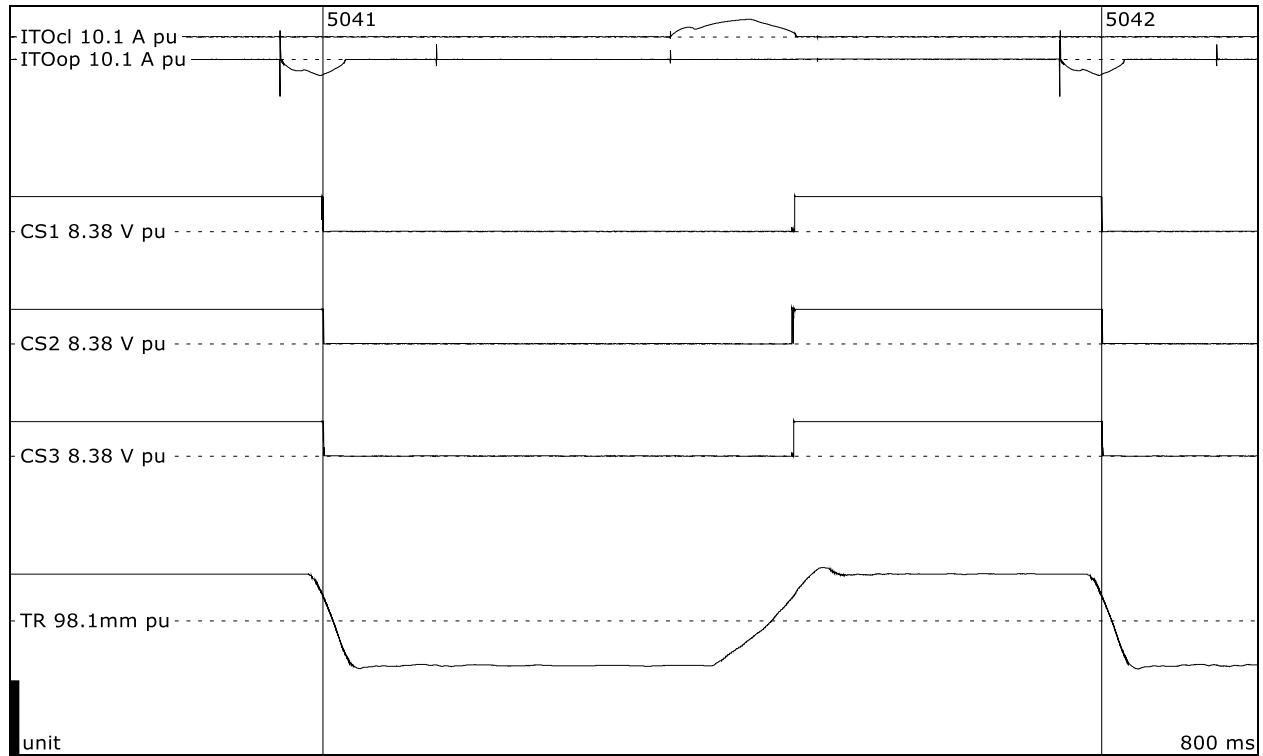
Test number: 170505-5040

Time interval between operations	s	0,302		
Operation	CO			
Phase		A	B	C
Current closing coil	A	2,63		
Closing time	ms	78,2	76,6	77,9
Current opening coil	A	-2,42		
Opening time	ms	25,9	26,3	26,4

Voltage closing coil	242 Vd.c.	Gas pressure at 20 °C	0,60 MPa
Voltage opening coil	242 Vd.c.	Operating pressure	- MPa

Remarks: -

No-load test



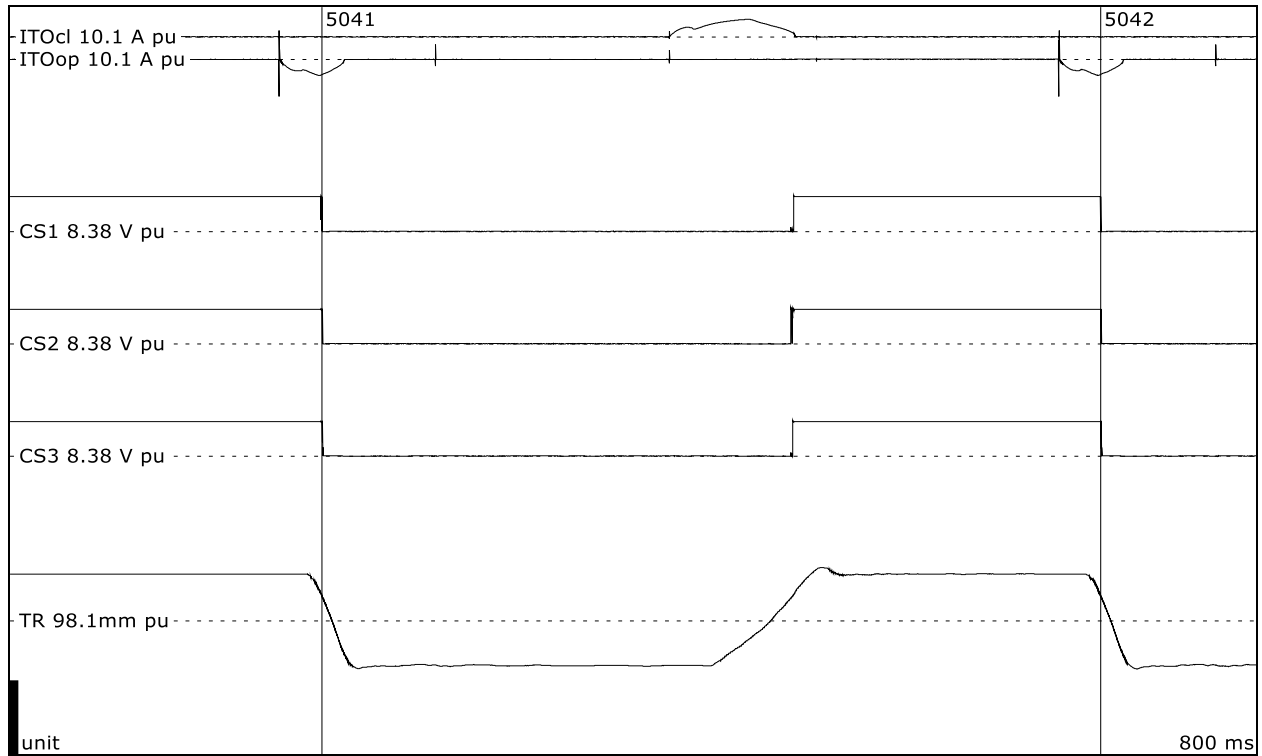
Test number: 170505-5041

Operation		O		
Phase		A	B	C
Current opening coil	A	-2,20		
Opening time	ms	27,0	27,8	28,0

Voltage opening coil	220 Vd.c.	Gas pressure at 20 °C	0,60 MPa
		Operating pressure	- MPa

Remarks: -

No-load test



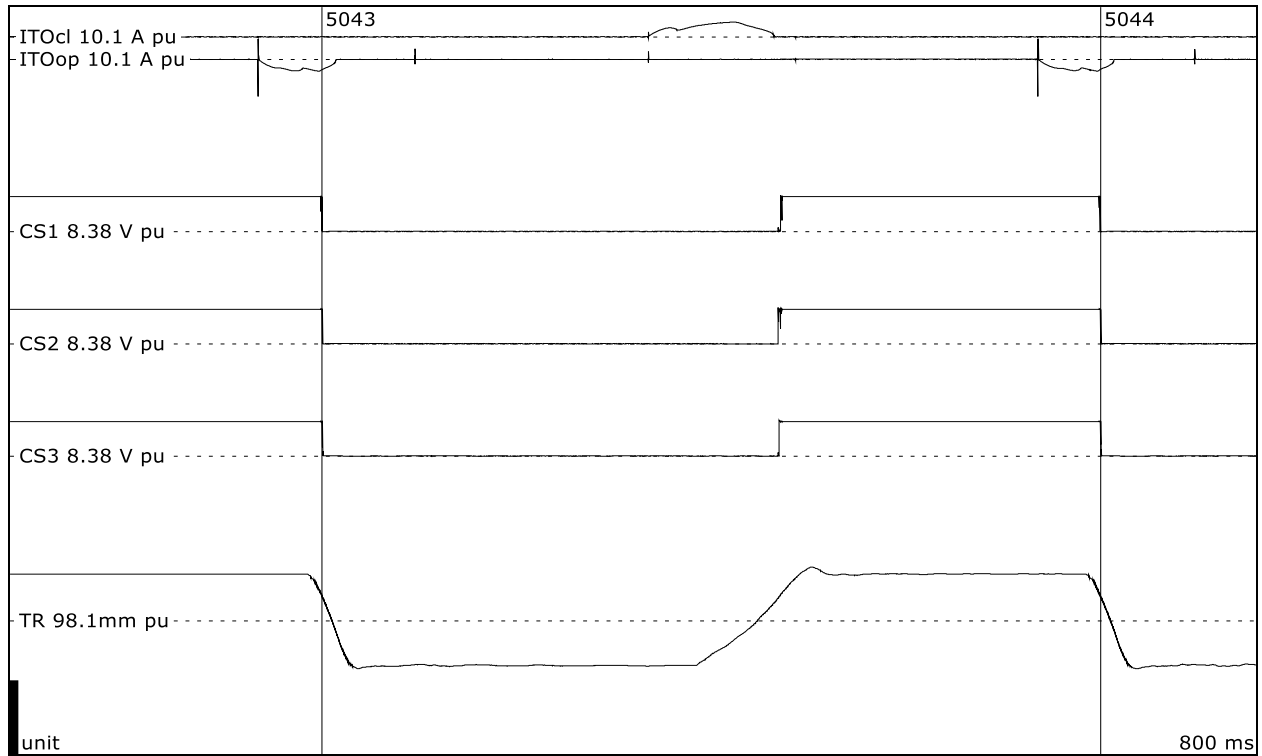
Test number: 170505-5042

Time interval between operations	s	0,302		
Operation	CO			
Phase		A	B	C
Current closing coil	A	2,36		
Closing time	ms	79,5	77,6	78,9
Current opening coil	A	-2,16		
Opening time	ms	26,9	27,2	27,2

Voltage closing coil	220 Vd.c.	Gas pressure at 20 °C	0,60 MPa
Voltage opening coil	220 Vd.c.	Operating pressure	- MPa

Remarks: -

No-load test



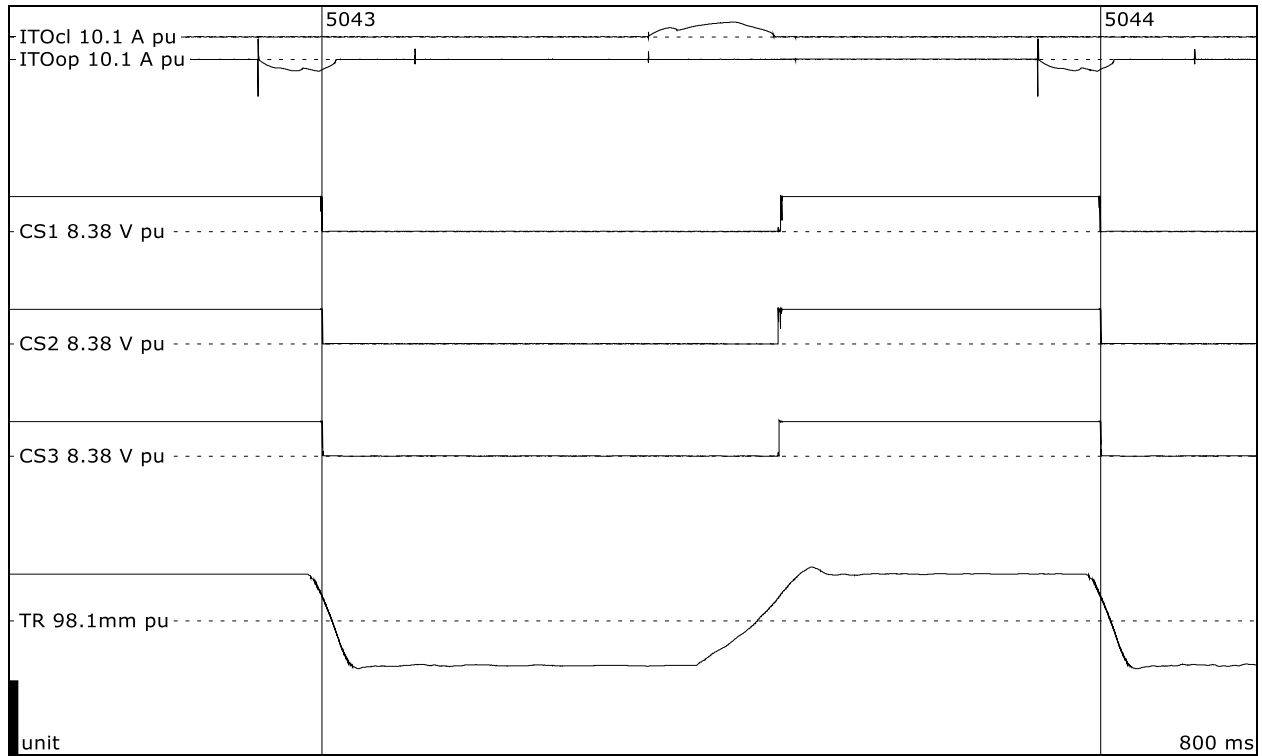
Test number: 170505-5043

Operation		O		
Phase		A	B	C
Current opening coil	A	-1,61		
Opening time	ms	40,8	41,2	41,3

Voltage opening coil	154 Vd.c.	Gas pressure at 20 °C	0,60 MPa
		Operating pressure	- MPa

Remarks: -

No-load test



Test number: 170505-5044

Time interval between operations	s	0,294		
Operation	CO			
Phase		A	B	C
Current closing coil	A	1,98		
Closing time	ms	84,7	83,3	83,9
Current opening coil	A	-1,61		
Opening time	ms	40,0	40,2	40,3

Voltage closing coil	187 Vd.c.	Gas pressure at 20 °C	0,60 MPa
Voltage opening coil	154 Vd.c.	Operating pressure	- MPa

Remarks: -

10.3 Condition / inspection after test

Externally no visible change.

Inspection of contacts:

Fixed arcing contact moderately burnt.

Moving arcing contact moderately burnt.

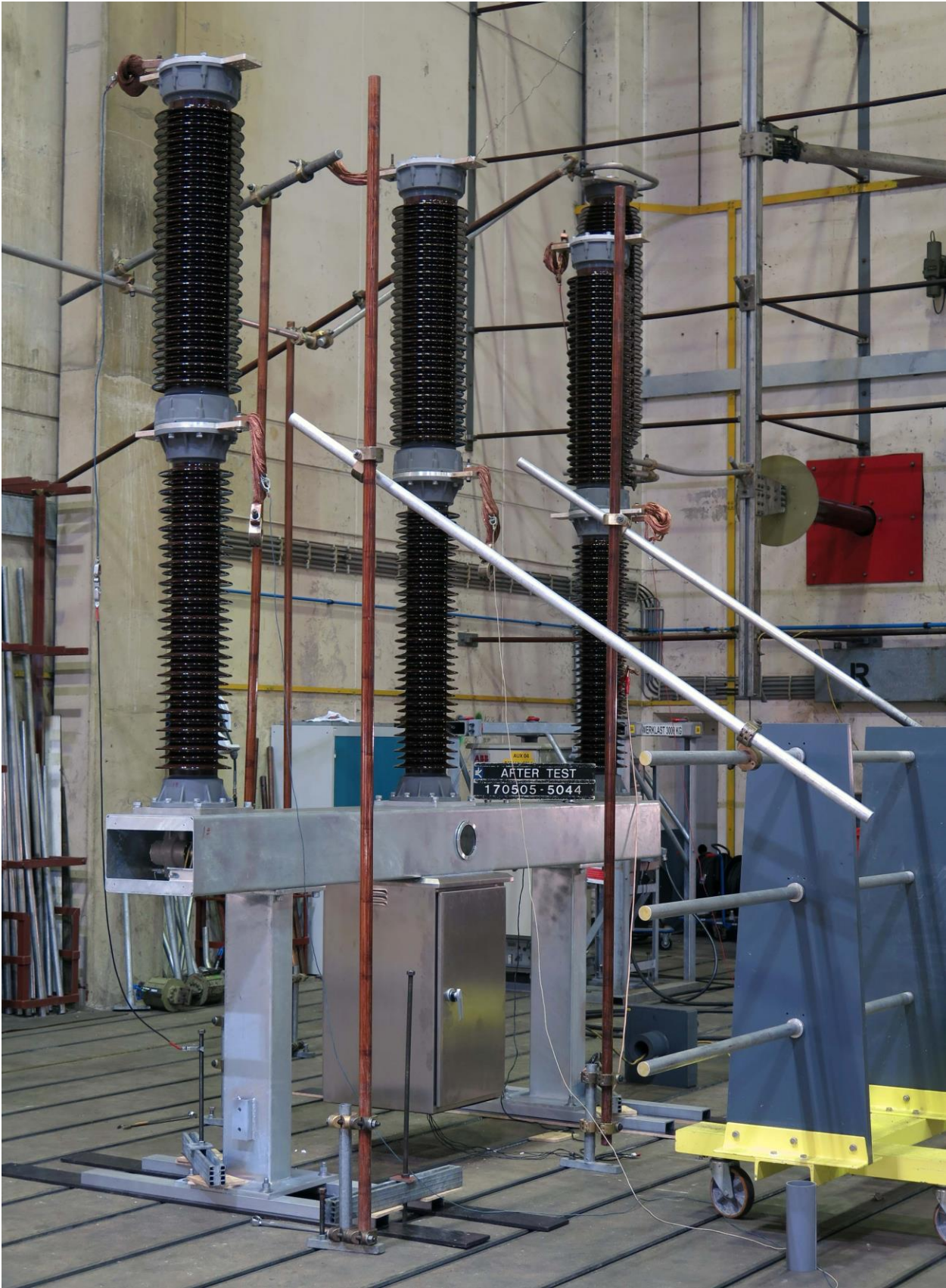
Fixed main contact finger tips showed locally moderate commutation marks. Silver layer on main contact area intact.

Moving main contact rim showed locally moderate commutation marks. Silver layer on main contact area intact.

Nozzle moderately eroded.

Auxiliary nozzle moderately eroded.

10.4 Photographs after test

















11 T60

Standard and date

Standard	IEC 62271-100
Test date	5 May 2017

11.1 Condition before test

Breaker (Serial No 17101) in same condition.

Pole B under test.

Supply to fixed contact.

Moving contact earthed.

Frame earthed via a CT.

Auxiliary breaker:

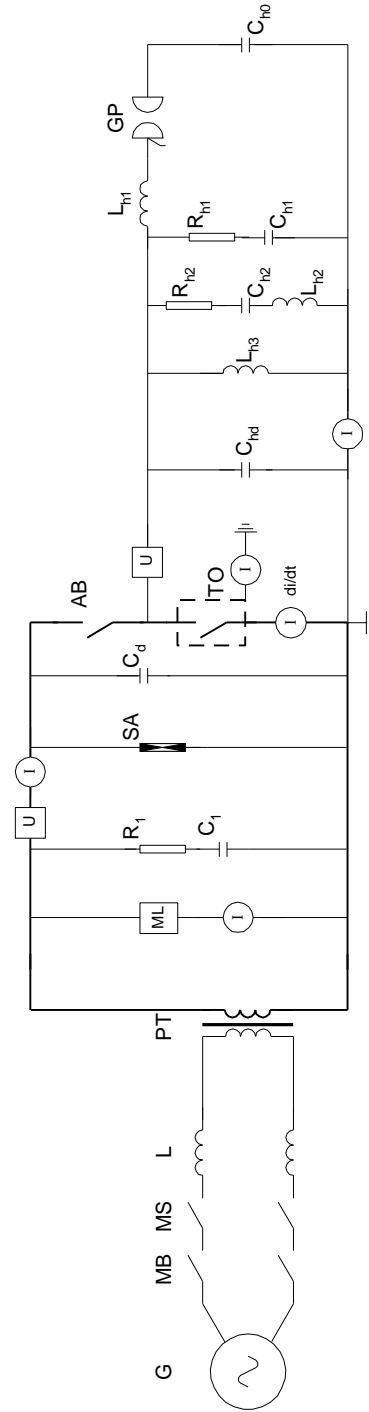
An SF₆ breaker, provided by KEMA Laboratories.

Number of elements: 1 per breaker.

11.2 Test circuit S08

Diagram

Current injection



G = Generator	L = Reactor	U = Voltage Measurement to earth	SA = Surge Arrester
MB = Master Breaker	TO = Test Object	I = Current Measurement	AB = Auxiliary Breaker
MS = Make Switch	R = Resistor	VS = Voltage Source	GP = Gap
PT = Power Transformer	C = Capacitor	ML = Multi-loop device	

Values

Supply		
Power	MVA	792
Frequency	Hz	50
Phase(s)		1
Voltage	kV	33,0
Current	kA	24,0
Impedance	Ω	1,38
Power factor		< 0,1
Neutral		not earthed

Injection circuit		
C _{h0}	μF	8,00
U _{h0}	kVd.c.	217
L _{h1}	mH	19,3
f _h	Hz	400
R _{h1}	Ω	275
C _{h1}	μF	0,05
C _{hd}	nF	5,00
R _{hc}	Ω	275
C _{hc}	nF	51,0
R _{h2}	Ω	125
C _{h2}	μF	0,30
L _{h2}	mH	13,2
R _{hp}	k Ω	-
L _{h3}	H	1,20
f _{RV}	Hz	48,7

Prospective TRV		
U _{recovery}	kVa.c.	141
u ₁	kV	133
u _c	kV	266
t _d	μs	2,00
t ₁	μs	44,0
t ₂	μs	264
t ₃	μs	-
Rate of rise	kV/ μs	3,00

Load	
Short-circuit point	earthed

TRV control elements added (supply)		
C ₁	μF	0,44
R ₁	Ω	102
C _d	nF	15,0

Remarks: -

11.3 Test results and oscillograms

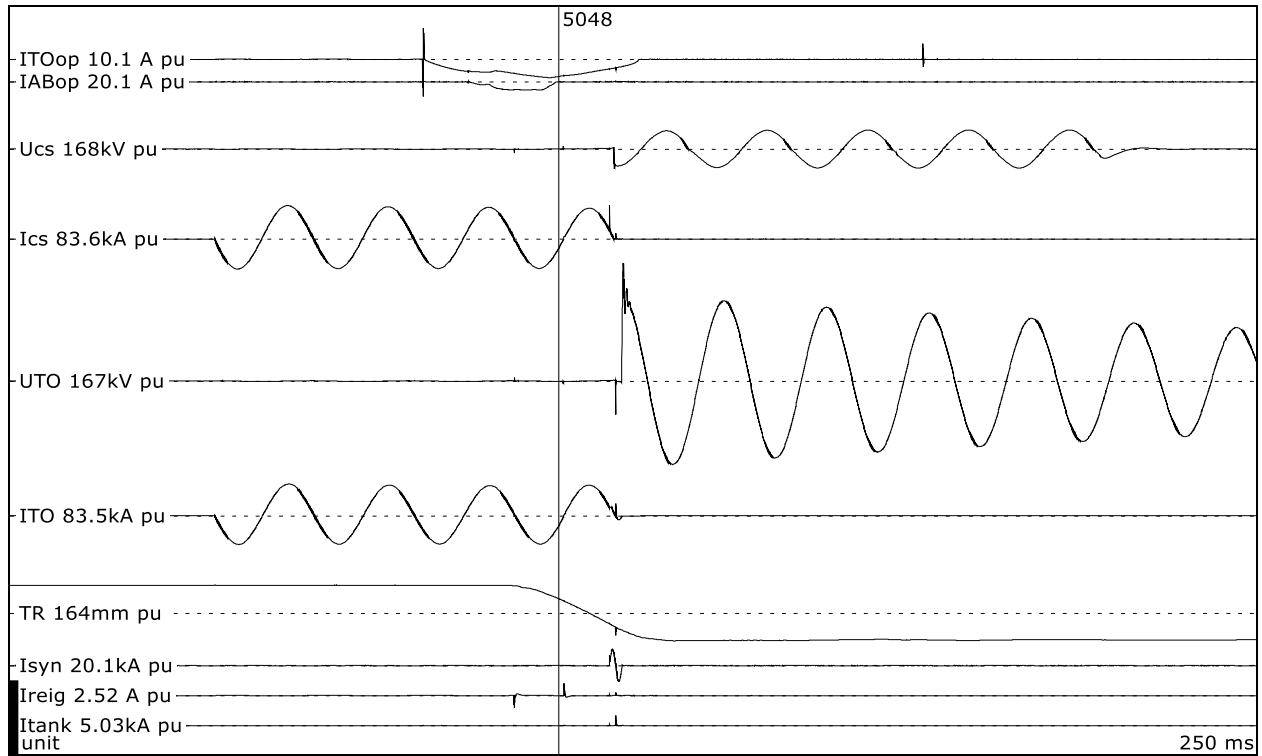
Overview of test numbers

170505-5048 to 5050, 5053 to 5055

Remarks

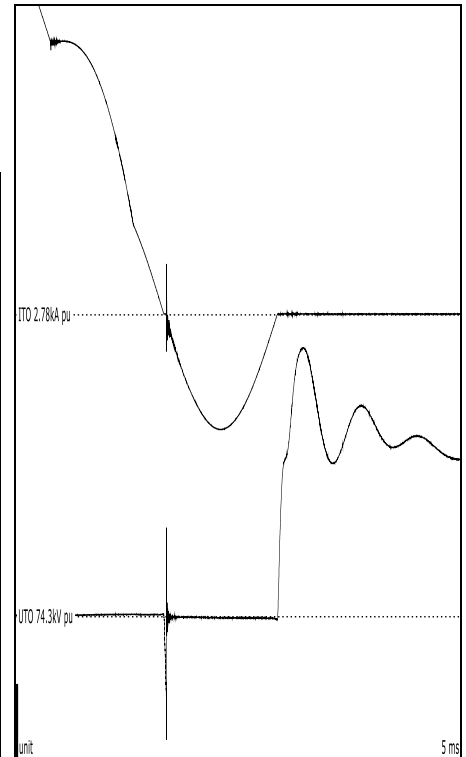
-

T60



Test number: 170505-5048

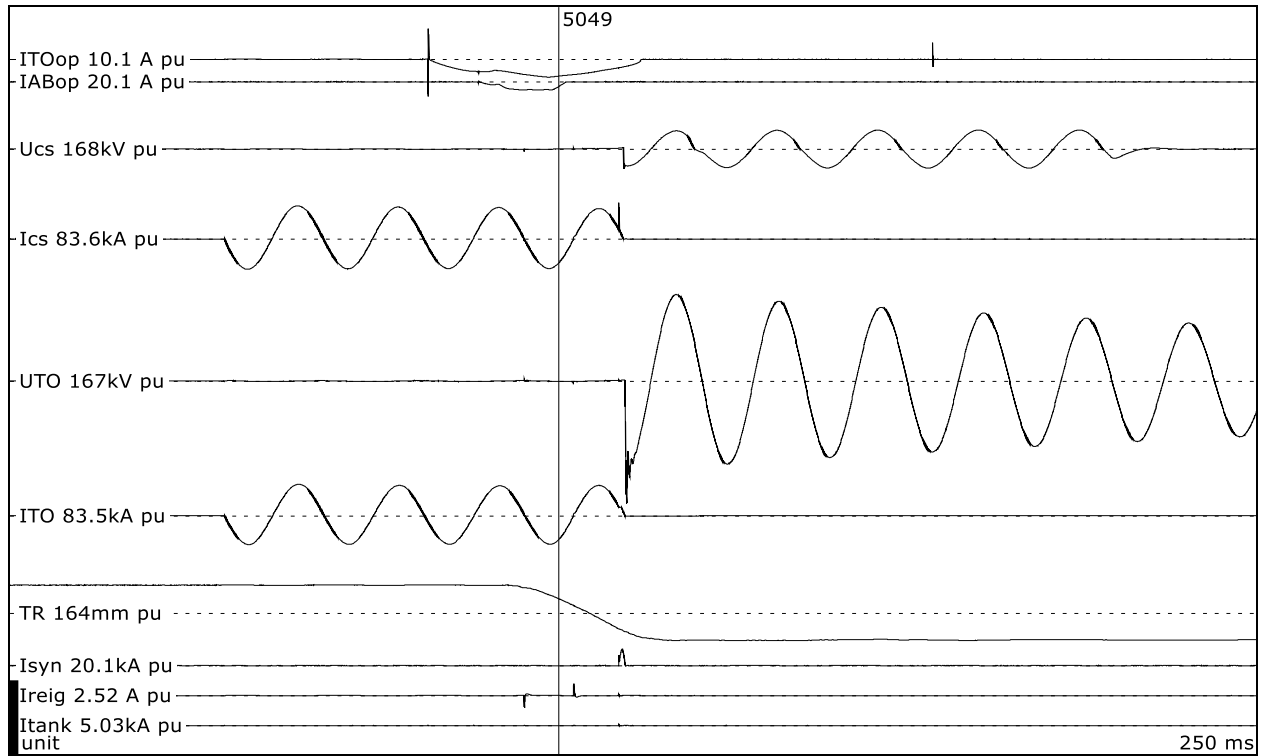
Time interval since previous test	min	-
Operation		O _s
Phase		B
Applied voltage, current source, phase value	kV	29,0
Charging voltage capacitor bank, DC value	kVd.c.	216
Breaking current, symmetrical, phase value	kA	24,2
Breaking current, DC-component	%	3
di/dt at last current zero	A/μs	10,7
TRV, peak	kV	-
Recovery voltage, phase value	kV	-
Arc duration	ms	(1)
Opening time	ms	27,2
Break time	ms	-
t _h	μs	362
Current last loop, peak	kA	33,5



Voltage opening coil	242 Vd.c.	Gas pressure at 20 °C	0,60 MPa
		Operating pressure	- MPa

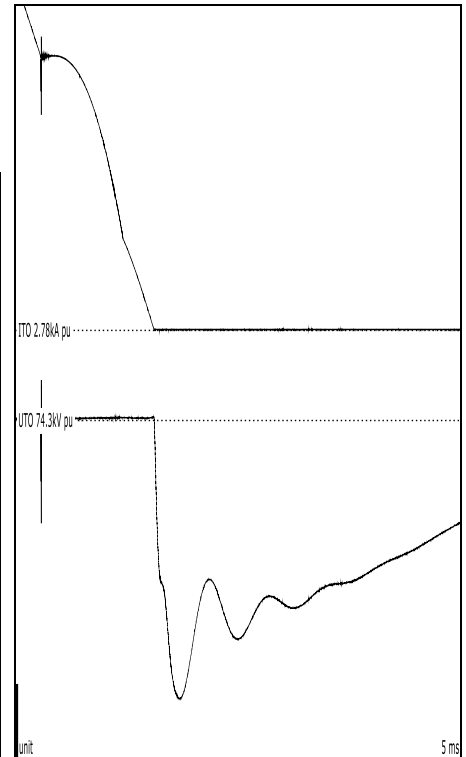
Remarks: (1) Arcing time of 11,4 ms is too short for test breaker to clear.
O_s = Operation in a synthetic circuit.

T60



Test number: 170505-5049

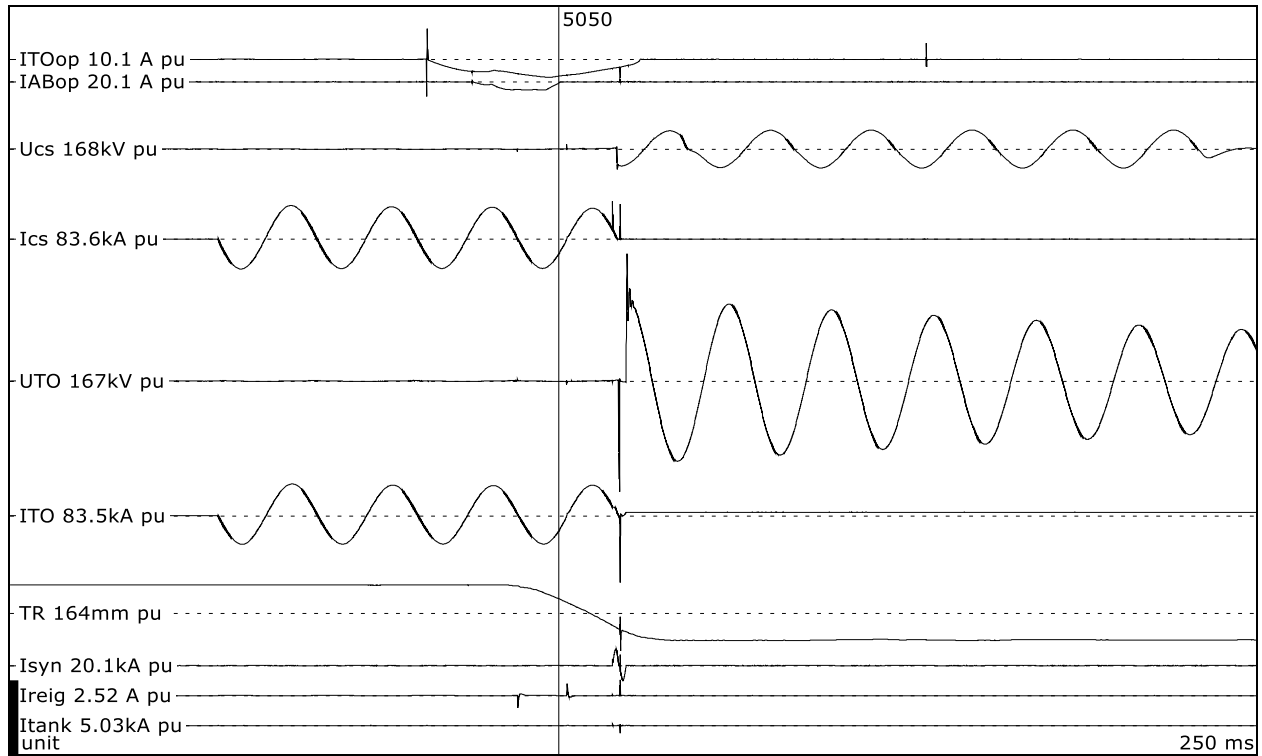
Time interval since previous test	min	-
Operation		O _s
Phase		B
Applied voltage, current source, phase value	kV	28,6
Charging voltage capacitor bank, DC value	kVd.c.	218
Breaking current, symmetrical, phase value	kA	24,1
Breaking current, DC-component	%	3
di/dt at last current zero	A/μs	10,7
TRV, peak	kV	-271
Recovery voltage, phase value	kV	142
Arc duration	ms	13,2
Opening time	ms	26,2
Break time	ms	39,4
t _h	μs	365
Current last loop, peak	kA	33,3



Voltage opening coil	242 Vd.c.	Gas pressure at 20 °C	0,60 MPa
		Operating pressure	- MPa

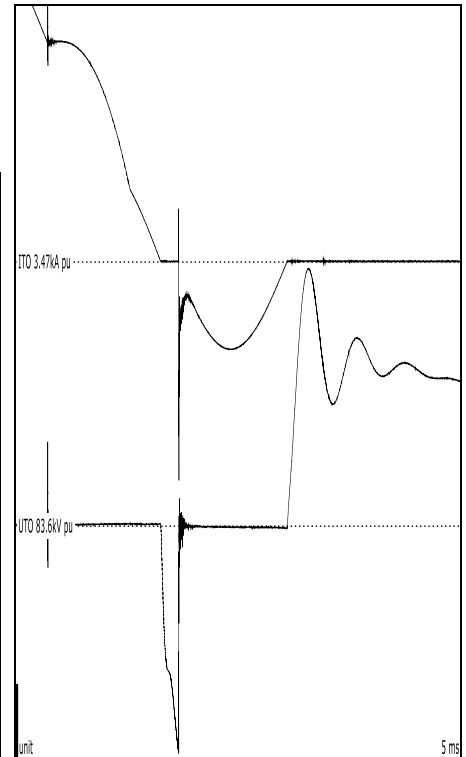
Remarks: Breaker cleared.
O_s = Operation in a synthetic circuit.

T60



Test number: 170505-5050

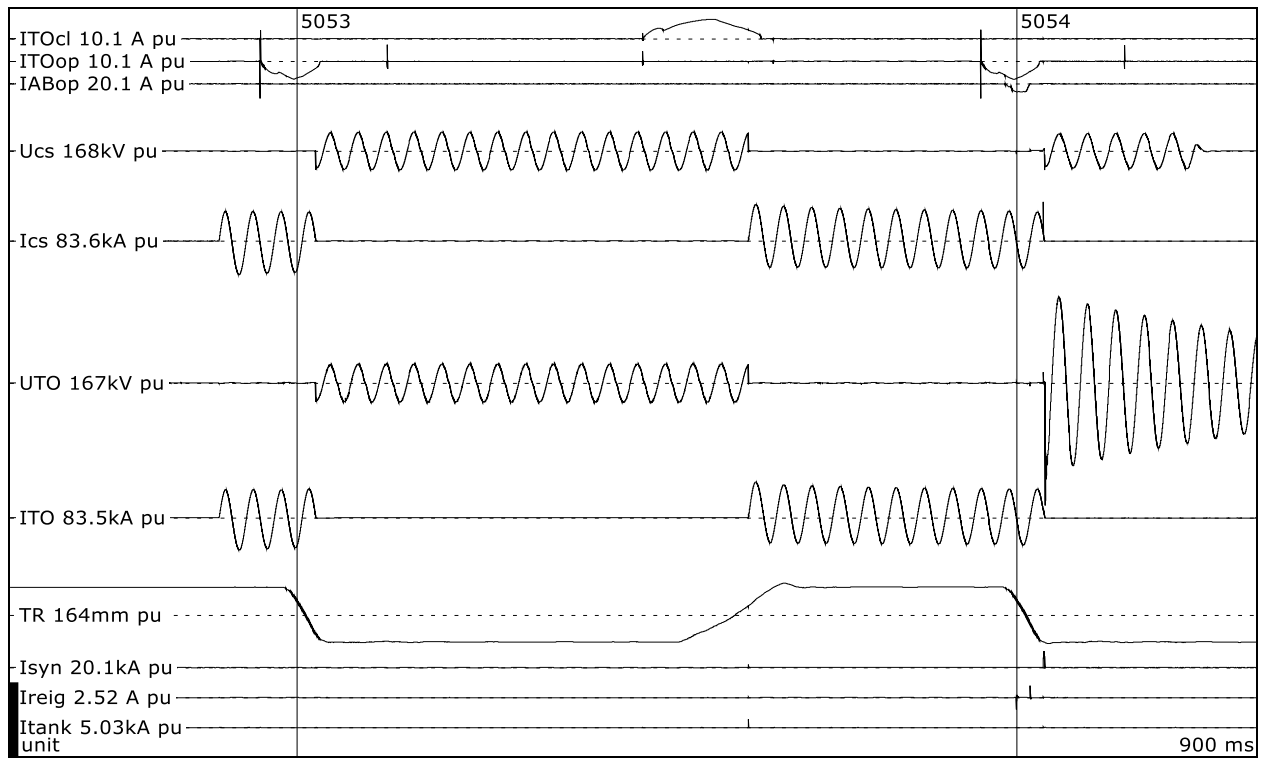
Time interval since previous test	min	-
Operation		O _s
Phase		B
Applied voltage, current source, phase value	kV	28,5
Charging voltage capacitor bank, DC value	kVd.c.	217
Breaking current, symmetrical, phase value	kA	24,1
Breaking current, DC-component	%	3
di/dt at last current zero	A/μs	10,7
TRV, peak	kV	-
Recovery voltage, phase value	kV	-
Arc duration	ms	(1)
Opening time	ms	26,5
Break time	ms	-
t _h	μs	358
Current last loop, peak	kA	33,6



Voltage opening coil	242 Vd.c.	Gas pressure at 20 °C	0,60 MPa
		Operating pressure	- MPa

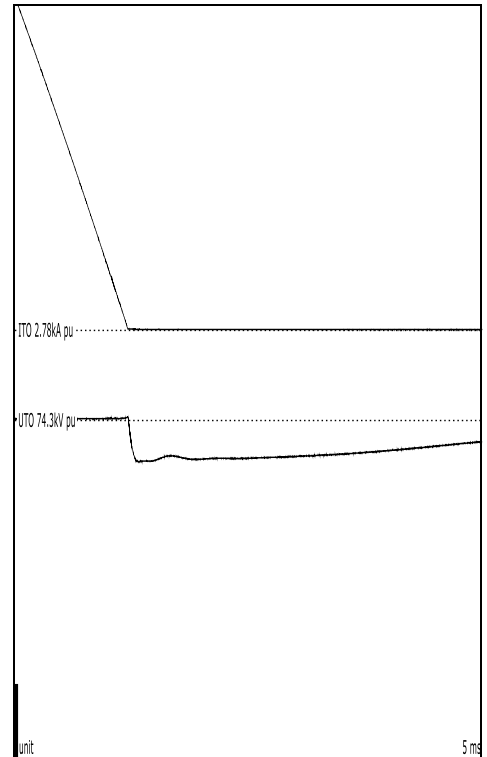
Remarks: Test to verify the correct reignition behaviour of the breaker (subclause 6.102.10 of IEC 62271-101).
 (1) Arcing time set for 12,1 ms.
 O_s = Operation in a synthetic circuit.

T60



Test number: 170505-5053

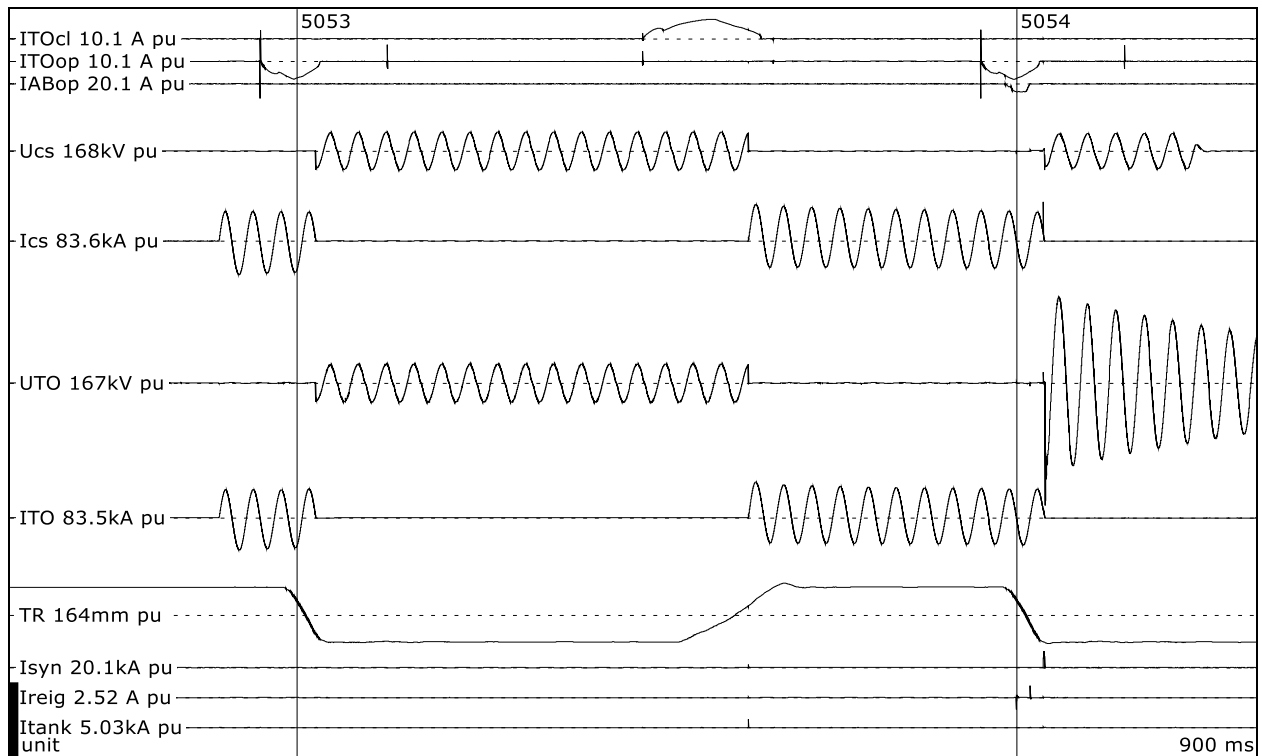
Time interval since previous test	min	-
Operation		O _D
Phase		B
Breaking current, symmetrical, phase value	kA	24,2
Breaking current, DC-component	%	3
Recovery voltage, phase value	kV	29,0
Arc duration	ms	13,5
Opening time	ms	26,4
Break time	ms	39,9



Voltage opening coil	242 Vd.c.	Gas pressure at 20 °C	0,60 MPa
		Operating pressure	- MPa

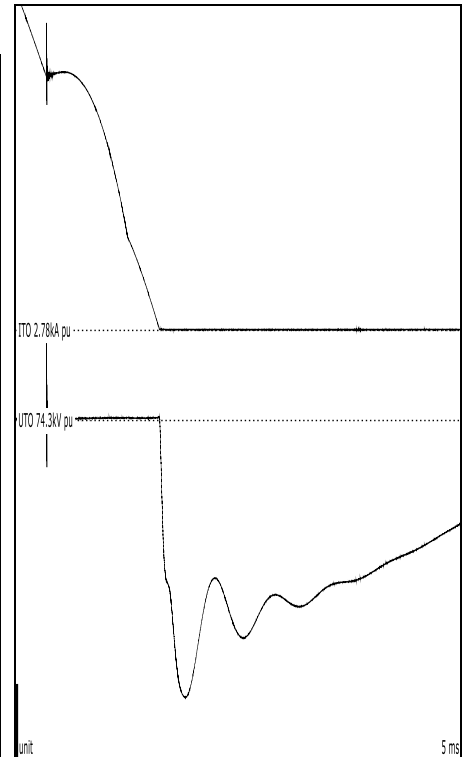
Remarks: Breaker cleared.
O_D = Operation with current source only.

T60



Test number: 170505-5054

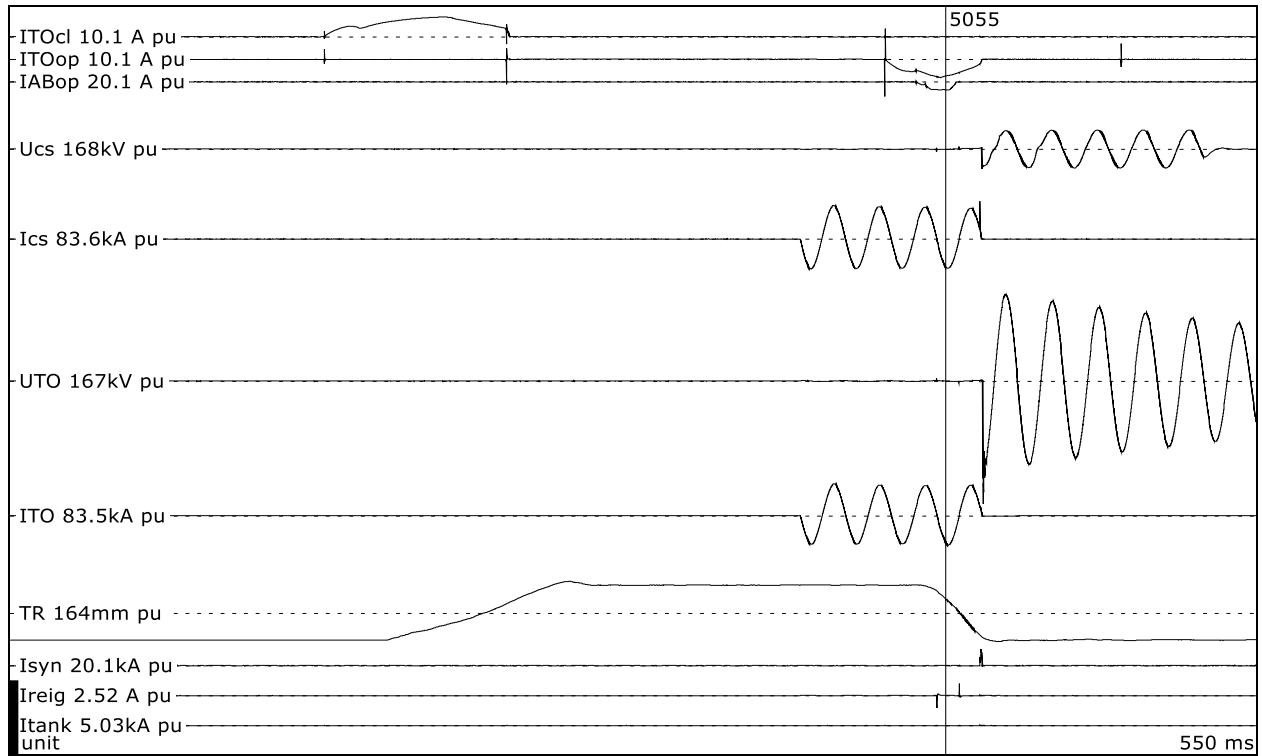
Time interval since previous test	min	-
Time interval between operations	s	0,312
Operation		C _D O _S
Phase		B
Applied voltage, current source, phase value	kV	29,7
Charging voltage capacitor bank, DC value	kVd.c.	217
Making current, peak	kA	40,7
Breaking current, symmetrical, phase value	kA	24,0
Breaking current, DC-component	%	4
di/dt at last current zero	A/μs	10,7
TRV, peak	kV	-272
Recovery voltage, phase value	kV	141
Make time	ms	76,0
Arc duration	ms	20,1
Opening time	ms	26,4
Break time	ms	46,5
t _h	μs	371
Current last loop, peak	kA	31,4



Voltage closing coil	242 Vd.c.	Gas pressure at 20 °C	0,60 MPa
Voltage opening coil	242 Vd.c.	Operating pressure	- MPa

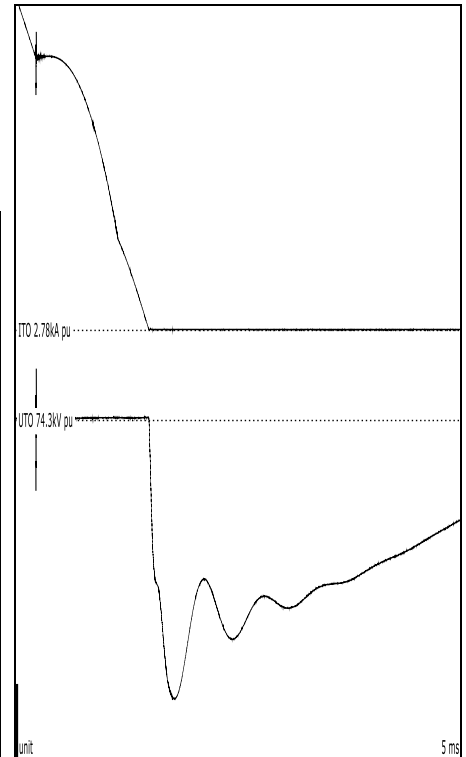
Remarks: Breaker closed and cleared.
 C_D = Operation with current source only. O_S = Operation in a synthetic circuit.

T60



Test number: 170505-5055

Time interval since previous test	min	8
Operation		(C)Os
Phase		B
Charging voltage capacitor bank, DC value	kVd.c.	218
Breaking current, symmetrical, phase value	kA	24,2
Breaking current, DC-component	%	2
di/dt at last current zero	A/μs	10,7
TRV, peak	kV	-274
Recovery voltage, phase value	kV	142
Arc duration	ms	16,3
Opening time	ms	26,8
Break time	ms	43,1
t _h	μs	362
Current last loop, peak	kA	33,5



Voltage closing coil	242 Vd.c.	Gas pressure at 20 °C	0,60 MPa
Voltage opening coil	242 Vd.c.	Operating pressure	- MPa

Remarks: Breaker closed in no-load and cleared.
Os = Operation in a synthetic circuit.

12 NO-LOAD TESTS

Standard and date

Standard IEC 62271-100

Test date 8 May 2017

12.1 Condition before test

Breaker (Serial No 17101) in same condition.

12.2 Test results and oscillograms

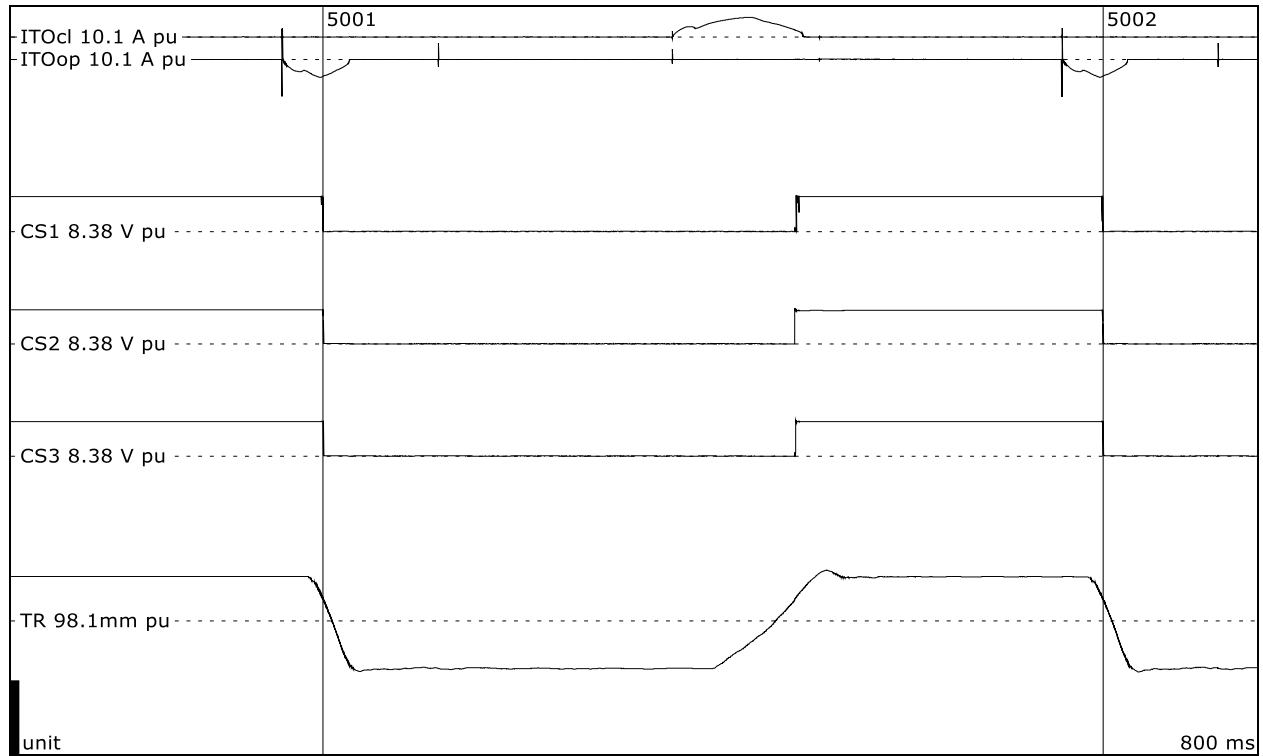
Overview of test numbers

170508-5001 to 5006

Remarks

-

No-load test



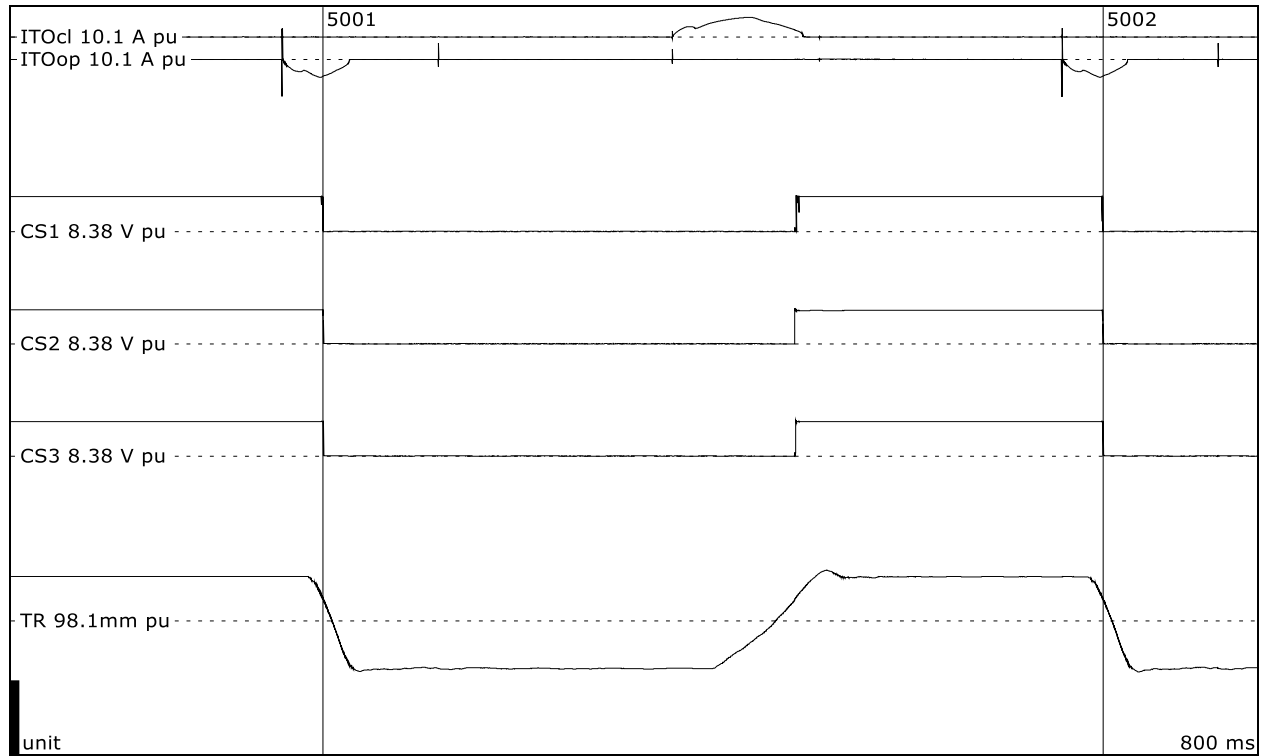
Test number: 170508-5001

Operation		O		
Phase		A	B	C
Current opening coil	A	-2,45		
Opening time	ms	26,2	26,4	26,5

Voltage opening coil	242 Vd.c.	Gas pressure at 20 °C	0,60 MPa
		Operating pressure	- MPa

Remarks: -

No-load test



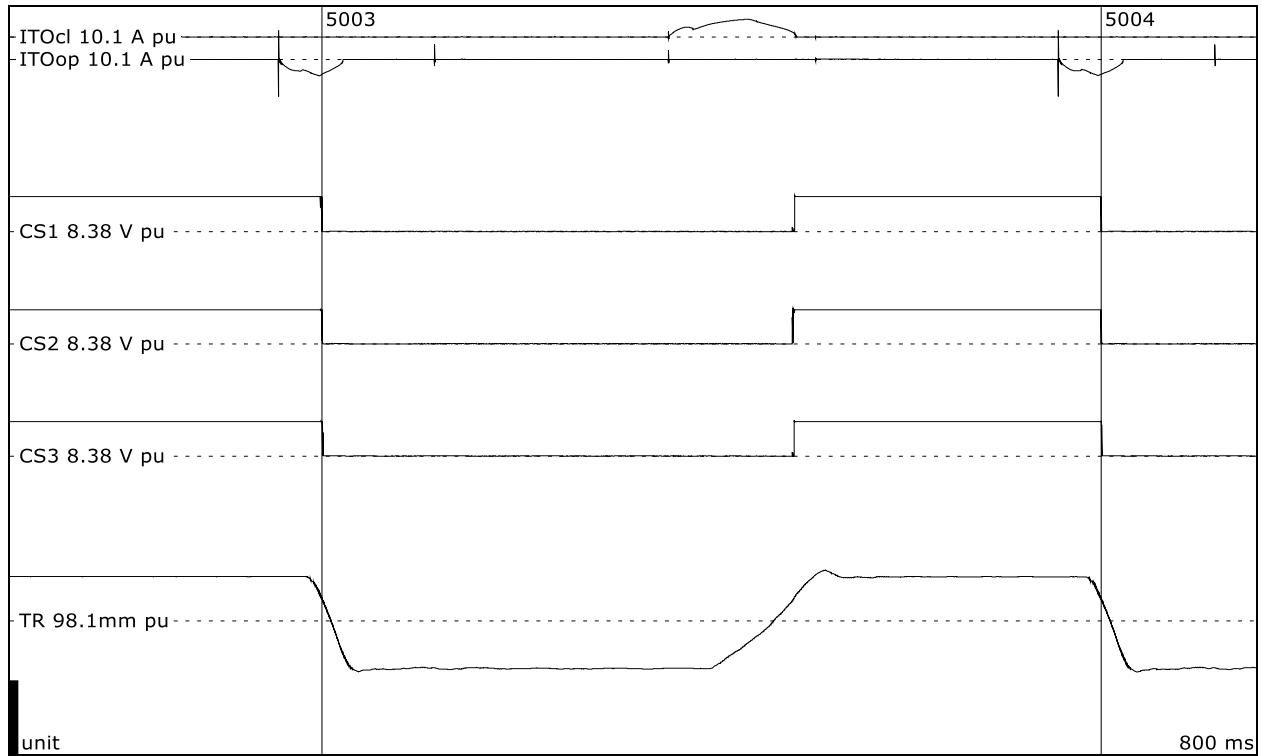
Test number: 170508-5002

Time interval between operations	s	0,304		
Operation	CO			
Phase		A	B	C
Current closing coil	A	2,63		
Closing time	ms	79,7	78,4	79,4
Current opening coil	A	-2,42		
Opening time	ms	26,3	26,3	26,5

Voltage closing coil	242 Vd.c.	Gas pressure at 20 °C	0,60 MPa
Voltage opening coil	242 Vd.c.	Operating pressure	- MPa

Remarks: -

No-load test



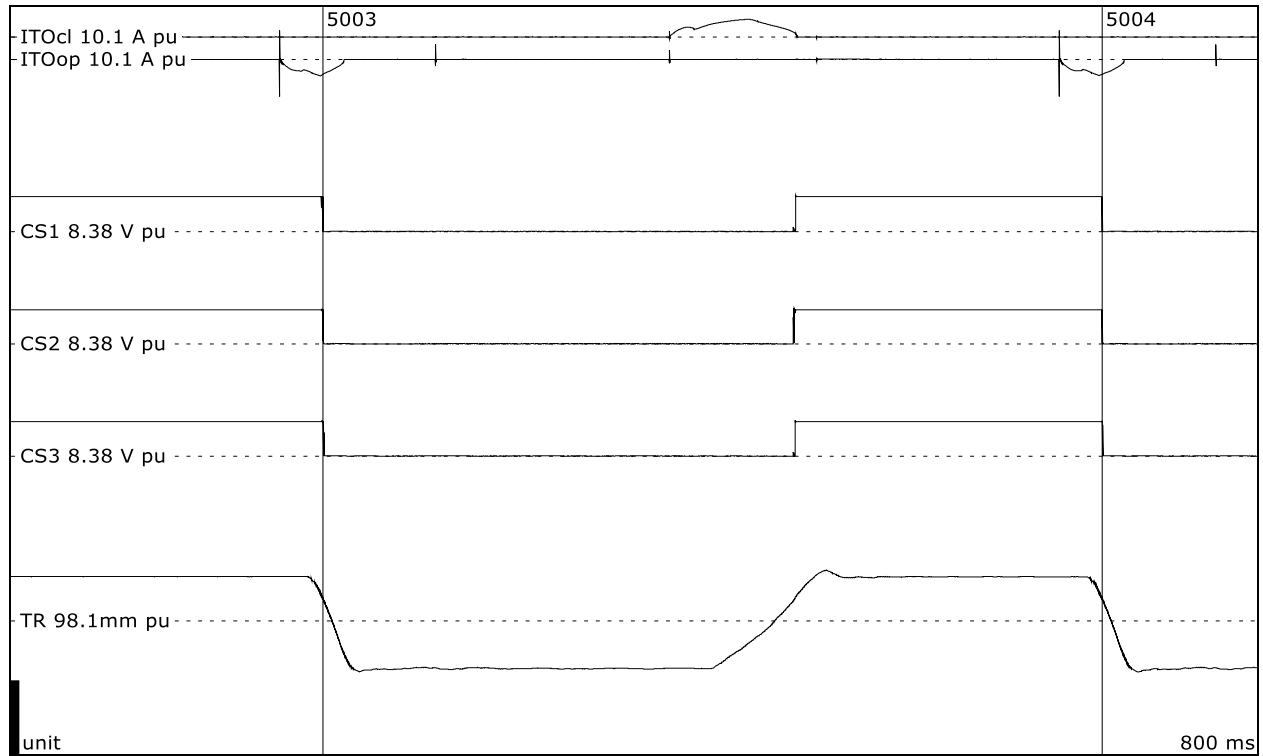
Test number: 170508-5003

Operation		O		
Phase		A	B	C
Current opening coil	A	-2,22		
Opening time	ms	27,9	28,1	28,4

Voltage opening coil	220 Vd.c.	Gas pressure at 20 °C	0,60 MPa
		Operating pressure	- MPa

Remarks: -

No-load test



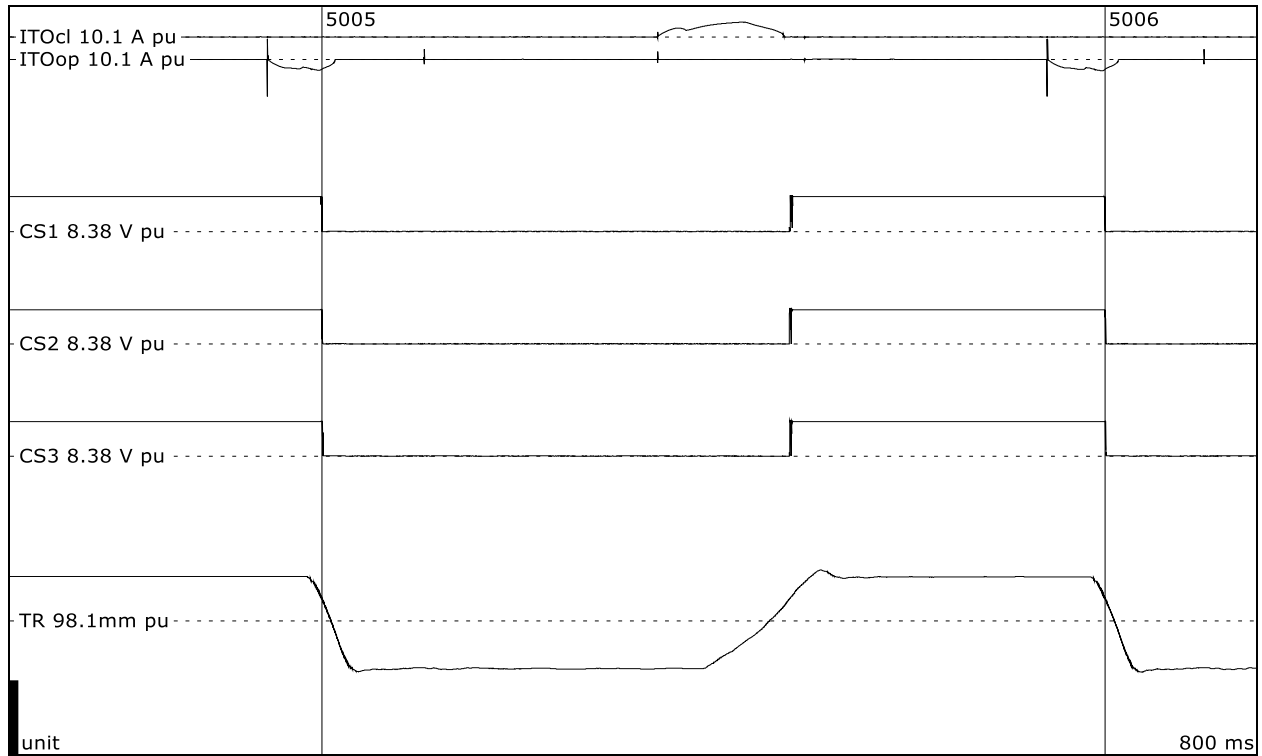
Test number: 170508-5004

Time interval between operations	s	0,303		
Operation	CO			
Phase		A	B	C
Current closing coil	A	2,36		
Closing time	ms	81,2	79,4	80,5
Current opening coil	A	-2,18		
Opening time	ms	27,6	27,6	27,8

Voltage closing coil	220 Vd.c.	Gas pressure at 20 °C	0,60 MPa
Voltage opening coil	220 Vd.c.	Operating pressure	- MPa

Remarks: -

No-load test



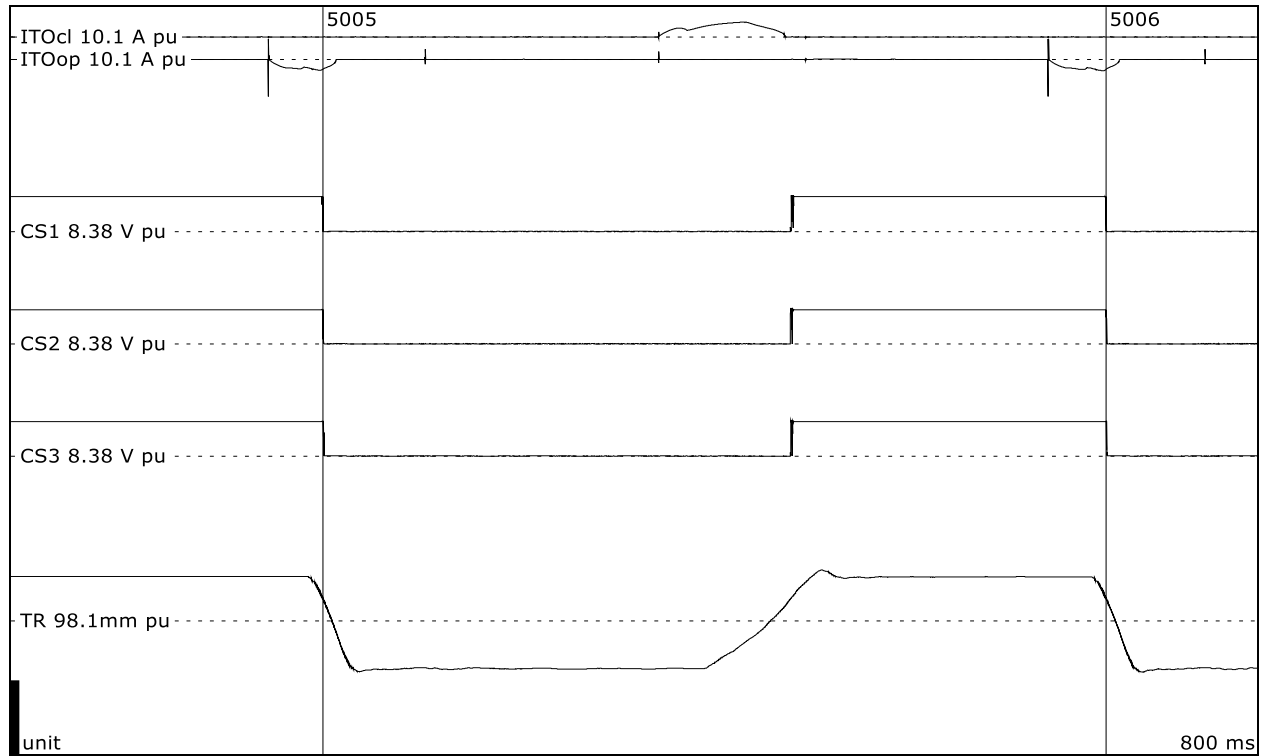
Test number: 170508-5005

Operation		O		
Phase		A	B	C
Current opening coil	A	-1,51		
Opening time	ms	34,9	35,1	35,3

Voltage opening coil	154 Vd.c.	Gas pressure at 20 °C	0,60 MPa
		Operating pressure	- MPa

Remarks: -

No-load test



Test number: 170508-5006

Time interval between operations	s	0,300		
Operation	CO			
Phase		A	B	C
Current closing coil	A	1,96		
Closing time	ms	85,2	84,6	84,9
Current opening coil	A	-1,54		
Opening time	ms	37,2	37,3	37,6

Voltage closing coil	187 Vd.c.	Gas pressure at 20 °C	0,60 MPa
Voltage opening coil	154 Vd.c.	Operating pressure	- MPa

Remarks: -

12.3 Condition / inspection after test

Externally no visible change.

Inspection of contacts:

Fixed arcing contact moderately burnt.

Moving arcing contact moderately burnt.

Fixed main contact finger tips showed locally moderate commutation marks. Silver layer on main contact area intact.

Moving main contact rim showed locally moderate commutation marks. Silver layer on main contact area intact.

Nozzle moderately eroded.

Auxiliary nozzle moderately eroded.

12.4 Photographs after test





Note: "170505-5061" is incorrect, please read "170508-5006".



Note: "170505-5061" is incorrect, please read "170508-5006".



Note: "170505-5061" is incorrect, please read "170508-5006".



Note: "170505-5061" is incorrect, please read "170508-5006".



Note: "170505-5061" is incorrect, please read "170508-5006".



Note: "170505-5061" is incorrect, please read "170508-5006".



Note: "170505-5061" is incorrect, please read "170508-5006".

13 NO-LOAD TESTS

Standard and date

Standard IEC 62271-100

Test date 12 May 2017

13.1 Condition before test

Breaker (Serial No. 17101) reconditioned.

13.2 Photograph before test



13.3 Test results and oscillograms

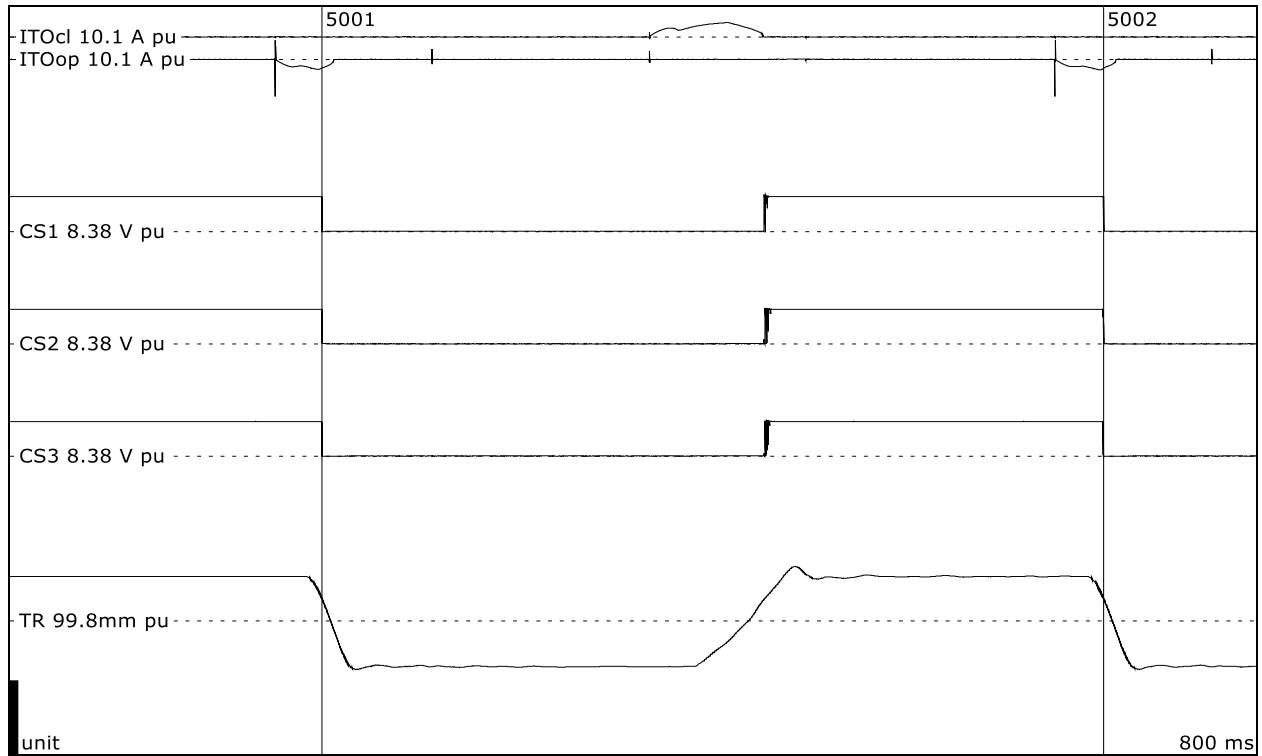
Overview of test numbers

170512-5001 to 5006

Remarks

-

No-load test



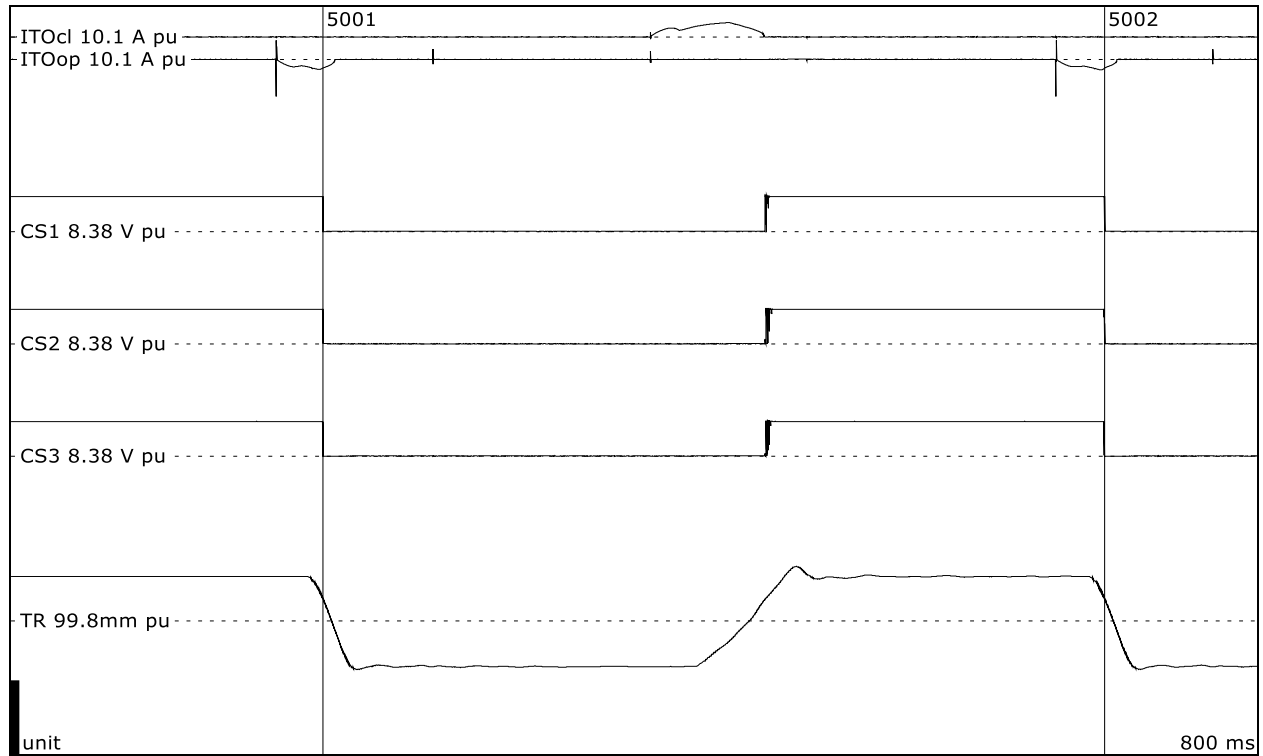
Test number: 170512-5001

Operation		O		
Phase		A	B	C
Current opening coil	A	-1,40		
Opening time	ms	30,0	30,0	29,9

Voltage opening coil	154 Vd.c.	Gas pressure at 20 °C	0,60 MPa
		Operating pressure	- MPa

Remarks: -

No-load test



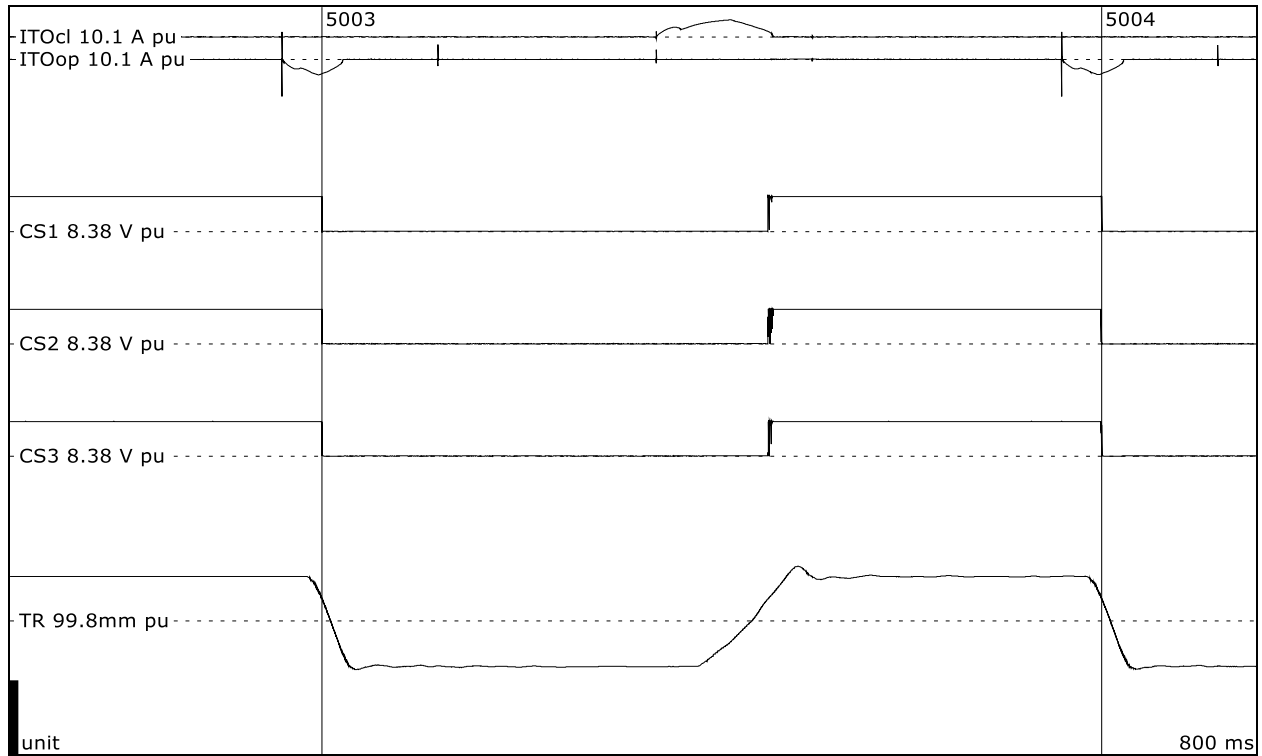
Test number: 170512-5002

Time interval between operations	s	0,284		
Operation	CO			
Phase		A	B	C
Current closing coil	A	1,91		
Closing time	ms	73,3	73,9	73,9
Current opening coil	A	-1,40		
Opening time	ms	31,1	31,0	30,9

Voltage closing coil	187 Vd.c.	Gas pressure at 20 °C	0,60 MPa
Voltage opening coil	154 Vd.c.	Operating pressure	- MPa

Remarks: -

No-load test



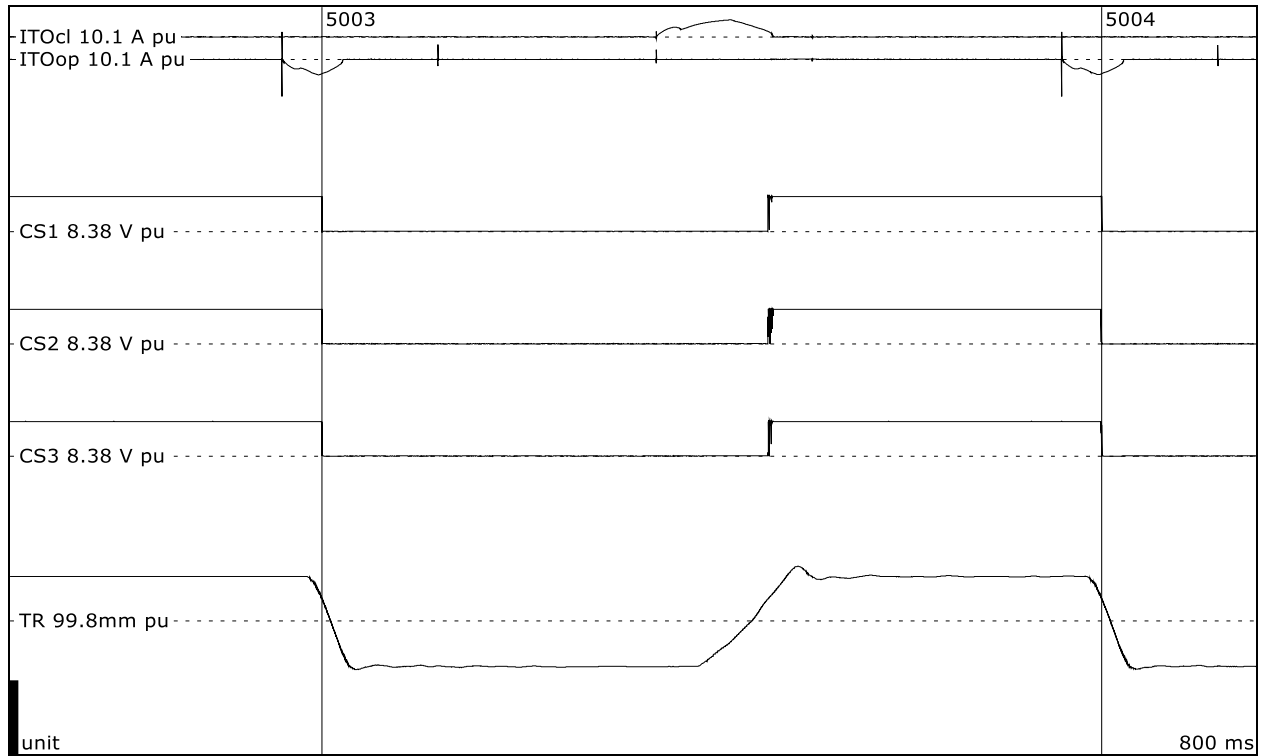
Test number: 170512-5003

Operation		O		
Phase		A	B	C
Current opening coil	A	-2,10		
Opening time	ms	25,7	25,8	25,7

Voltage opening coil	220 Vd.c.	Gas pressure at 20 °C	0,60 MPa
		Operating pressure	- MPa

Remarks: -

No-load test



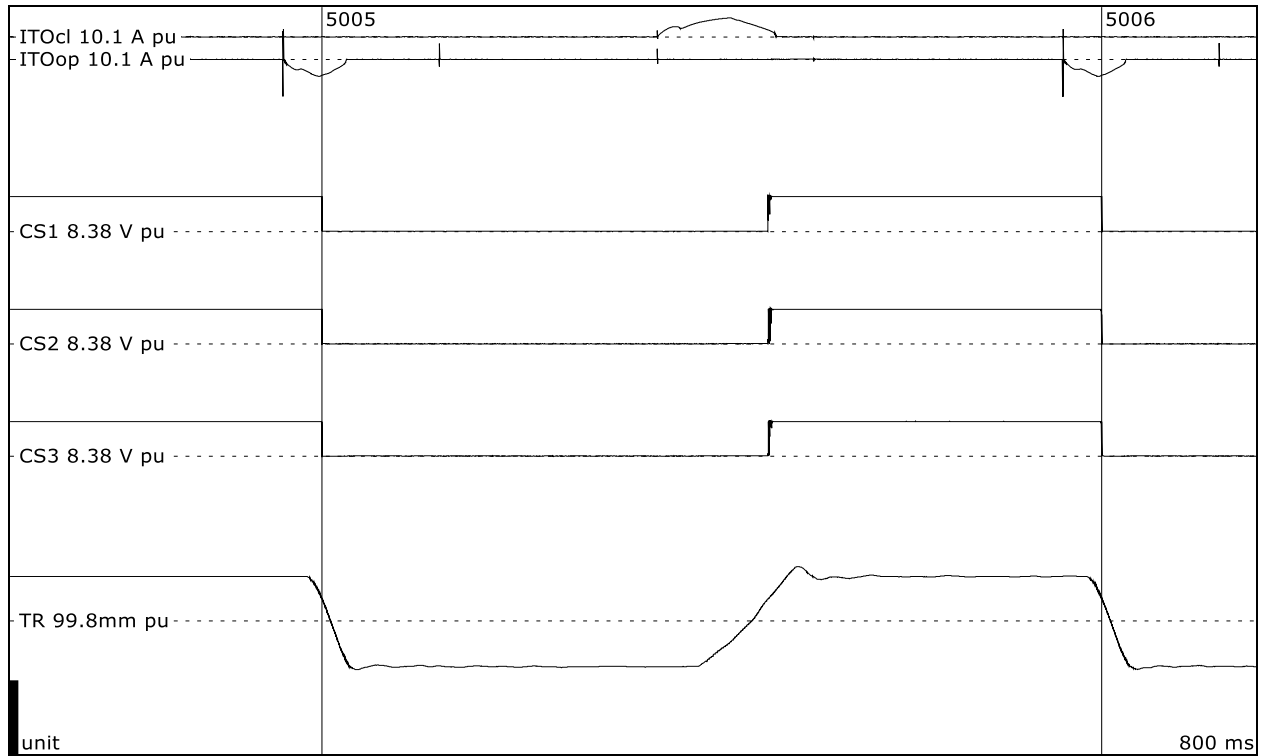
Test number: 170512-5004

Time interval between operations	s	0,286		
Operation	CO			
Phase		A	B	C
Current closing coil	A	2,28		
Closing time	ms	71,5	71,6	71,8
Current opening coil	A	-2,10		
Opening time	ms	25,6	25,5	25,6

Voltage closing coil	220 Vd.c.	Gas pressure at 20 °C	0,60 MPa
Voltage opening coil	220 Vd.c.	Operating pressure	- MPa

Remarks: -

No-load test



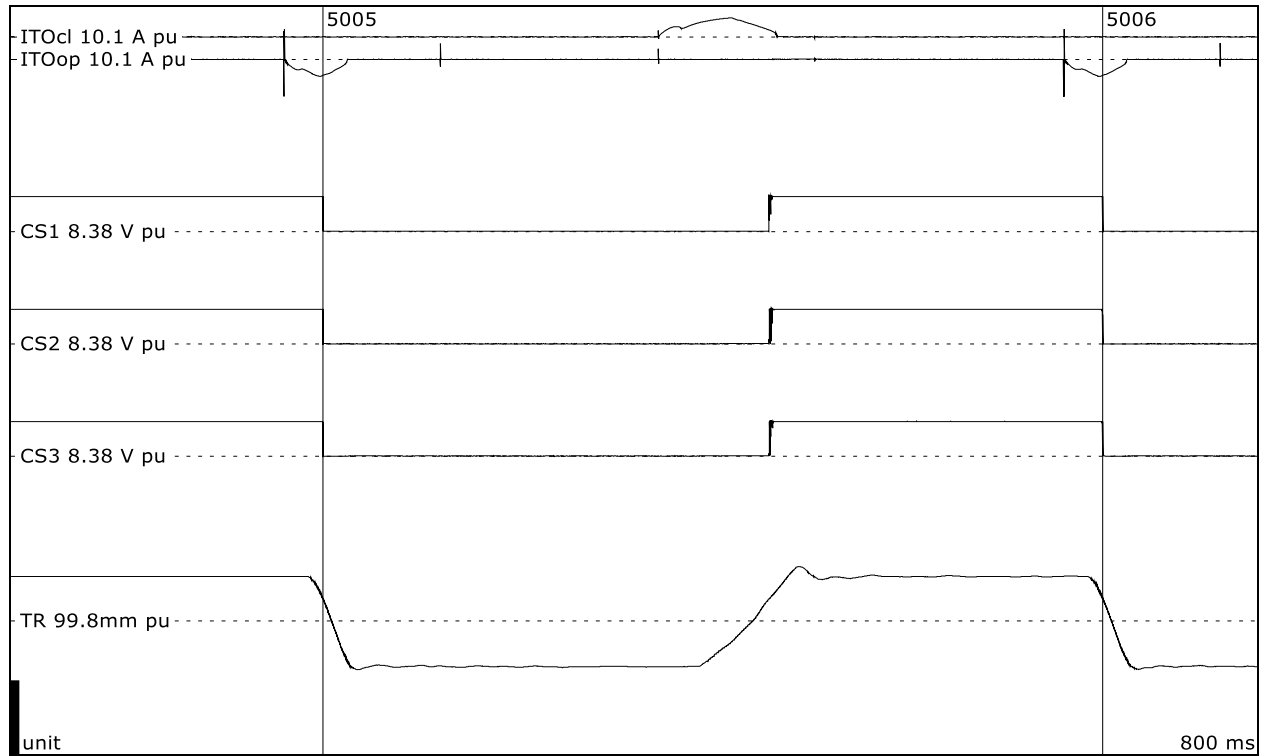
Test number: 170512-5005

Operation		O		
Phase		A	B	C
Current opening coil	A	-2,31		
Opening time	ms	25,0	24,9	24,9

Voltage opening coil	242 Vd.c.	Gas pressure at 20 °C	0,60 MPa
		Operating pressure	- MPa

Remarks: -

No-load test



Test number: 170512-5006

Time interval between operations	s	0,286		
Operation	CO			
Phase		A	B	C
Current closing coil	A	2,54		
Closing time	ms	70,7	70,9	71,0
Current opening coil	A	-2,31		
Opening time	ms	24,9	24,8	25,0

Voltage closing coil	242 Vd.c.	Gas pressure at 20 °C	0,60 MPa
Voltage opening coil	242 Vd.c.	Operating pressure	- MPa

Remarks: -

14 T100a

Standard and date

Standard	IEC 62271-100
Test date	12 May 2017

14.1 Condition before test

Breaker (Serial No 17101) in same condition.
Supply to moving contacts.
Short-circuit on fixed contacts.
Frame earthed via a CT.

Auxiliary breaker:

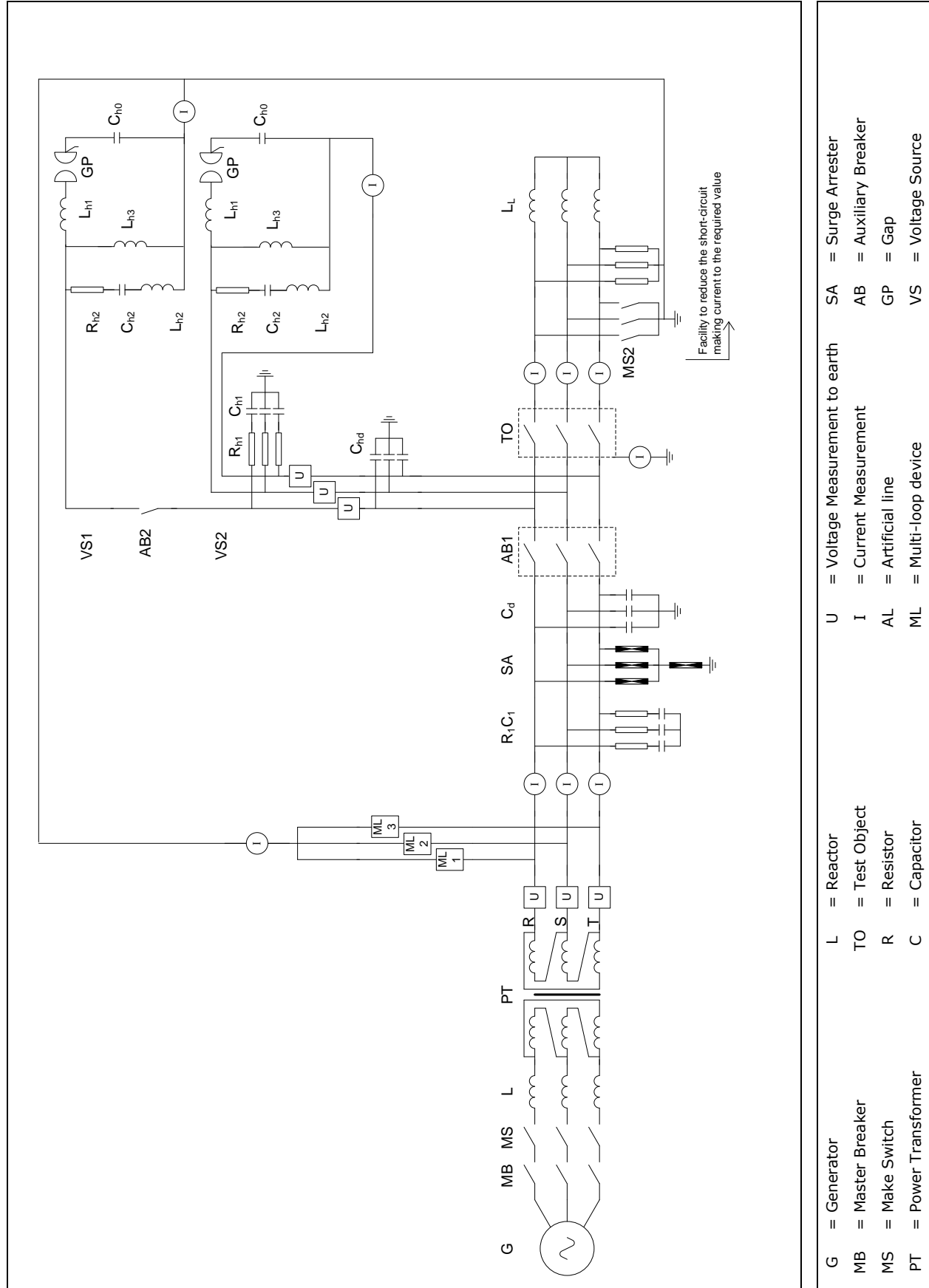
An SF₆ breaker, provided by KEMA Laboratories.
Number of elements: 1 per breaker.

Parameters of the last major loop based on table15 for a minimum clearing time of 47,7 ms:
Duration of last loop: 11,5 ms.
Current peak of last loop: 1,21 p.u.

DC component at the instant of contact separation during the test deviates from the rated DC component of the test breaker, due to the difference between the rated time constant of the rated short-circuit current of the breaker and the time constant of the current of the test plant.

14.2 Test circuit S03

Diagram



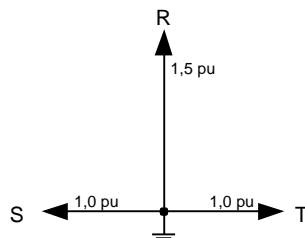
Values

Supply		
Power	MVA	2494
Frequency	Hz	50
Phase(s)		3
Voltage	kV	36,0
Current	kA	40,0
Impedance	Ω	0,52
Power factor		< 0,1
Neutral		not earthed

Load	
Short-circuit point	earthed

TRV control elements added (supply)		
C ₁	μF	0,30
R ₁	Ω	50,0
C _d	nF	15,0

Injection circuit					
		First phase	Second and third phase		
		R	T	Between phases	S
C _{h0}	μF	8,00	-	8,00	-
U _{h0}	kVd.c.	195	-	260	-
L _{h1}	mH	10,5	-	15,6	-
f _h	Hz	554	-	440	-
R _{h1}	Ω	108	102	-	102
C _{h1}	μF	0,20	0,24	-	0,24
C _{hd}	nF	14,0	14,0	-	14,0
R _{hc}	Ω	-	-	-	-
C _{hc}	nF	-	-	-	-
R _{h2}	Ω	58,8	-	167	-
C _{h2}	μF	0,444	-	0,56	-
L _{h2}	mH	8,4	-	9,80	-
R _{hp}	k Ω	-	-	-	-
L _{h3}	H	1,20	-	1,20	-
f _{RV}	Hz	48,0	-	48,3	-

Voltage distribution in FPTC 1,5 test-circuit

Prospective TRV of supply				
		First phase	Second phase	Third phase
		R	T	S
U _{recovery}	kVa.c.	126	83,7	83,7
u ₁	kV	113	76,5	77
u _c	kV	249	143	159
t _d	μs	< 2,0	< 2,0	< 2,0
t ₁	μs	67	55	55
t ₂	μs	266	219	219
RRRV	kV/ μs	2,00	1,40	1,40

The circuit is composed of:

a) **A three-phase current source**

The neutral point of the supply circuit is isolated and the short-circuit-point is earthed.

b) **Two parallel current injection circuits**

One of the two circuits is used for the test of the first-pole-to-clear conditions. This circuit, one side of which is earthed and based on a fptc-factor of 1,5, is applied to the terminals of the first clearing pole, phase R.

The second circuit is used to obtain the conditions of the second and third clearing poles. This circuit, which is floating in relation to earth, is applied across these two poles, phase S and phase T. The voltage is divided at 50% / 50% between the two poles by means of capacitors

The recovery voltage for both circuits is transformed in a decaying power-frequency voltage by the use of air-cored reactors.

c) **Multi-loop reignition circuits**

For all poles standard RC-reignition circuits have been used.

The phases R, S and T relate to the diagram, presented on the previous page.

Remarks: -

14.3 Test results and oscillograms

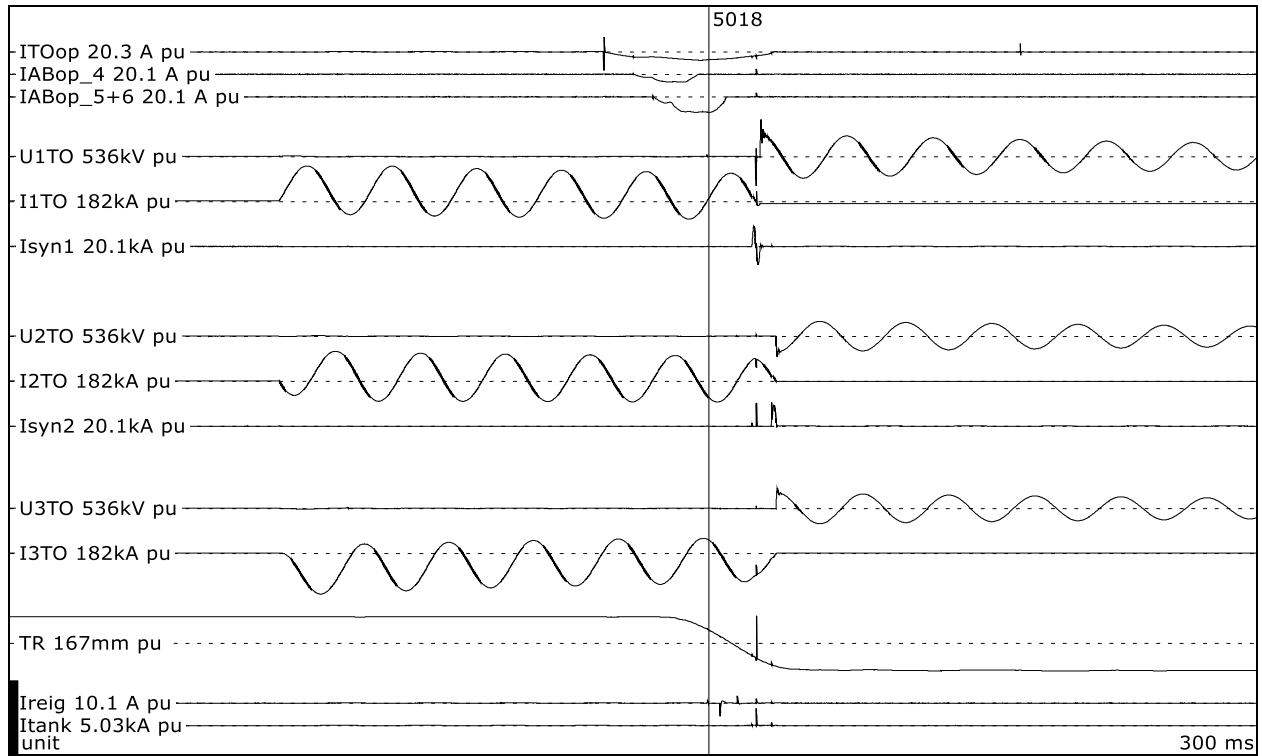
Overview of test numbers

170512-5018, 5020, 5022, 5024

Remarks

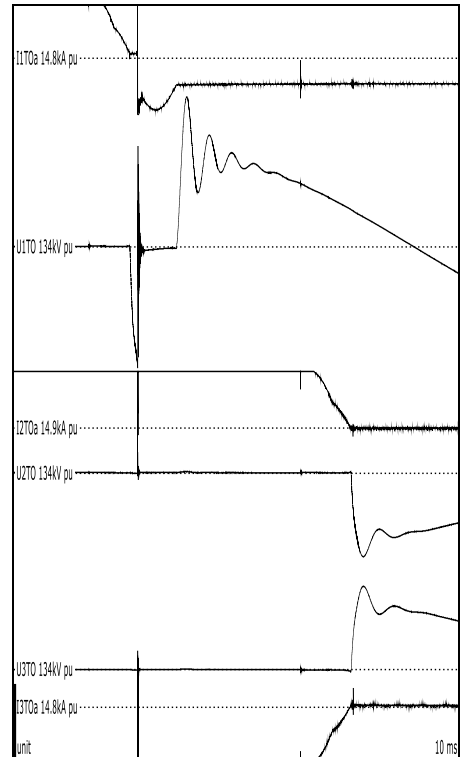
-

T100a



Test number: 170512-5018

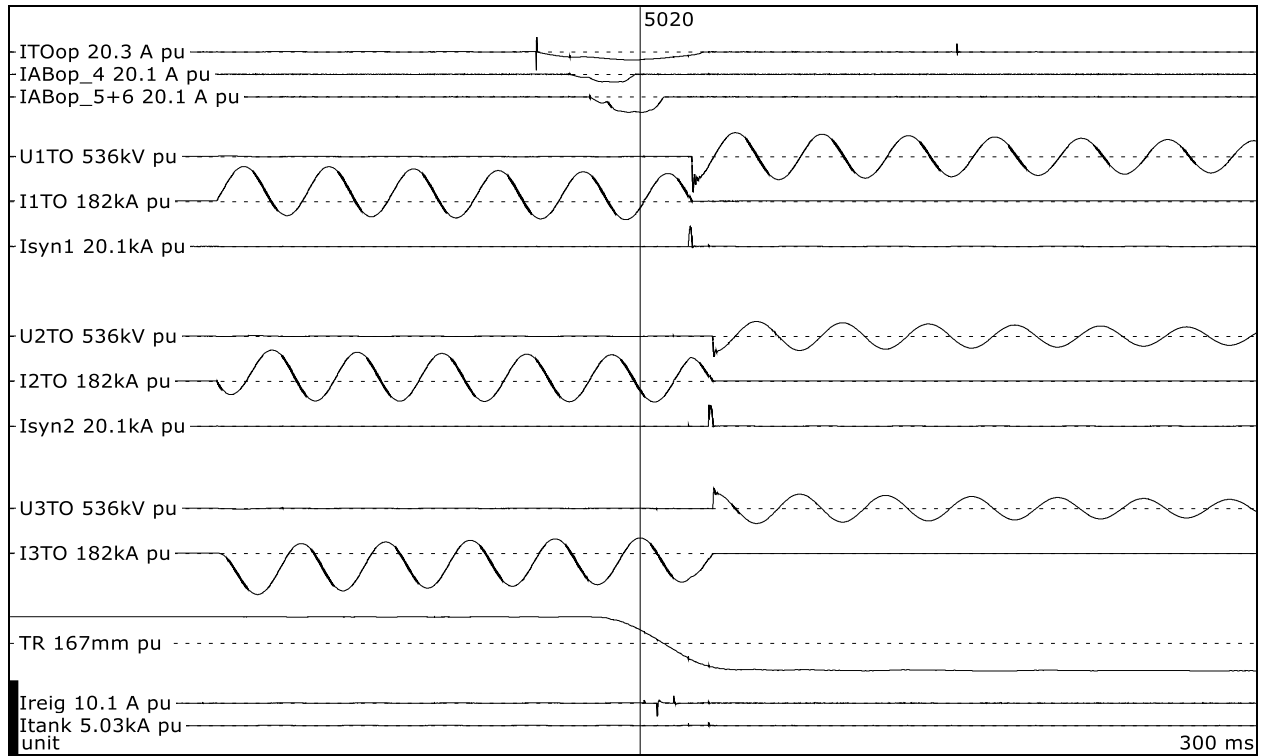
Time interval since previous test	min	-		
Operation		O _S		
Phase		A	B	C
Applied voltage, current source, phase value	kV	21,3	21,3	21,3
Charging voltage capacitor bank, DC value	kVd.c.	198	122	122
Breaking current, symmetrical, phase value	kA	40,7	40,2	40,0
Current last loop, peak	kA	67,7	55,4	-69,8
Duration last loop	ms	12,3	9,43	13,6
Breaking current, DC-component	%	22	9	32
di/dt at last current zero	A/μs	18,5	15,4	15,4
TRV, peak	kV	-	-	-
Recovery voltage, phase value	kV	-	-	-
Arc duration	ms	(1)	16,3	16,3
Opening time	ms	25,2		
Break time	ms	-	41,5	41,5
t _h	μs	364	440	444



Voltage opening coil	242 Vd.c.	Gas pressure at 20 °C	0,60 MPa
		Operating pressure	- MPa

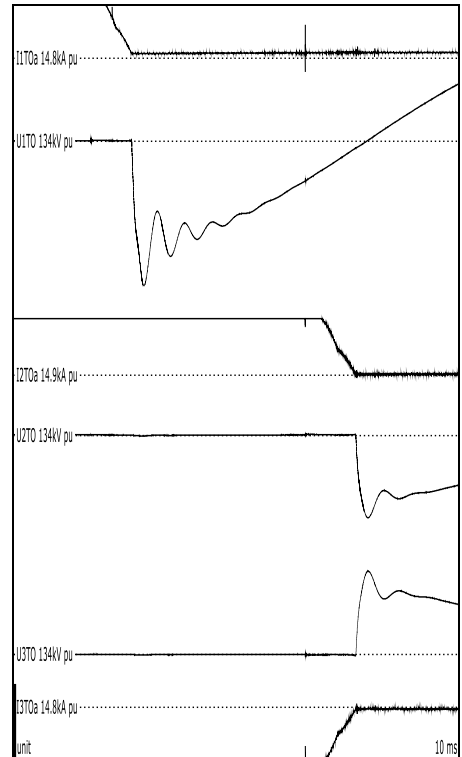
Remarks: Test to verify the correct reignition behaviour of the breaker (subclause 6.102.10 of IEC 62271-101).
 (1) Arcing time set for 11,3 ms.
 O_S = Operation in a synthetic circuit.

T100a



Test number: 170512-5020

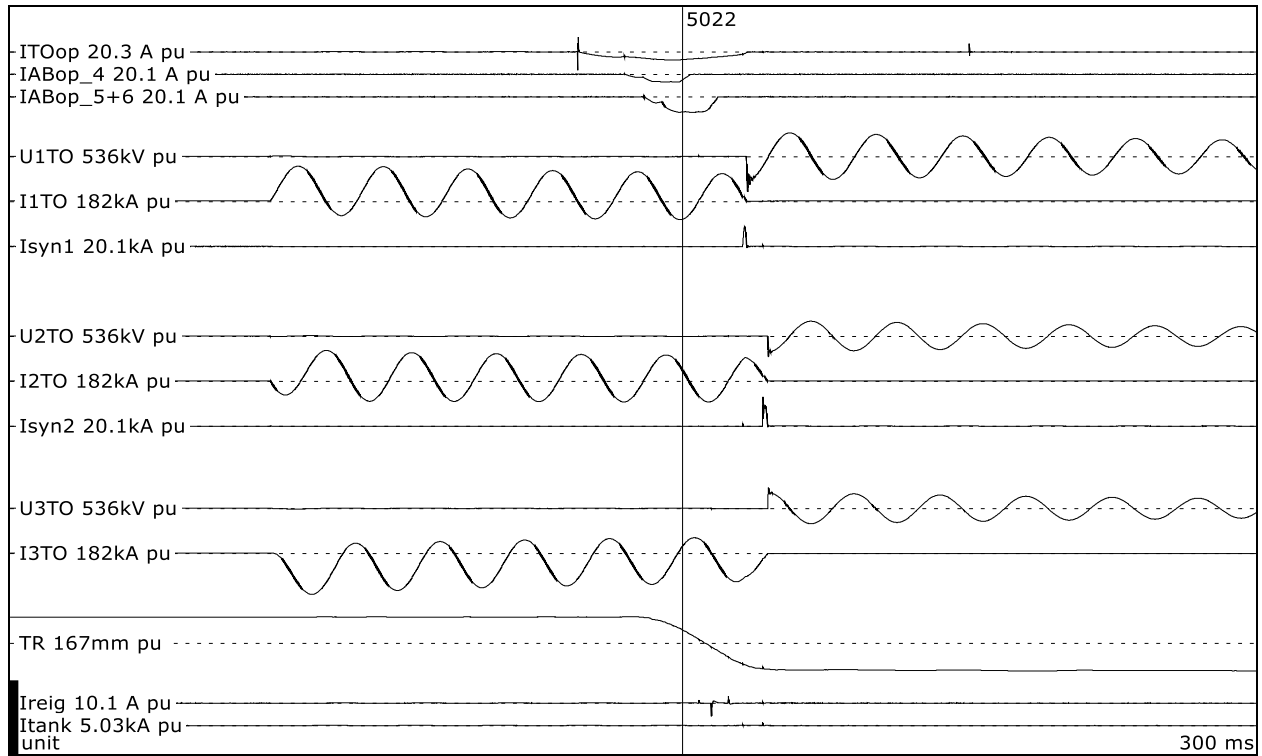
Time interval since previous test	min	-		
Operation		O _s		
Phase		A	B	C
Applied voltage, current source, phase value	kV	21,5	21,5	21,5
Charging voltage capacitor bank, DC value	kVd.c.	196	121	121
Breaking current, symmetrical, phase value	kA	41,0	40,7	40,4
Current last loop, peak	kA	67,1	56,9	-70,2
Duration last loop	ms	11,6	9,49	13,6
Breaking current, DC-component	%	21	10	30
di/dt at last current zero	A/μs	18,2	15,4	15,4
TRV, peak	kV	-256	-146	146
Recovery voltage, phase value	kV	125	79,0	80,9
Arc duration	ms	12,4	17,6	17,6
Opening time	ms	25,0		
Break time	ms	37,4	42,6	42,6
t _h	μs	368	429	426



Voltage opening coil	242 Vd.c.	Gas pressure at 20 °C	0,60 MPa
		Operating pressure	- MPa

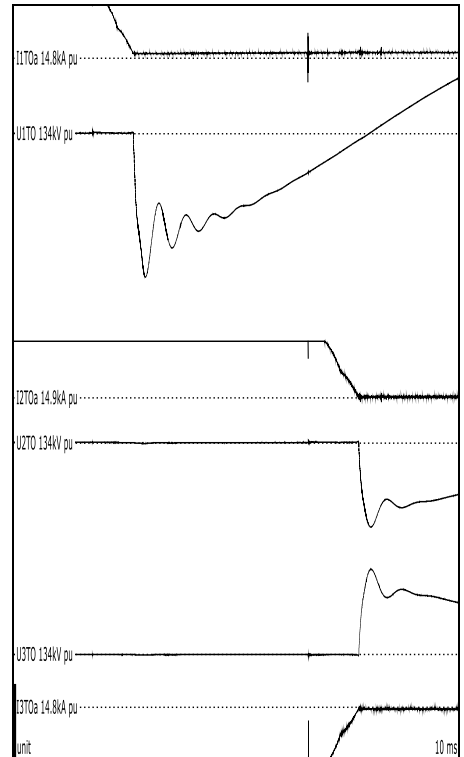
Remarks: Breaker cleared.
O_s = Operation in a synthetic circuit.

T100a



Test number: 170512-5022

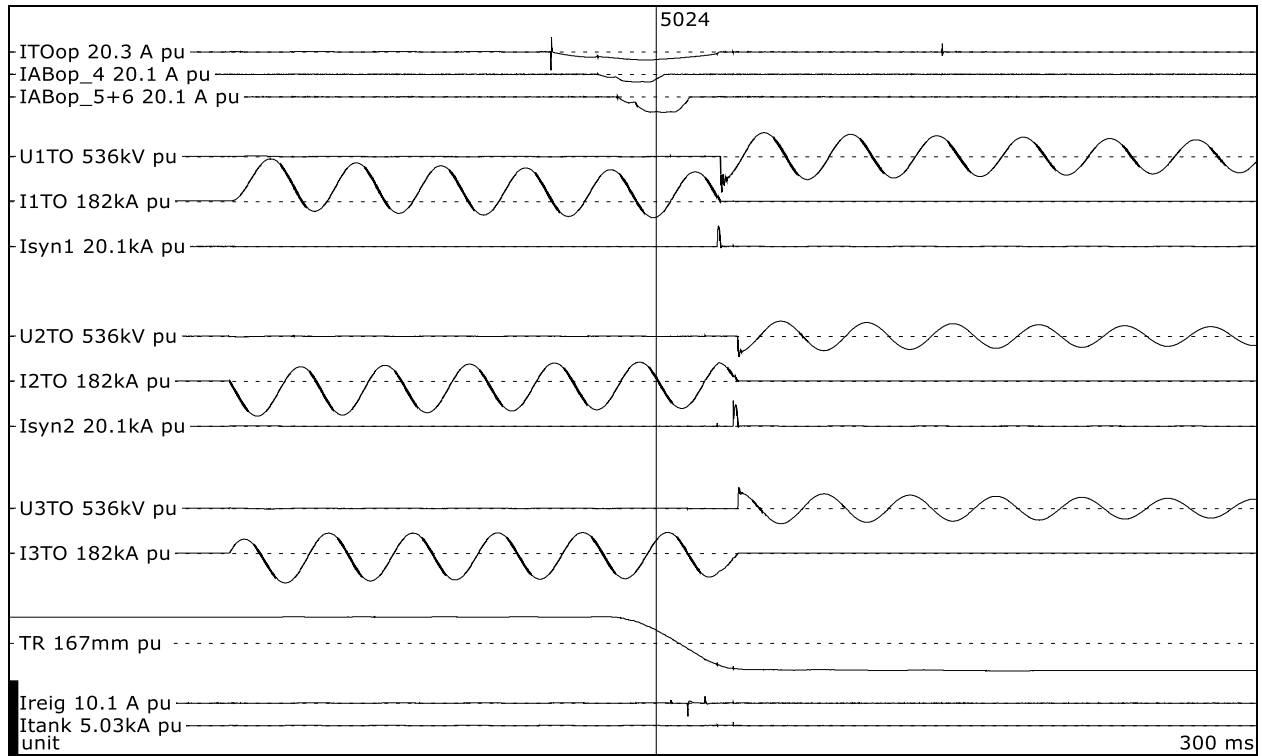
Time interval since previous test	min	-		
Operation		O _s		
Phase		A	B	C
Applied voltage, current source, phase value	kV	21,5	21,5	21,5
Charging voltage capacitor bank, DC value	kVd.c.	195	124	124
Breaking current, symmetrical, phase value	kA	41,0	40,6	40,4
Current last loop, peak	kA	66,6	56,5	-69,5
Duration last loop	ms	11,6	9,49	13,6
Breaking current, DC-component	%	21	10	31
di/dt at last current zero	A/μs	18,2	15,5	15,6
TRV, peak	kV	-254	-148	145
Recovery voltage, phase value	kV	124	80,2	82,5
Arc duration	ms	15,4	20,5	20,5
Opening time	ms	25,2		
Break time	ms	40,6	45,7	45,7
t _h	μs	362	426	424



Voltage opening coil	242 Vd.c.	Gas pressure at 20 °C	0,60 MPa
		Operating pressure	- MPa

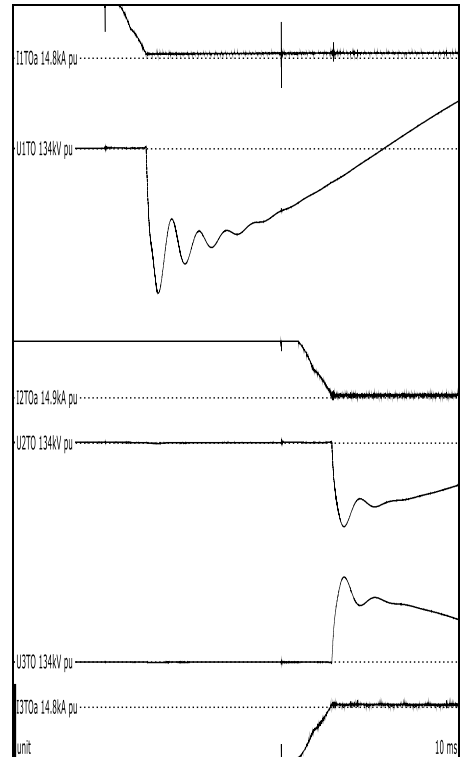
Remarks: Breaker cleared.
O_s = Operation in a synthetic circuit.

T100a



Test number: 170512-5024

Time interval since previous test	min	-		
Operation		O _s		
Phase		A	B	C
Applied voltage, current source, phase value	kV	21,5	21,5	21,5
Charging voltage capacitor bank, DC value	kVd.c.	196	123	123
Breaking current, symmetrical, phase value	kA	40,9	40,5	40,2
Current last loop, peak	kA	71,1	43,8	-59,1
Duration last loop	ms	12,1	8,09	12,1
Breaking current, DC-component	%	29	20	9
di/dt at last current zero	A/μs	18,4	15,4	15,5
TRV, peak	kV	-256	-148	150
Recovery voltage, phase value	kV	125	80,2	82,0
Arc duration	ms	15,6	19,9	19,7
Opening time	ms	25,2		
Break time	ms	40,8	45,1	44,9
t _h	μs	367	438	434



Voltage opening coil	242 Vd.c.	Gas pressure at 20 °C	0,60 MPa
		Operating pressure	- MPa

Remarks: Breaker cleared.
O_s = Operation in a synthetic circuit.

15 NO-LOAD TESTS

Standard and date

Standard	IEC 62271-100
Test date	12 May 2017

15.1 Condition before test

Breaker (Serial No 17101) in same condition.

15.2 Test results and oscillograms

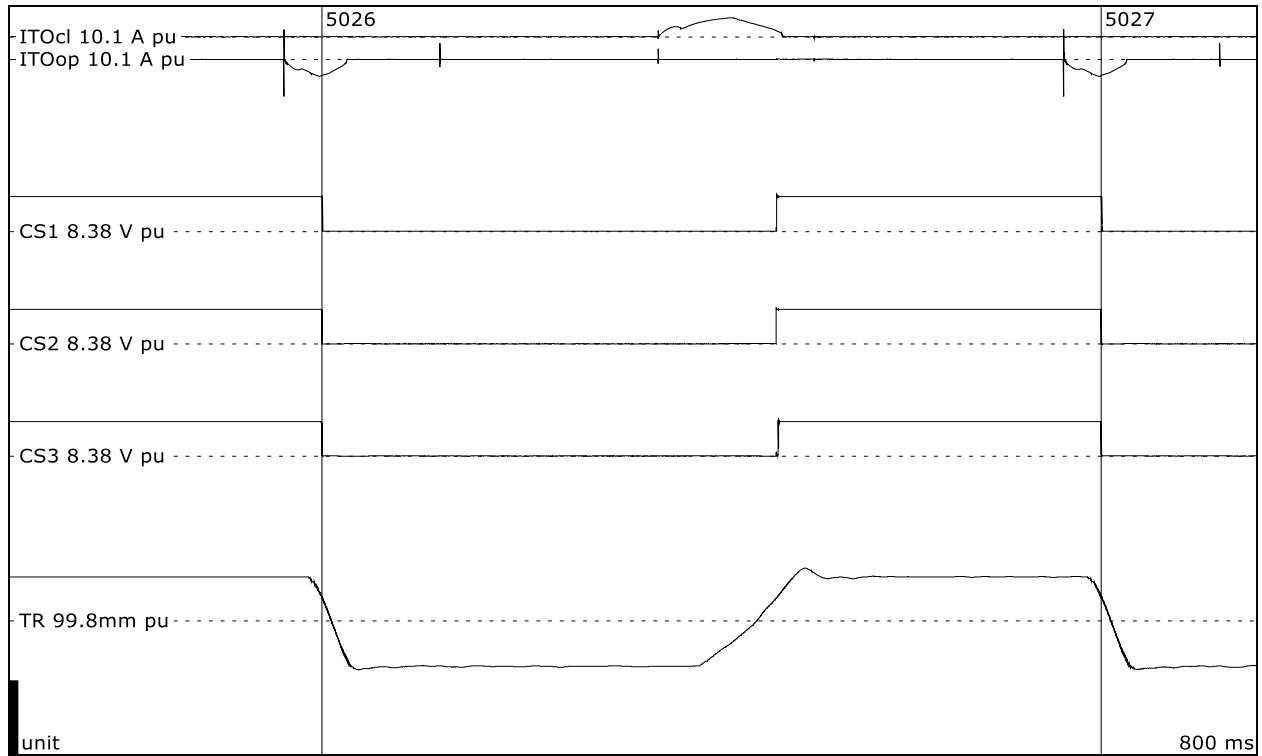
Overview of test numbers

170512-5026 to 5031

Remarks

-

No-load test



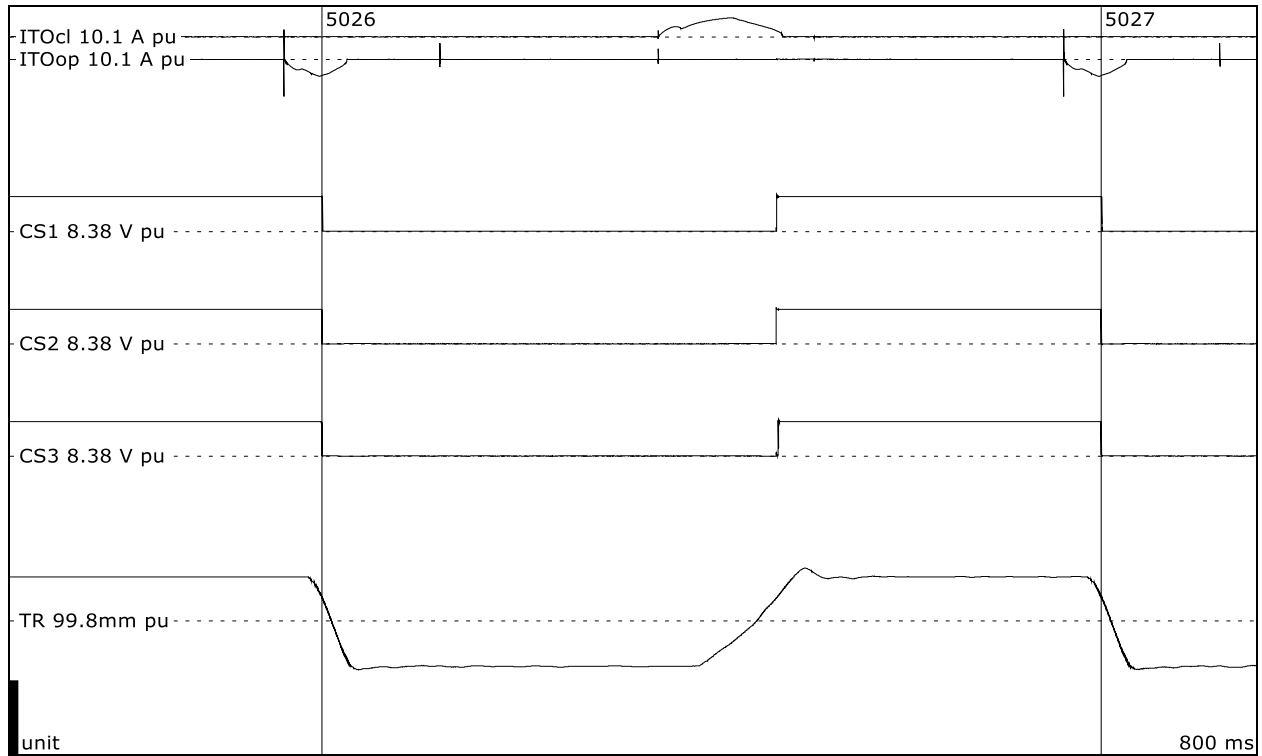
Test number: 170512-5026

Operation		O		
Phase		A	B	C
Current opening coil	A	-2,30		
Opening time	ms	24,8	24,4	24,5

Voltage opening coil	242 Vd.c.	Gas pressure at 20 °C	0,60 MPa
		Operating pressure	- MPa

Remarks: -

No-load test



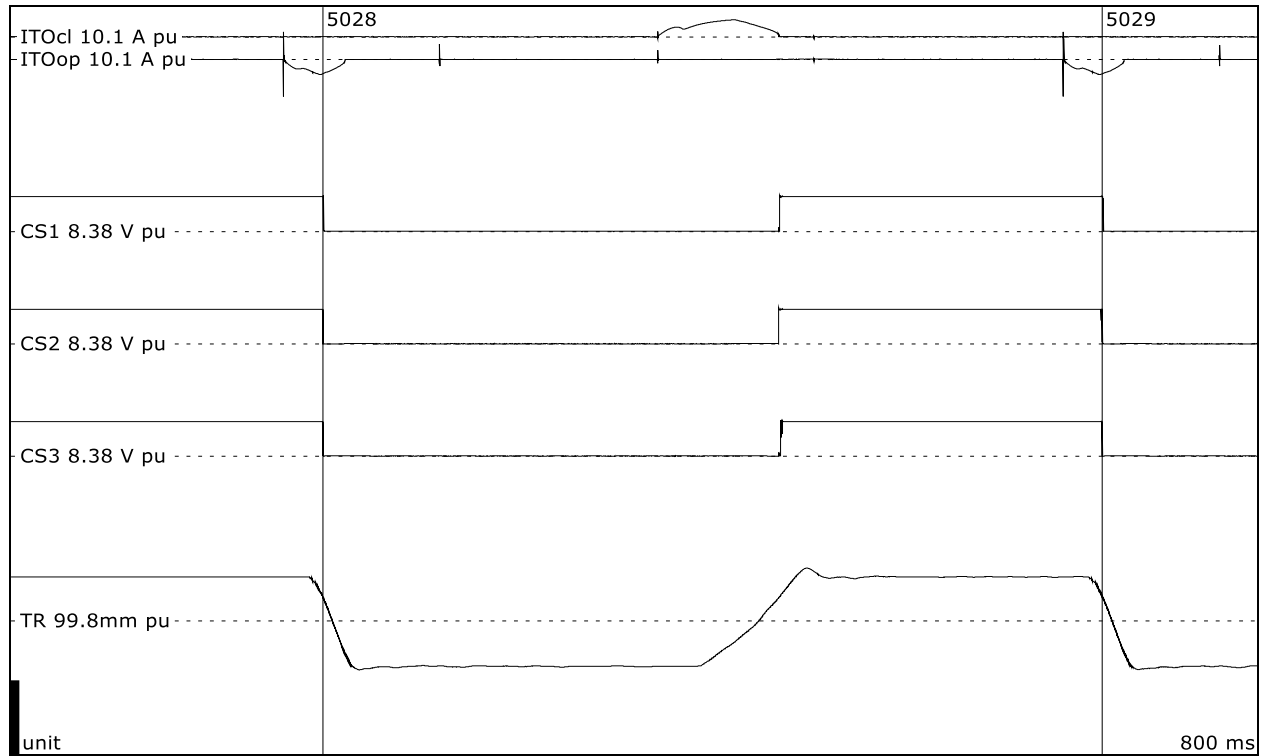
Test number: 170512-5027

Time interval between operations	s	0,292		
Operation	CO			
Phase		A	B	C
Current closing coil	A	2,56		
Closing time	ms	75,9	75,5	76,7
Current opening coil	A	-2,30		
Opening time	ms	24,6	24,2	24,3

Voltage closing coil	242 Vd.c.	Gas pressure at 20 °C	0,60 MPa
Voltage opening coil	242 Vd.c.	Operating pressure	- MPa

Remarks: -

No-load test



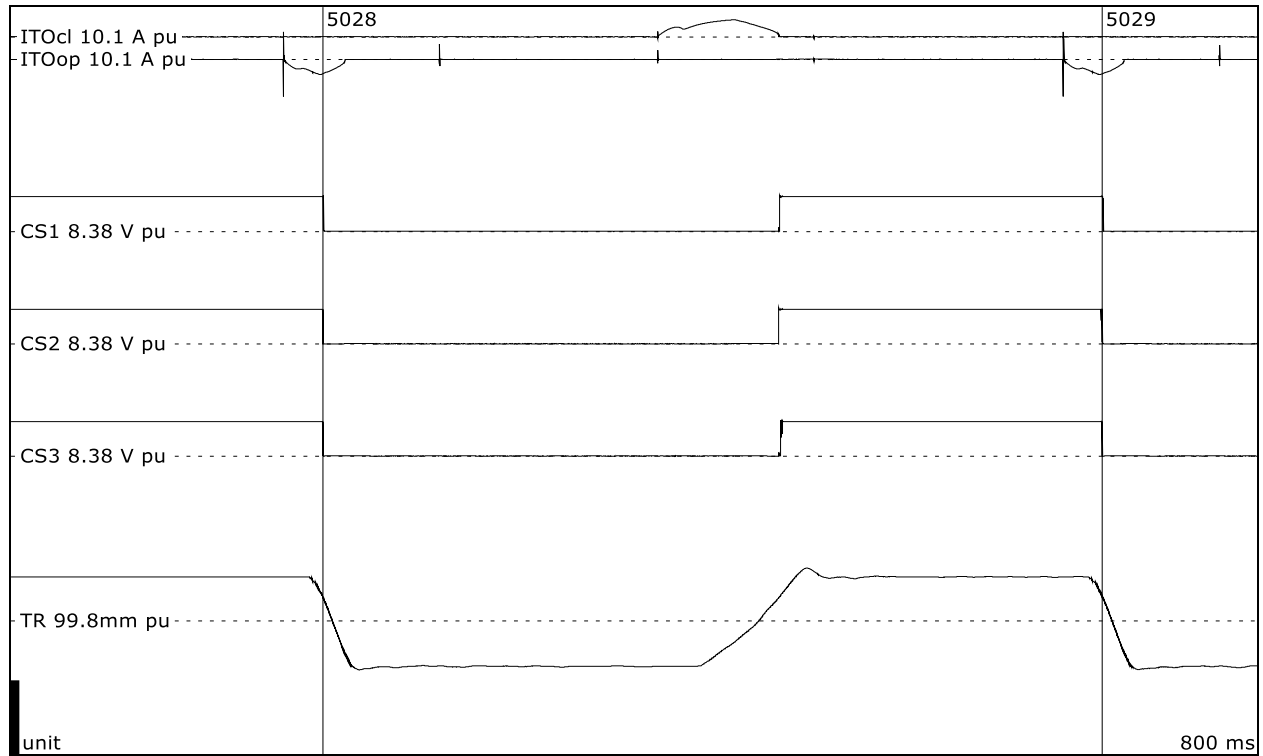
Test number: 170512-5028

Operation		O		
Phase		A	B	C
Current opening coil	A	-2,07		
Opening time	ms	25,6	25,3	25,3

Voltage opening coil	220 Vd.c.	Gas pressure at 20 °C	0,60 MPa
		Operating pressure	- MPa

Remarks: -

No-load test



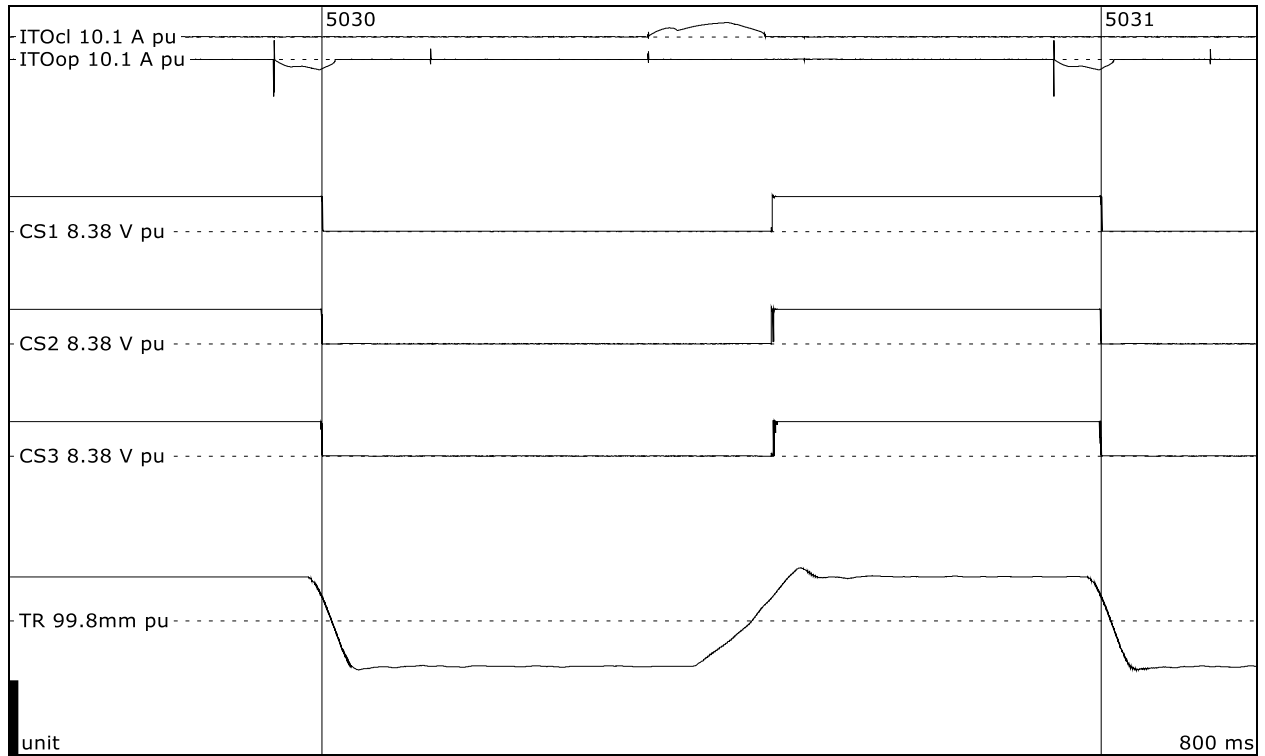
Test number: 170512-5029

Time interval between operations	s	0,293		
Operation	CO			
Phase		A	B	C
Current closing coil	A	2,29		
Closing time	ms	77,9	77,2	78,6
Current opening coil	A	-2,07		
Opening time	ms	25,5	25,1	24,9

Voltage closing coil	220 Vd.c.	Gas pressure at 20 °C	0,60 MPa
Voltage opening coil	220 Vd.c.	Operating pressure	- MPa

Remarks: -

No-load test



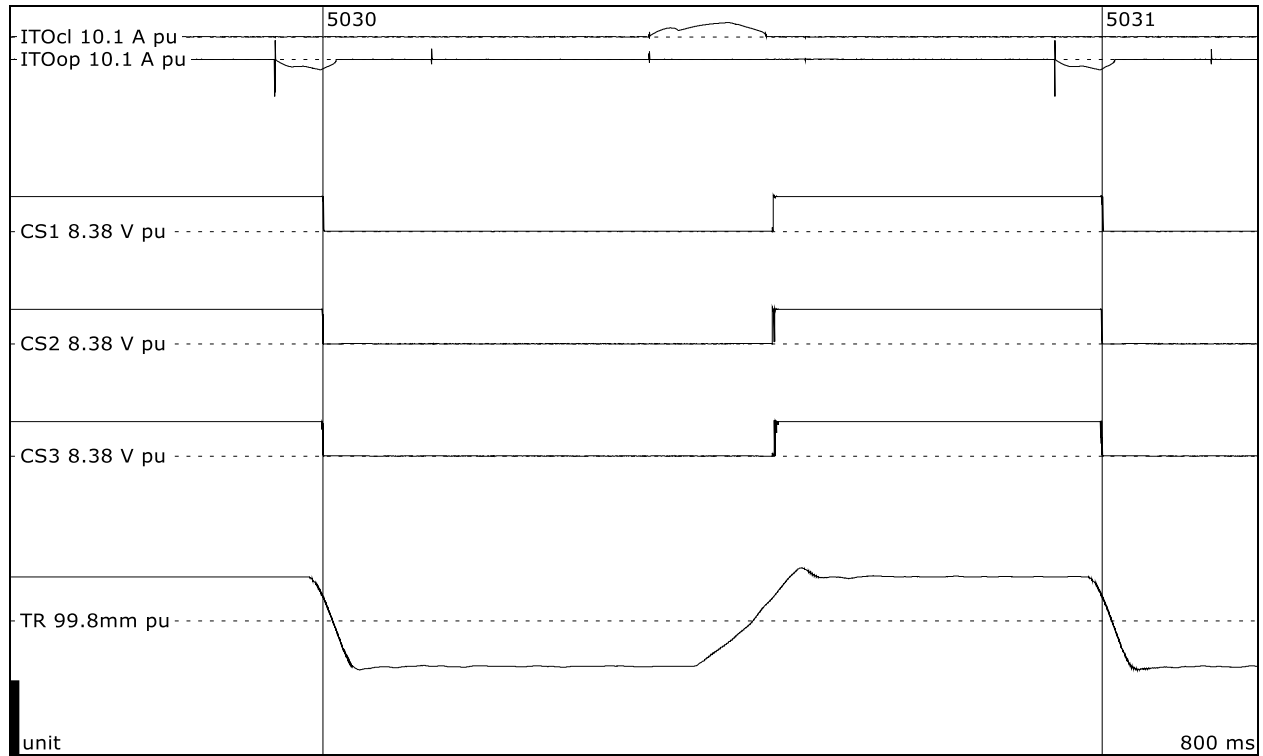
Test number: 170512-5030

Operation		O		
Phase		A	B	C
Current opening coil	A	-1,42		
Opening time	ms	31,3	30,7	30,8

Voltage opening coil	154 Vd.c.	Gas pressure at 20 °C	0,60 MPa
		Operating pressure	- MPa

Remarks: -

No-load test



Test number: 170512-5031

Time interval between operations	s	0,289		
Operation	CO			
Phase		A	B	C
Current closing coil	A	1,91		
Closing time	ms	79,3	78,8	79,9
Current opening coil	A	-1.42		
Opening time	ms	30,8	30,3	29,7

Voltage closing coil	187 Vd.c.	Gas pressure at 20 °C	0,60 MPa
Voltage opening coil	154 Vd.c.	Operating pressure	- MPa

Remarks: -

15.3 Condition / inspection after test

Externally no visible change.

Inspection of contacts:

Fixed arcing contact moderately burnt.

Moving arcing contact moderately burnt.

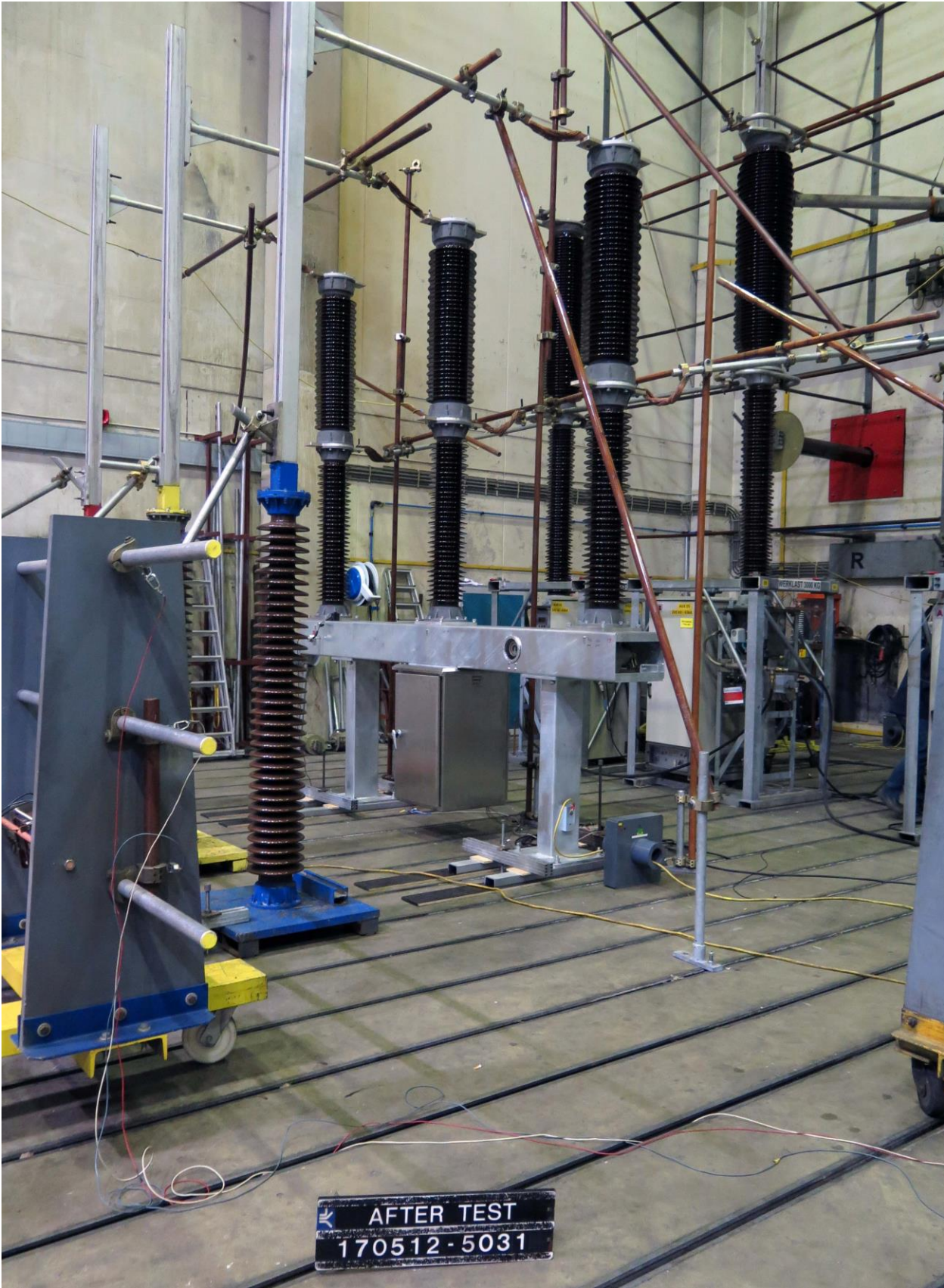
Fixed main contact finger tips showed locally moderate commutation marks. Silver layer on main contact area intact.

Moving main contact rim showed locally moderate commutation marks. Silver layer on main contact area intact.

Nozzle moderately eroded.

Auxiliary nozzle moderately eroded.

15.4 Photographs after test



















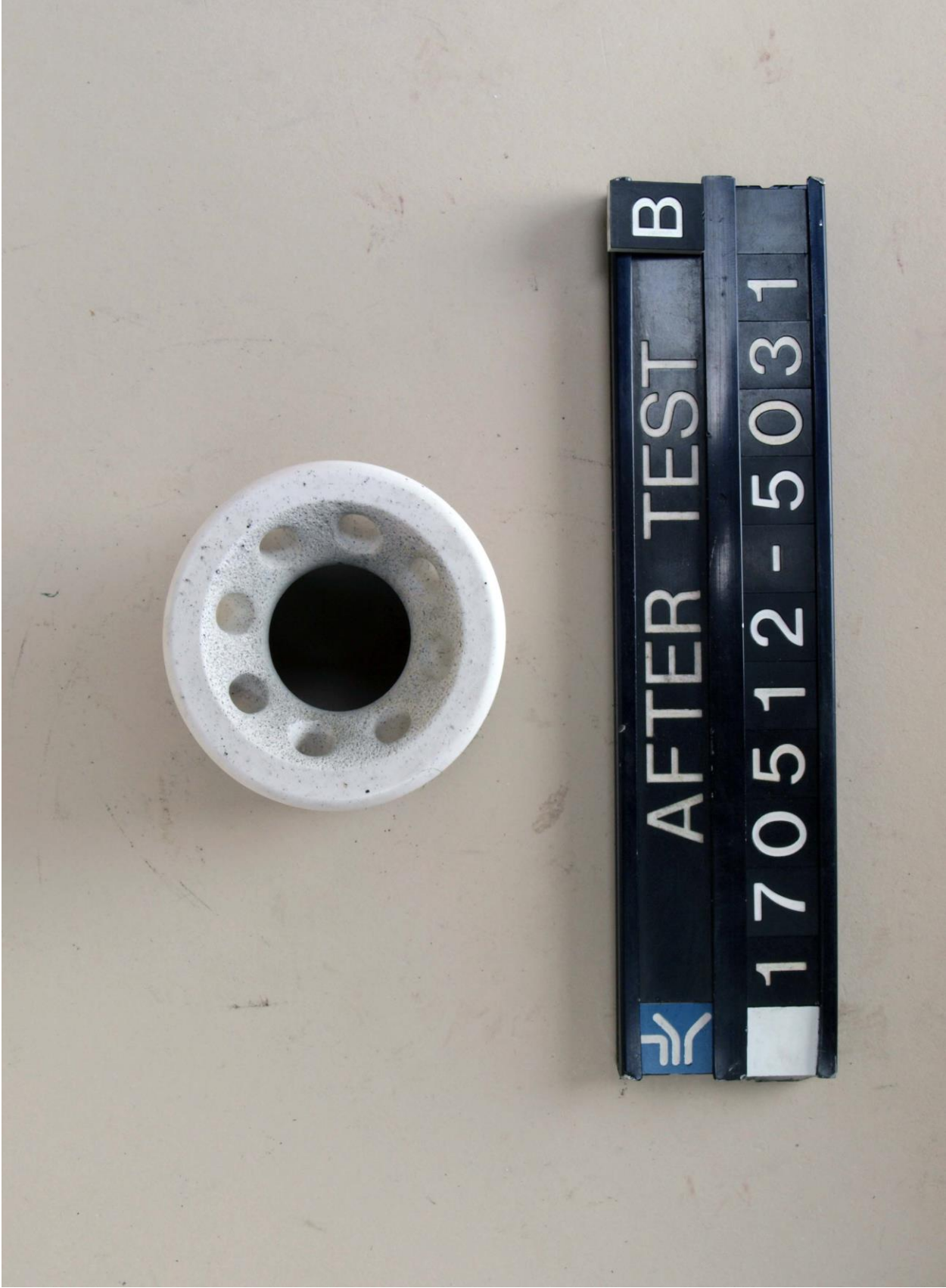














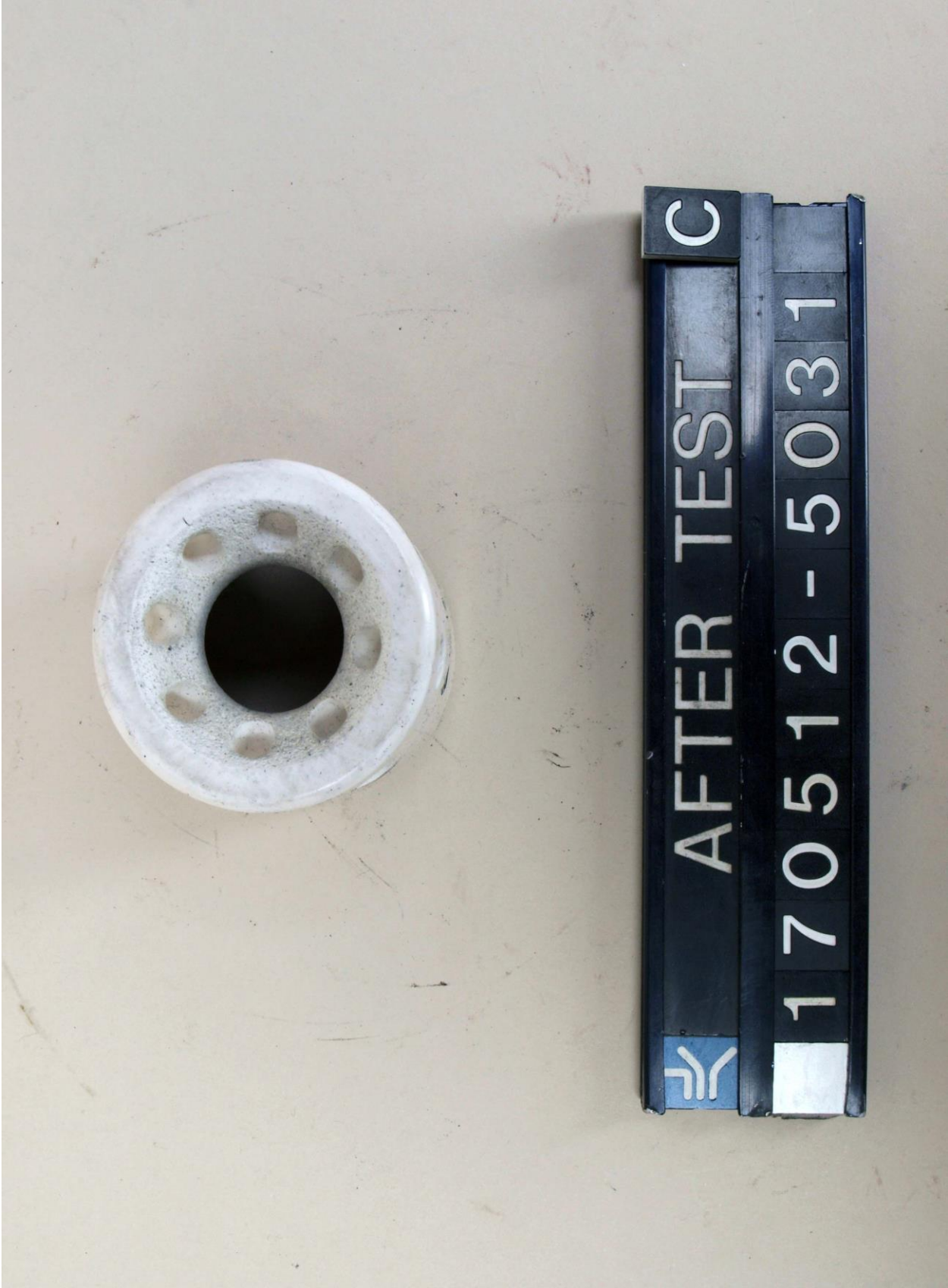












16 NO-LOAD TESTS

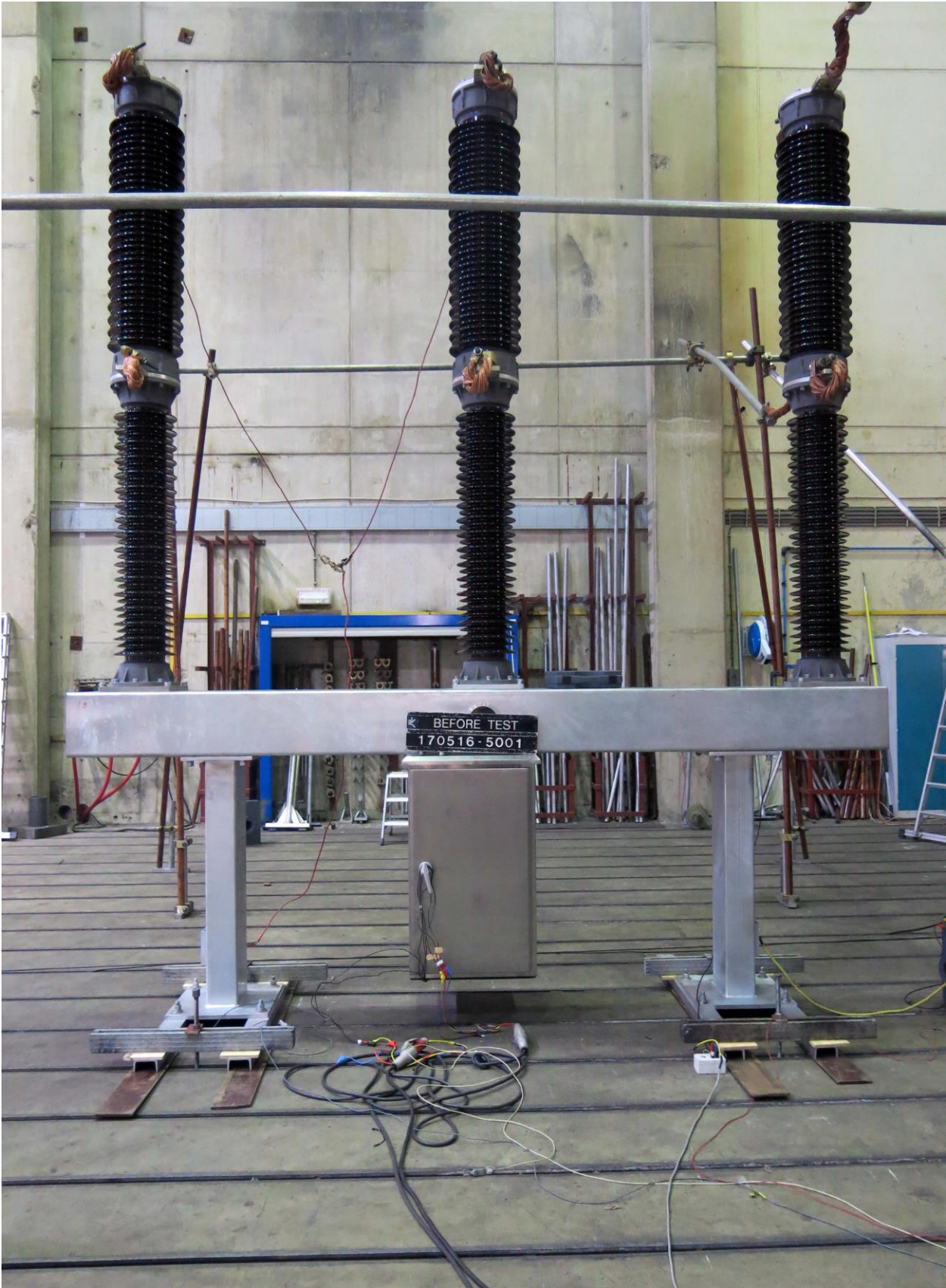
Standard and date

Standard	IEC 62271-100
Test date	16 May 2017

16.1 Condition before test

Breaker (Serial No 17101) reconditioned.

16.2 Photograph before test



16.3 Test results and oscillograms

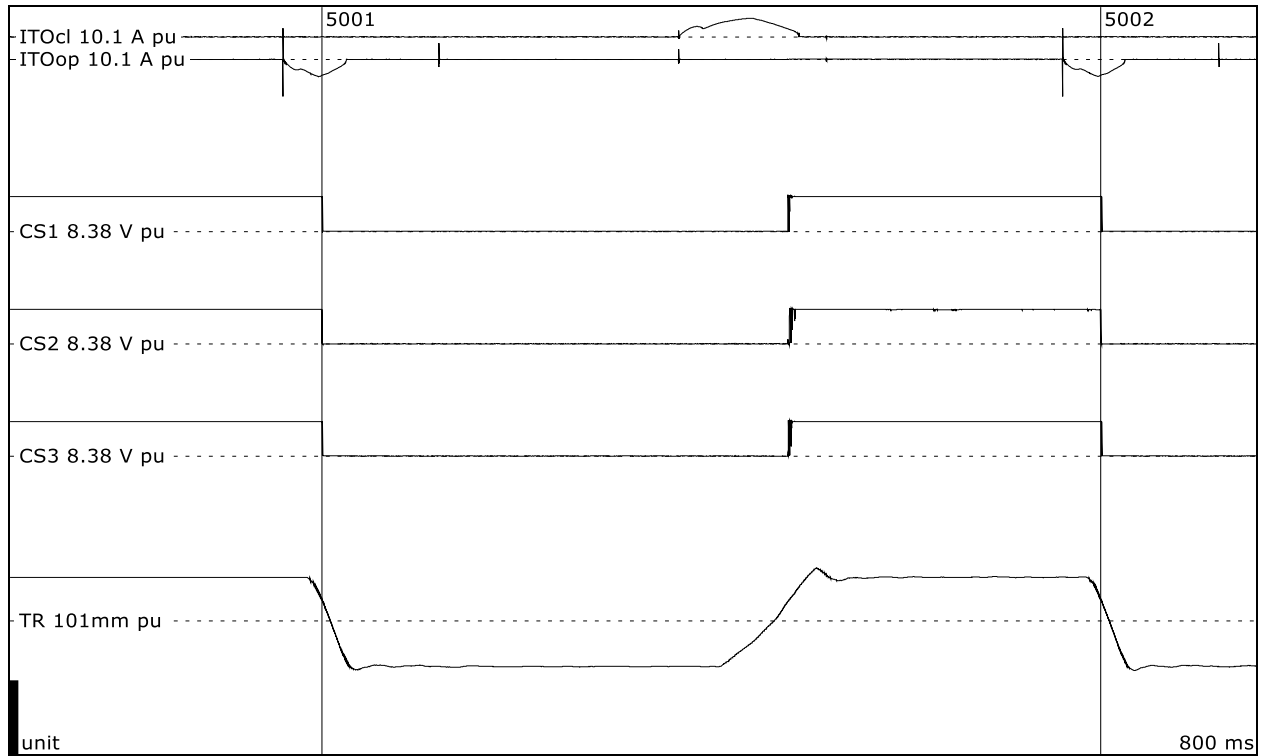
Overview of test numbers

170516-5001 to 5006

Remarks

-

No-load test



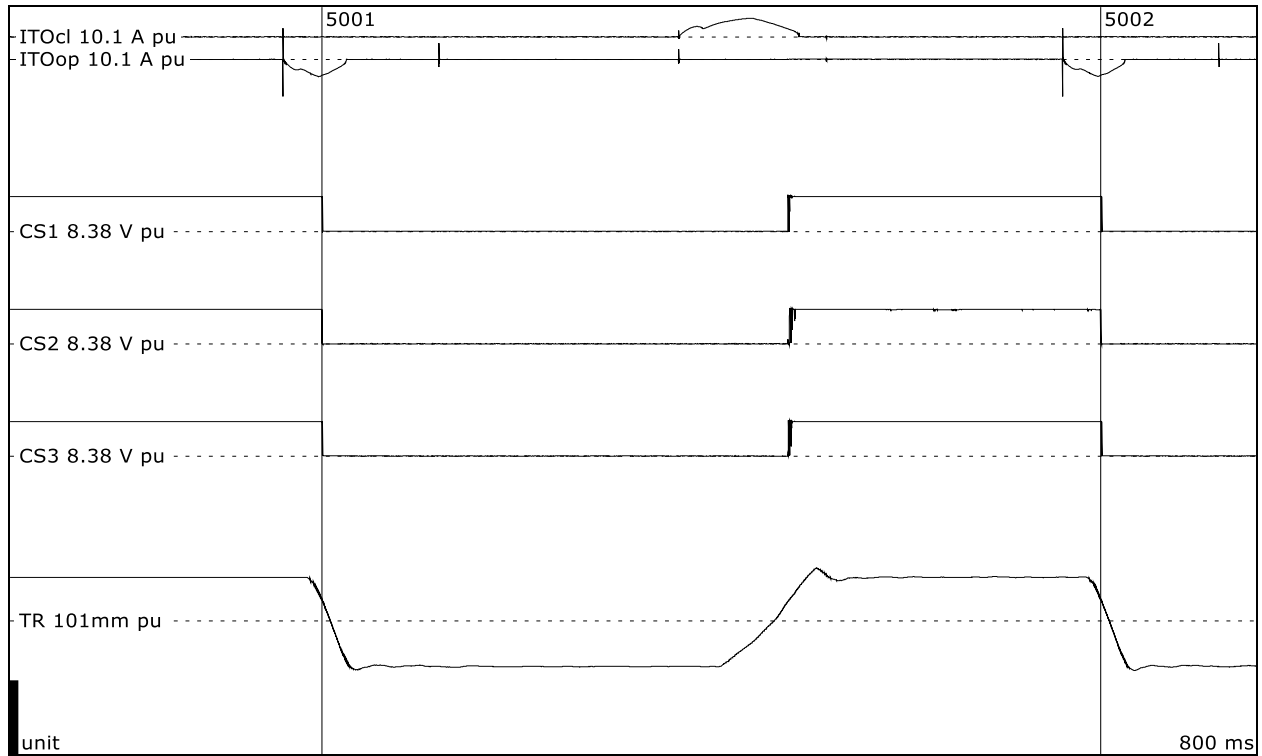
Test number: 170516-5001

Operation		O		
Phase		A	B	C
Current opening coil	A	-2,34		
Opening time	ms	25,5	25,1	25,6

Voltage opening coil	242 Vd.c.	Gas pressure at 20 °C	0,60 MPa
		Operating pressure	- MPa

Remarks: -

No-load test



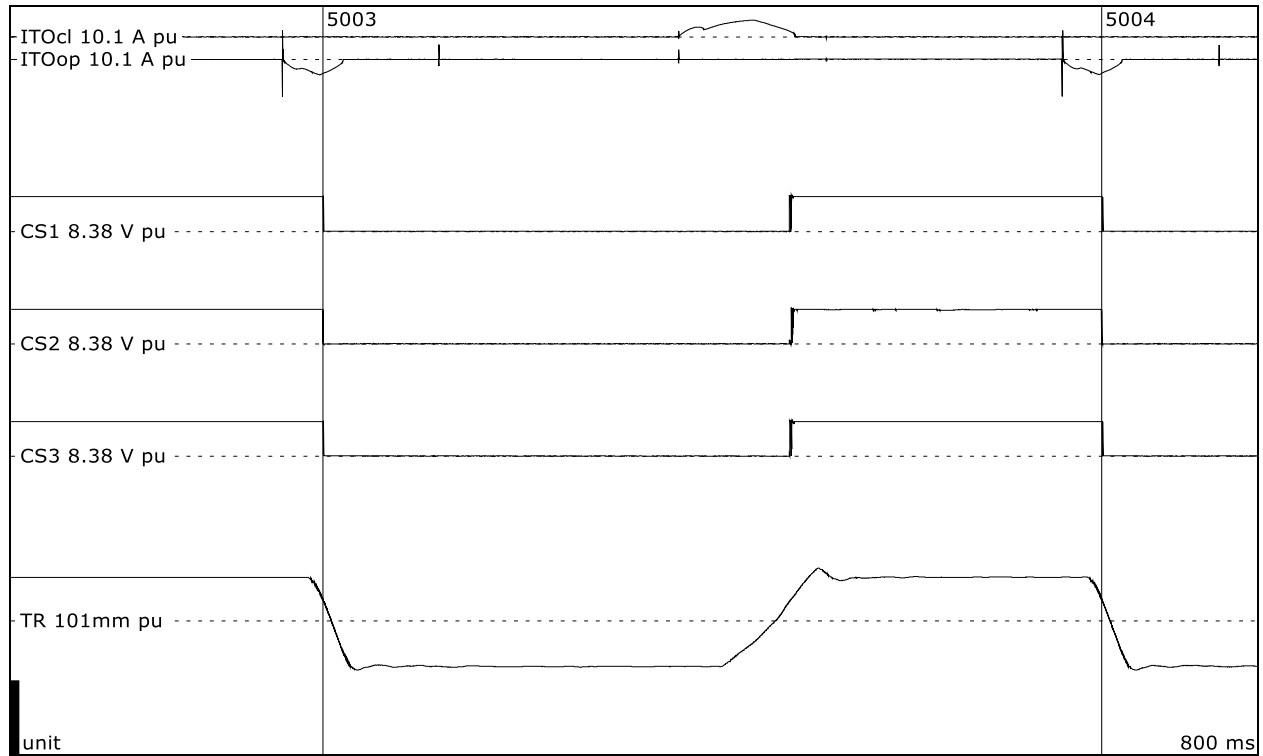
Test number: 170516-5002

Time interval between operations	s	0,299		
Operation	CO			
Phase		A	B	C
Current closing coil	A	2,50		
Closing time	ms	69,5	70,6	69,7
Current opening coil	A	-2,31		
Opening time	ms	25,1	24,5	25,1

Voltage closing coil	- Vd.c.	Gas pressure at 20 °C	0,60 MPa
Voltage opening coil	242 Vd.c.	Operating pressure	- MPa

Remarks: -

No-load test



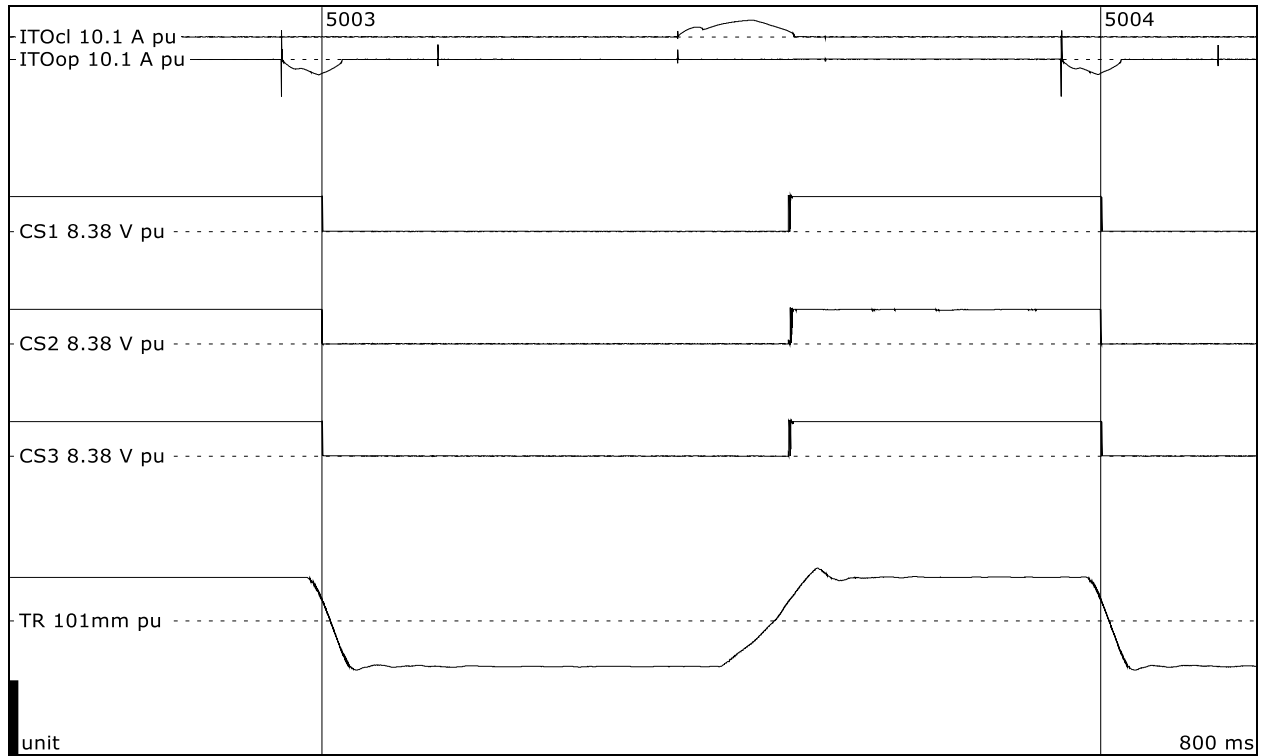
Test number: 170516-5003

Operation		O		
Phase		A	B	C
Current opening coil	A	-2,09		
Opening time	ms	26,4	26,0	26,4

Voltage opening coil	220 Vd.c.	Gas pressure at 20 °C	0,60 MPa
		Operating pressure	- MPa

Remarks: -

No-load test



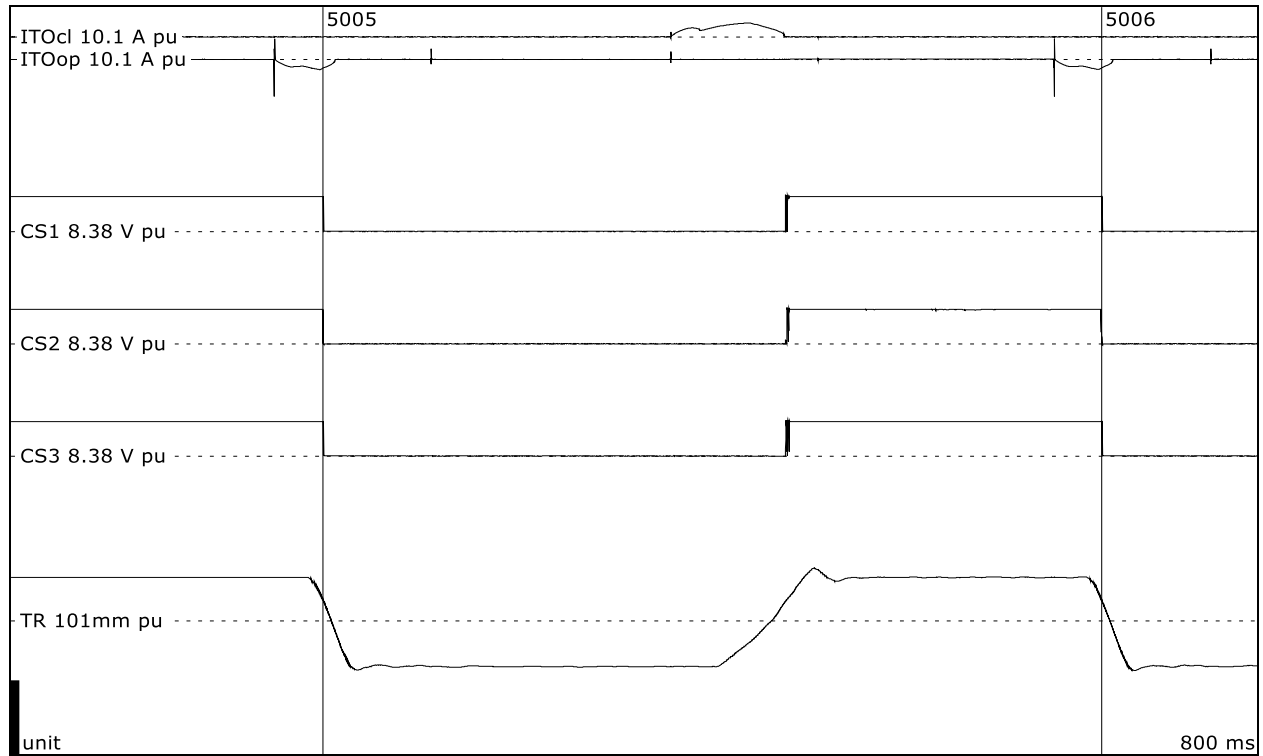
Test number: 170516-5004

Time interval between operations	s	0,299		
Operation	CO			
Phase		A	B	C
Current closing coil	A	2,24		
Closing time	ms	70,6	71,8	70,9
Current opening coil	A	-2,06		
Opening time	ms	25,8	25,2	25,8

Voltage closing coil	220 Vd.c.	Gas pressure at 20 °C	0,60 MPa
Voltage opening coil	220 Vd.c.	Operating pressure	- MPa

Remarks: -

No-load test



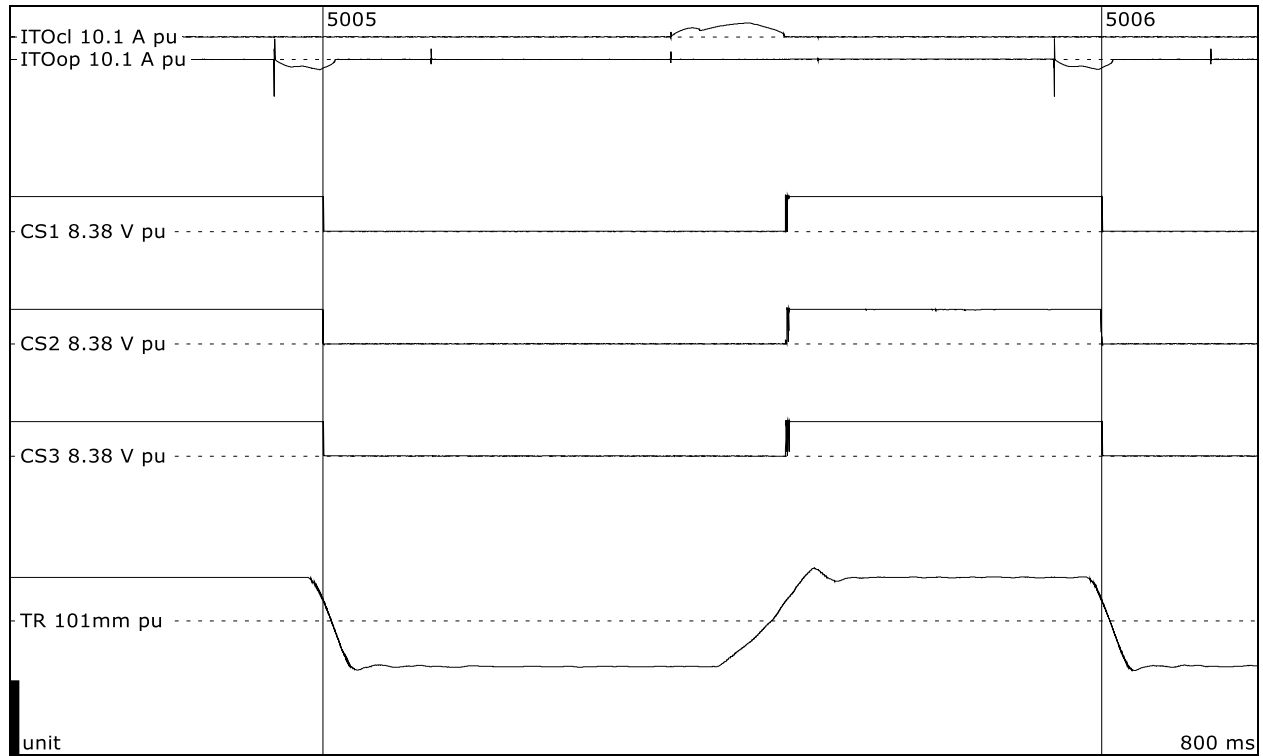
Test number: 170516-5005

Operation		O		
Phase		A	B	C
Current opening coil	A	-1,41		
Opening time	ms	31,6	31,1	31,6

Voltage opening coil	154 Vd.c.	Gas pressure at 20 °C	0,60 MPa
		Operating pressure	- MPa

Remarks: -

No-load test



Test number: 170516-5006

Time interval between operations	s	0,296		
Operation	CO			
Phase		A	B	C
Current closing coil	A	1,87		
Closing time	ms	73,3	74,4	73,5
Current opening coil	A	-1,36		
Opening time	ms	30,8	30,3	30,9

Voltage closing coil	187 Vd.c.	Gas pressure at 20 °C	0,60 MPa
Voltage opening coil	154 Vd.c.	Operating pressure	- MPa

Remarks: -

17 T10

Standard and date

Standard	IEC 62271-100
Test date	16 May 2017

17.1 Condition before test

Breaker (Serial No 17101) in same condition.

Pole A under test.

Supply to fixed contact.

Moving contact earthed.

Frame earthed via a CT.

Auxiliary breaker:

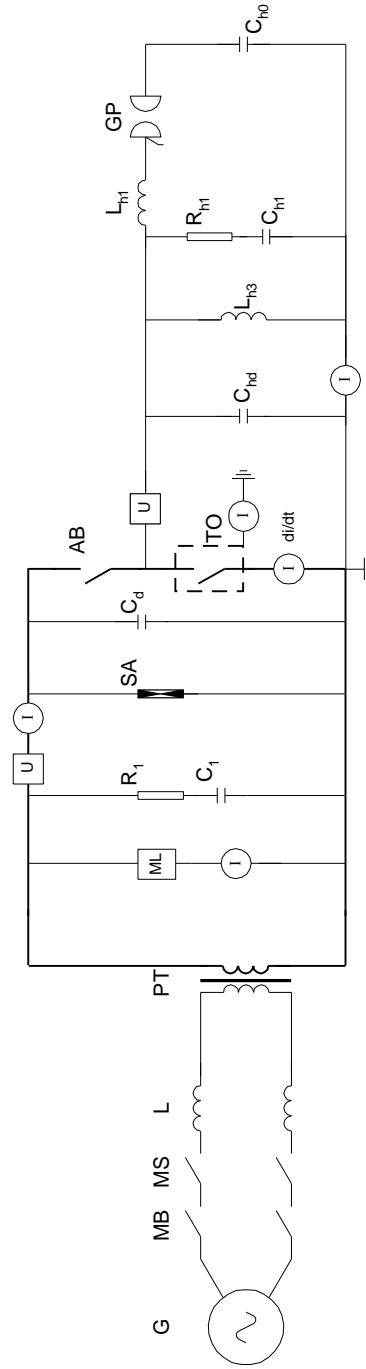
An SF₆ breaker, provided by KEMA Laboratories.

Number of elements: 1 per breaker.

17.2 Test circuit S09

Diagram

Current injection



G = Generator	L = Reactor	U = Voltage Measurement to earth	SA = Surge Arrester
MB = Master Breaker	TO = Test Object	I = Current Measurement	AB = Auxiliary Breaker
MS = Make Switch	R = Resistor	VS = Voltage Source	GP = Gap
PT = Power Transformer	C = Capacitor	ML = Multi-loop device	

Values

Supply			Injection circuit			Prospective TRV		
Power	MVA	200	C _{h0}	μF	2,80	U _{recovery}	kVa.c.	126
Frequency	Hz	50	U _{h0}	kVd.c.	187	U _C	kV	272
Phase(s)		1	L _{h1}	mH	100	t _d	μs	6,00
Voltage	kV	50	f _h	Hz	300	t ₃	μs	39,0
Current	kA	4	R _{h1}	kΩ	16,0	Rate of rise	kV/μs	7,00
Impedance	Ω	12,5	C _{h1}	nF	21,4			
Power factor		< 0,1	C _{hd}	nF	2,00			
Neutral		not earthed	L _{h3}	H	3,60			
			f _{Rv}	Hz	48,6			

Load	
Short-circuit point	earthed

TRV control elements added (supply)		
C ₁	μF	0,22
R1 (in series)	Ω	408
C _d	nF	15,0

Remarks: -

17.3 Test results and oscillograms

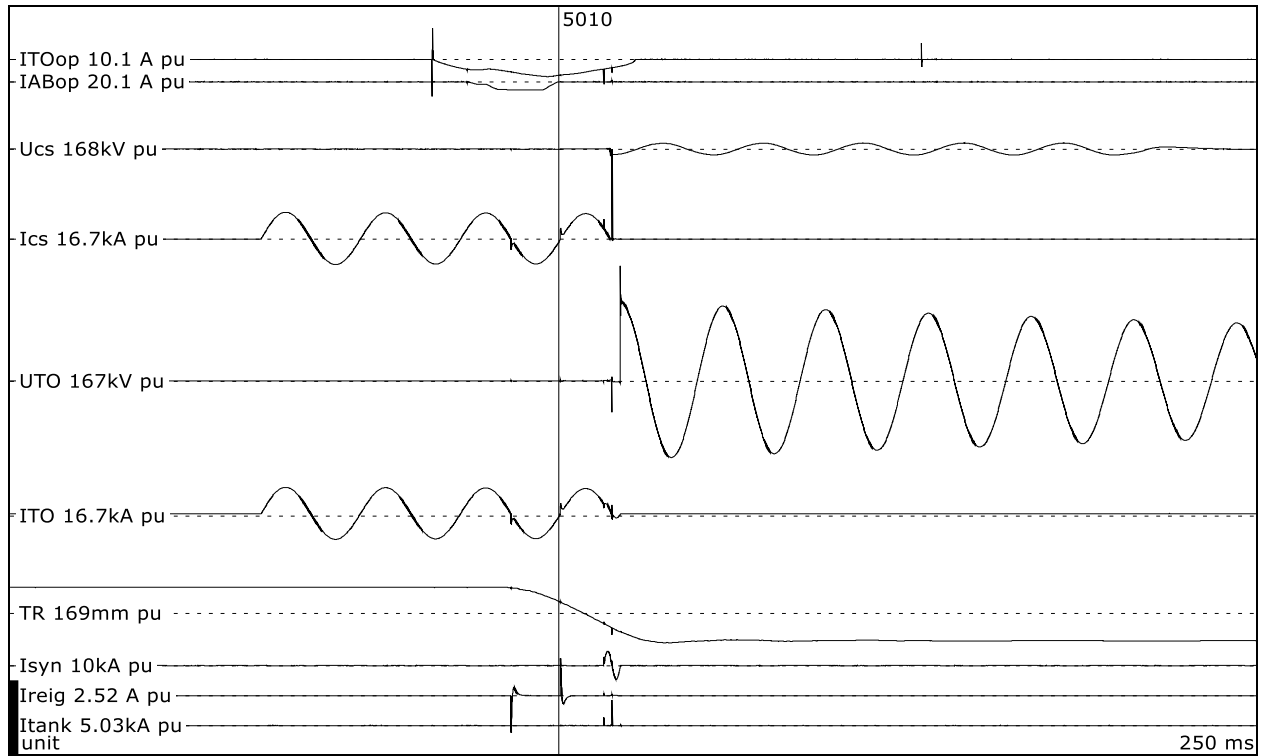
Overview of test numbers

170516-5010, 5011, 5014 to 5016

Remarks

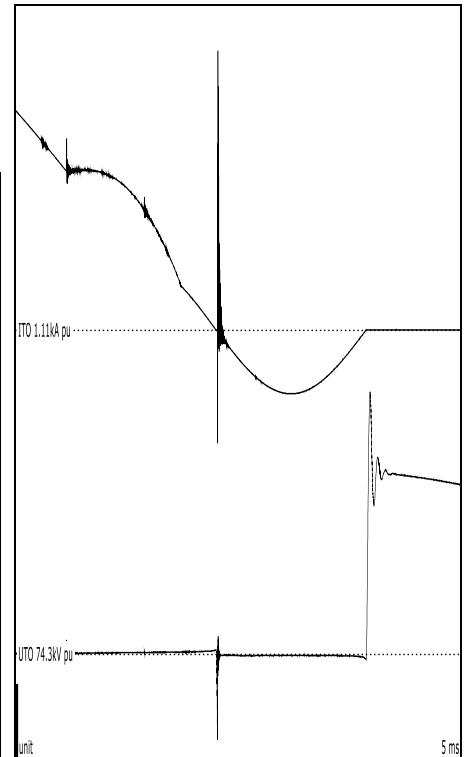
-

T10



Test number: 170516-5010

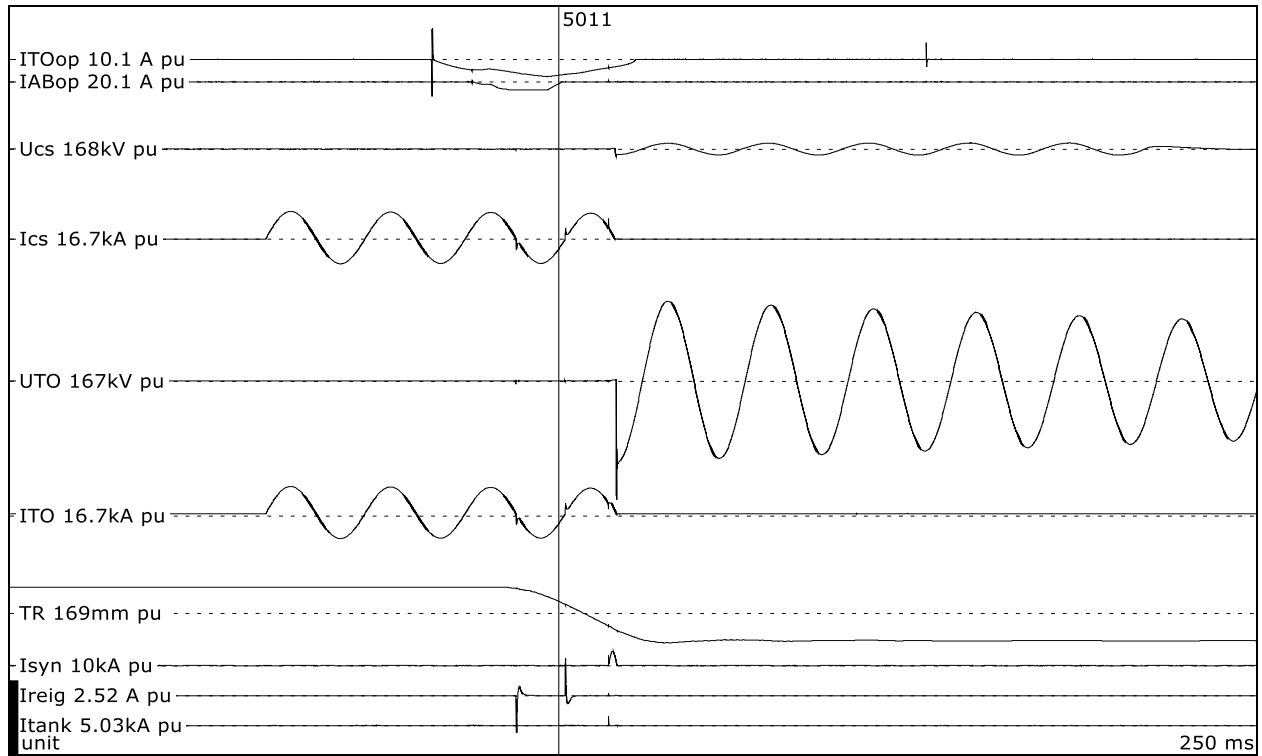
Time interval since previous test	min	-
Operation		O _s
Phase		A
Applied voltage, current source, phase value	kV	46,2
Charging voltage capacitor bank, DC value	kVd.c.	181
Breaking current, symmetrical, phase value	kA	4,03
Breaking current, DC-component	%	2
di/dt at last current zero	A/μs	1,79
TRV, peak	kV	-
Recovery voltage, phase value	kV	-
Arc duration	ms	(1)
Opening time	ms	25,4
Break time	ms	-
t _h	μs	400
Current last loop, peak	kA	5,64



Voltage opening coil	242 Vd.c.	Gas pressure at 20 °C	0,60 MPa
		Operating pressure	- MPa

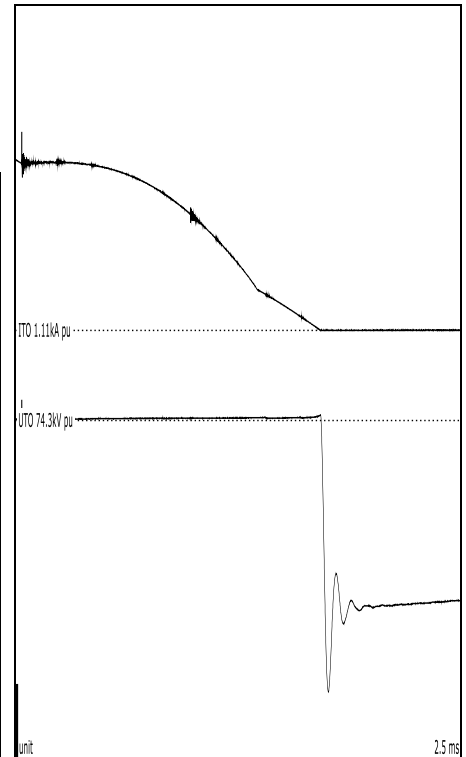
Remarks: Test to verify the correct reignition behaviour of the breaker (subclause 6.102.10 of IEC 62271-101).
 (1) Arcing time set for 10,7 ms.
 O_s = Operation in a synthetic circuit.

T10



Test number: 170516-5011

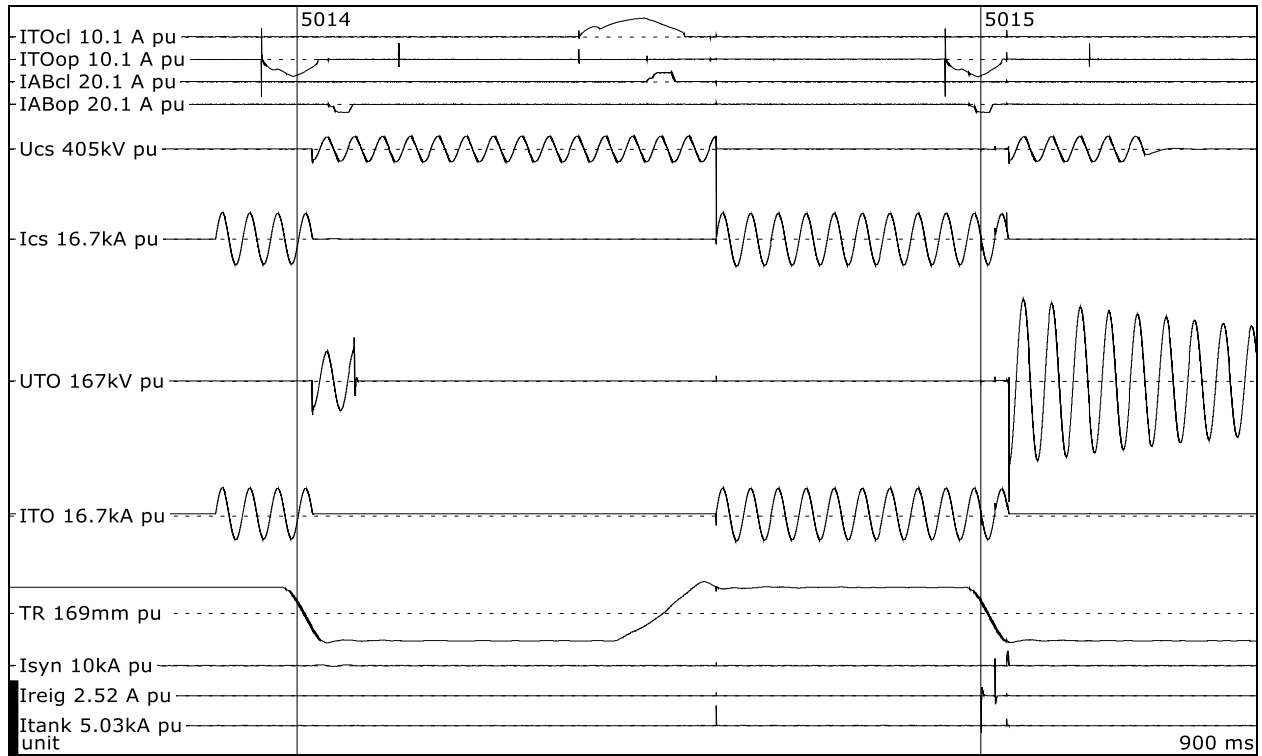
Time interval since previous test	min	-
Operation		O _s
Phase		A
Applied voltage, current source, phase value	kV	46,2
Charging voltage capacitor bank, DC value	kVd.c.	182
Breaking current, symmetrical, phase value	kA	4,03
Breaking current, DC-component	%	4
di/dt at last current zero	A/μs	1,80
TRV, peak	kV	-272
Recovery voltage, phase value	kV	122
Arc duration	ms	11,6
Opening time	ms	25,4
Break time	ms	37,0
t _h	μs	360
Current last loop, peak	kA	5,74



Voltage opening coil	242 Vd.c.	Gas pressure at 20 °C	0,60 MPa
		Operating pressure	- MPa

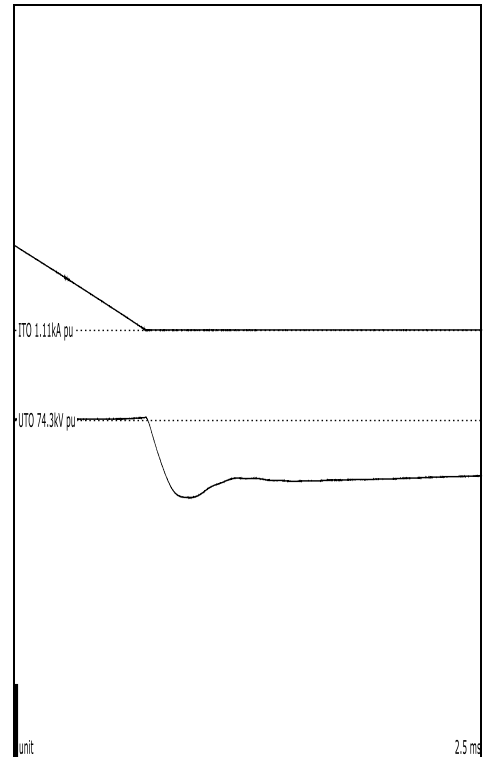
Remarks: Breaker cleared.
O_s = Operation in a synthetic circuit.

T10



Test number: 170516-5014

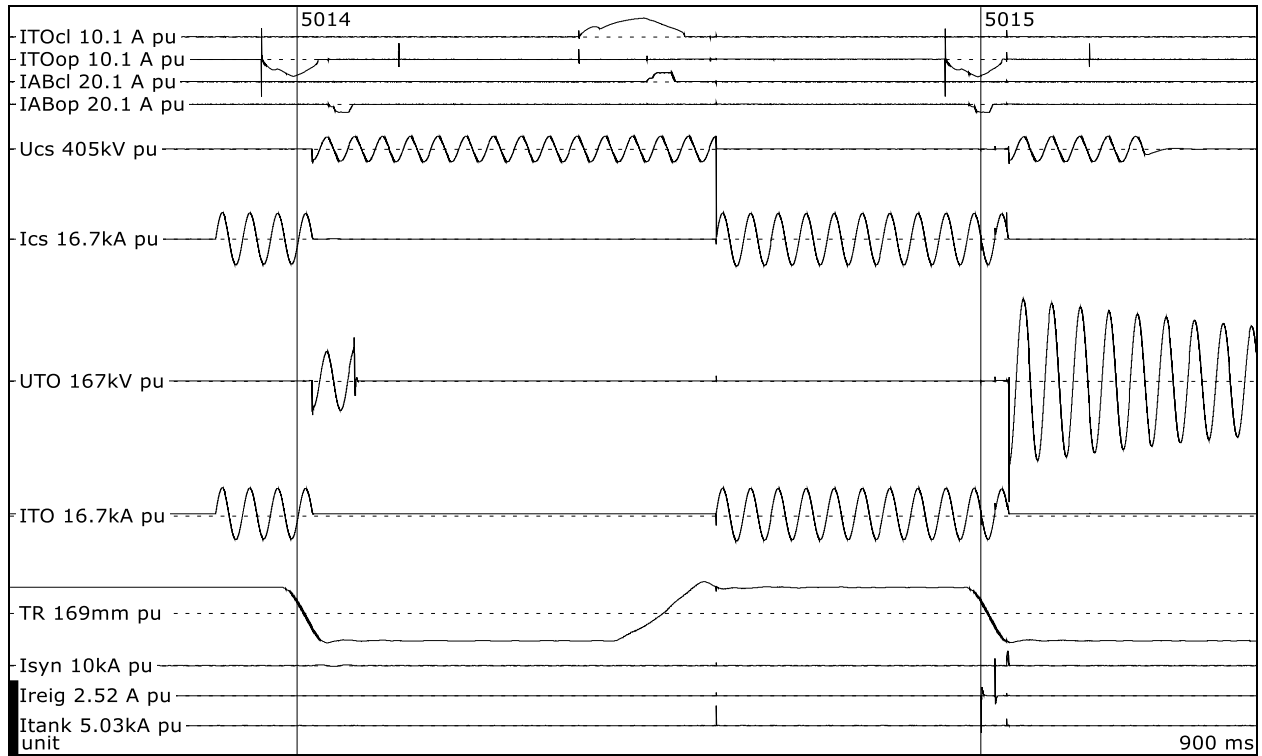
Time interval since previous test	min	-
Operation		O _D
Phase		A
Breaking current, symmetrical, phase value	kA	4,02
Breaking current, DC-component	%	1
Recovery voltage, phase value	kV	46,6
Arc duration	ms	11,2
Opening time	ms	25,5
Break time	ms	36,7



Voltage opening coil	242 Vd.c.	Gas pressure at 20 °C	0,60 MPa
		Operating pressure	- MPa

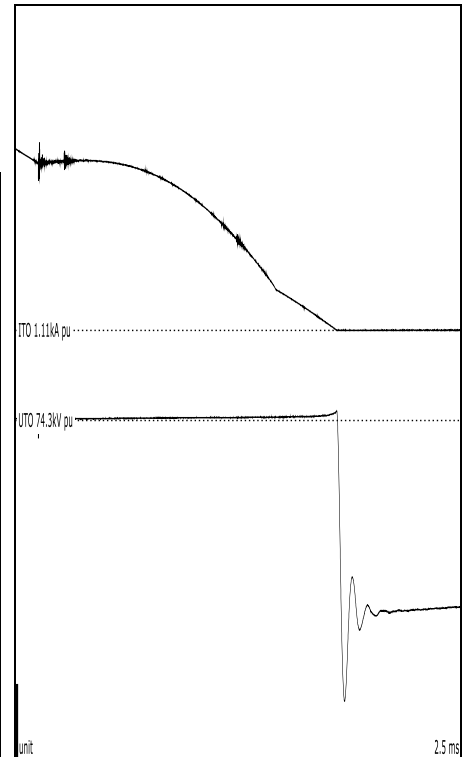
Remarks: Breaker cleared.
 O_D = Operation with current source only.

T10



Test number: 170516-5015

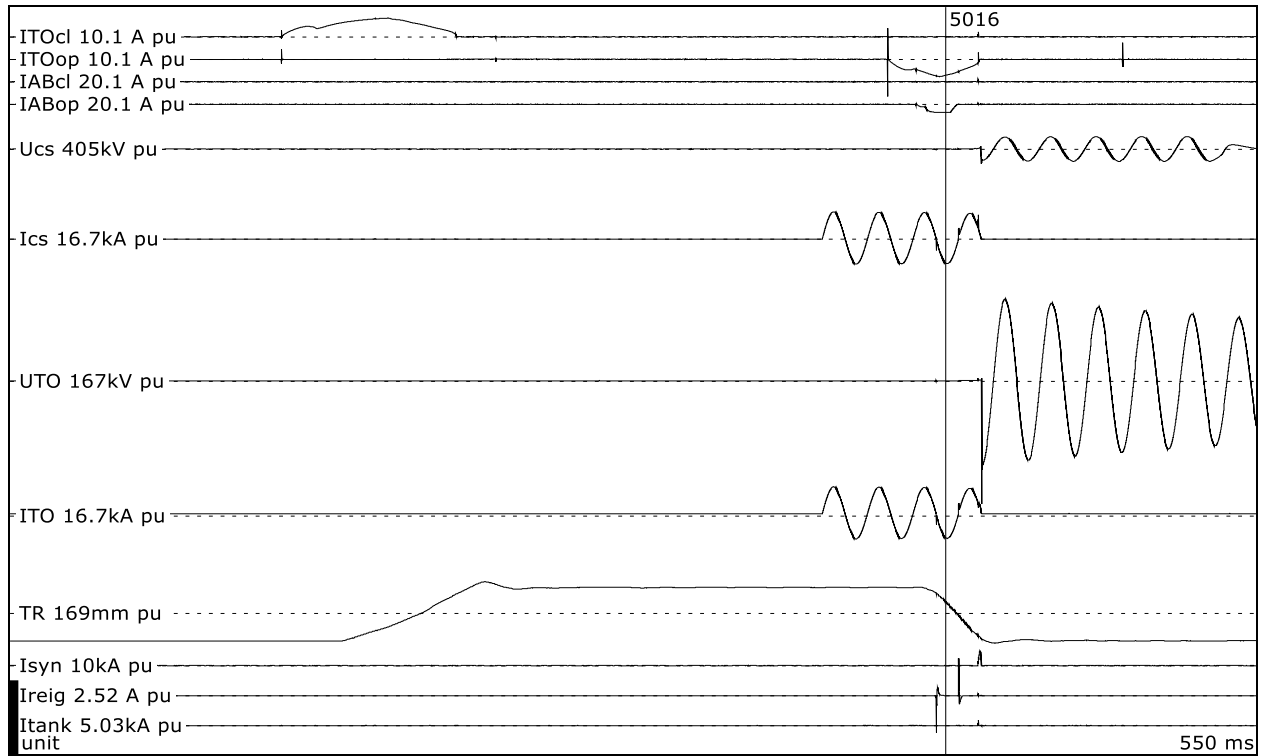
Time interval since previous test	min	-
Time interval between operations	s	0,291
Operation		(C)O _s
Phase		A
Charging voltage capacitor bank, DC value	kVd.c.	187
Breaking current, symmetrical, phase value	kA	4,08
Breaking current, DC-component	%	1
di/dt at last current zero	A/μs	1,87
TRV, peak	kV	-276
Recovery voltage, phase value	kV	126
Arc duration	ms	20,6
Opening time	ms	25,7
Break time	ms	46,3
t _h	μs	351
Current last loop, peak	kA	5,58



Voltage closing coil	242 Vd.c.	Gas pressure at 20 °C	0,60 MPa
Voltage opening coil	242 Vd.c.	Operating pressure	- MPa

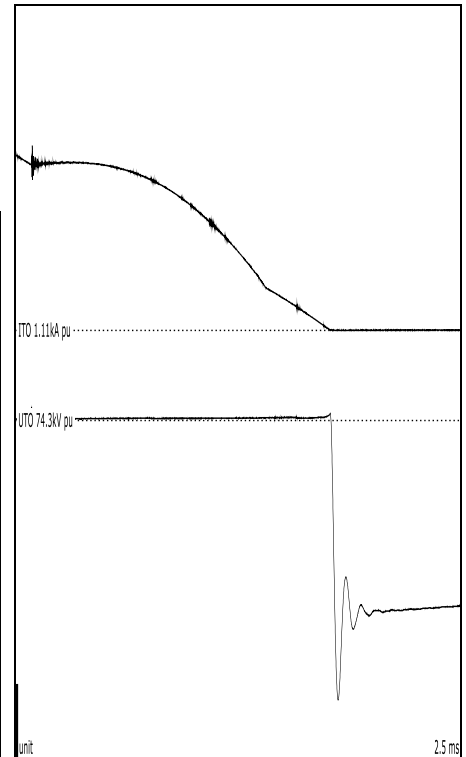
Remarks: Breaker closed in no-load and cleared.
O_s = Operation in a synthetic circuit.

T10



Test number: 170516-5016

Time interval since previous test	min	9
Operation		(C)Os
Phase		A
Charging voltage capacitor bank, DC value	kVd.c.	187
Breaking current, symmetrical, phase value	kA	4,05
Breaking current, DC-component	%	2
di/dt at last current zero	A/μs	1,84
TRV, peak	kV	-275
Recovery voltage, phase value	kV	125
Arc duration	ms	15,9
Opening time	ms	25,6
Break time	ms	41,5
t _h	μs	361
Current last loop, peak	kA	5,69



Voltage closing coil	242 Vd.c.	Gas pressure at 20 °C	0,60 MPa
Voltage opening coil	242 Vd.c.	Operating pressure	- MPa

Remarks: Breaker closed in no-load and cleared.
 Os = Operation in a synthetic circuit.

18 T30

Standard and date

Standard	IEC 62271-100
Test date	16 May 2017

18.1 Condition before test

Breaker (Serial No 17101) in same condition.

Pole B under test.

Supply to moving contact.

Fixed contact earthed.

Frame earthed via a CT.

Auxiliary breaker:

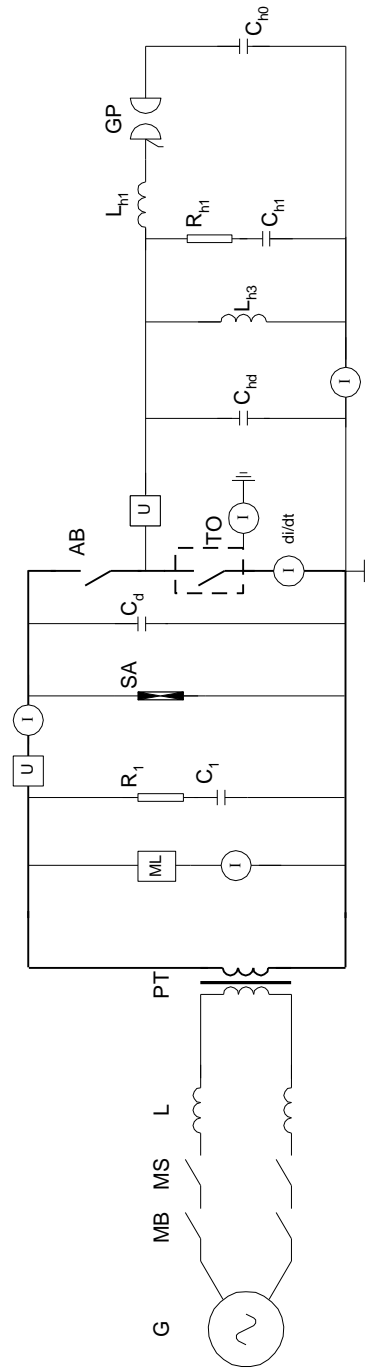
An SF₆ breaker, provided by KEMA Laboratories.

Number of elements: 1 per breaker.

18.2 Test circuit S10

Diagram

Current injection



G = Generator	L = Reactor	U = Voltage Measurement to earth	SA = Surge Arrester
MB = Master Breaker	TO = Test Object	I = Current Measurement	AB = Auxiliary Breaker
MS = Make Switch	R = Resistor	VS = Voltage Source	GP = Gap
PT = Power Transformer	C = Capacitor	ML = Multi-loop device	

Values

Supply			Injection circuit			Prospective TRV		
Power	MVA	432	C _{h0}	μF	8,00	U _{recovery}	kVa.c.	126
Frequency	Hz	50	U _{h0}	kVd.c.	183	U _C	kV	273
Phase(s)		1	L _{h1}	mH	34,0	t _d	μs	7,00
Voltage	kV	36	f _h	Hz	298	t ₃	μs	55,0
Current	kA	12	R _{h1}	kΩ	4,00	Rate of rise	kV/μs	5,00
Impedance	Ω	3	C _{h1}	μF	0,11			
Power factor		< 0,1	C _{hd}	nF	7,50			
Neutral		not earthed	L _{h3}	H	1,20			
			f _{Rv}	Hz	49,4			

Load	
Short-circuit point	earthed

TRV control elements added (supply)		
C ₁	μF	0,22
R1 (in series)	Ω	192
C _d	nF	15,0

Remarks: -

18.3 Test results and oscillograms

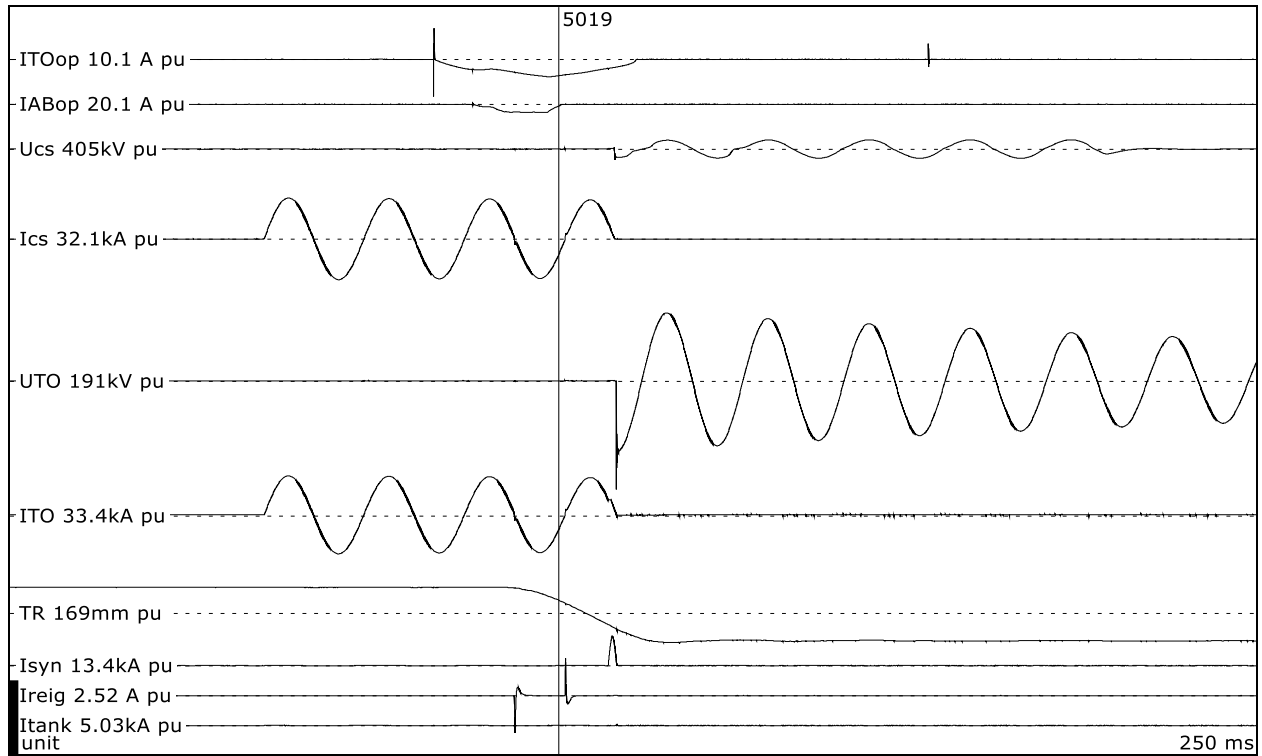
Overview of test numbers

170516-5019, 5020, 5023 to 5025

Remarks

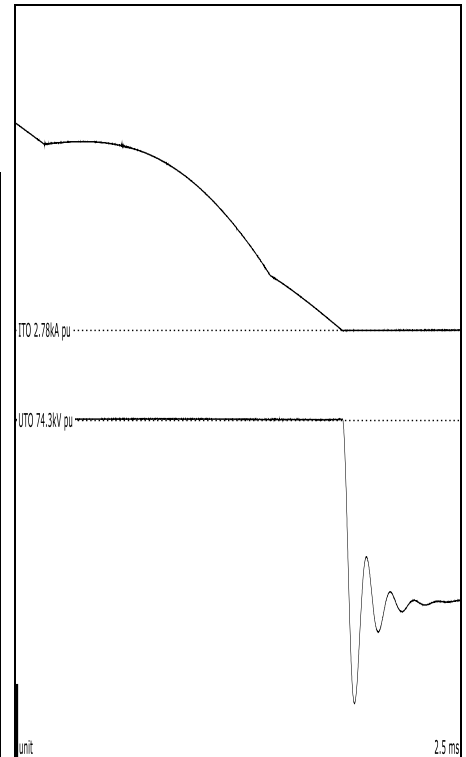
-

T30



Test number: 170516-5019

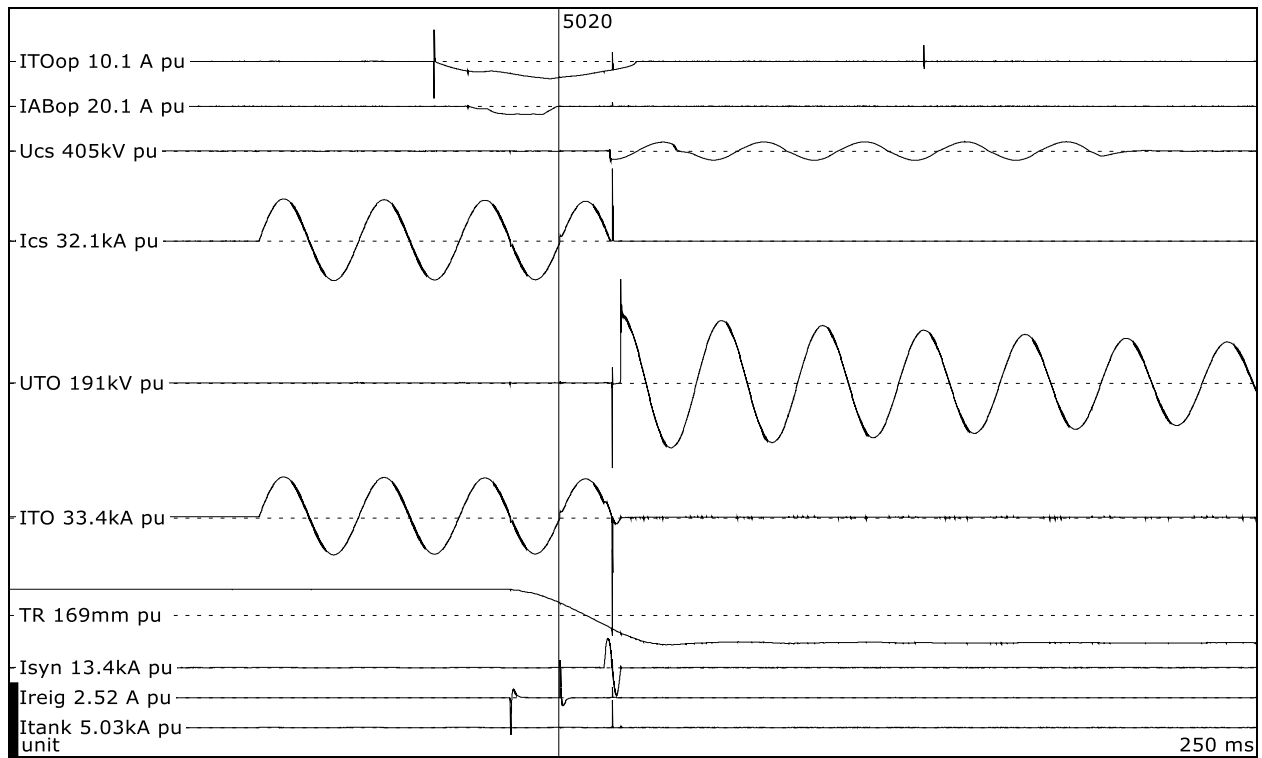
Time interval since previous test	min	-
Operation		O _s
Phase		B
Applied voltage, current source, phase value	kV	34,7
Charging voltage capacitor bank, DC value	kVd.c.	187
Breaking current, symmetrical, phase value	kA	12,1
Breaking current, DC-component	%	1
di/dt at last current zero	A/μs	5,41
TRV, peak	kV	-280
Recovery voltage, phase value	kV	129
Arc duration	ms	11,6
Opening time	ms	25,1
Break time	ms	36,7
t _h	μs	406
Current last loop, peak	kA	16,7



Voltage opening coil	242 Vd.c.	Gas pressure at 20 °C	0,60 MPa
		Operating pressure	- MPa

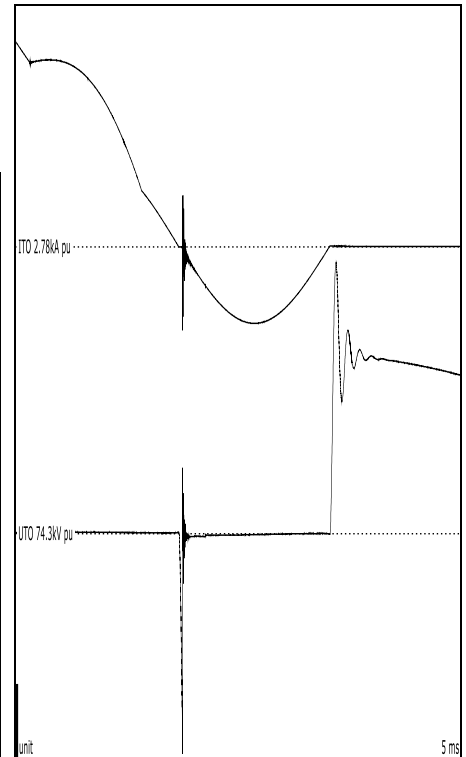
Remarks: Breaker cleared.
O_s = Operation in a synthetic circuit.

T30



Test number: 170516-5020

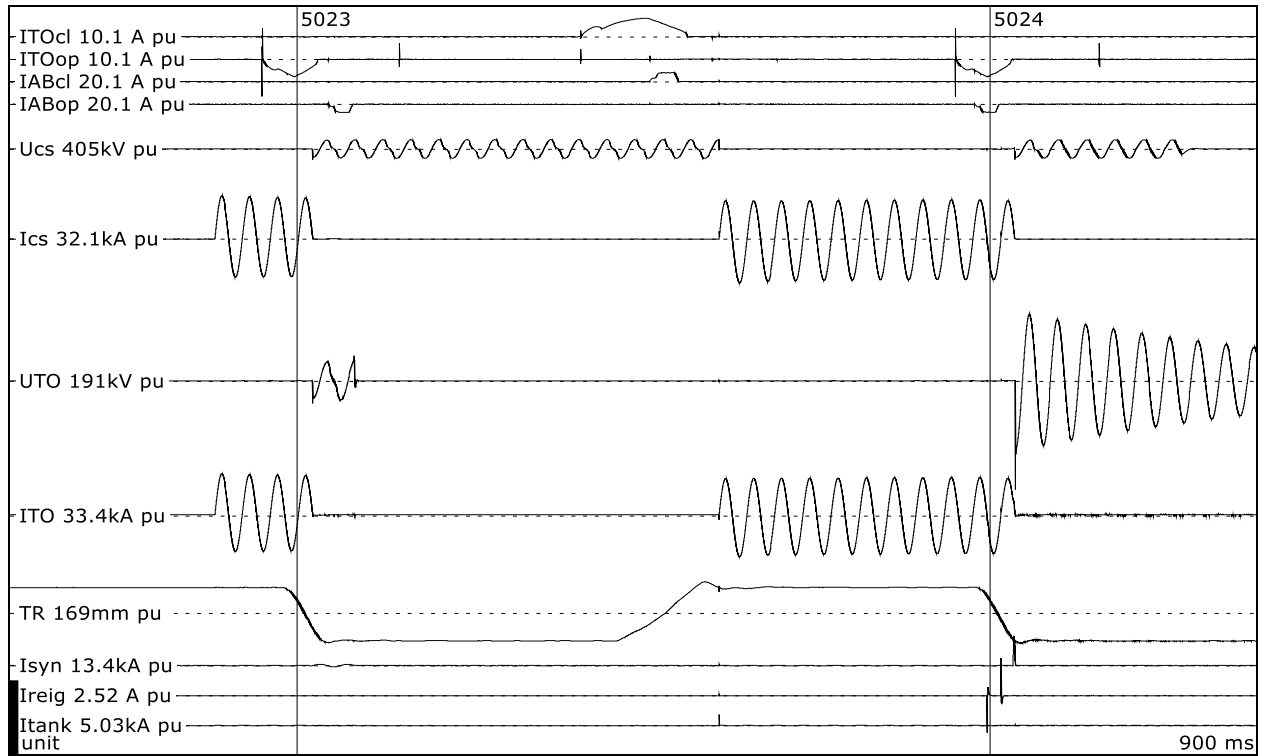
Time interval since previous test	min	-
Operation		O _s
Phase		B
Applied voltage, current source, phase value	kV	33,2
Charging voltage capacitor bank, DC value	kVd.c.	187
Breaking current, symmetrical, phase value	kA	12,1
Breaking current, DC-component	%	3
di/dt at last current zero	A/μs	5,40
TRV, peak	kV	-
Recovery voltage, phase value	kV	-
Arc duration	ms	(1)
Opening time	ms	25,0
Break time	ms	-
t _h	μs	418
Current last loop, peak	kA	17,0



Voltage opening coil	242 Vd.c.	Gas pressure at 20 °C	0,60 MPa
		Operating pressure	- MPa

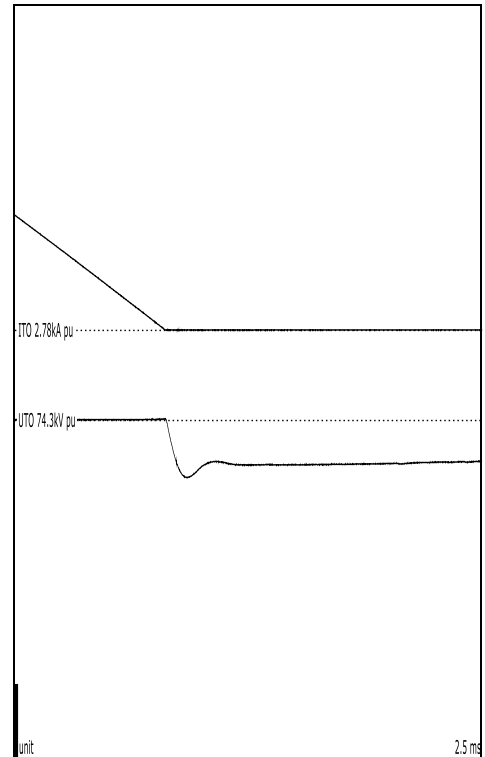
Remarks: Test to verify the correct reignition behaviour of the breaker (subclause 6.102.10 of IEC 62271-101).
 (1) Arcing time set for 10,6 ms.
 O_s = Operation in a synthetic circuit.

T30



Test number: 170516-5023

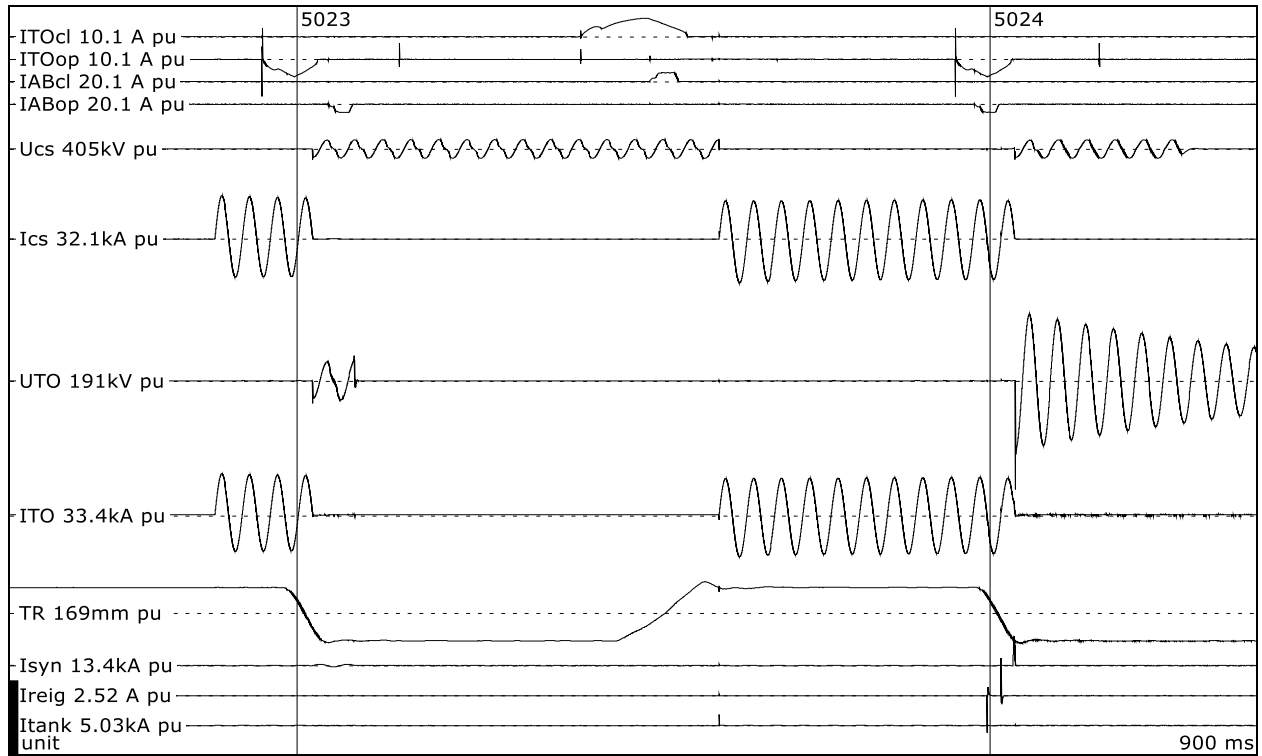
Time interval since previous test	min	-
Operation		O _D
Phase		B
Breaking current, symmetrical, phase value	kA	12,0
Breaking current, DC-component	%	5
Recovery voltage, phase value	kV	33,1
Arc duration	ms	11,3
Opening time	ms	25,0
Break time	ms	36,3



Voltage opening coil	242 Vd.c.	Gas pressure at 20 °C	0,60 MPa
		Operating pressure	- MPa

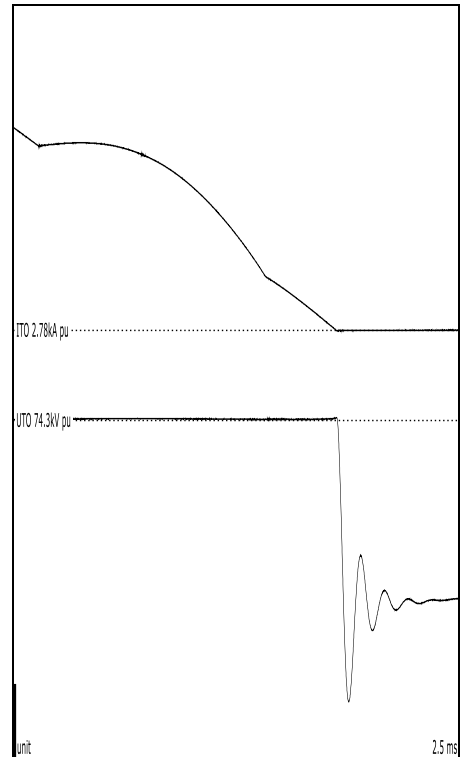
Remarks: Breaker cleared.
 O_D = Operation with current source only.

T30



Test number: 170516-5024

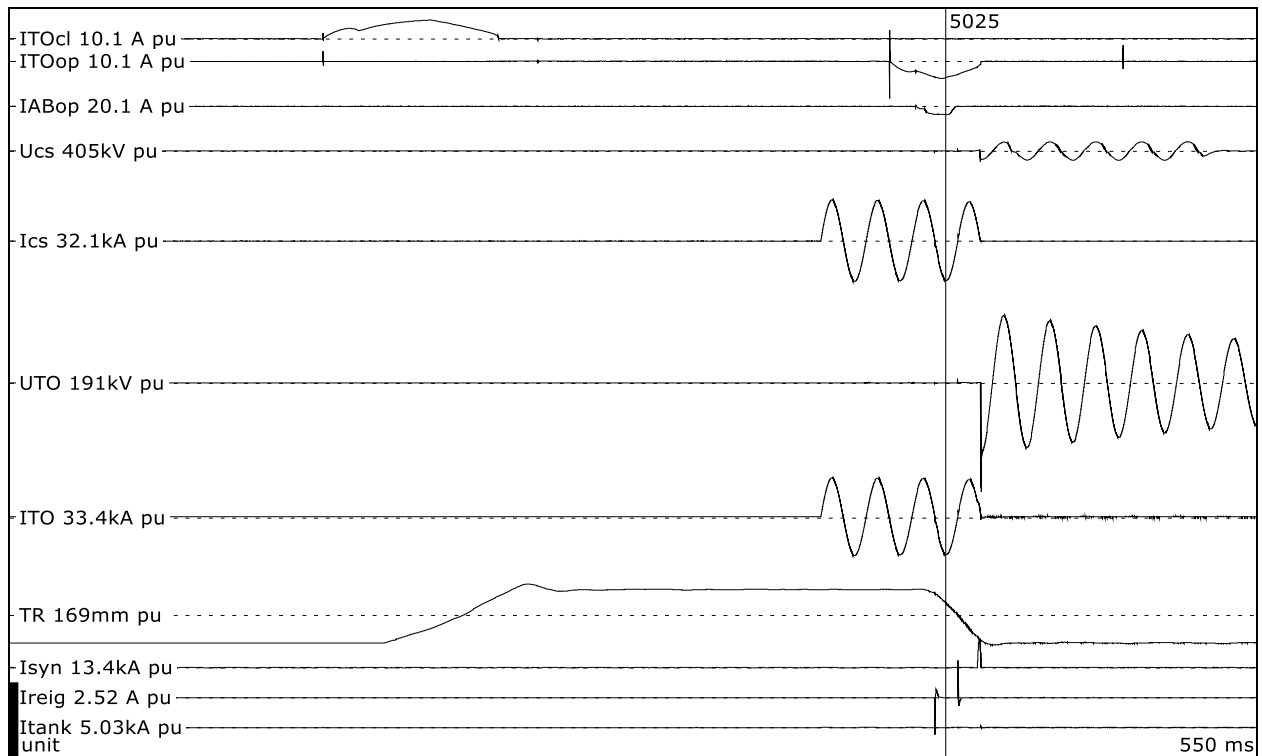
Time interval since previous test	min	-
Time interval between operations	s	0,293
Operation		(C)Os
Phase		B
Charging voltage capacitor bank, DC value	kVd.c.	186
Breaking current, symmetrical, phase value	kA	12,1
Breaking current, DC-component	%	2
di/dt at last current zero	A/μs	5,40
TRV, peak	kV	-277
Recovery voltage, phase value	kV	128
Arc duration	ms	18,6
Opening time	ms	24,9
Break time	ms	43,5
t _h	μs	402
Current last loop, peak	kA	16,4



Voltage closing coil	242 Vd.c.	Gas pressure at 20 °C	0,60 MPa
Voltage opening coil	242 Vd.c.	Operating pressure	- MPa

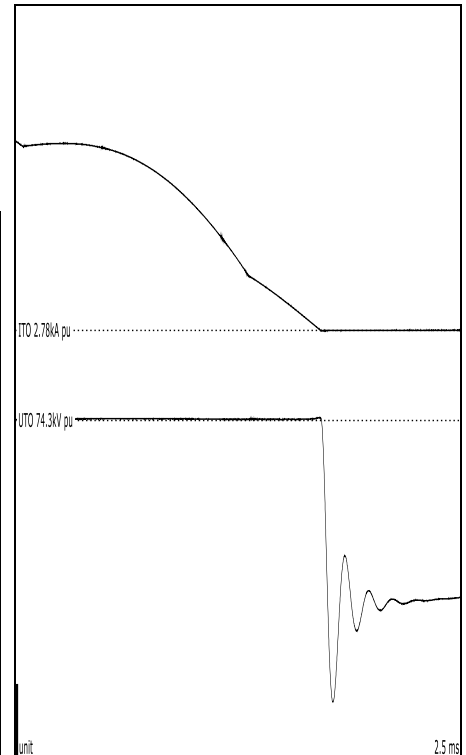
Remarks: Breaker closed in no-load and cleared.
Os = Operation in a synthetic circuit.

T30



Test number: 170516-5025

Time interval since previous test	min	8
Operation		(C)Os
Phase		B
Charging voltage capacitor bank, DC value	kVd.c.	186
Breaking current, symmetrical, phase value	kA	12,1
Breaking current, DC-component	%	0
di/dt at last current zero	A/μs	5,40
TRV, peak	kV	-278
Recovery voltage, phase value	kV	116
Arc duration	ms	15,6
Opening time	ms	24,7
Break time	ms	40,3
t _h	μs	411
Current last loop, peak	kA	16,7



Voltage closing coil	242 Vd.c.	Gas pressure at 20 °C	0,60 MPa
Voltage opening coil	242 Vd.c.	Operating pressure	- MPa

Remarks: Breaker closed in no-load and cleared.
Os = Operation in a synthetic circuit.

19 DOUBLE-EARTH FAULT TEST

Standard and date

Standard	IEC 62271-100
Test date	16 May 2017

19.1 Condition before test

Breaker (Serial No 17101) in same condition.

Pole C under test.

Supply to fixed contact.

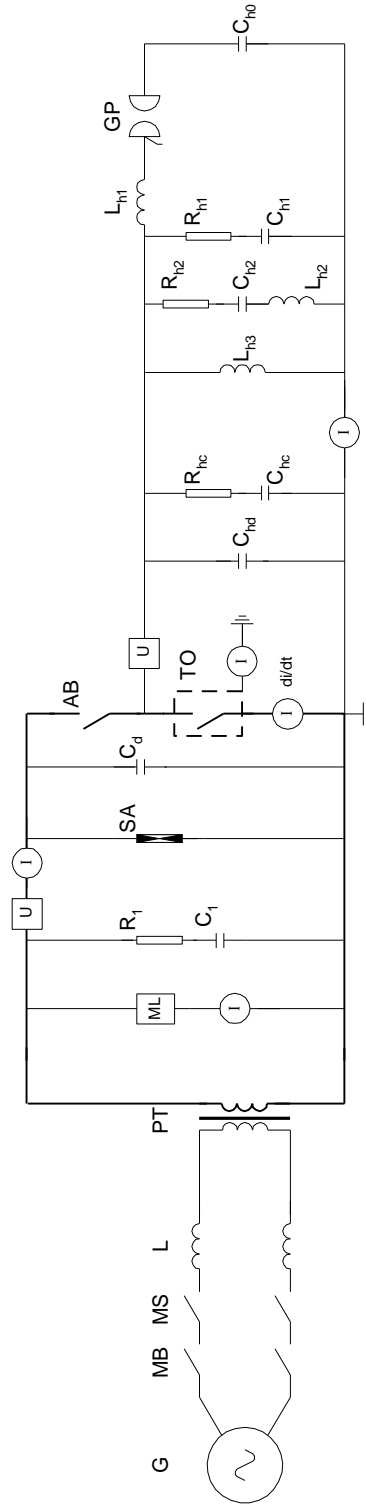
Moving contact earthed.

Frame earthed via a CT.

19.2 Test circuit S11

Diagram

Current injection



G = Generator	L = Reactor	U = Voltage Measurement to earth	SA = Surge Arrester
MB = Master Breaker	TO = Test Object	I = Current Measurement	AB = Auxiliary Breaker
MS = Make Switch	R = Resistor	VS = Voltage Source	GP = Gap
PT = Power Transformer	C = Capacitor	ML = Multi-loop device	

Values

Supply		
Power	MVA	1107
Frequency	Hz	50
Phase(s)		1
Voltage	kV	32
Current	kA	34,6
Impedance	Ω	0,925
Power factor		< 0,1
Neutral		not earthed

Injection circuit		
C _{h0}	μF	8,00
U _{h0}	kVd.c.	220
L _{h1}	mH	14,0
f _h	Hz	461
R _{h1}	Ω	133
C _{h1}	μF	0,22
C _{hd}	nF	10,7
R _{hc}	Ω	133
C _{hc}	nF	15,0
R _{h2}	Ω	80,0
C _{h2}	μF	0,44
L _{h2}	mH	11,6
L _{h3}	H	1,20
f _{RV}	Hz	48,0

Prospective TRV		
U _{recovery}	kVa.c.	145
u ₁	kV	154
u _c	kV	287
t _d	μs	2,00
t ₁	μs	77,0
t ₂	μs	309
Rate of rise	kV/ μs	2,00

Load	
Short-circuit point	earthed

TRV control elements added (supply)		
C ₁	μF	0,61
R1 (in series)	Ω	66,0
C _d	nF	15,0

Remarks: -

19.3 Test results and oscillograms

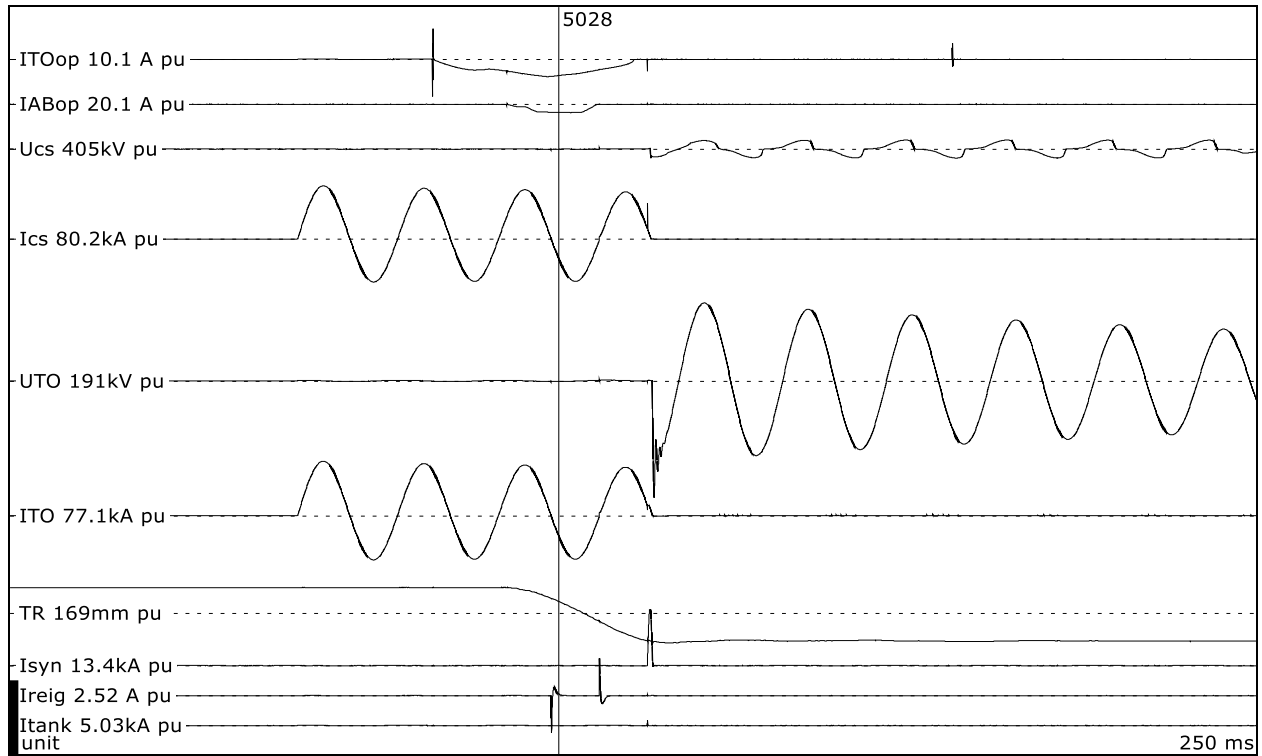
Overview of test numbers

170516-5028

Remarks

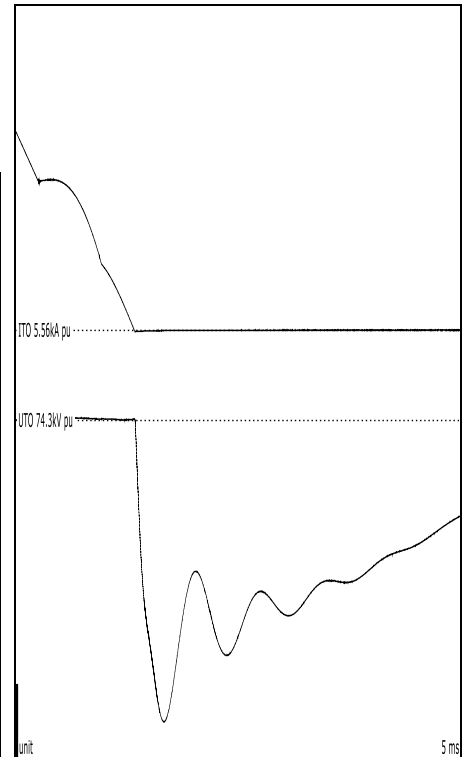
-

Double-earth fault test



Test number: 170516-5028

Time interval since previous test	min	-
Operation		O _s
Phase		C
Applied voltage, current source, phase value	kV	33,9
Charging voltage capacitor bank, DC value	kVd.c.	227
Breaking current, symmetrical, phase value	kA	35,0
Breaking current, DC-component	%	5
di/dt at last current zero	A/μs	12,4
TRV, peak	kV	-297
Recovery voltage, phase value	kV	147
Arc duration	ms	18,8
Opening time	ms	25,3
Break time	ms	44,1
t _h	μs	388
Current last loop, peak	kA	50,4



Voltage opening coil	242 Vd.c.	Gas pressure at 20 °C	0,60 MPa
		Operating pressure	- MPa

Remarks: Breaker cleared.
O_s = Operation in a synthetic circuit.

20 NO-LOAD TESTS

Standard and date

Standard	IEC 62271-100
Test date	16 May 2017

20.1 Condition before test

Breaker (Serial No 17101) in same condition.

20.2 Test results and oscillograms

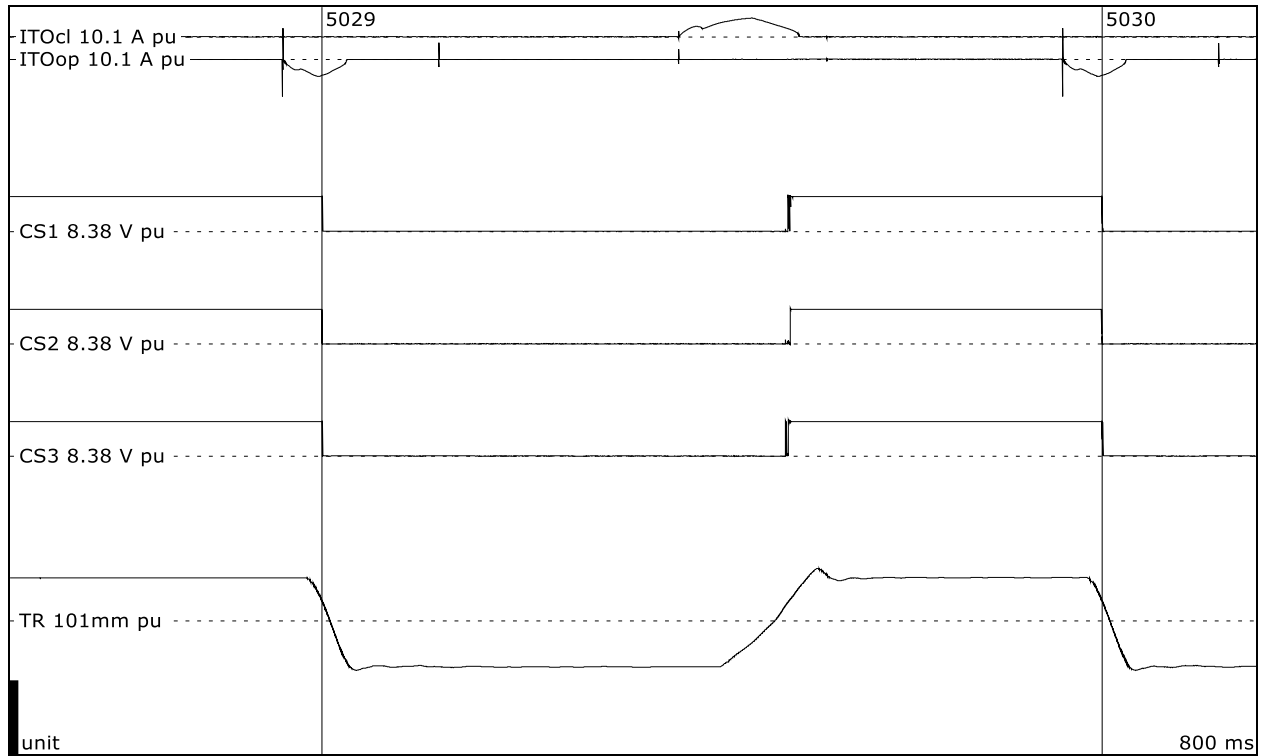
Overview of test numbers

170516-5029 to 5034

Remarks

-

No-load test



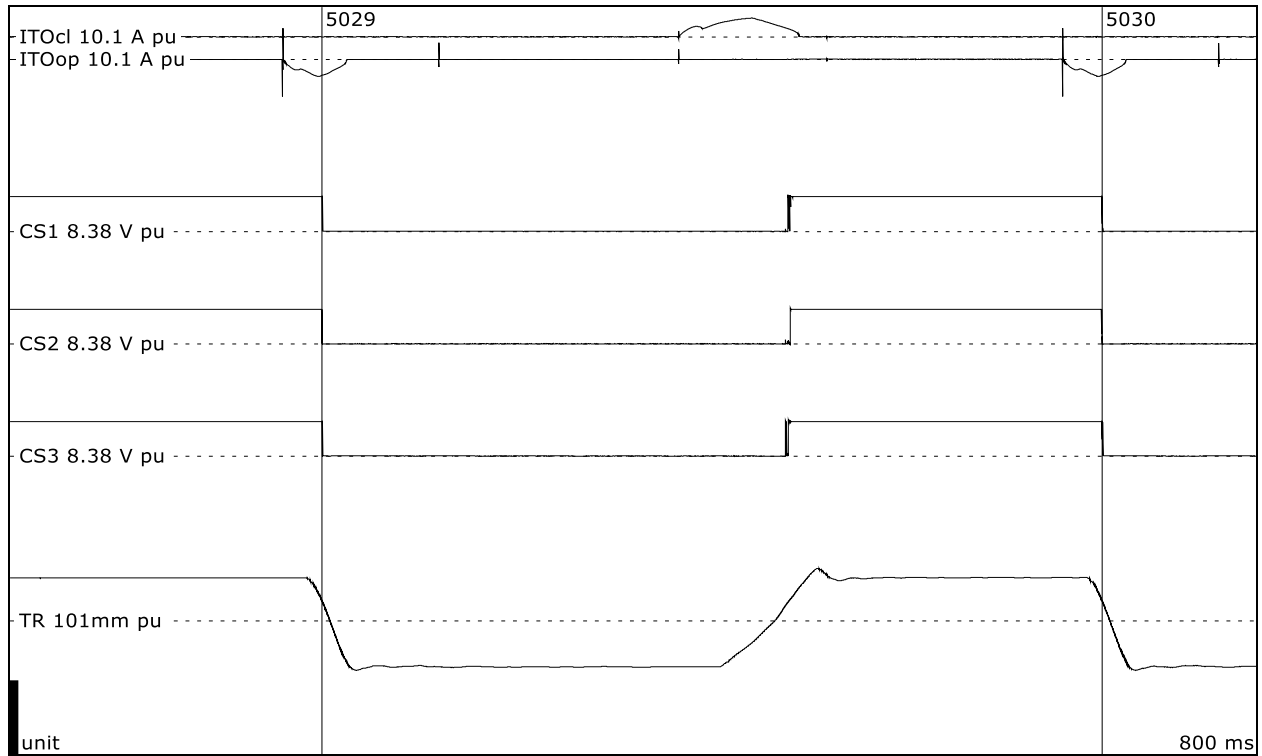
Test number: 170516-5029

Operation		O		
Phase		A	B	C
Current opening coil	A	-2,33		
Opening time	ms	25,6	25,2	25,6

Voltage opening coil	242 Vd.c.	Gas pressure at 20 °C	0,60 MPa
		Operating pressure	- MPa

Remarks: -

No-load test



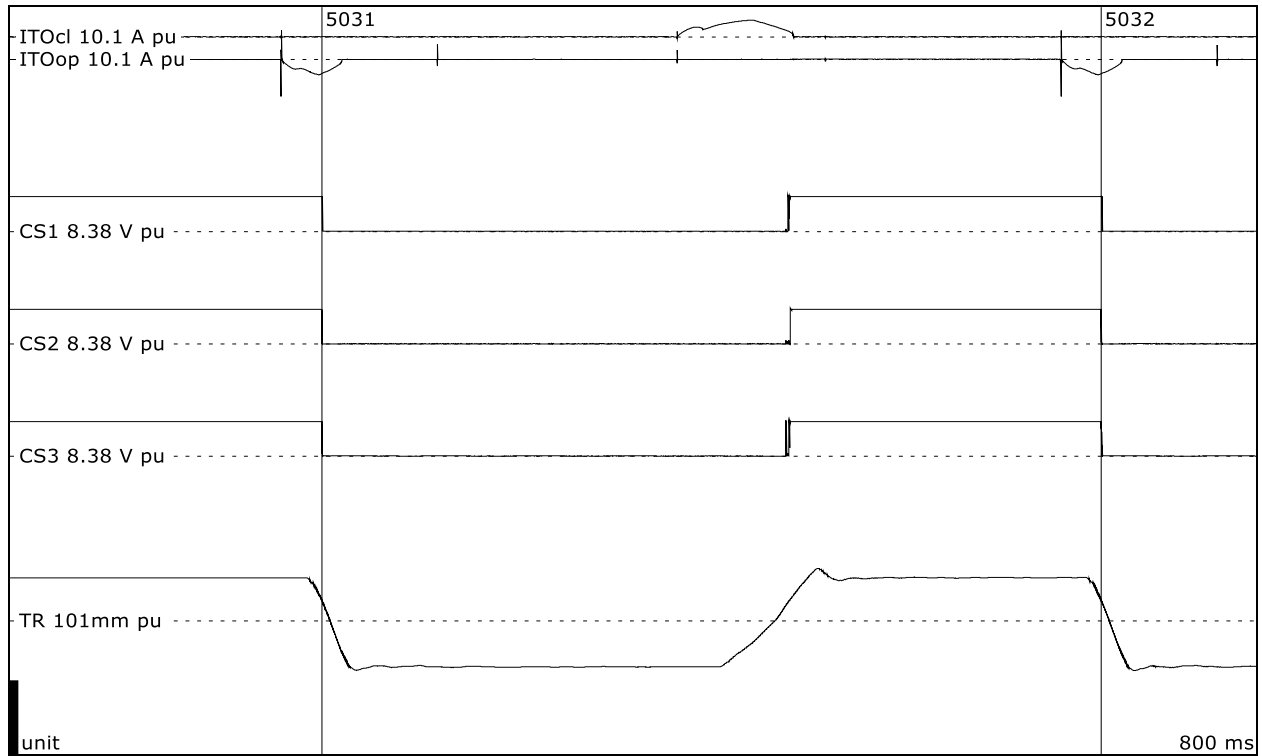
Test number: 170516-5030

Time interval between operations	s	0,299		
Operation	CO			
Phase		A	B	C
Current closing coil	A	2,52		
Closing time	ms	69,5	71,0	68,1
Current opening coil	A	-5,00		
Opening time	ms	25,7	25,3	25,7

Voltage closing coil	242 Vd.c.	Gas pressure at 20 °C	0,60 MPa
Voltage opening coil	242 Vd.c.	Operating pressure	- MPa

Remarks: -

No-load test



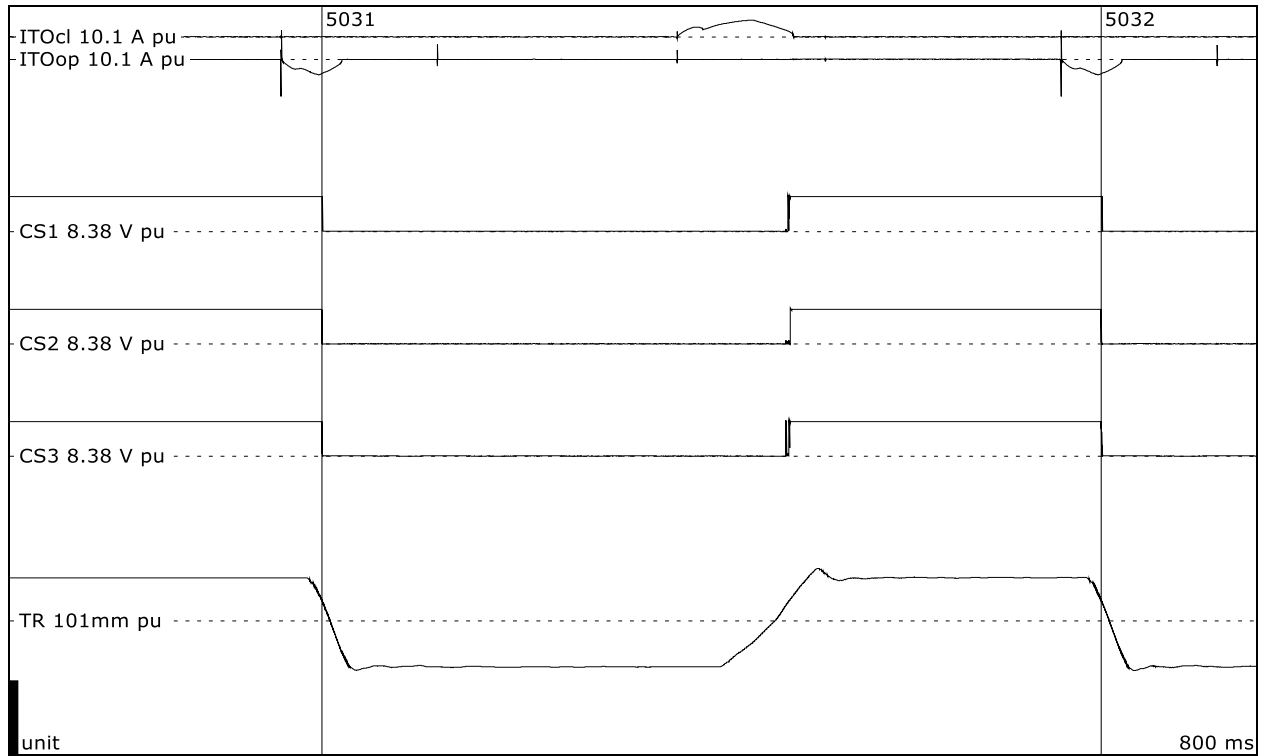
Test number: 170516-5031

Operation		O		
Phase		A	B	C
Current opening coil	A	-2,09		
Opening time	ms	26,6	26,2	26,3

Voltage opening coil	220 Vd.c.	Gas pressure at 20 °C	0,60 MPa
		Operating pressure	- MPa

Remarks: -

No-load test



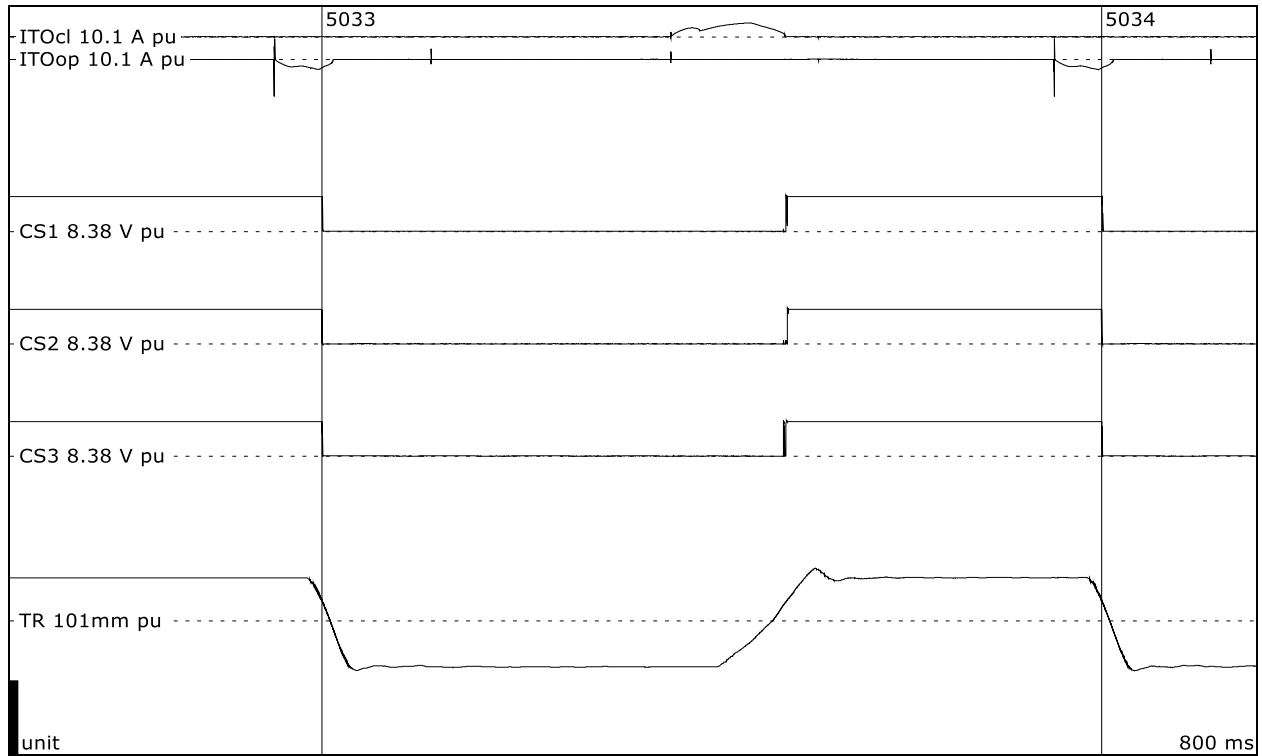
Test number: 170516-5032

Time interval between operations	s	0,299		
Operation	CO			
Phase		A	B	C
Current closing coil	A	2,25		
Closing time	ms	70,6	72,2	69,3
Current opening coil	A	-5,00		
Opening time	ms	26,4	25,9	26,0

Voltage closing coil	220 Vd.c.	Gas pressure at 20 °C	0,60 MPa
Voltage opening coil	220 Vd.c.	Operating pressure	- MPa

Remarks: -

No-load test



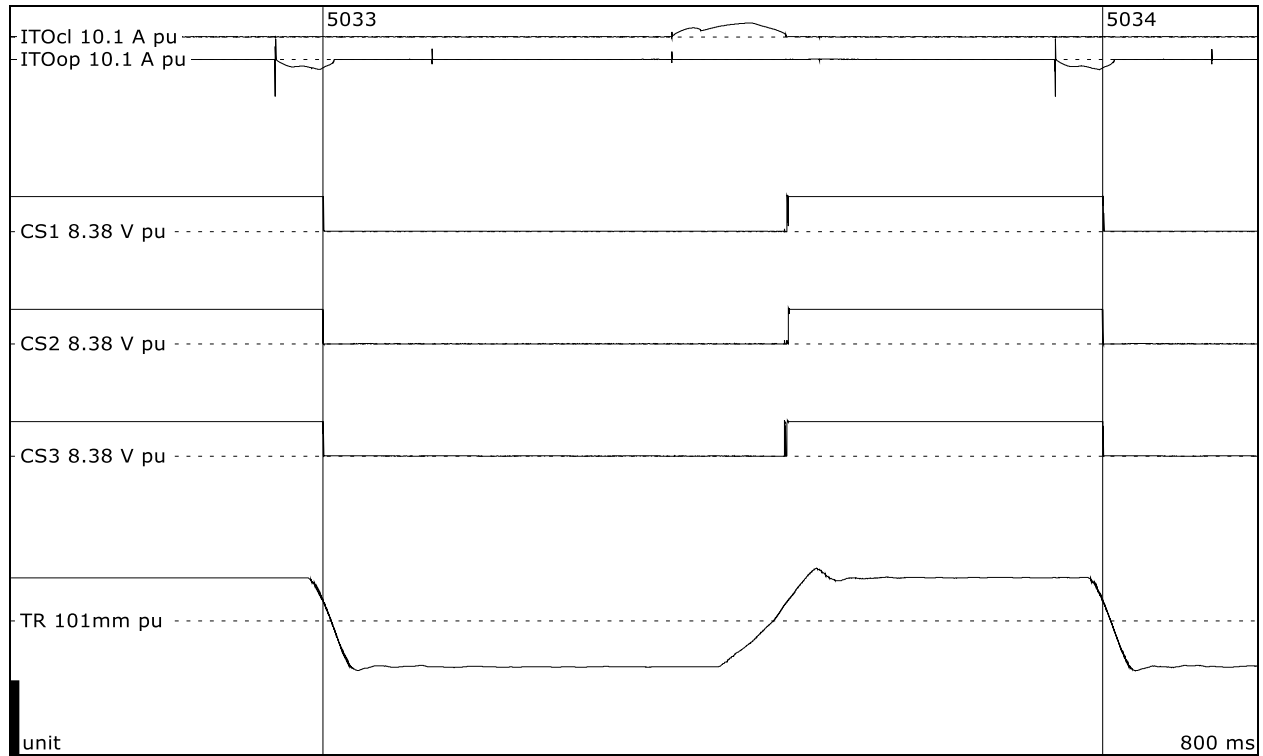
Test number: 170516-5033

Operation		O		
Phase		A	B	C
Current opening coil	A	-1,37		
Opening time	ms	31,0	30,5	30,8

Voltage opening coil	154 Vd.c.	Gas pressure at 20 °C	0,60 MPa
		Operating pressure	- MPa

Remarks: -

No-load test



Test number: 170516-5034

Time interval between operations	s	0,297		
Operation	CO			
Phase		A	B	C
Current closing coil	A	1,87		
Closing time	ms	73,5	74,7	72,1
Current opening coil	A	-5,00		
Opening time	ms	31,0	30,6	30,7

Voltage closing coil	187 Vd.c.	Gas pressure at 20 °C	0,60 MPa
Voltage opening coil	154 Vd.c.	Operating pressure	- MPa

Remarks: -

20.3 Condition / inspection after test

Externally no visible change.

Inspection of contacts:

Pole A (T10)

Fixed arcing contact very slightly burnt.

Moving arcing contact very slightly burnt.

Fixed main contact finger tips showed locally very slight commutation marks. Silver layer on main contact area intact.

Moving main contact rim showed locally very slight commutation marks. Silver layer on main contact area intact.

Nozzle very slightly eroded.

Auxiliary nozzle very slightly eroded.

Pole B (T30)

Fixed arcing contact slightly burnt.

Moving arcing contact slightly burnt.

Fixed main contact finger tips showed locally slight commutation marks. Silver layer on main contact area intact.

Moving main contact rim showed locally slight commutation marks. Silver layer on main contact area intact.

Nozzle slightly eroded.

Auxiliary nozzle slightly eroded.

Pole C (DEF)

Fixed arcing contact slightly burnt.

Moving arcing contact slightly burnt.

Fixed main contact finger tips showed locally slight commutation marks. Silver layer on main contact area intact.

Moving main contact rim showed locally slight commutation marks. Silver layer on main contact area intact.

Nozzle slightly eroded.

Auxiliary nozzle slightly eroded.

20.4 Photographs after test











































21 NO-LOAD TESTS

Standard and date

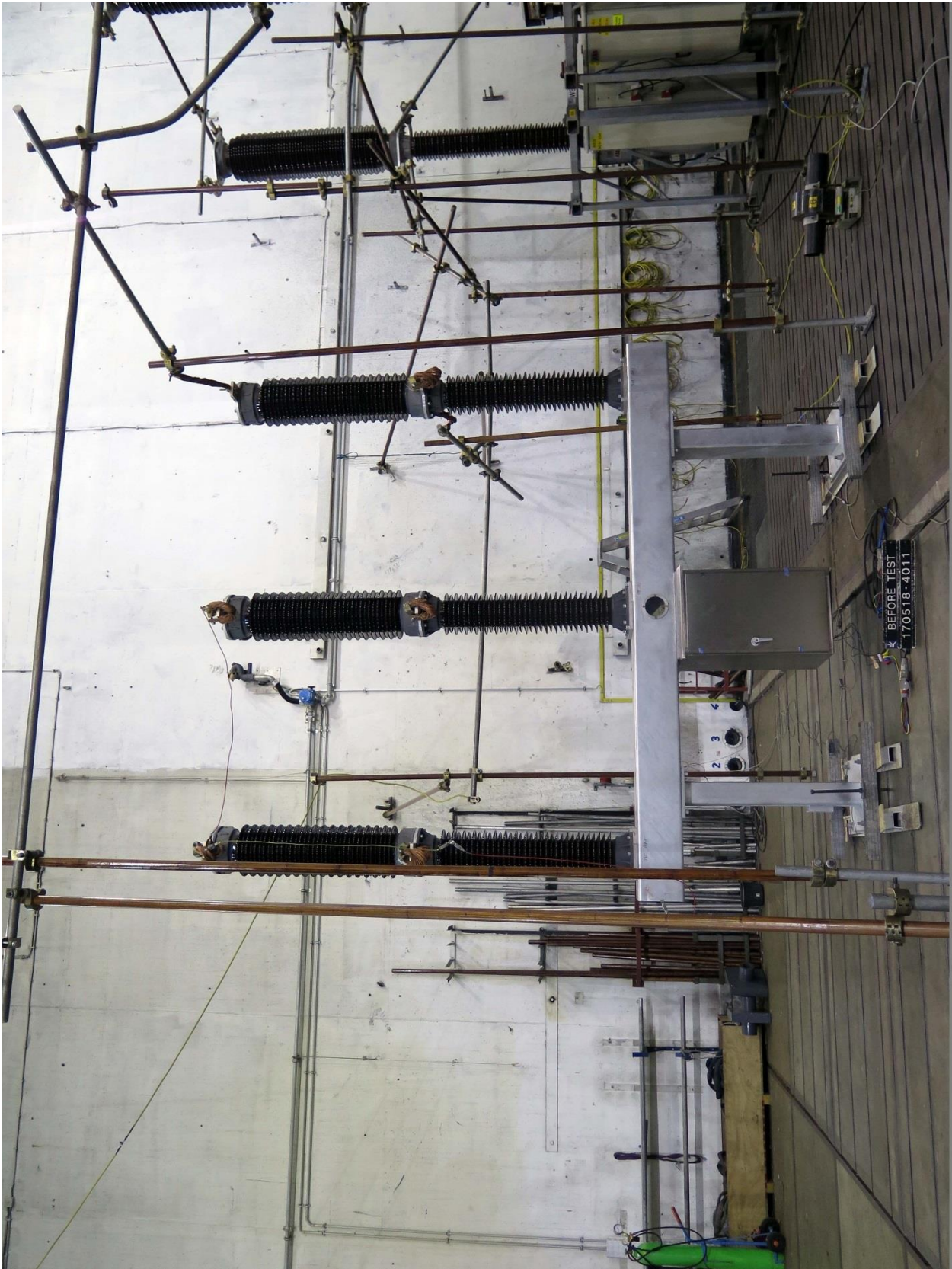
Standard IEC 62271-100

Test date 18 May 2017

21.1 Condition before test

Breaker (Serial No 17102) reconditioned.

21.2 Photograph before test



21.3 Test results and oscillograms

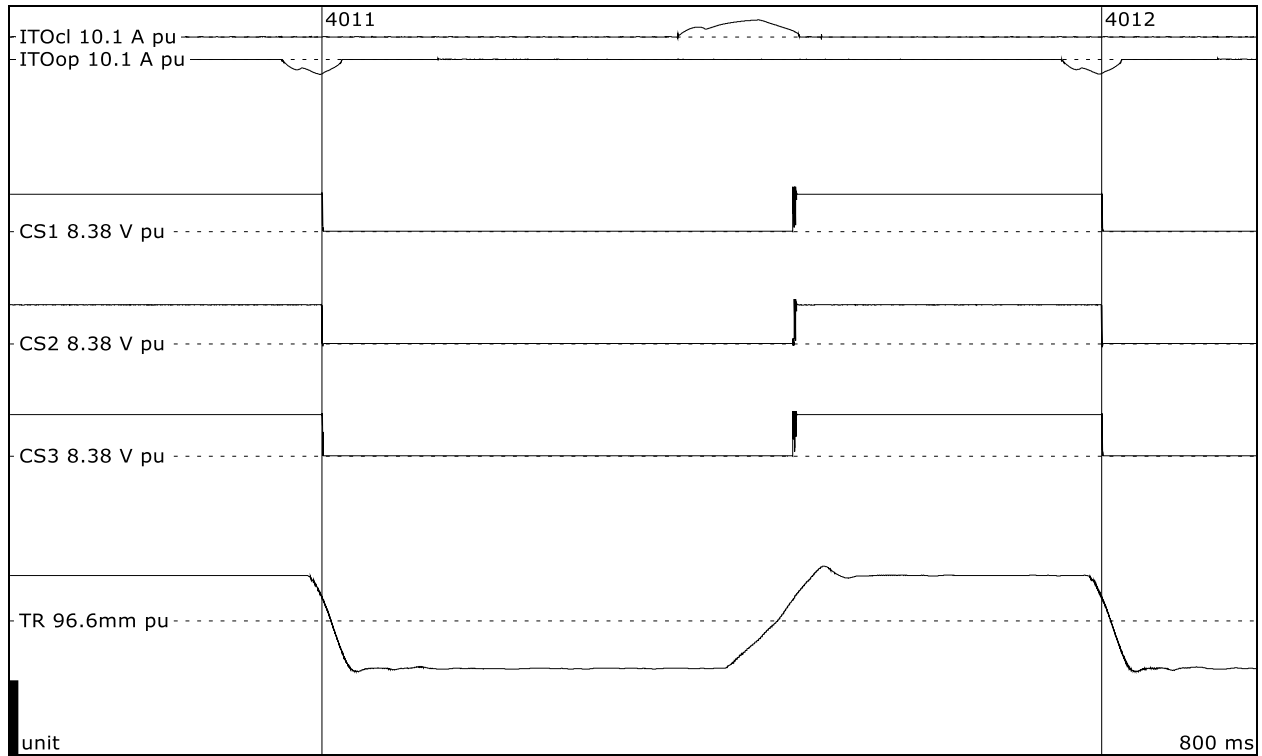
Overview of test numbers

170518-4011 to 4016

Remarks

-

No-load test



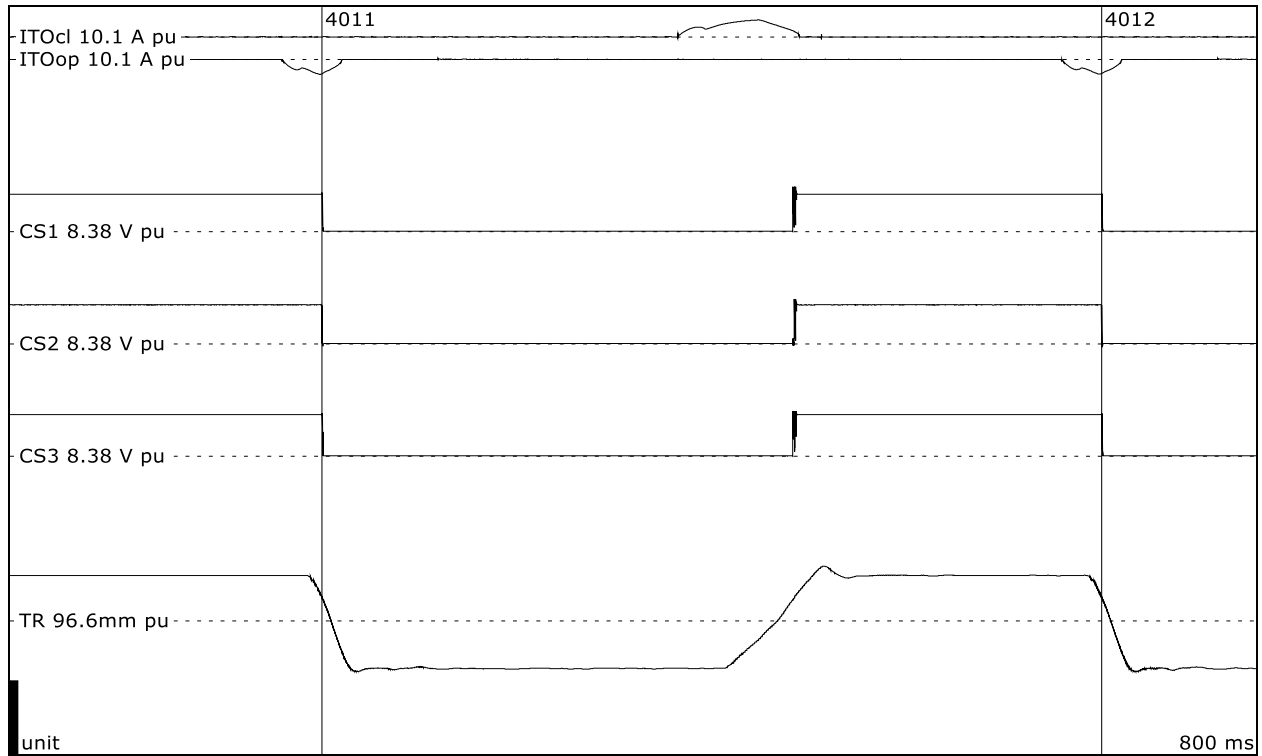
Test number: 170518-4011

Operation		O		
Phase		A	B	C
Current opening coil	A	-2,03		
Opening time	ms	26,4	25,9	26,5

Voltage opening coil	220 Vd.c.	Gas pressure at 20 °C	0,60 MPa
		Operating pressure	- MPa

Remarks: -

No-load test



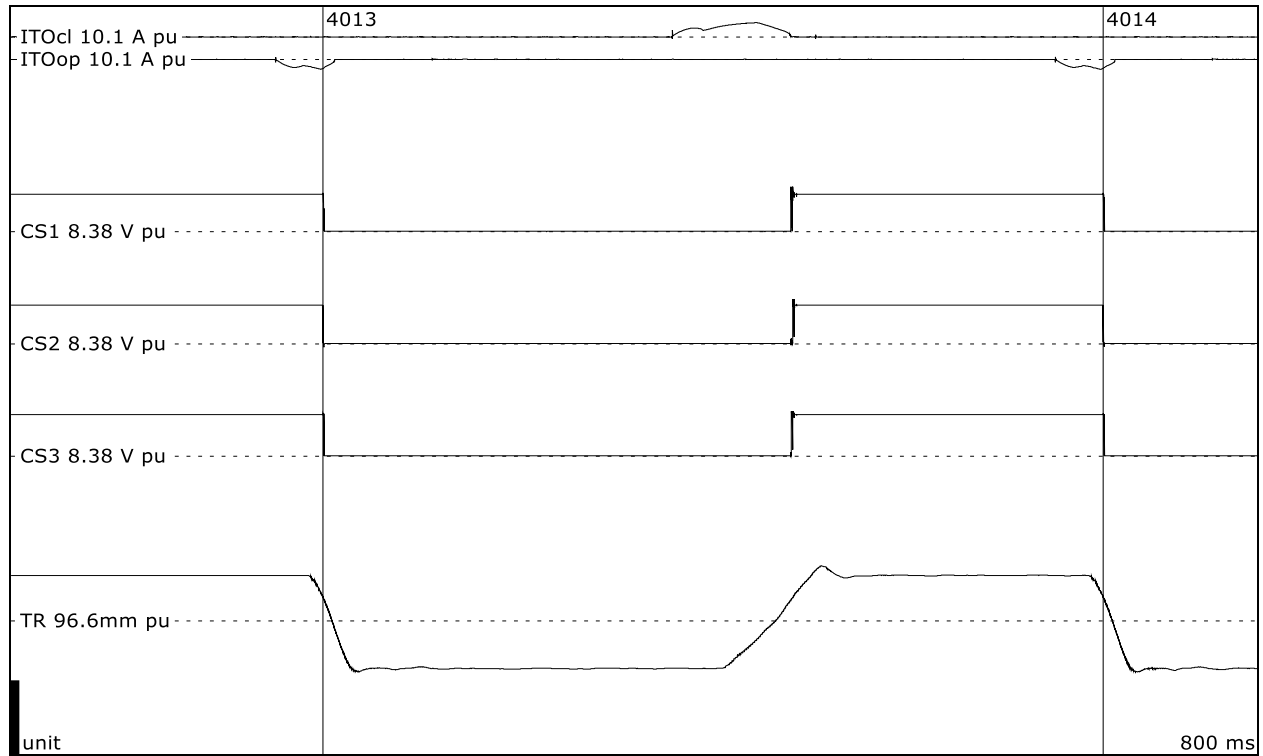
Test number: 170518-4012

Time interval between operations	s	0,302		
Operation	CO			
Phase		A	B	C
Current closing coil	A	2,27		
Closing time	ms	73,4	74,5	73,6
Current opening coil	A	-2,02		
Opening time	ms	26,3	25,9	26,4

Voltage closing coil	220 Vd.c.	Gas pressure at 20 °C	0,60 MPa
Voltage opening coil	220 Vd.c.	Operating pressure	- MPa

Remarks: -

No-load test



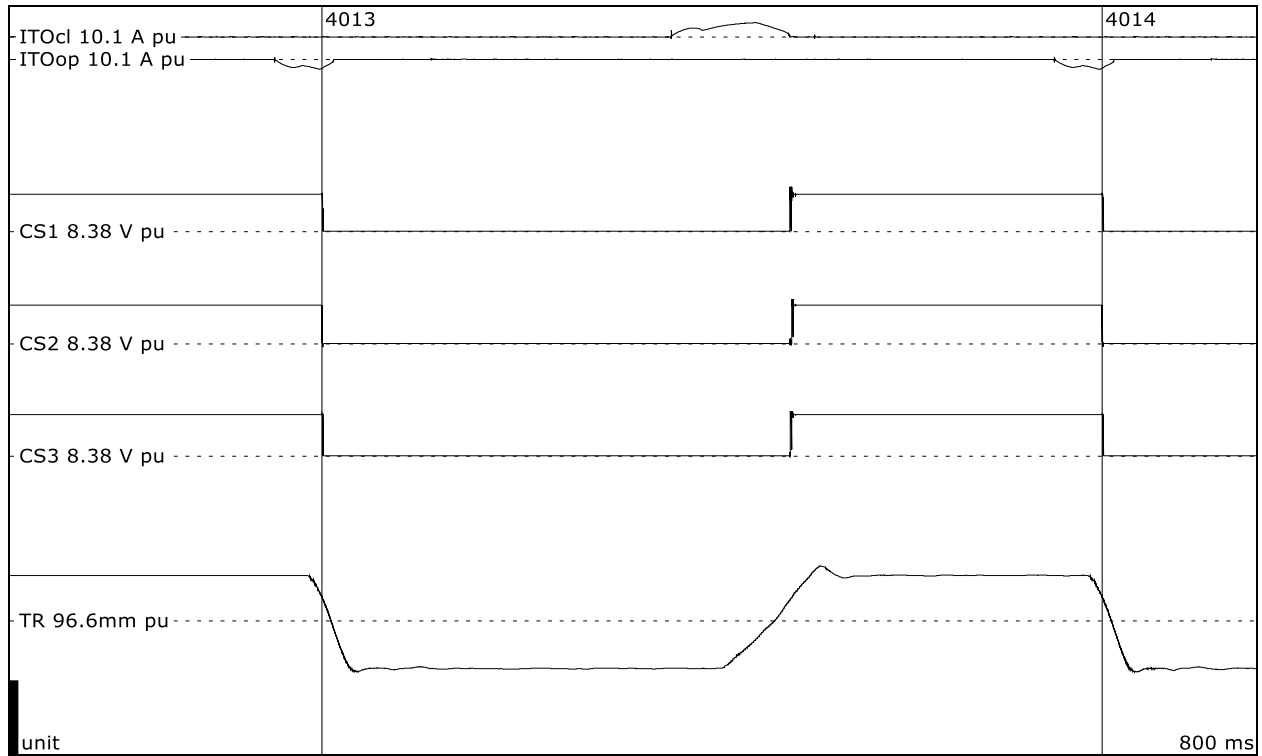
Test number: 170518-4013

Operation		O		
Phase		A	B	C
Current opening coil	A	-1,34		
Opening time	ms	30,9	30,4	31,0

Voltage opening coil	154 Vd.c.	Gas pressure at 20 °C	0,60 MPa
		Operating pressure	- MPa

Remarks: -

No-load test



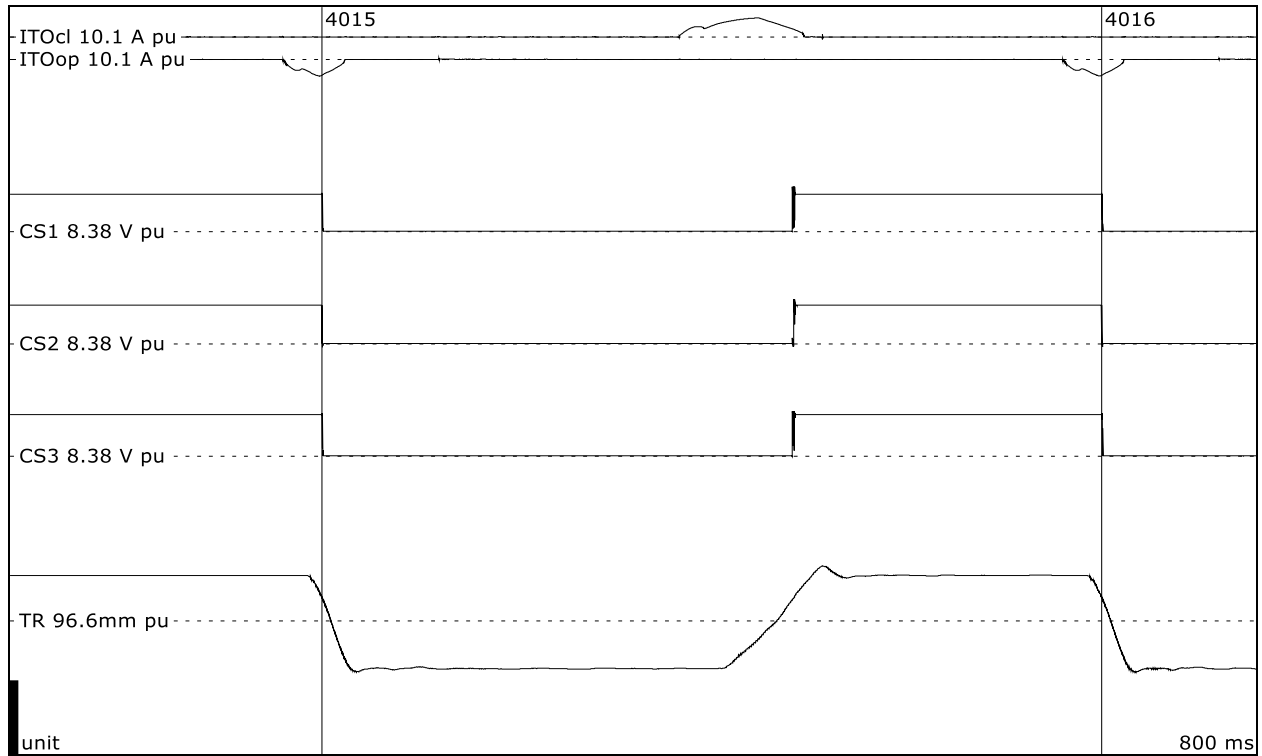
Test number: 170518-4014

Time interval between operations	s	0,300		
Operation	CO			
Phase		A	B	C
Current closing coil	A	1,89		
Closing time	ms	75,9	77,1	76,2
Current opening coil	A	-1,36		
Opening time	ms	31,2	30,7	31,2

Voltage closing coil	187 Vd.c.	Gas pressure at 20 °C	0,60 MPa
Voltage opening coil	154 Vd.c.	Operating pressure	- MPa

Remarks: -

No-load test



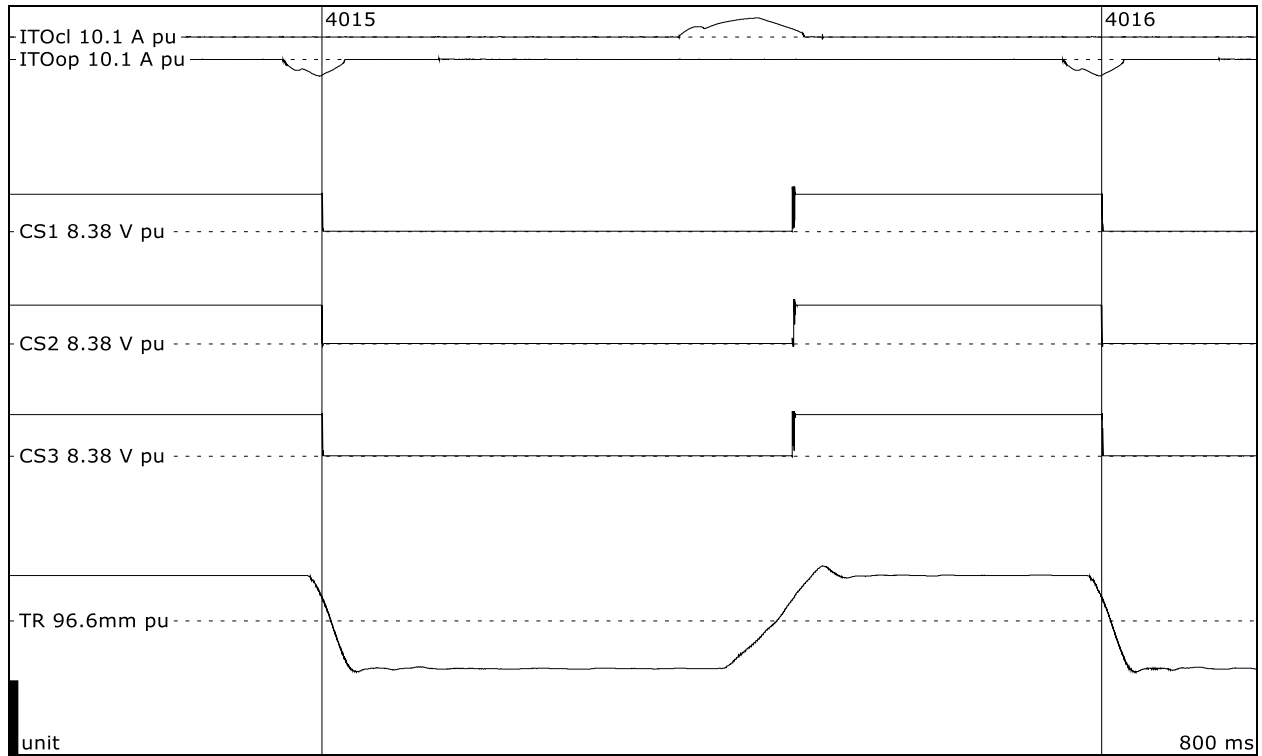
Test number: 170518-4015

Operation		O		
Phase		A	B	C
Current opening coil	A	-2,29		
Opening time	ms	25,7	25,2	25,7

Voltage opening coil	242 Vd.c.	Gas pressure at 20 °C	0,60 MPa
		Operating pressure	- MPa

Remarks: -

No-load test



Test number: 170518-4016

Time interval between operations	s	0,301		
Operation	CO			
Phase		A	B	C
Current closing coil	A	2,54		
Closing time	ms	72,3	73,3	72,4
Current opening coil	A	-2,27		
Opening time	ms	25,5	25,0	25,6

Voltage closing coil	242 Vd.c.	Gas pressure at 20 °C	0,60 MPa
Voltage opening coil	242 Vd.c.	Operating pressure	- MPa

Remarks: -

22 OP2 (make)

Standard and date

Standard IEC 62271-100

Test date 18 May 2017

22.1 Condition before test

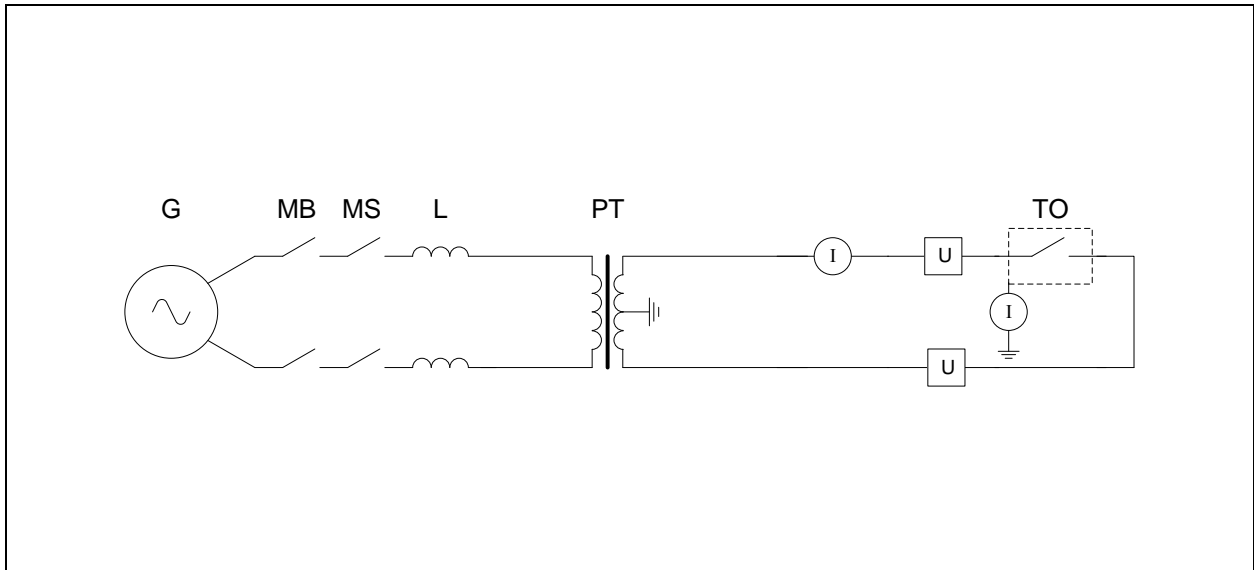
Breaker (Serial No 17102) in same condition.

Pole B under test.

Supply divided into 50% to fixed contact and 50% to moving contact.

Enclosure earthed via a CT.

22.2 Test circuit S12



G = Generator TO = Test Object U = Voltage Measurement to earth
 MB = Master Breaker L = Reactor I = Current Measurement
 MS = Make Switch
 PT = Power Transformer

Supply		
Power	MVA	1674
Frequency	Hz	50
Phase(s)		1
Voltage	kV	167
Current	kA	10,0
Impedance	Ω	16,7
Power factor		< 0,1
Neutral		intermediate point earthed at 50% - 50%

Load	
Short-circuit point	not earthed

Remarks: -

22.3 Test results and oscillograms

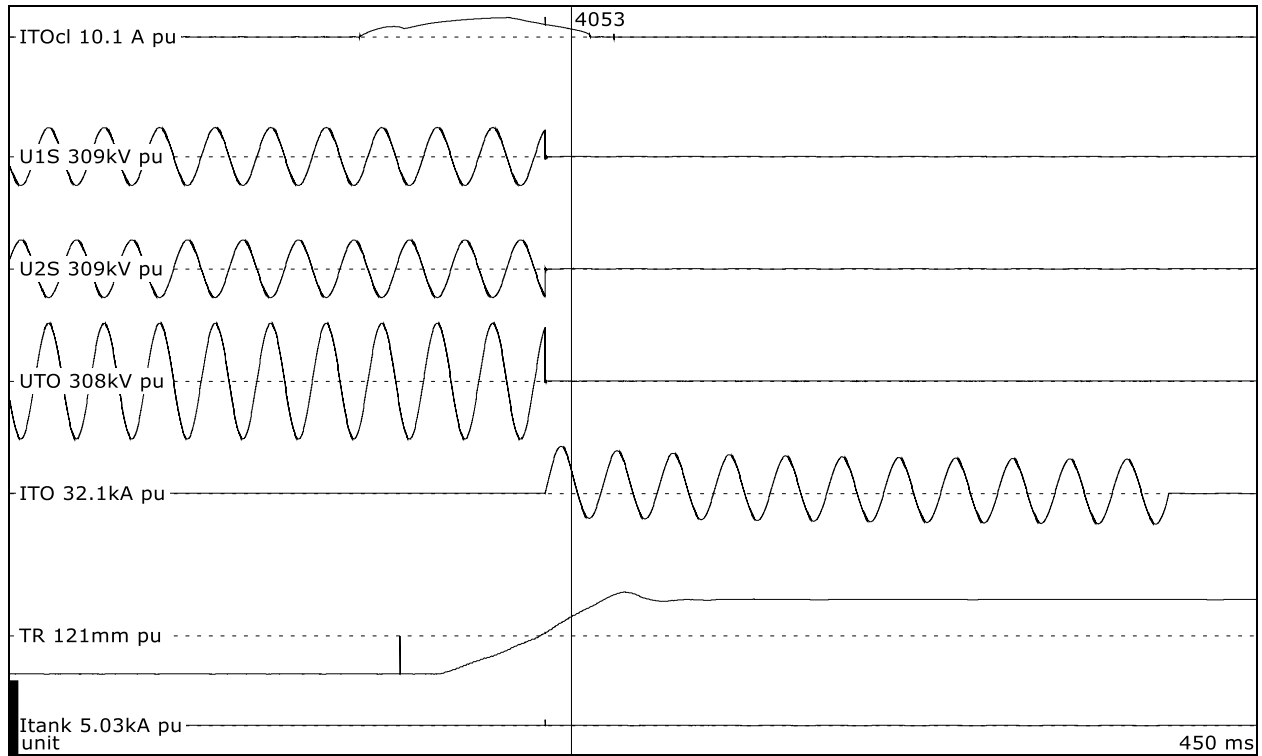
Overview of test numbers

170518-4053, 4054

Remarks

-

OP2 (make)



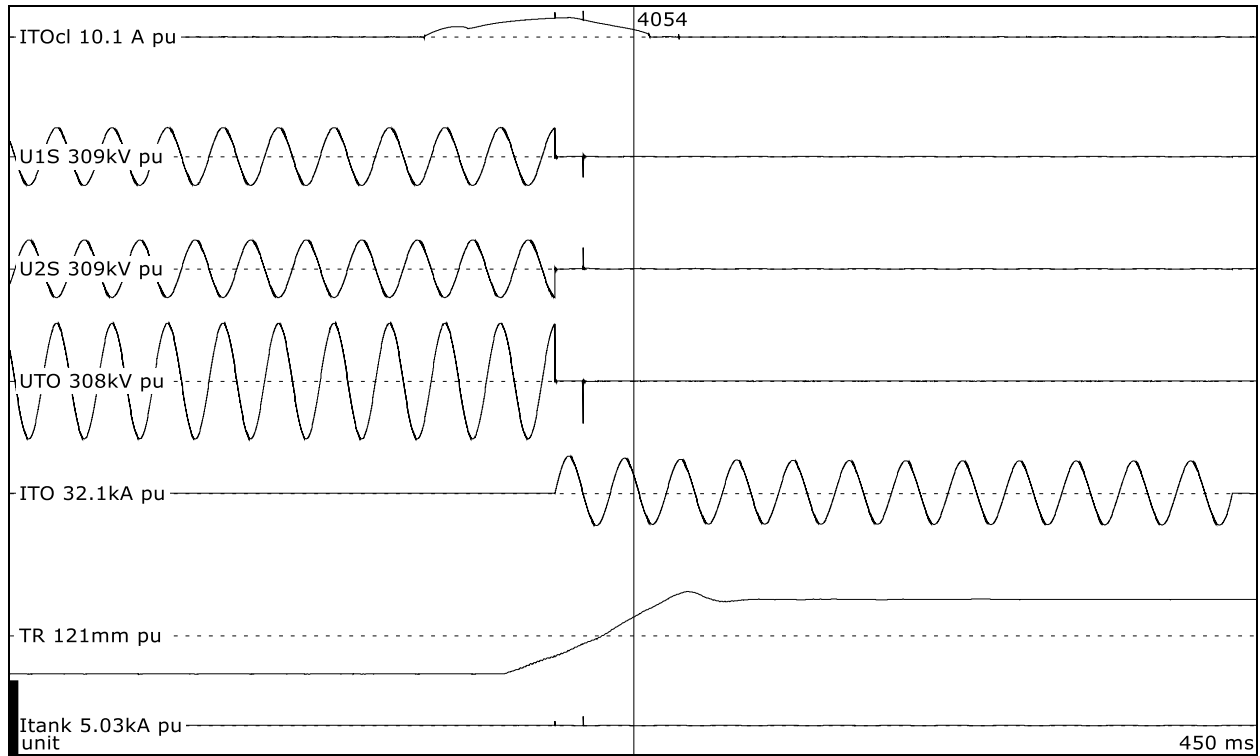
Test number: 170518-4053

Time interval since previous test	min	-
Operation		C
Phase		B
Applied voltage, phase value	kV	168
Applied voltage, between phases	kV	-
Making current, peak	kA	20,1
Symmetrical current, end	kA	9,84
Average curr. end, three phase	kA	-
Make time	ms	66,9
Pre-arcing time	ms	9,5
Current duration	ms	225

Voltage closing coil	242 Vd.c.	Gas pressure at 20 °C	0,60 MPa
		Operating pressure	- MPa

Remarks: Breaker closed.

OP2 (make)



Test number: 170518-4054

Time interval since previous test	min	-
Operation		C
Phase		B
Applied voltage, phase value	kV	168
Applied voltage, between phases	kV	-
Making current, peak	kA	16,0
Symmetrical current, end	kA	9,70
Average curr. end, three phase	kA	-
Make time	ms	47,2
Pre-arcing time	ms	28,4
Current duration	ms	244

Voltage closing coil	242 Vd.c.	Gas pressure at 20 °C	0,60 MPa
		Operating pressure	- MPa

Remarks: Breaker closed.

23 OP2 (break)

Standard and date

Standard	IEC 62271-100
Test date	19 May 2017

23.1 Condition before test

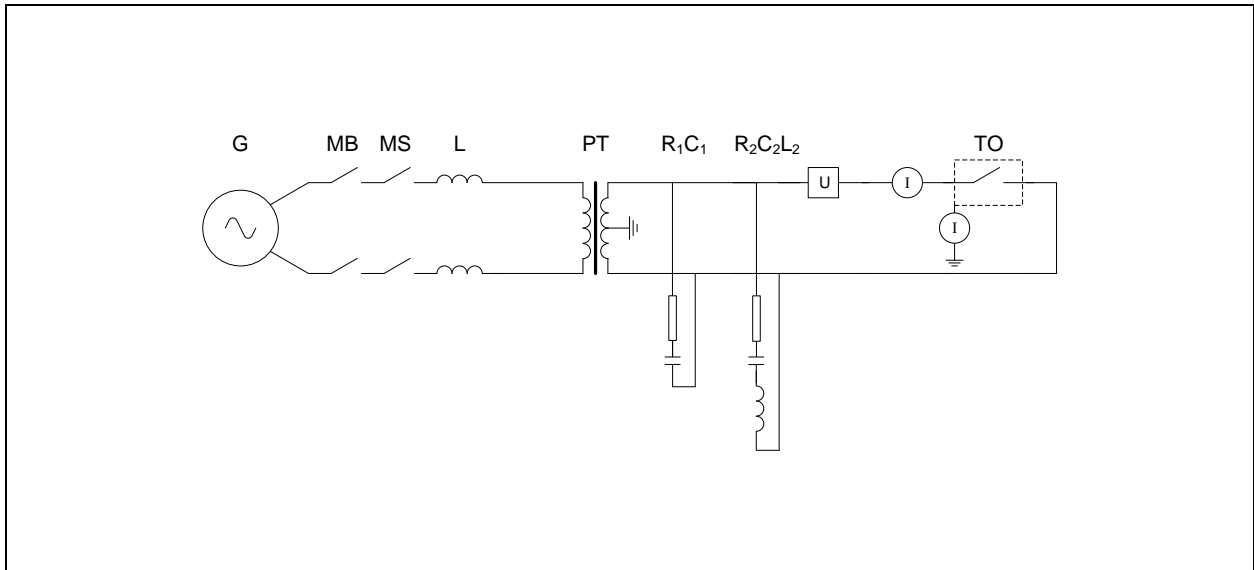
Breaker (Serial No 17102) in same condition.

Pole B under test.

Supply divided into 50% to fixed contact and 50% to moving contact.

Enclosure earthed via a CT.

23.2 Test circuit S13



G = Generator	TO = Test Object	U = Voltage Measurement to earth
MB = Master Breaker	L = Reactor	I = Current Measurement
MS = Make Switch	R = Resistor	ML = Multi-loop device
PT = Power Transformer	C = Capacitor	

Supply		
Power	MVA	2090
Frequency	Hz	50
Phase(s)		1
Voltage	kV	209
Current	kA	10,0
Impedance	Ω	20,9
Power factor		< 0,1
Neutral		intermediate point earthed at 50% - 50%

TRV control elements added (supply)		
C ₁	μF	0,09
R ₁	Ω	300
C ₂	nF	165
R ₂	Ω	100
L ₂	mH	88,0

Prospective TRV of supply		
u ₁	kV	222
u _c	kV	371
t _d	μs	13,0
t ₁	μs	134
t ₂	μs	536
RRRV	kV/ μs	1,67

Remarks: -

23.3 Test results and oscillograms

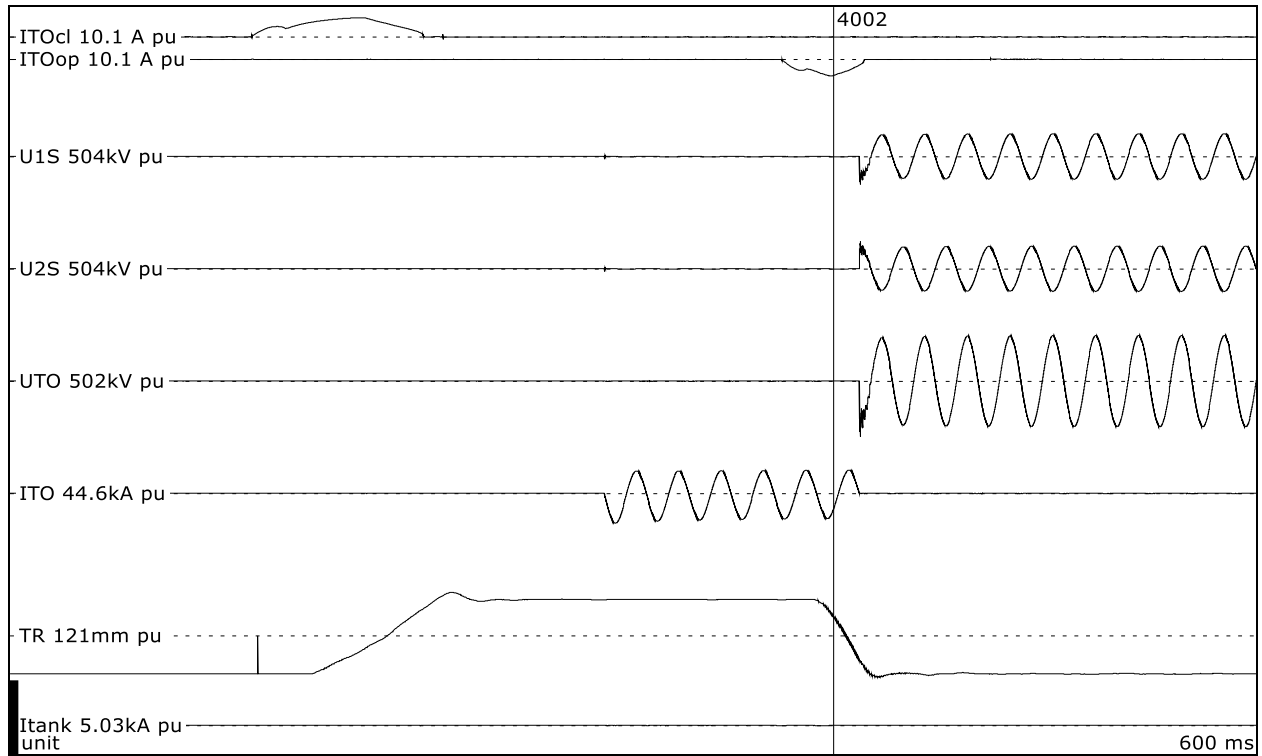
Overview of test numbers

170519-4002 to 4006

Remarks

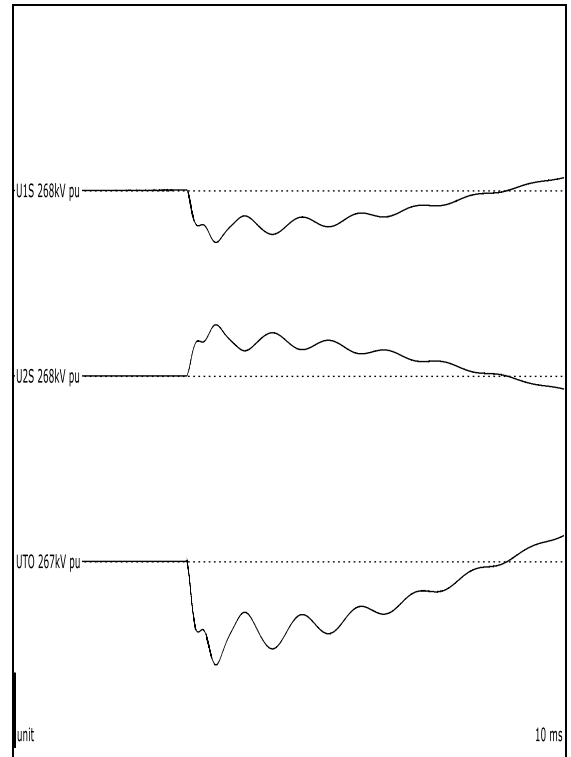
-

OP2 (break)



Test number: 170519-4002

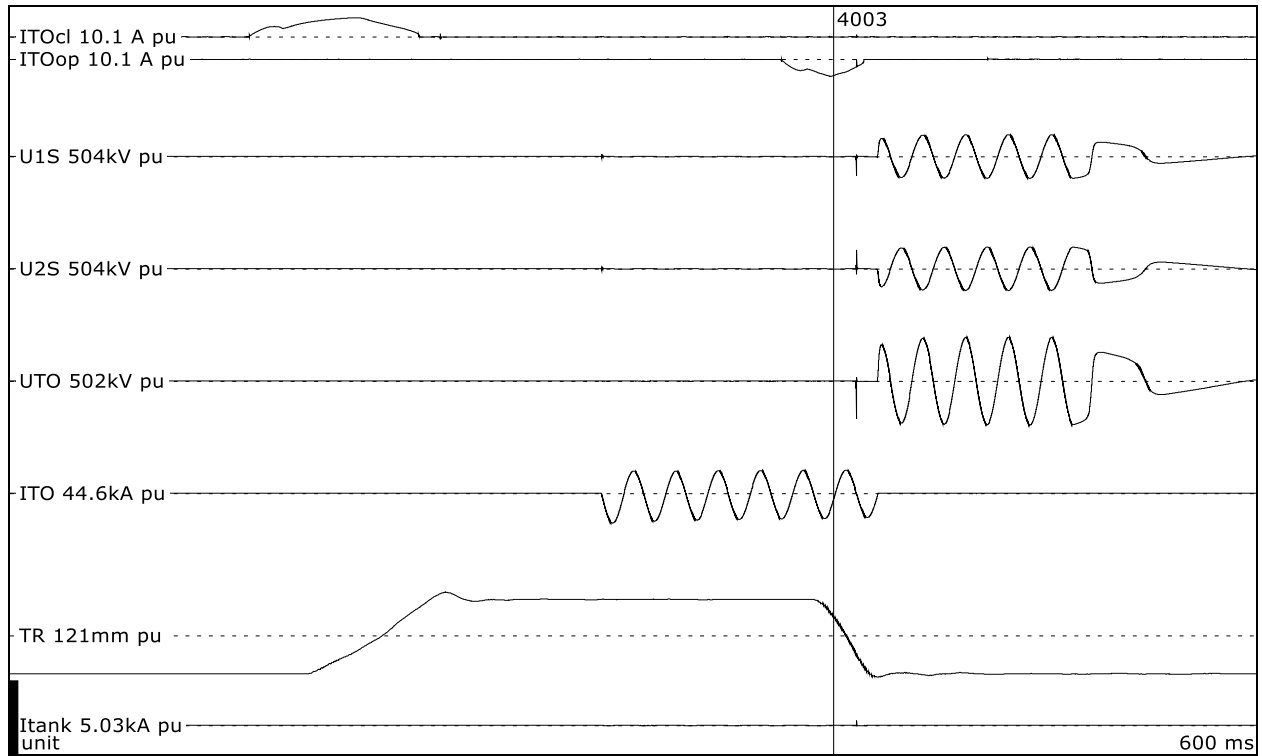
Time interval since previous test	min	-
Operation		(C)O
Phase		B
Breaking current, phase value	kA	10,2
Average current, three phase	kA	-
Breaking current, DC-component	%	4
Recovery voltage, phase value	kV	208
Recovery voltage, between phases	kV	-
TRV, peak	kV	-373
Arc duration	ms	12,4
Opening time	ms	24,6
Break time	ms	37,0



Voltage opening coil	242 Vd.c.	Gas pressure at 20 °C	0,60 MPa
		Operating pressure	- MPa

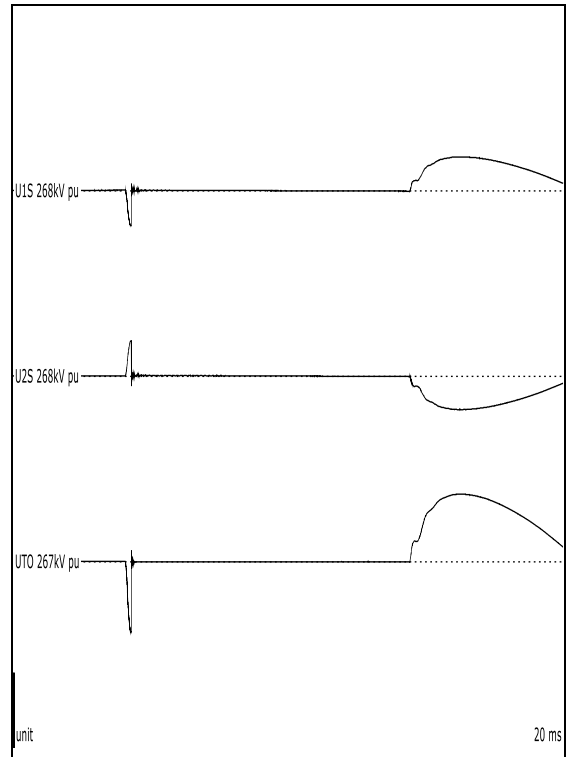
Remarks: Breaker closed in no-load and cleared.

OP2 (break)



Test number: 170519-4003

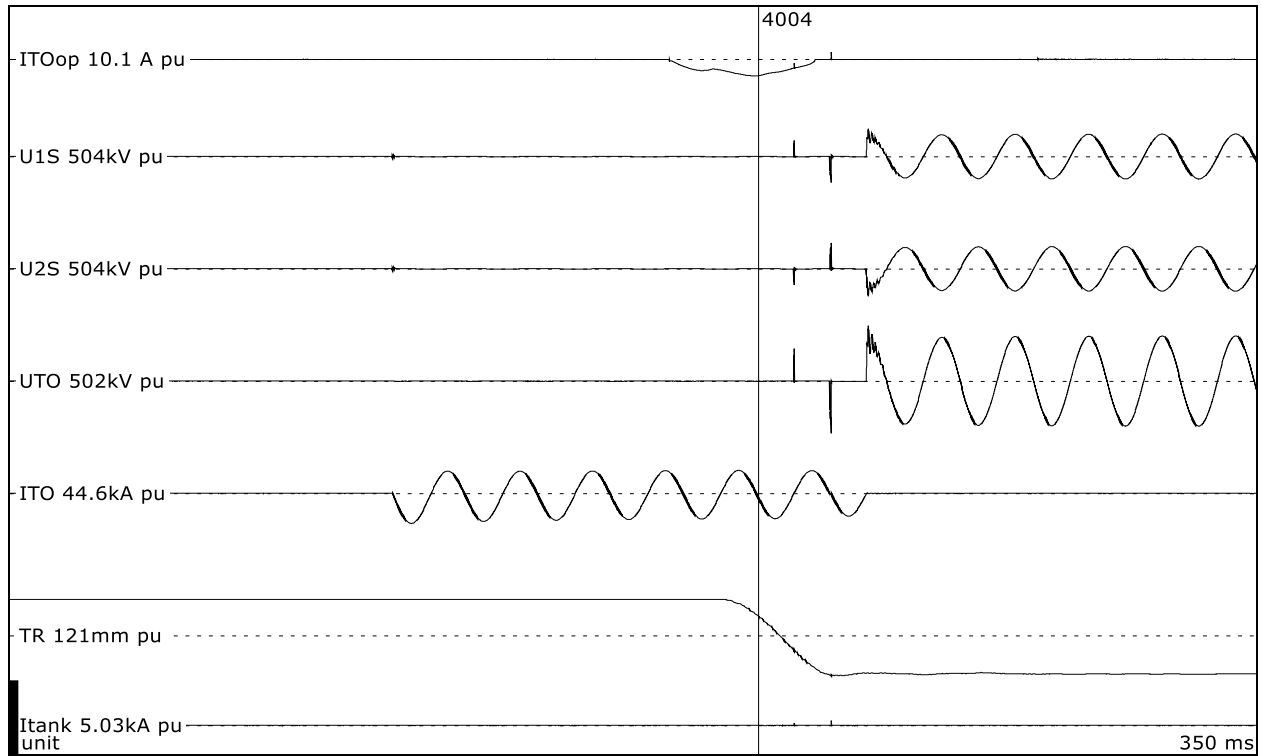
Time interval since previous test	min	6
Operation		(C)O
Phase		B
Breaking current, phase value	kA	10,2
Average current, three phase	kA	-
Breaking current, DC-component	%	4
Recovery voltage, phase value	kV	-
Recovery voltage, between phases	kV	-
TRV, peak	kV	-
Arc duration	ms	(1)
Opening time	ms	25,1
Break time	ms	-



Voltage opening coil	242 Vd.c.	Gas pressure at 20 °C	0,60 MPa
		Operating pressure	- MPa

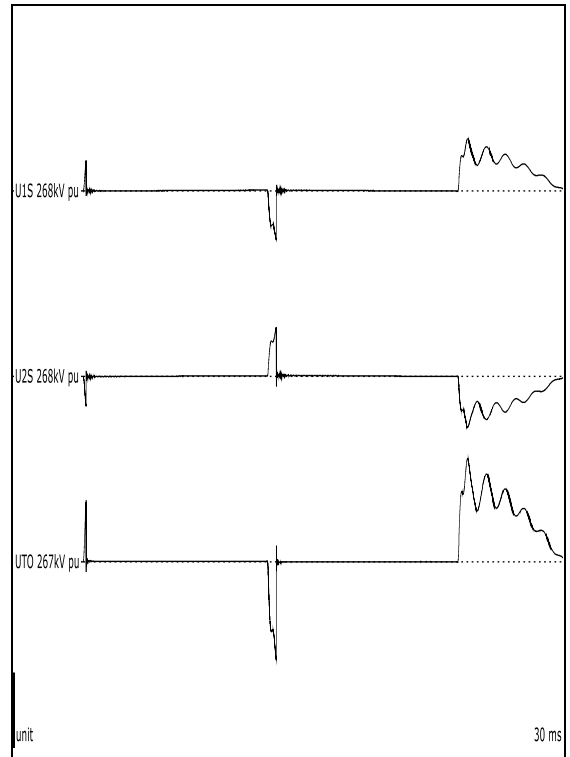
Remarks: Test to verify the correct reignition behaviour of the breaker (subclause 6.102.10 of IEC 62271-101).
 (1) Arcing time set for 11,2 ms.

OP2 (break)



Test number: 170519-4004

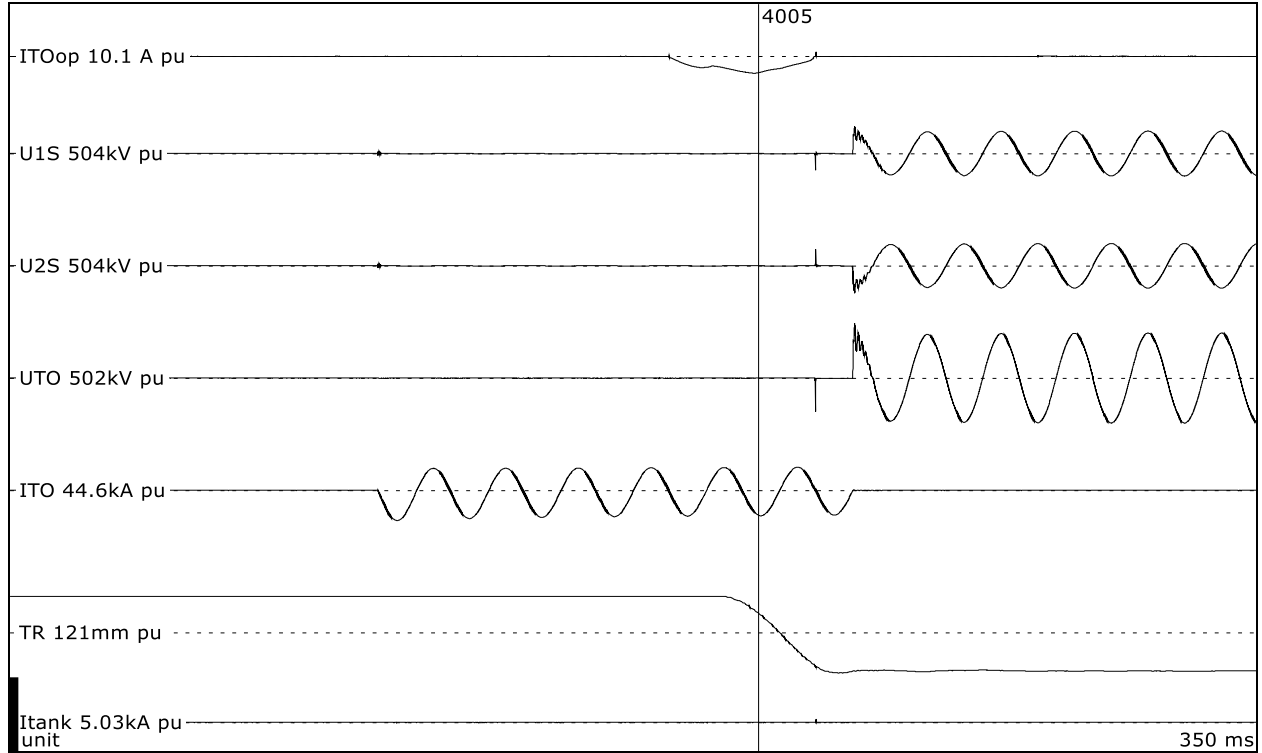
Time interval since previous test	min	6
Operation		O
Phase		B
Breaking current, phase value	kA	10,2
Average current, three phase	kA	-
Breaking current, DC-component	%	5
Recovery voltage, phase value	kV	207
Recovery voltage, between phases	kV	-
TRV, peak	kV	372
Arc duration	ms	30,3 (1)
Opening time	ms	25,0
Break time	ms	55,3



Voltage opening coil	242 Vd.c.	Gas pressure at 20 °C	0,60 MPa
		Operating pressure	- MPa

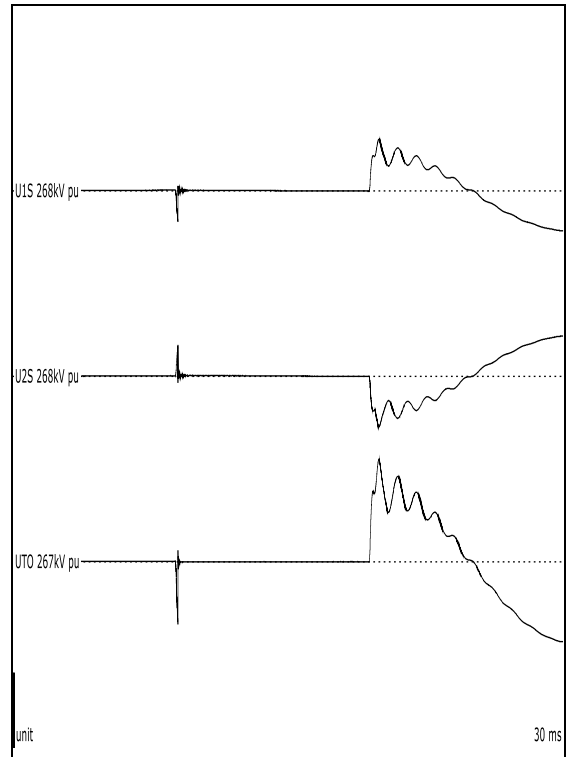
Remarks: Breaker cleared.
 (1) Arcing time set for 19,7 ms.

OP2 (break)



Test number: 170519-4005

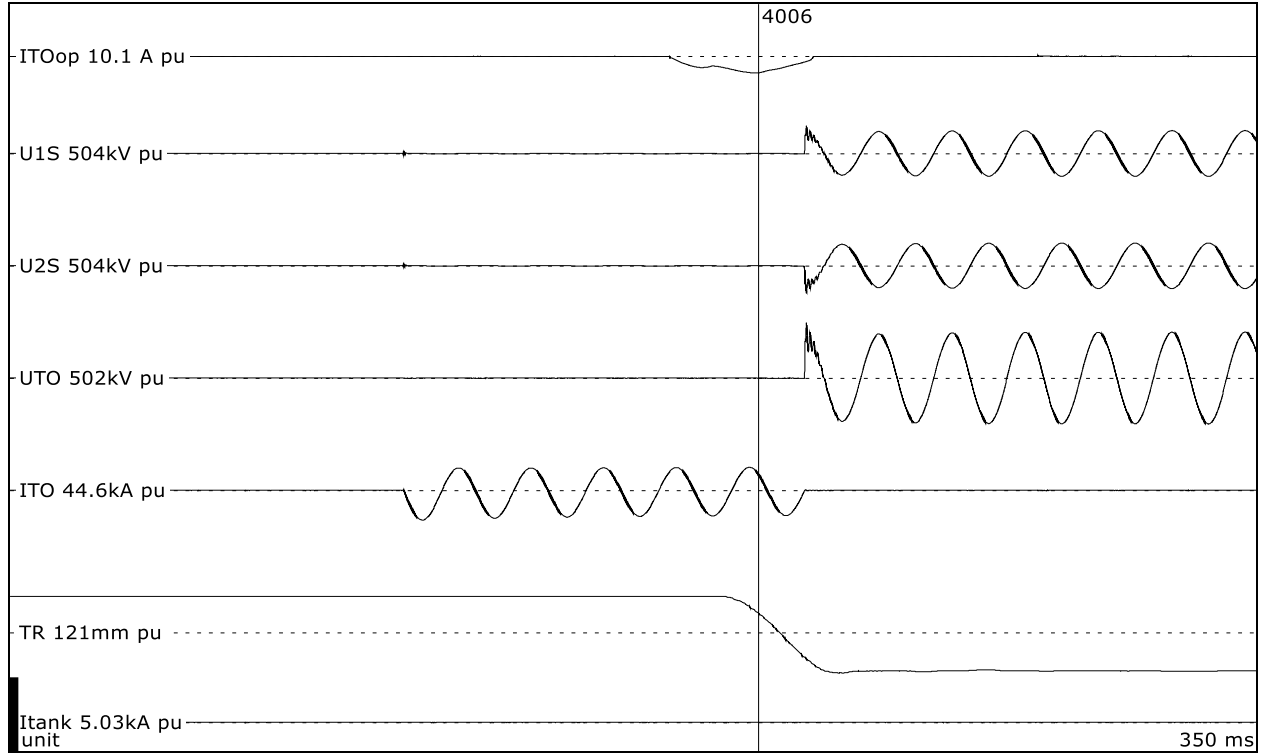
Time interval since previous test	min	9
Operation		O
Phase		B
Breaking current, phase value	kA	10,2
Average current, three phase	kA	-
Breaking current, DC-component	%	5
Recovery voltage, phase value	kV	207
Recovery voltage, between phases	kV	-
TRV, peak	kV	371
Arc duration	ms	26,5 (1)
Opening time	ms	25,1
Break time	ms	51,6



Voltage opening coil	242 Vd.c.	Gas pressure at 20 °C	0,60 MPa
		Operating pressure	- MPa

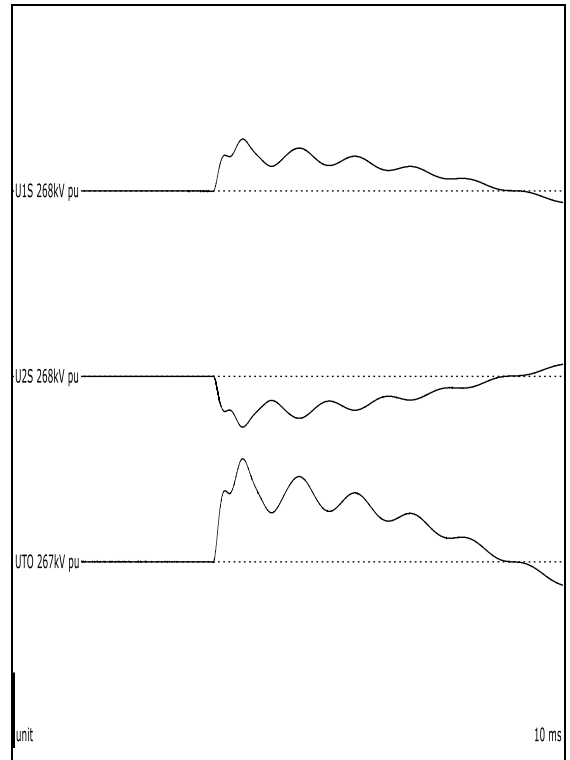
Remarks: Breaker cleared.
 (1) Arcing time set for 16,0 ms.

OP2 (break)



Test number: 170519-4006

Time interval since previous test	min	13
Operation		O
Phase		B
Breaking current, phase value	kA	10,2
Average current, three phase	kA	-
Breaking current, DC-component	%	5
Recovery voltage, phase value	kV	209
Recovery voltage, between phases	kV	-
TRV, peak	kV	371
Arc duration	ms	13,0 (1)
Opening time	ms	25,0
Break time	ms	38,0



Voltage opening coil	242 Vd.c.	Gas pressure at 20 °C	0,60 MPa
		Operating pressure	- MPa

Remarks: Breaker cleared.
 (1) Arcing time set for 22,9 ms.

24 NO-LOAD TESTS

Standard and date

Standard IEC 62271-100

Test date 19 May 2017

24.1 Condition before test

Breaker (Serial No 17102) in same condition.

24.2 Test results and oscillograms

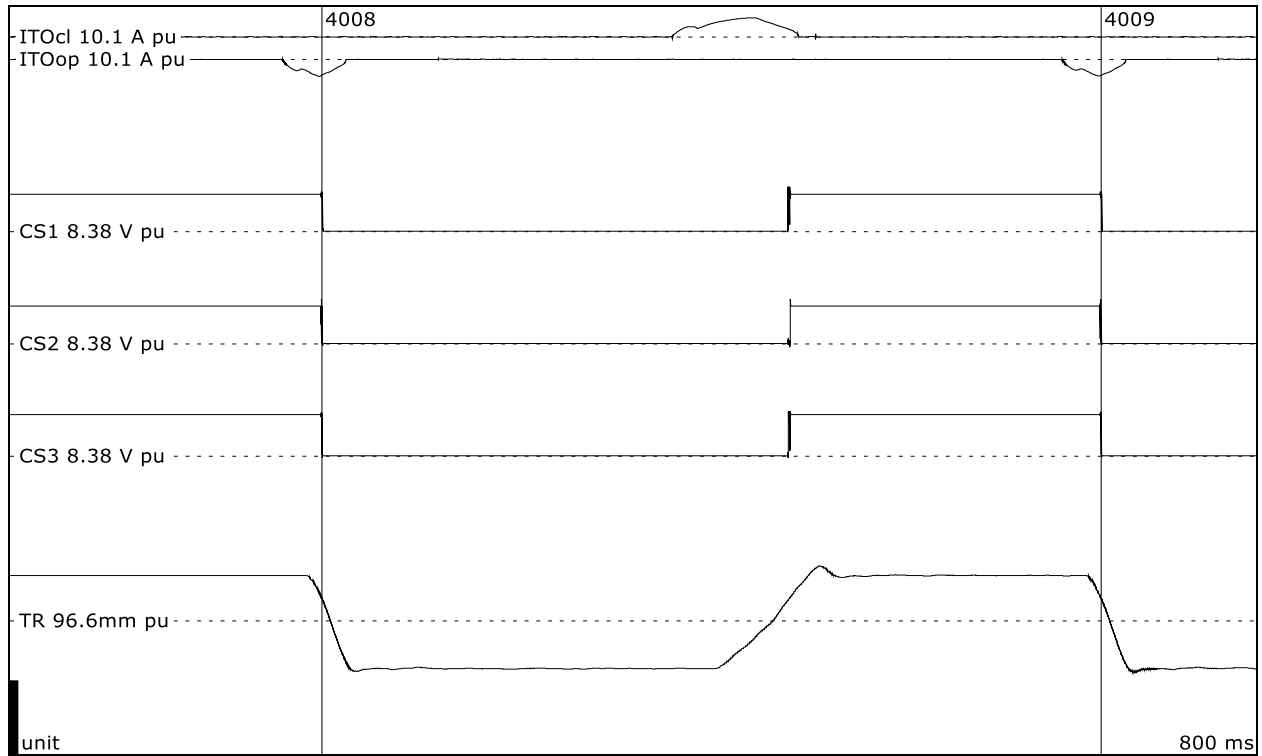
Overview of test numbers

170519-4008 to 4013

Remarks

-

No-load test



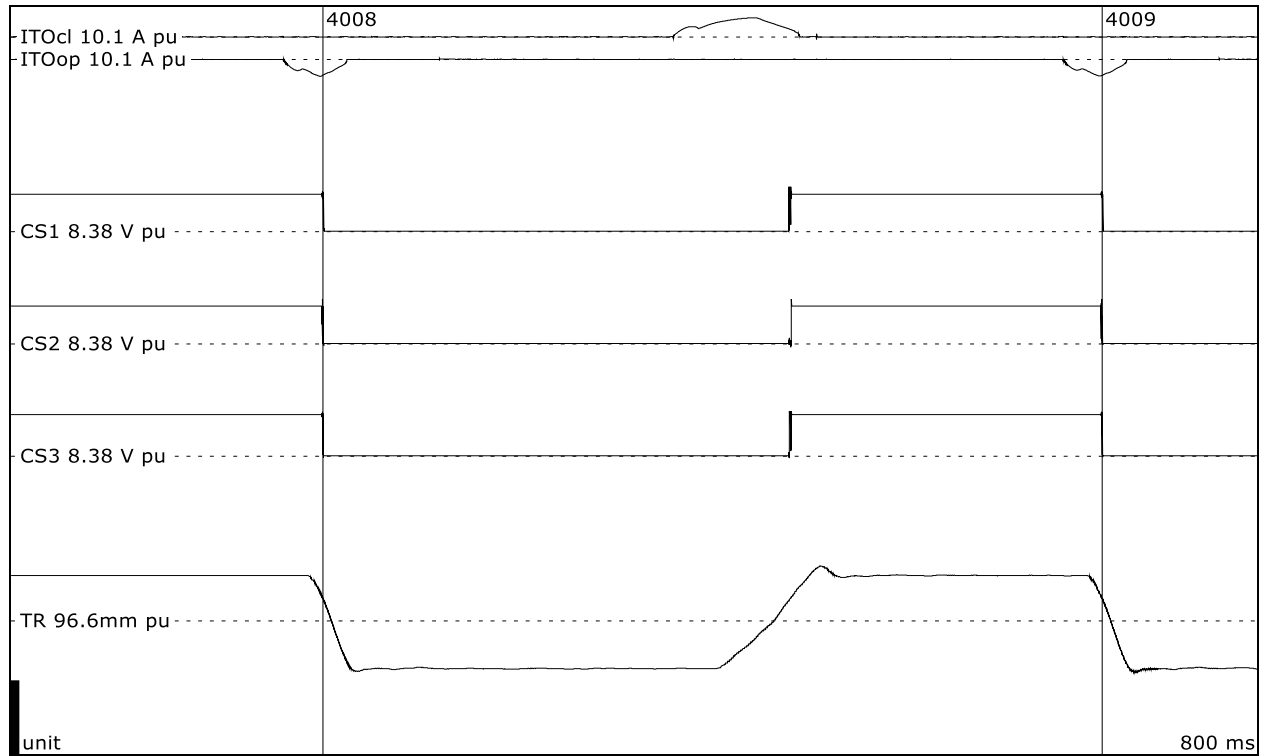
Test number: 170519-4008

Operation		O		
Phase		A	B	C
Current opening coil	A	-2,30		
Opening time	ms	26,1	25,3	25,7

Voltage opening coil	242 Vd.c.	Gas pressure at 20 °C	0,60 MPa
		Operating pressure	- MPa

Remarks: -

No-load test



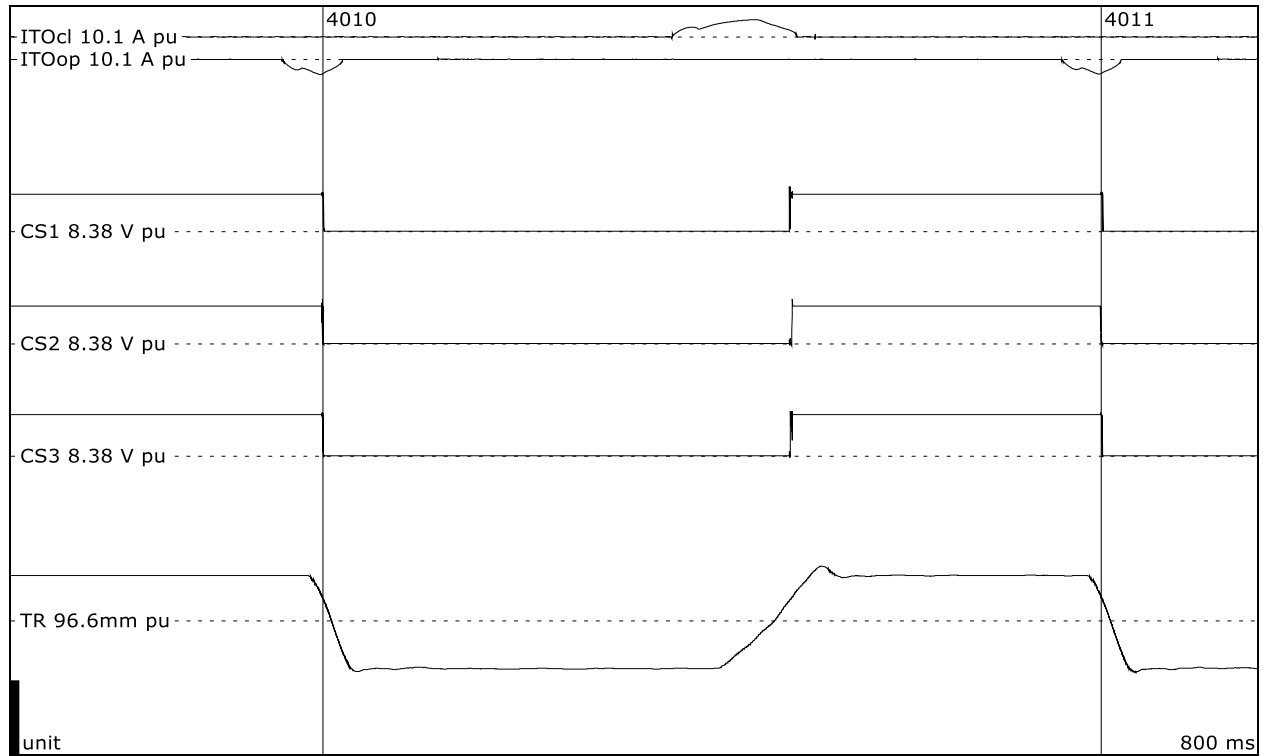
Test number: 170519-4009

Time interval between operations	s	0,299		
Operation	CO			
Phase		A	B	C
Current closing coil	A	2,57		
Closing time	ms	73,8	75,4	74,3
Current opening coil	A	-2,25		
Opening time	ms	25,6	24,7	25,2

Voltage closing coil	242 Vd.c.	Gas pressure at 20 °C	0,60 MPa
Voltage opening coil	242 Vd.c.	Operating pressure	- MPa

Remarks: -

No-load test



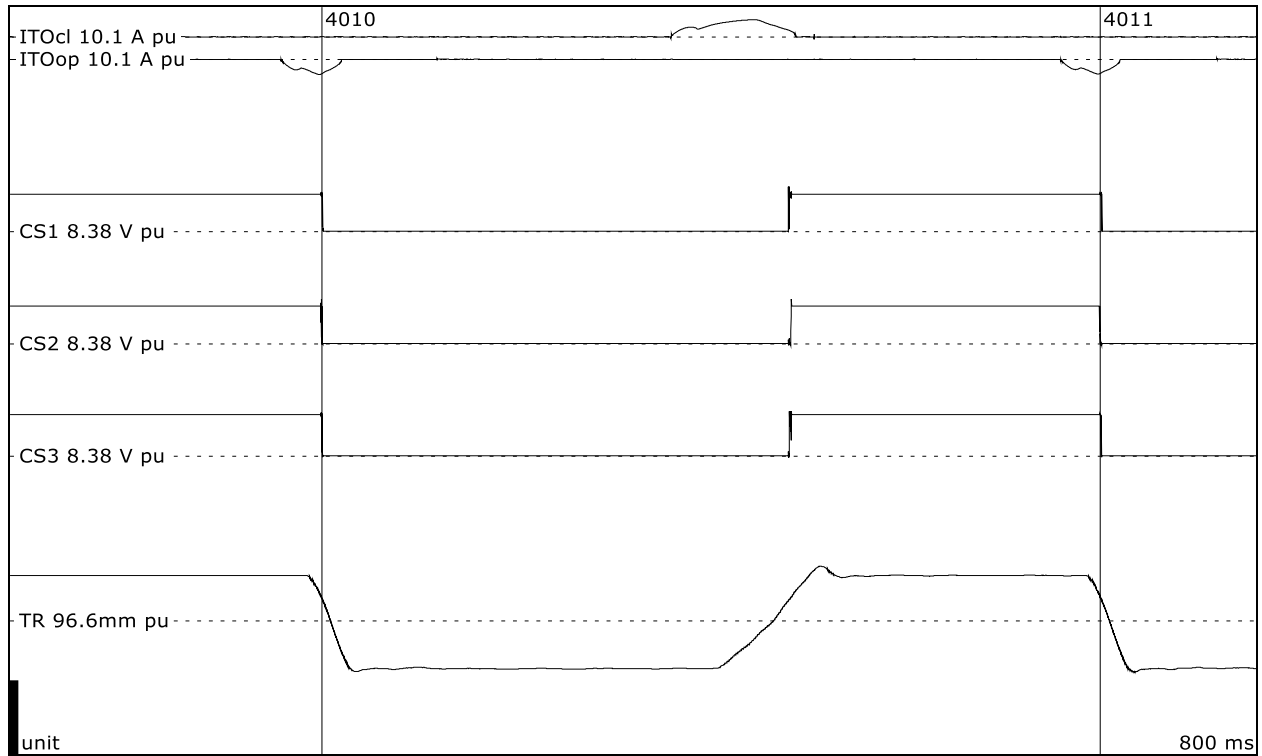
Test number: 170519-4010

Operation		O		
Phase		A	B	C
Current opening coil	A	-2,06		
Opening time	ms	26,9	26,0	26,6

Voltage opening coil	220 Vd.c.	Gas pressure at 20 °C	0,60 MPa
		Operating pressure	- MPa

Remarks: -

No-load test



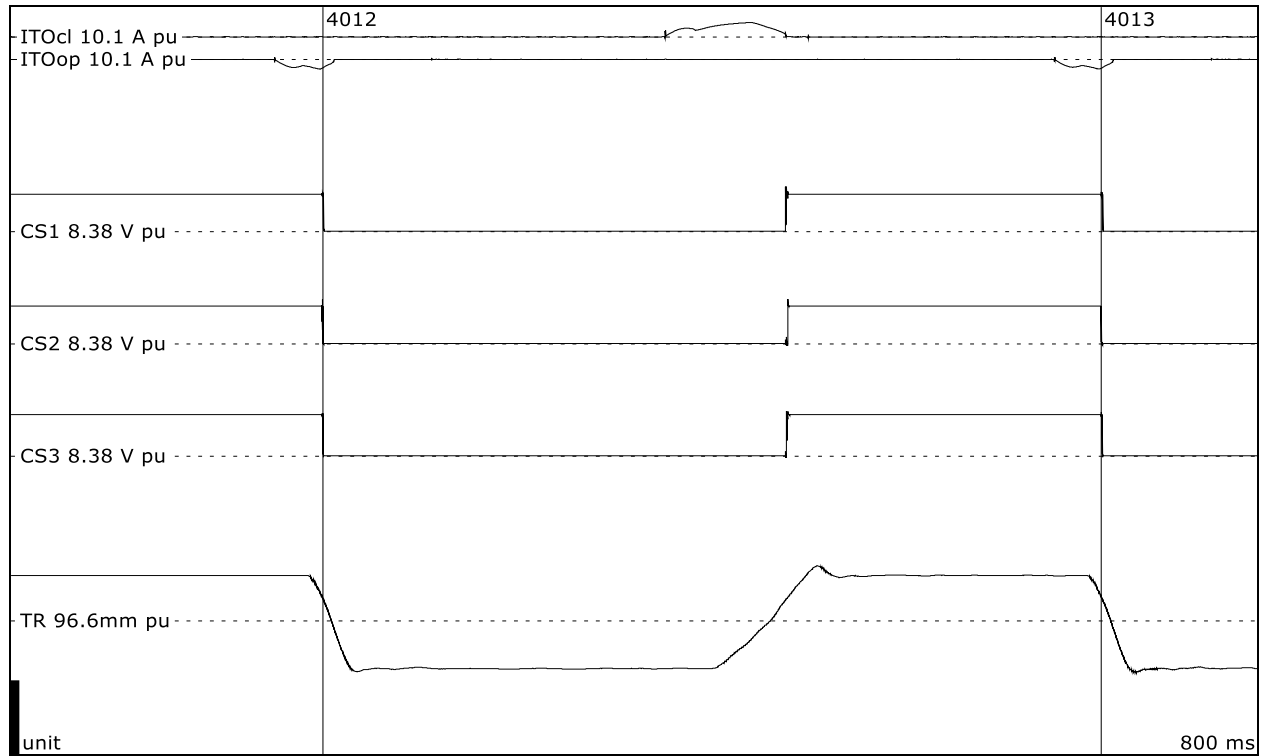
Test number: 170519-4011

Time interval between operations	s	0,299		
Operation	CO			
Phase		A	B	C
Current closing coil	A	2,31		
Closing time	ms	75,1	76,8	75,8
Current opening coil	A	-2,01		
Opening time	ms	26,4	25,3	26,0

Voltage closing coil	220 Vd.c.	Gas pressure at 20 °C	0,60 MPa
Voltage opening coil	220 Vd.c.	Operating pressure	- MPa

Remarks: -

No-load test



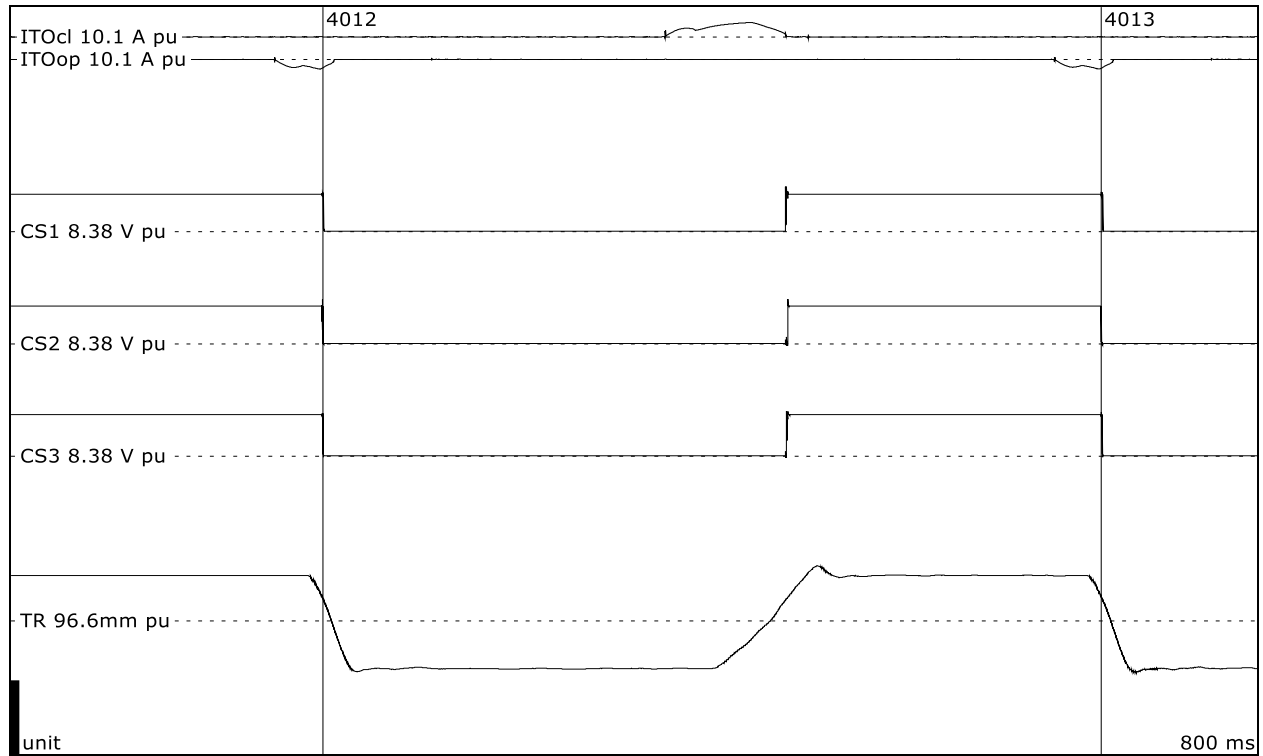
Test number: 170519-4012

Operation		O		
Phase		A	B	C
Current opening coil	A	-1,33		
Opening time	ms	31,2	30,4	30,9

Voltage opening coil	154 Vd.c.	Gas pressure at 20 °C	0,60 MPa
		Operating pressure	- MPa

Remarks: -

No-load test



Test number: 170519-4013

Time interval between operations	s	0,296		
Operation	CO			
Phase		A	B	C
Current closing coil	A	1,93		
Closing time	ms	77,0	78,7	77,7
Current opening coil	A	-1,33		
Opening time	ms	30,8	29,8	30,5

Voltage closing coil	187 Vd.c.	Gas pressure at 20 °C	0,60 MPa
Voltage opening coil	154 Vd.c.	Operating pressure	- MPa

Remarks: -

24.3 Condition / inspection after test

Externally no visible change.

Inspection of contacts:

Fixed arcing contact slightly burnt.

Moving arcing contact slightly burnt.

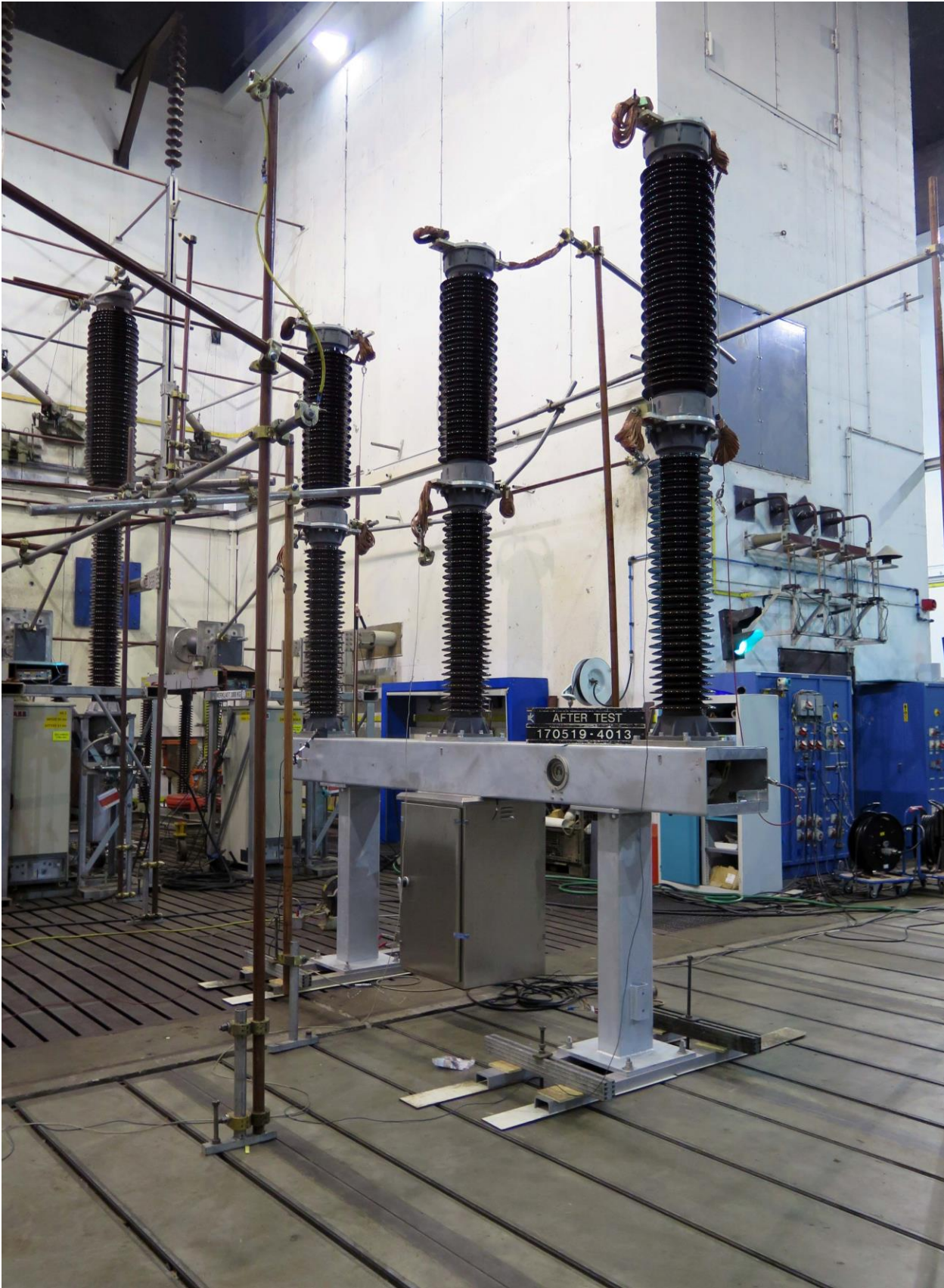
Fixed main contact finger tips showed locally slight commutation marks. Silver layer on main contact area intact.

Moving main contact rim showed locally slight commutation marks. Silver layer on main contact area intact.

Nozzle slightly eroded.

Auxiliary nozzle slightly eroded.

24.4 Photographs after test

















25 SHORT-TIME WITHSTAND CURRENT AND PEAK WITHSTAND CURRENT TEST

Standard and date

Standard IEC 62271-100
Test date 30 May 2017

25.1 Condition before test

Breaker (Serial No 17102) reconditioned.

For test purposes equipment filled with air at atmospheric pressure for insulation instead of SF₆ gas.

Supply to moving contacts.

Short-circuit on fixed contacts.

Frame earthed via a CT.

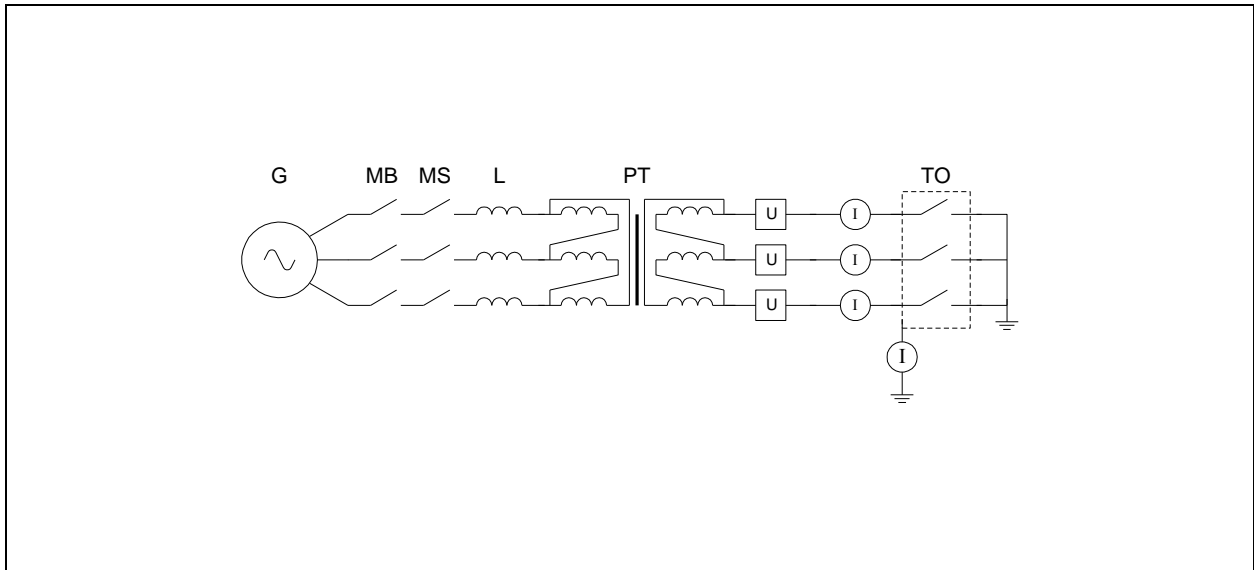
Measurement of resistance:

Pole A: 26,2 μΩ

Pole B: 26,3 μΩ

Pole C: 29,5 μΩ

25.2 Test circuit S21



G = Generator TO = Test Object U = Voltage Measurement to earth
 MB = Master Breaker L = Reactor I = Current Measurement
 MS = Make Switch
 PT = Power Transformer

Supply		
Power	MVA	242
Frequency	Hz	50
Phase(s)		3
Voltage	kV	3,5
Current	kA	40
Impedance	mΩ	51,0
Power factor		< 0,1
Neutral		not earthed

Load	
Short-circuit point	earthed

Remarks: -

25.3 Photograph before test



25.4 Test results and oscillograms

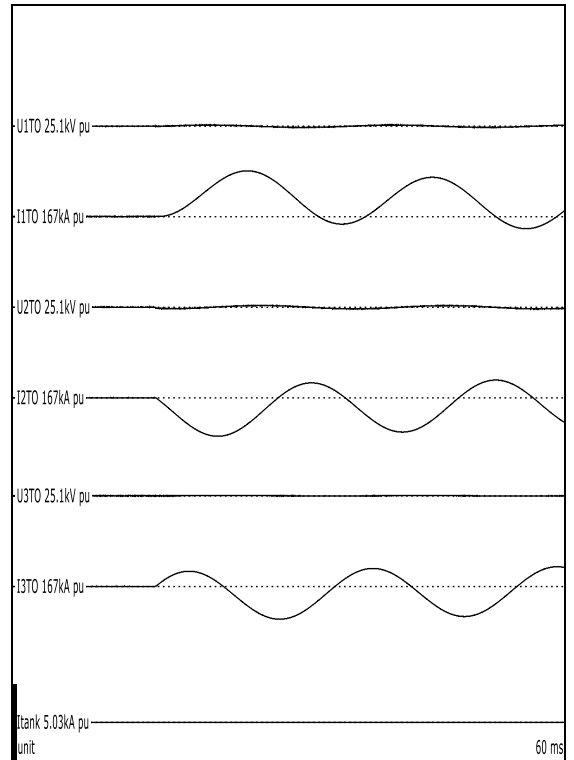
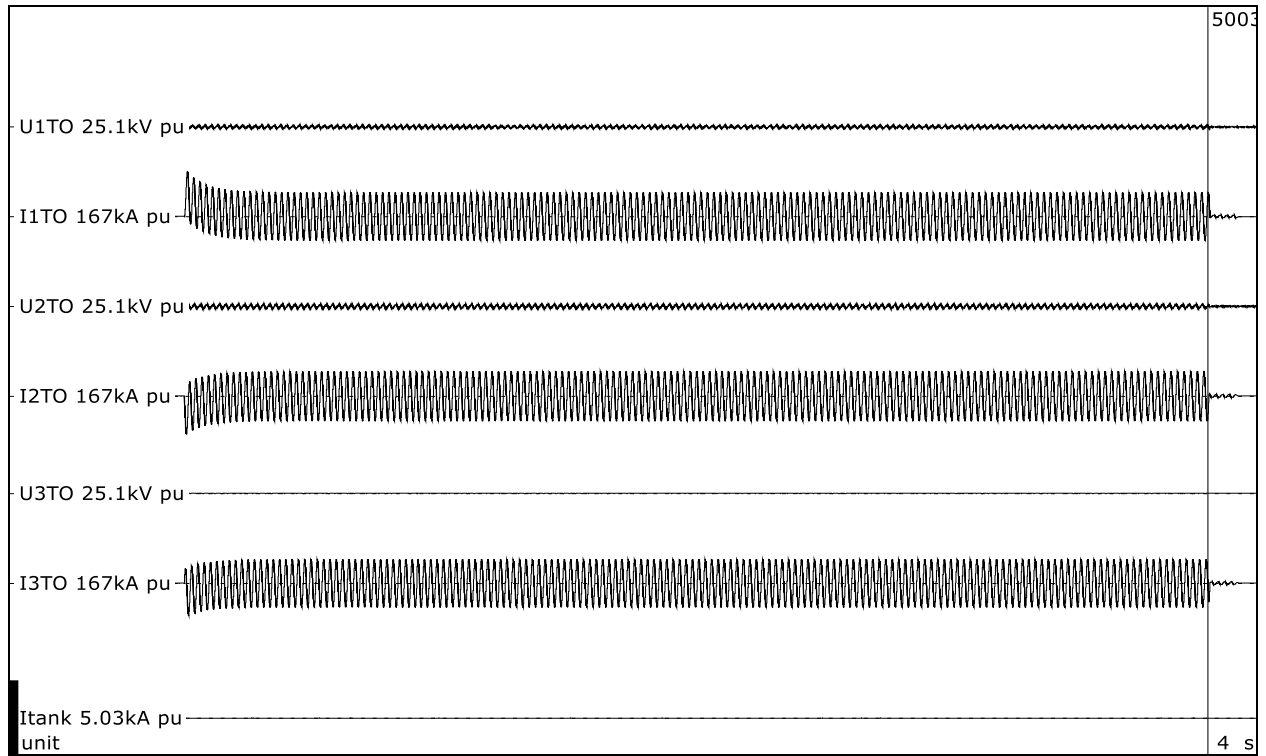
Overview of test numbers

170530-5003

Remarks

-

Short-time withstand current and peak withstand current test



Test number: 170530-5003

Phase		A	B	C
Peak value of current	kA	101	-85,5	-72,8
Symmetrical current, beginning	kA	38,4	39,4	38,1
Symmetrical current, middle	kA	38,2	39,4	38,1
Symmetrical current, end	kA	38,3	39,6	38,3
Symmetrical current, average	kA	38,3	39,5	38,2
Average current, three phase	kA	38,7		
Current duration	s	3,28	3,28	3,28
Thermal equivalent		40 kA during 3,06 s		

Gas pressure at 20 °C - MPa

Remarks: No visible disturbance.

25.5 Condition / inspection after test

Breaker could be tripped freely. See no-load test 170530-5003.

26 NO-LOAD TEST

Standard and date

Standard IEC 62271-100

Test date 30 May 2017

26.1 Condition before test

Breaker (Serial No 17102) in same condition.

26.2 Test results and oscillograms

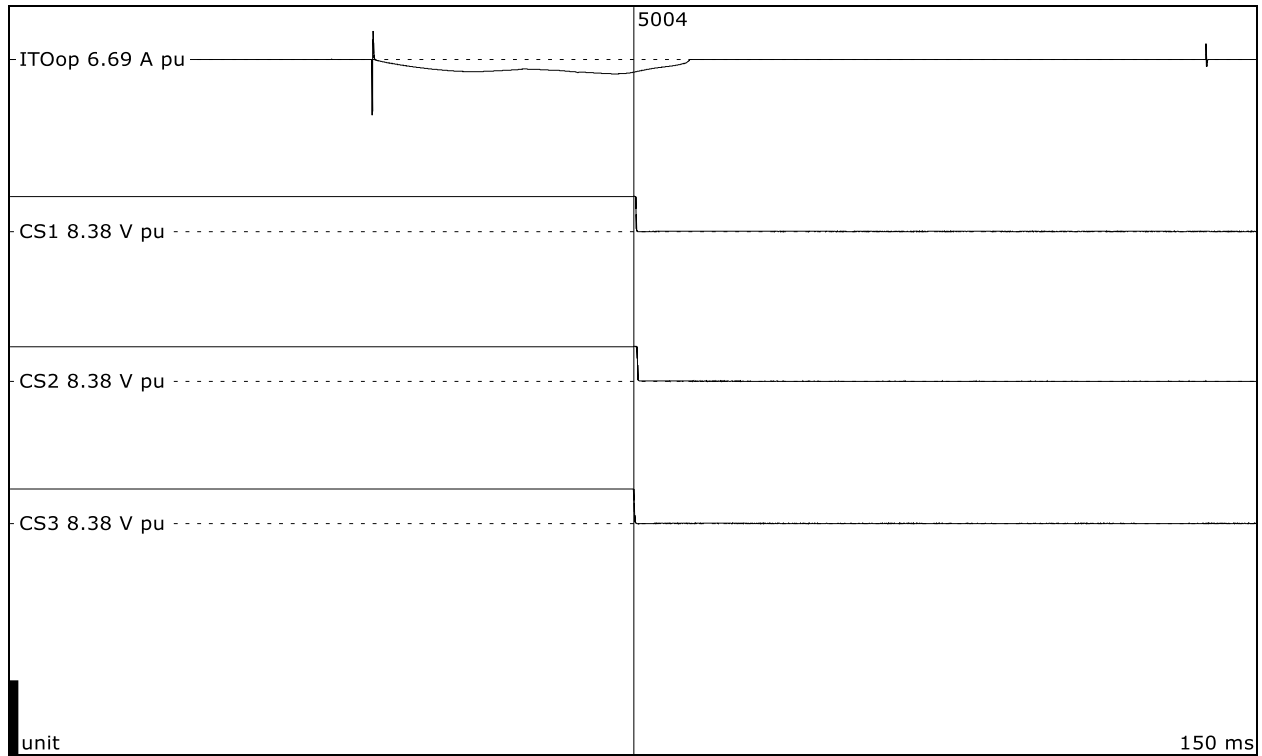
Overview of test numbers

170530-5004

Remarks

-

No-load test



Test number: 170530-5004

Operation		O		
Phase		A	B	C
Current opening coil	A	-1,31		
Opening time	ms	31,7	31,8	31,5

Voltage opening coil	- Vd.c.	Gas pressure at 20 °C	- MPa
		Operating pressure	- MPa

Remarks: -

26.3 Condition / inspection after test

Externally no visible change.

Measurement of resistance:

Pole A: 26,6 $\mu\Omega$

Pole B: 27,4 $\mu\Omega$

Pole C: 29,9 $\mu\Omega$

Inspection of contacts:

Fixed arcing contact practically new.

Moving arcing contact practically new.

Fixed main contact area practically new. Silver layer intact.

Moving main contact area practically new. Silver layer intact.

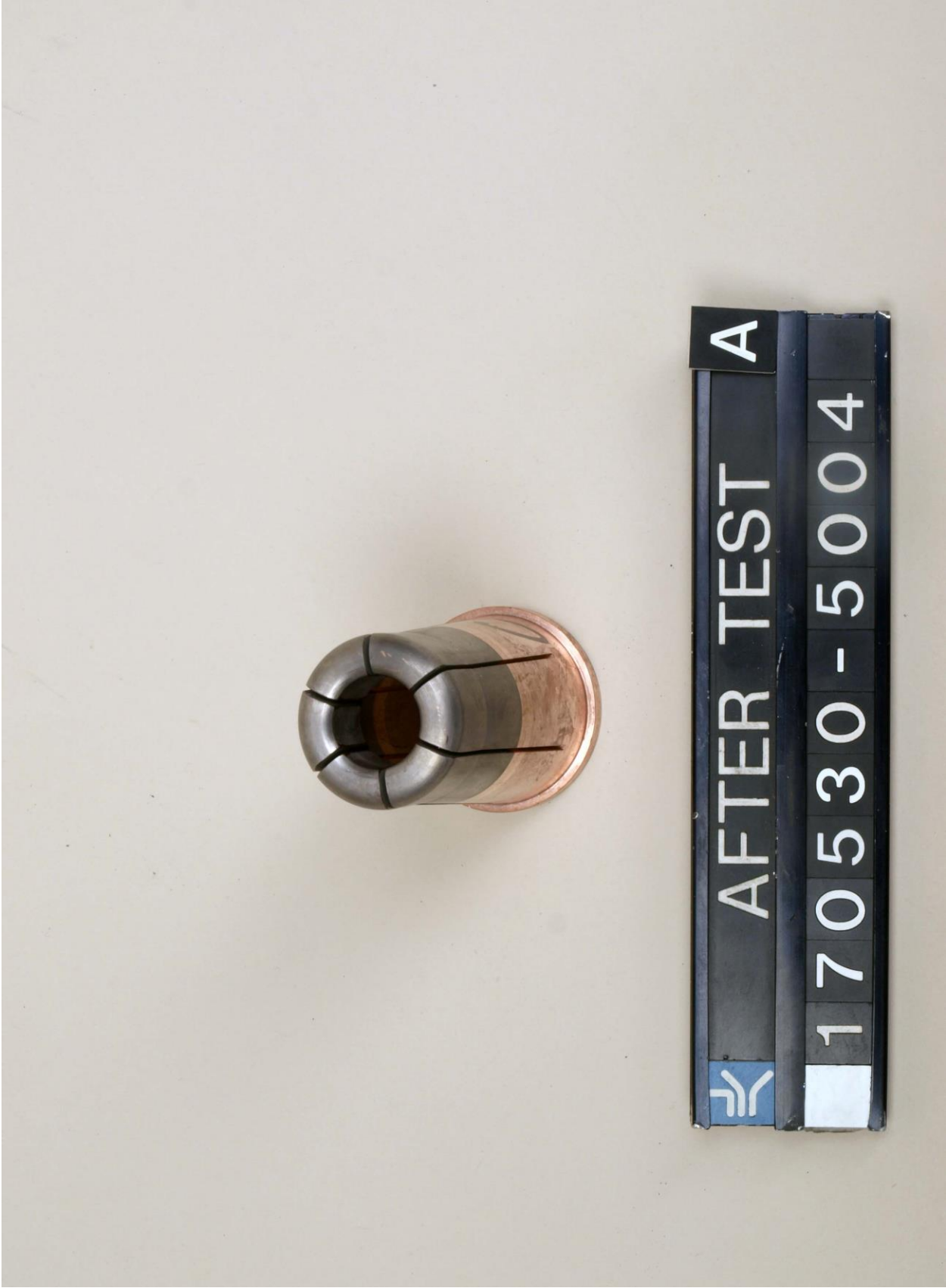
Nozzle practically new

Auxiliary nozzle practically new.

26.4 Photographs after test

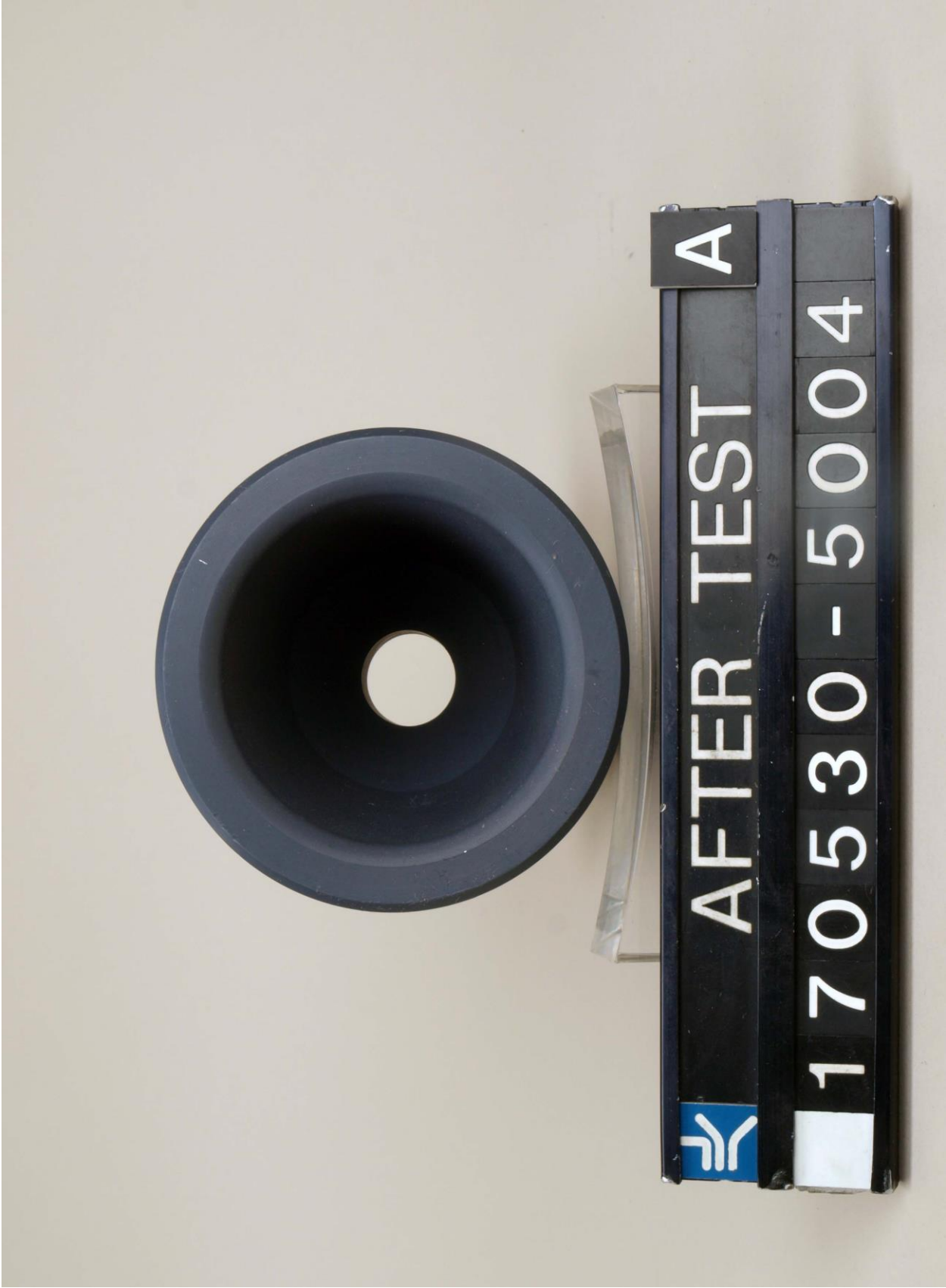












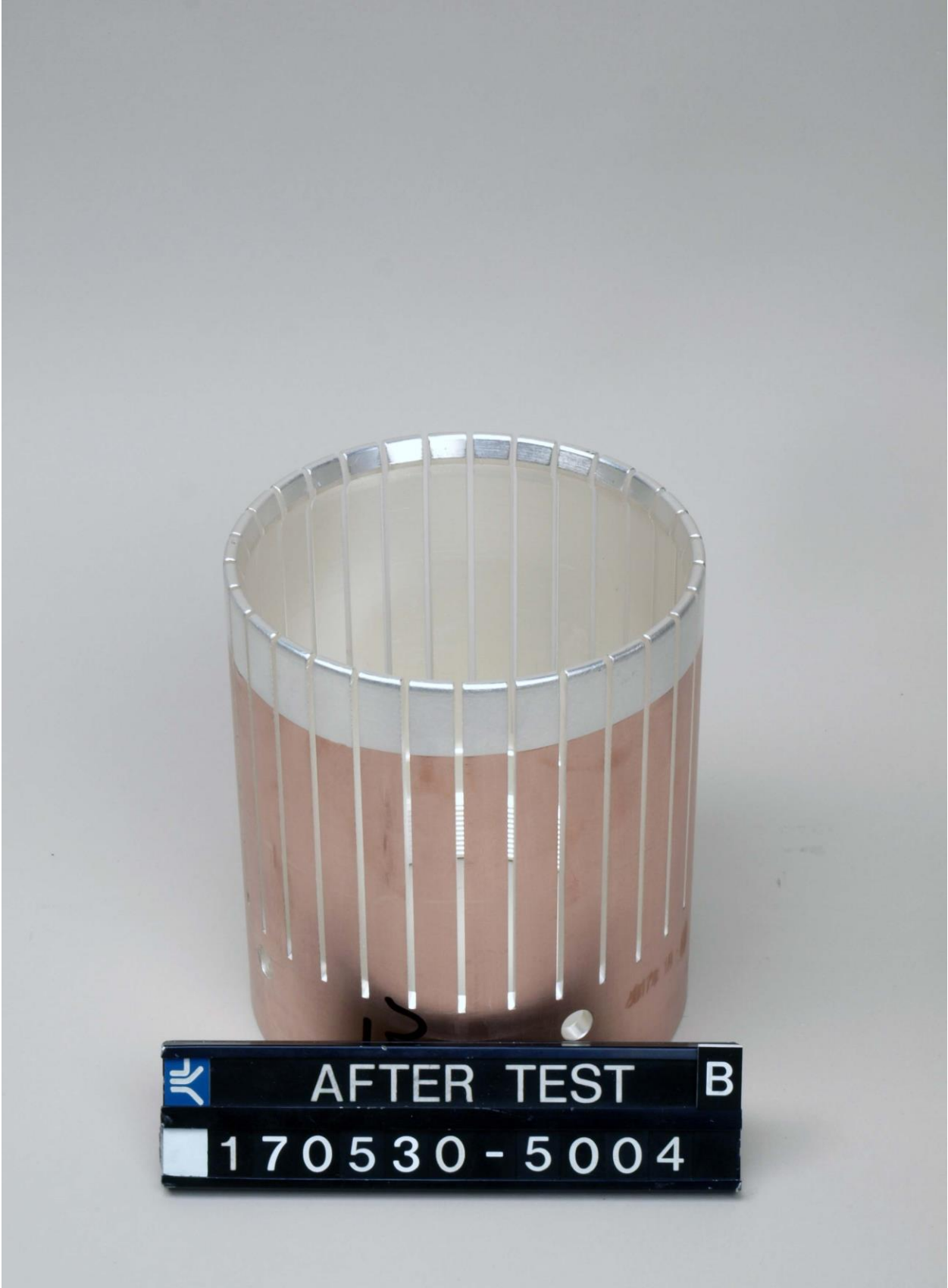














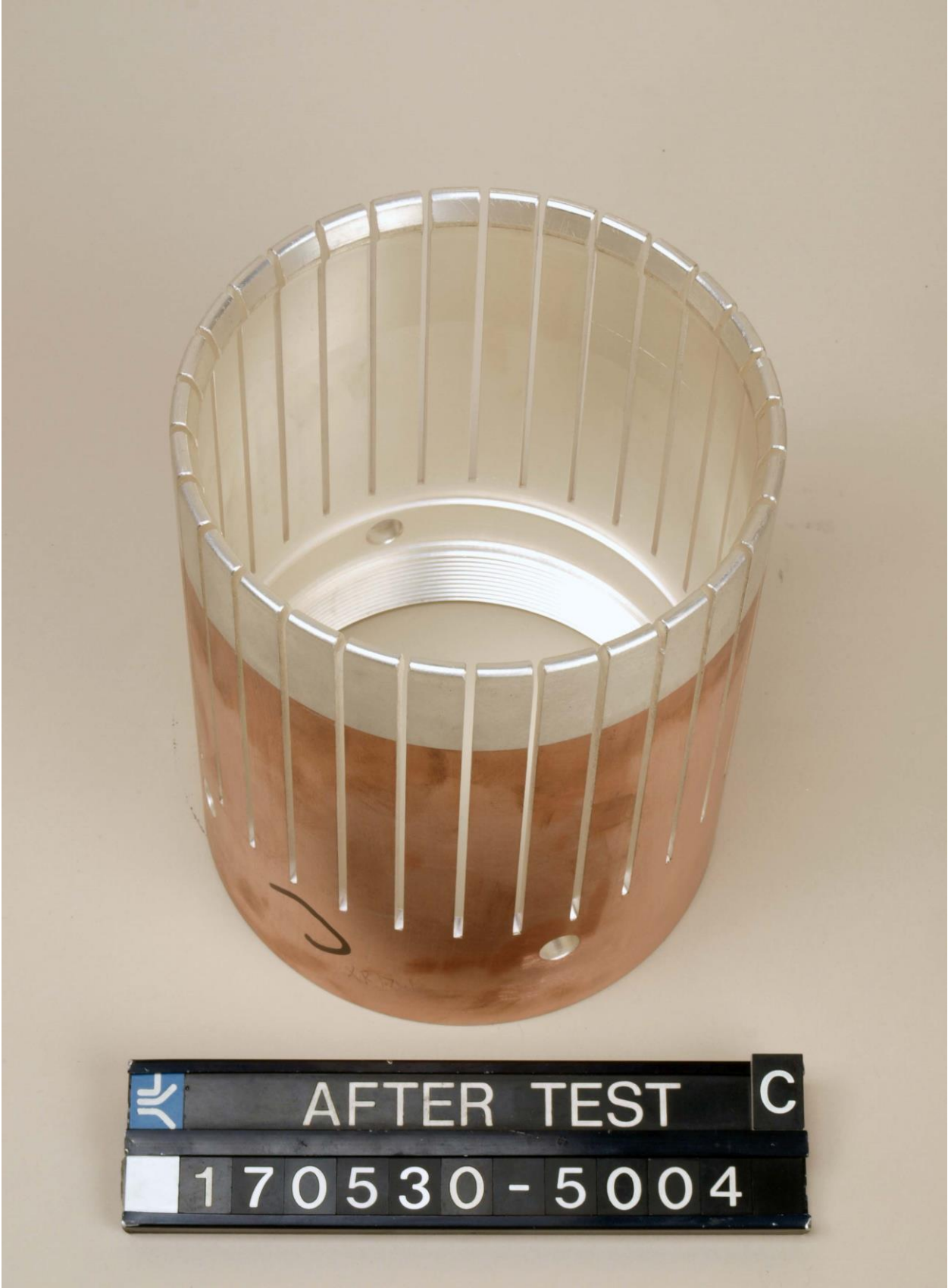


















27 NO-LOAD TESTS

Standard and date

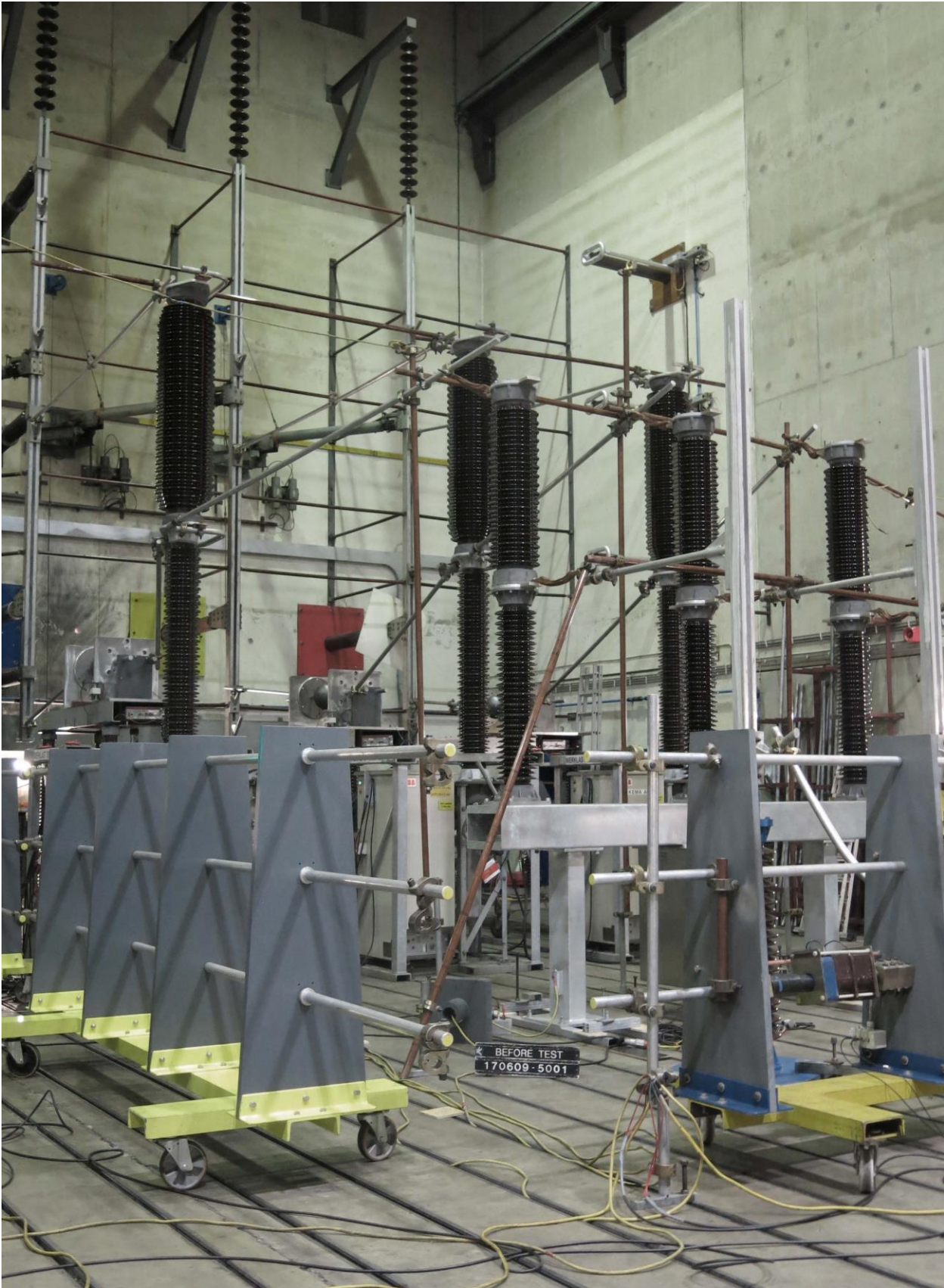
Standard IEC 62271-100

Test date 9 June 2017

27.1 Condition before test

Breaker (Serial No. 17101) reconditioned.

27.2 Photograph before test



27.3 Test results and oscillograms

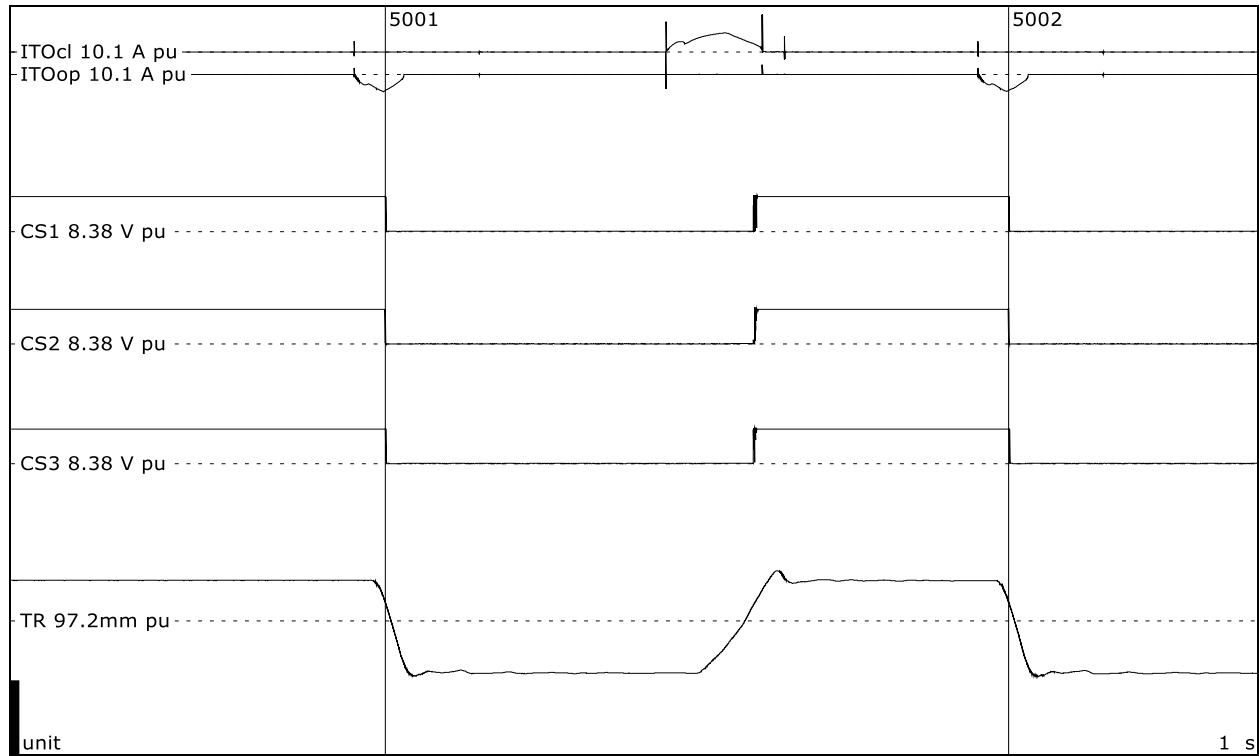
Overview of test numbers

170609-5001 to 5006

Remarks

-

No-load test



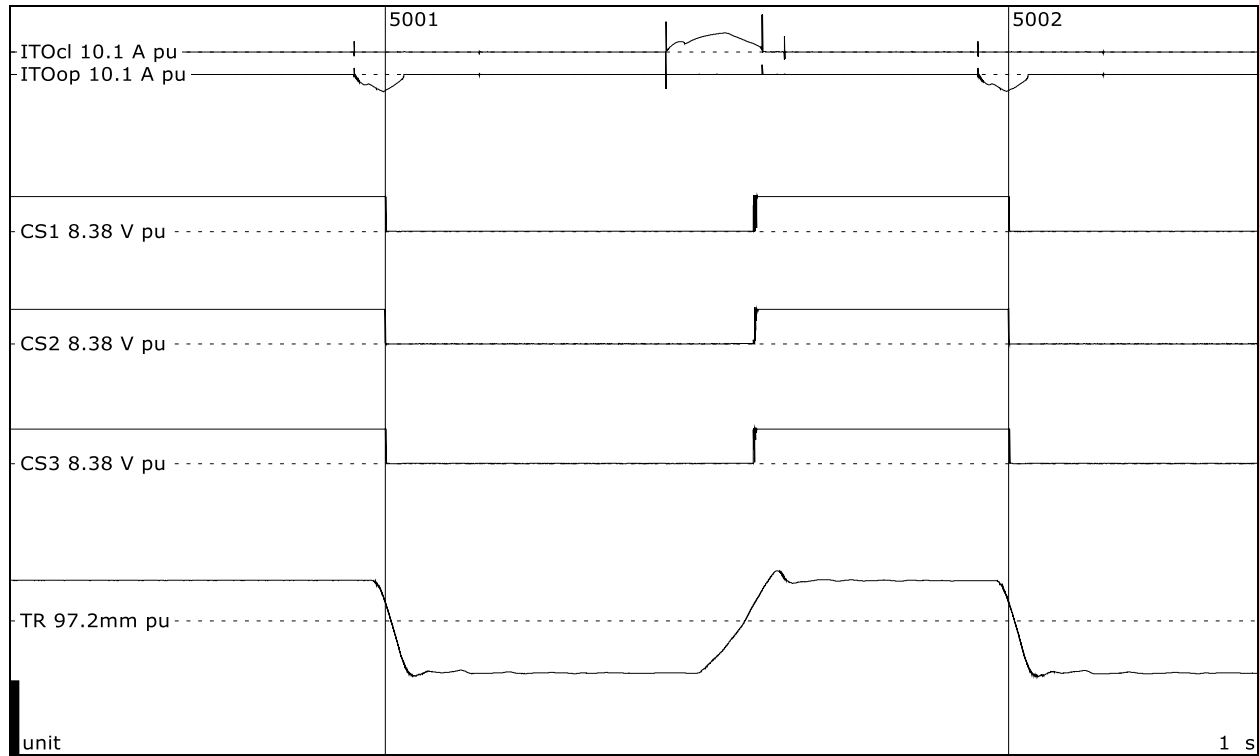
Test number: 170609-5001

Operation		O		
Phase		A	B	C
Current opening coil	A	-2,34		
Opening time	ms	25,3	25,0	25,5

Voltage opening coil	242 Vd.c.	Gas pressure at 20 °C	0,60 MPa
		Operating pressure	- MPa

Remarks: -

No-load test



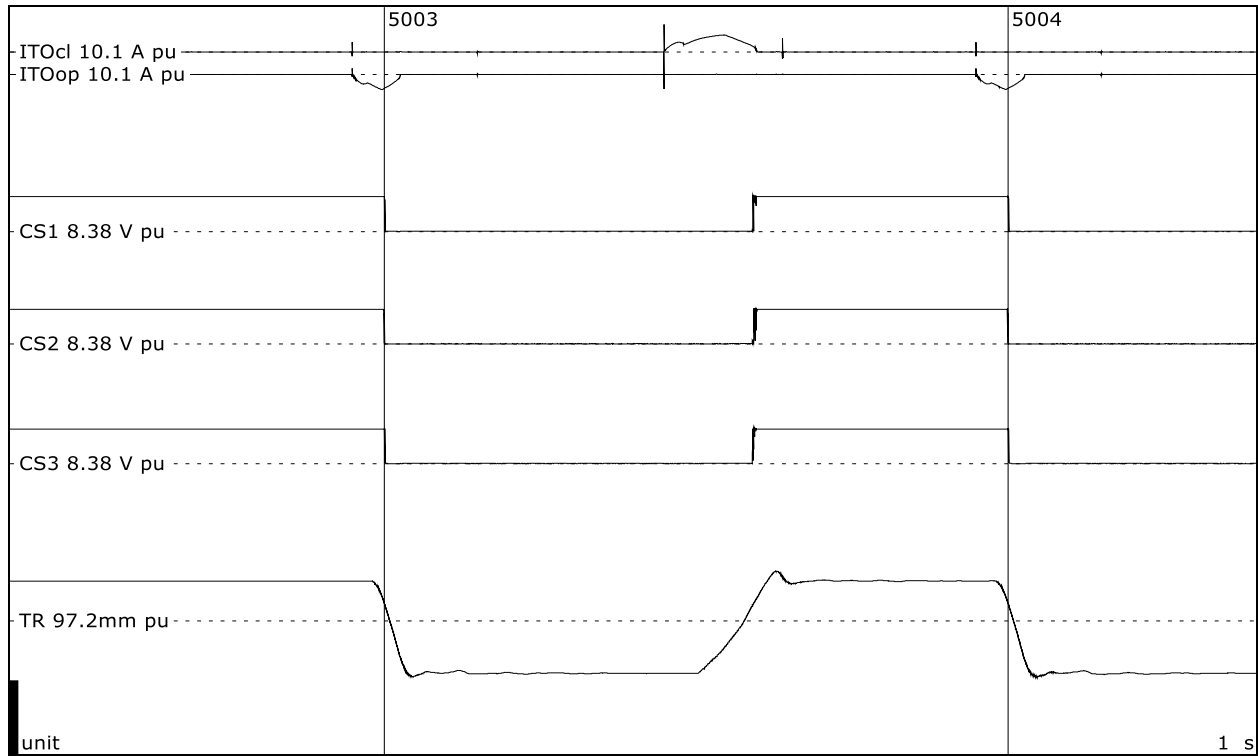
Test number: 170609-5002

Time interval between operations	s	0,295		
Operation	CO			
Phase		A	B	C
Current closing coil	A	2,53		
Closing time	ms	69,9	70,8	69,8
Current opening coil	A	-2,30		
Opening time	ms	25,0	24,6	25,2

Voltage closing coil	242 Vd.c.	Gas pressure at 20 °C	0,60 MPa
Voltage opening coil	242 Vd.c.	Operating pressure	- MPa

Remarks: -

No-load test



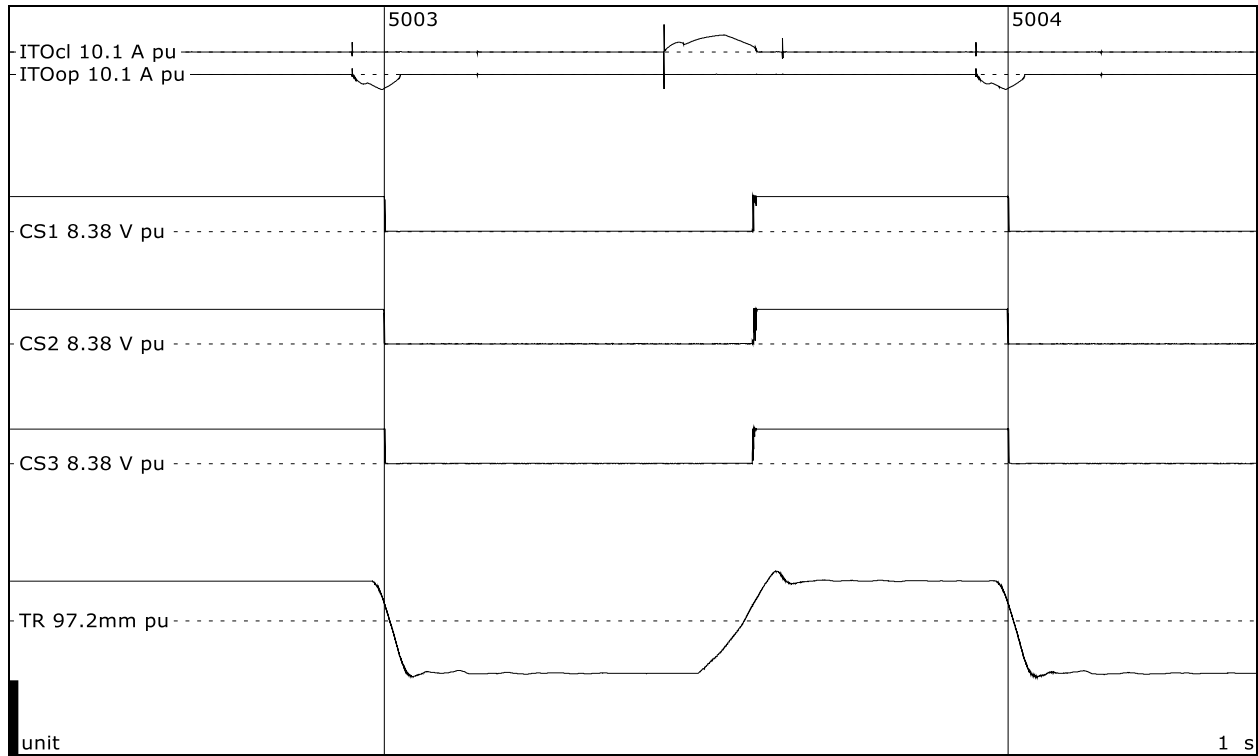
Test number: 170609-5003

Operation		O		
Phase		A	B	C
Current opening coil	A	-2,08		
Opening time	ms	26,0	25,6	26,2

Voltage opening coil	220 Vd.c.	Gas pressure at 20 °C	0,60 MPa
		Operating pressure	- MPa

Remarks: -

No-load test



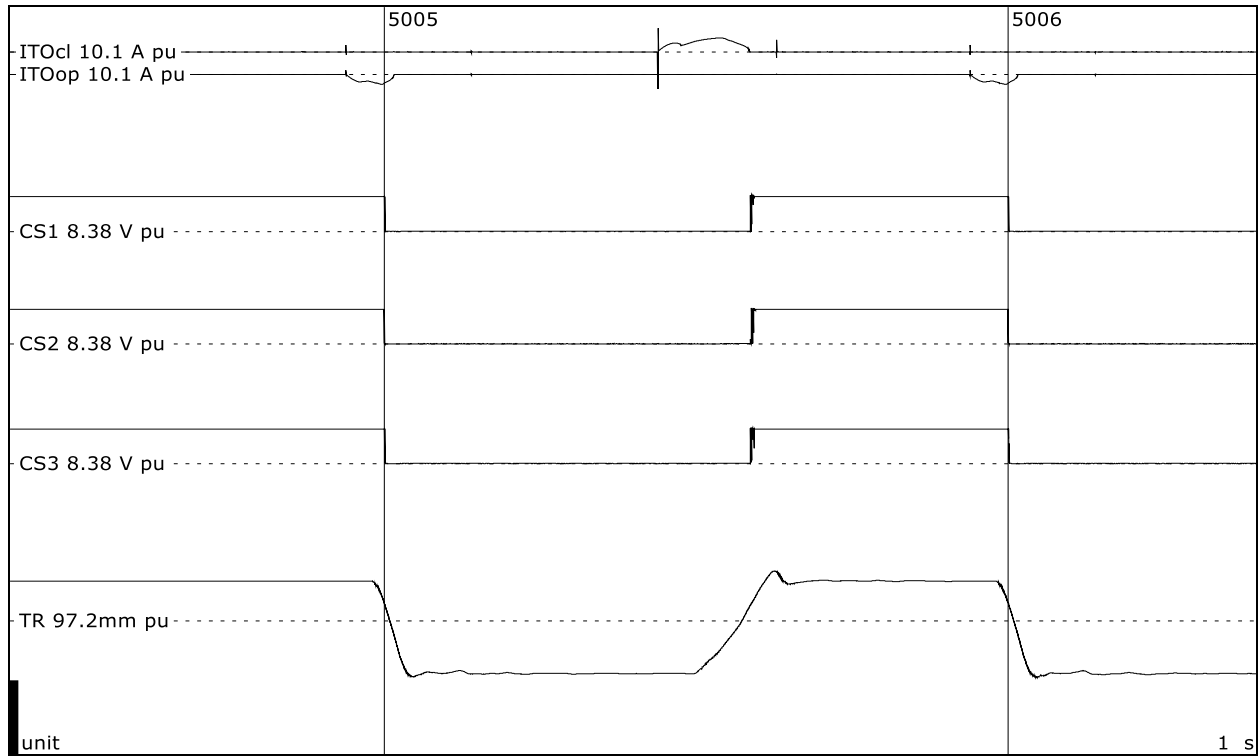
Test number: 170609-5004

Time interval between operations	s	0,295		
Operation	CO			
Phase		A	B	C
Current closing coil	A	2,26		
Closing time	ms	70,9	71,7	70,7
Current opening coil	A	-2,05		
Opening time	ms	25,8	25,3	26,0

Voltage closing coil	220 Vd.c.	Gas pressure at 20 °C	0,60 MPa
Voltage opening coil	220 Vd.c.	Operating pressure	- MPa

Remarks: -

No-load test



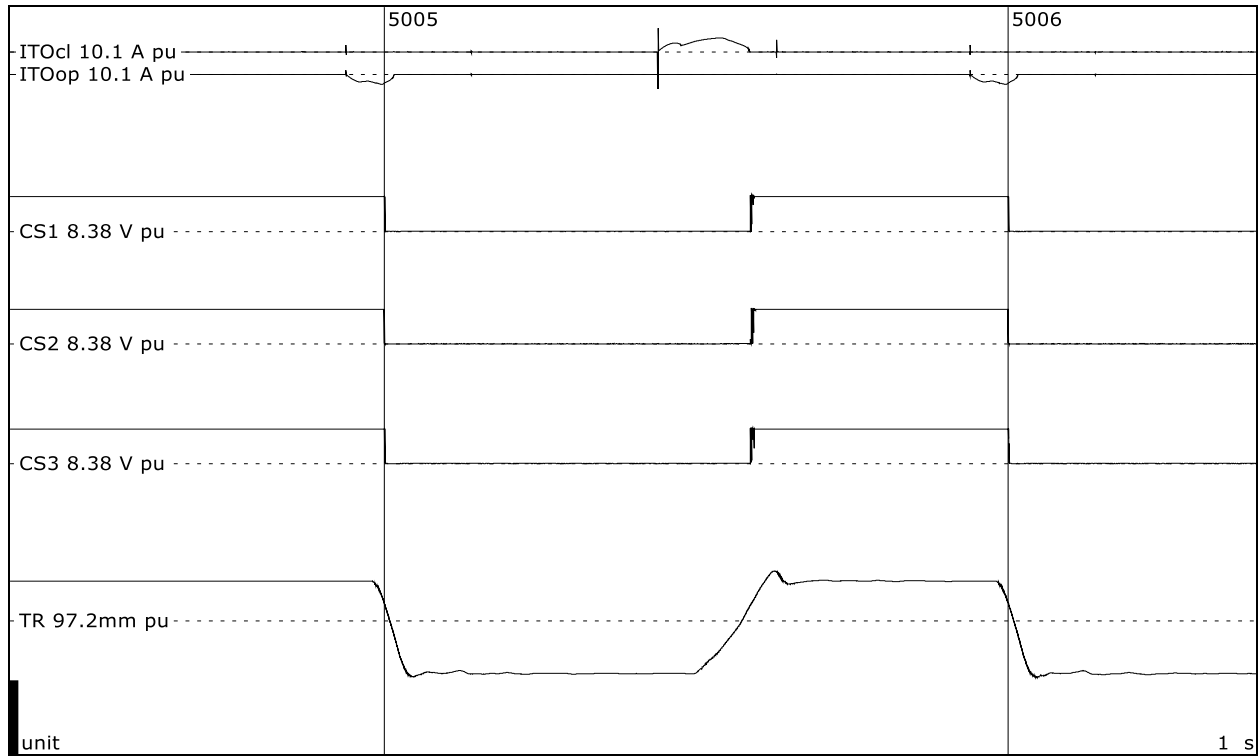
Test number: 170609-5005

Operation		O		
Phase		A	B	C
Current opening coil	A	-1,38		
Opening time	ms	30,9	30,5	31,1

Voltage opening coil	154 Vd.c.	Gas pressure at 20 °C	0,60 MPa
		Operating pressure	- MPa

Remarks: -

No-load test



Test number: 170609-5006

Time interval between operations	s	0,293		
Operation	CO			
Phase		A	B	C
Current closing coil	A	1,89		
Closing time	ms	73,9	74,6	73,8
Current opening coil	A	-1,39		
Opening time	ms	30,9	30,4	31,0

Voltage closing coil	187 Vd.c.	Gas pressure at 20 °C	0,60 MPa
Voltage opening coil	154 Vd.c.	Operating pressure	- MPa

Remarks: -

28 DETERMINATION OF PRE-ARCING TIME

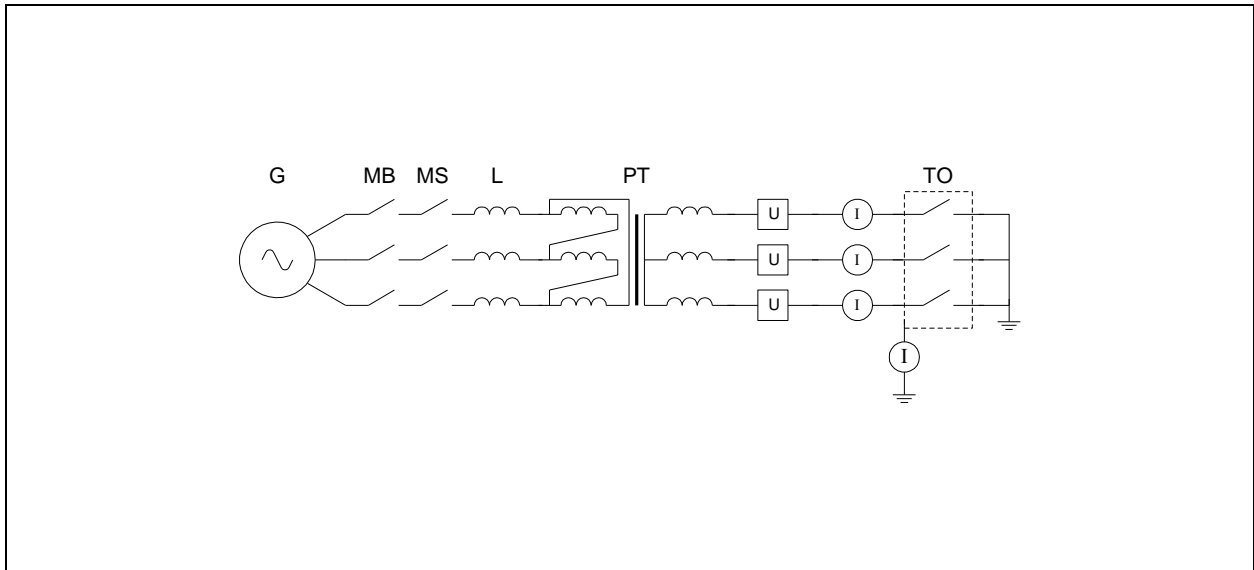
Standard and date

Standard	IEC 62271-100
Test date	9 June 2017

28.1 Condition before test

Breaker (Serial No. 17101) in same condition
Supply to fixed contacts.
Short-circuit on moving contacts.
Frame earthed via a CT.

28.2 Test circuit S28



G = Generator TO = Test Object U = Voltage Measurement to earth
 MB = Master Breaker L = Reactor I = Current Measurement
 MS = Make Switch
 PT = Power Transformer

Supply		
Power	MVA	427
Frequency	Hz	50
Phase(s)		3
Voltage	kV	145
Current	kA	1,7
Impedance	Ω	49,2
Power factor		< 0,1
Neutral		not earthed

Load	
Short-circuit point	earthed

Remarks: -

28.3 Test results and oscillograms

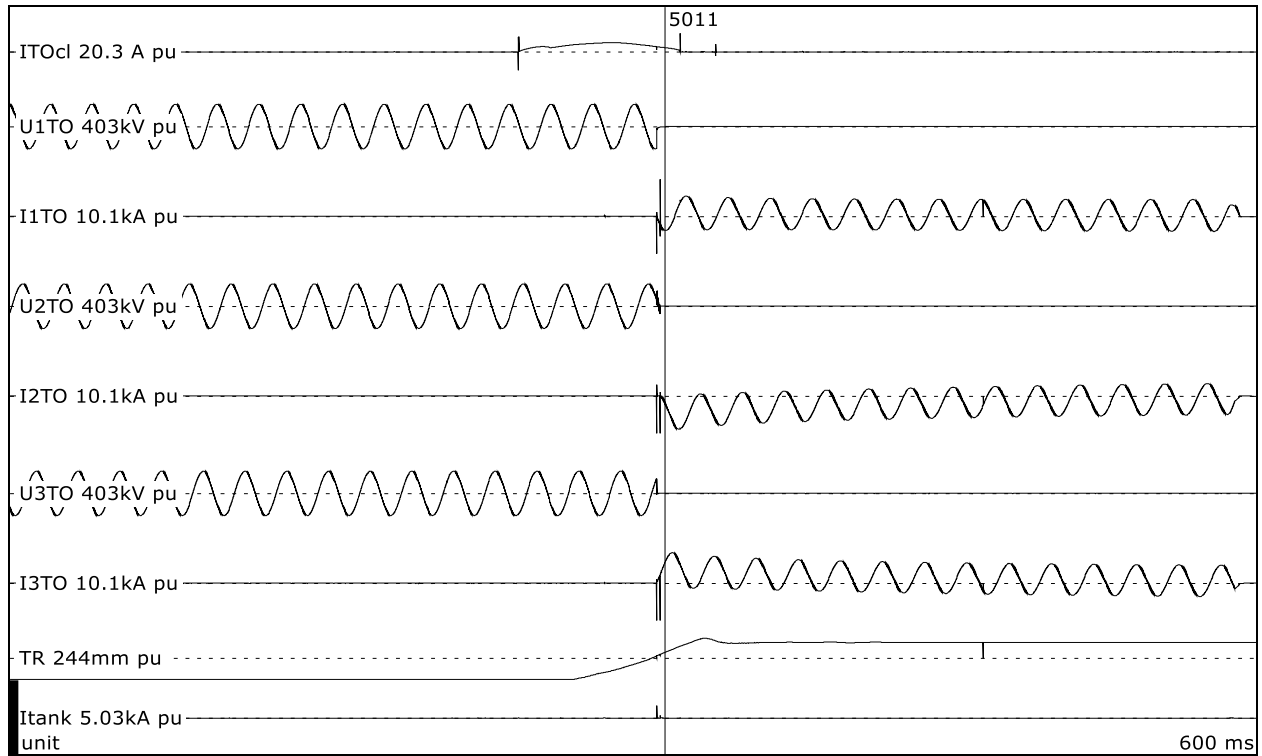
Overview of test numbers

170609-5011 to 5013

Remarks

-

Determination of pre-arcing time



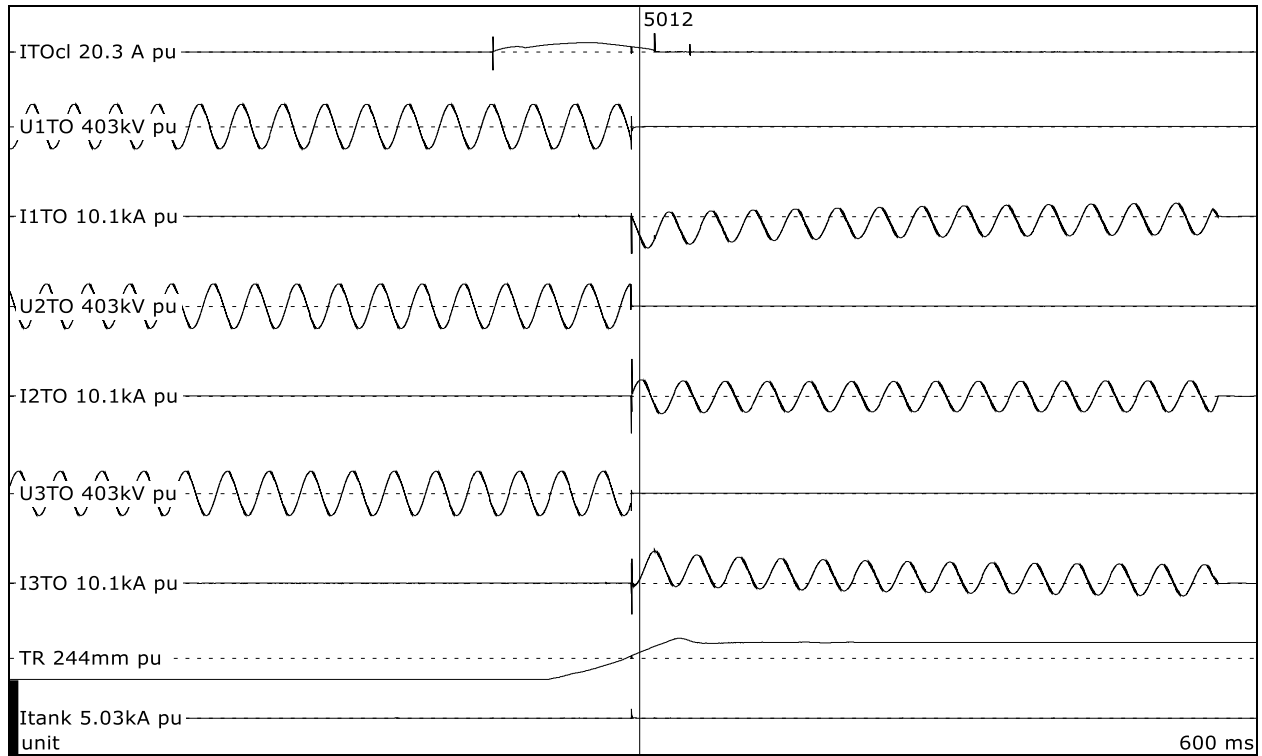
Test number: 170609-5011

Time interval since previous test	min	-		
Operation		C		
Phase		A	B	C
Applied voltage, phase value	kV	84,8	84,6	84,2
Applied voltage, between phases	kV	146		
Peak value of current	kA	2,72	-4,44	4,10
Symmetrical current, end	kA	1,51	1,49	1,50
Average curr. end, three phase	kA	1,50		
Make time	ms	67,2	68,1	67,3
Pre-arcing time	ms	3,9	2,4	3,2
Current duration	ms	280		

Voltage closing coil	242 Vd.c.	Gas pressure at 20 °C	0,60 MPa
		Operating pressure	- MPa

Remarks: Breaker closed.

Determination of pre-arcing time



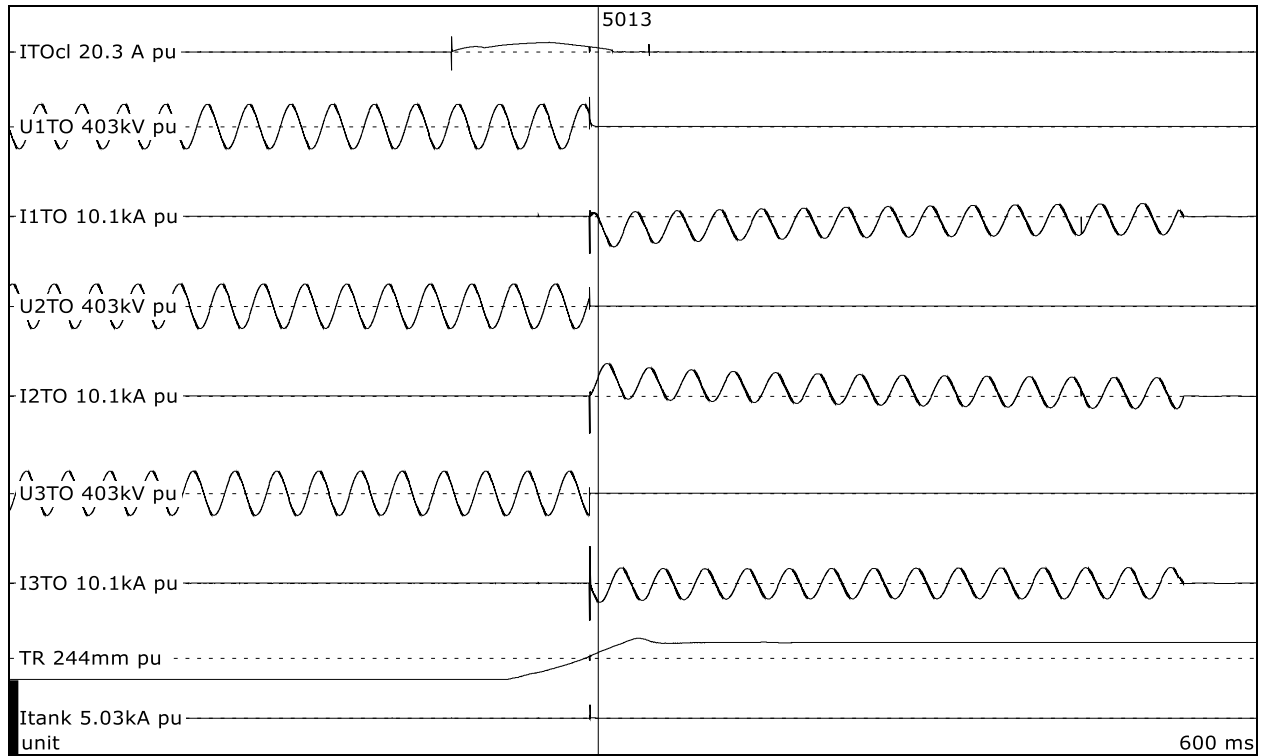
Test number: 170609-5012

Time interval since previous test	min	-		
Operation		C		
Phase		A	B	C
Applied voltage, phase value	kV	84,8	84,6	84,2
Applied voltage, between phases	kV	146		
Peak value of current	kA	-4,24	-2,38	4,30
Symmetrical current, end	kA	1,51	1,49	1,50
Average curr. end, three phase	kA	1,50		
Make time	ms	66,7	66,7	69,6
Pre-arcing time	ms	3,9	4,0	1,0
Current duration	ms	282		

Voltage closing coil	242 Vd.c.	Gas pressure at 20 °C	0,60 MPa
		Operating pressure	- MPa

Remarks: Breaker closed.

Determination of pre-arcing time



Test number: 170609-5013

Time interval since previous test	min	-		
Operation		C		
Phase		A	B	C
Applied voltage, phase value	kV	84,8	84,5	84,1
Applied voltage, between phases	kV	146		
Peak value of current	kA	-4,09	4,37	-2,56
Symmetrical current, end	kA	1,50	1,48	1,49
Average curr. end, three phase	kA	1,49		
Make time	ms	66,3	66,3	66,4
Pre-arcing time	ms	4,2	4,2	4,1
Current duration	ms	286		

Voltage closing coil	242 Vd.c.	Gas pressure at 20 °C	0,60 MPa
		Operating pressure	- MPa

Remarks: Breaker closed.

29 T100s(a)

Standard and date

Standard	IEC 62271-100
Test date	9 June 2017

29.1 Condition before test

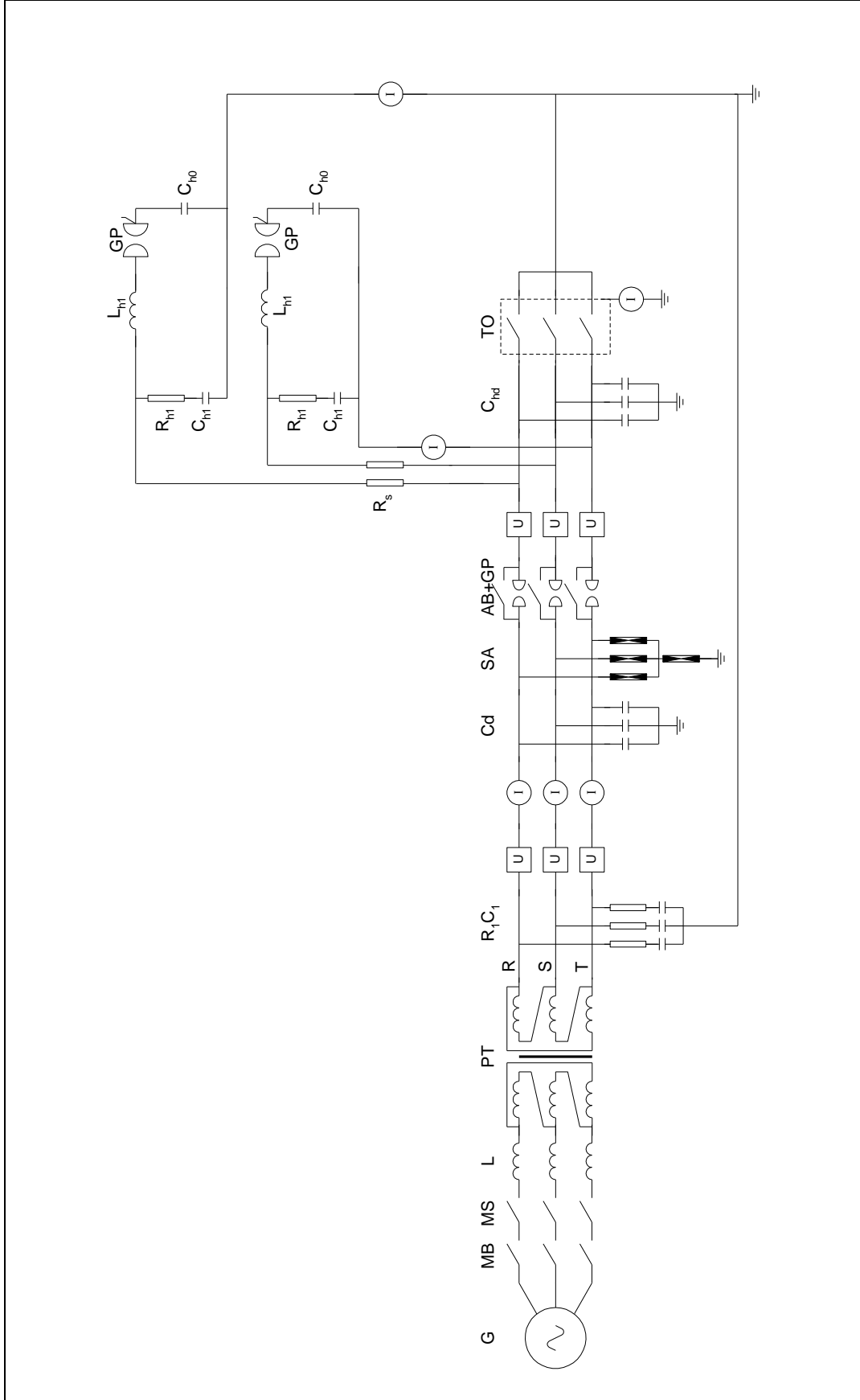
Breaker (Serial No 17101) in same condition.
Supply to fixed contacts.
Short-circuit on moving contacts.
Frame earthed via a CT.

Auxiliary breaker:

An SF₆ breaker, provided by KEMA Laboratories.
Number of elements: 1 per breaker.

29.2 Test circuit S29

Diagram



G = Generator	L = Reactor	U = Voltage Measurement to earth	SA = Surge Arrester
MB = Master Breaker	TO = Test Object	I = Current Measurement	AB = Auxiliary Breaker
MS = Make Switch	R = Resistor	AL = Artificial line	GP = Gap
PT = Power Transformer	C = Capacitor	ML = Multi-loop device	VS = Voltage Source

Values

Supply		
Power	MVA	1247
Frequency	Hz	50
Phase(s)		3
Voltage	kV	18,0
Current	kA	40,0
Impedance	Ω	0,26
Power factor		< 0,1
Neutral		not earthed

Load	
Short-circuit point	earthed

TRV control elements added (supply)		
C ₁	μF	4,62
R ₁	Ω	282
C _d	nF	15,0

Injection circuit				
		Last phase	First and second phase	
		R	T	S
C _{h0}	μF	4,00	-	4,00
U _{h0}	kVd.c.	107	-	200
L _{h1}	mH	32,0	-	32,0
f _h	Hz	-	-	-
R _{h1}	Ω	-	-	-
C _{h1}	μF	-	-	-
C _{hd}	nF	14,0	15,0	15,0
R _{hc}	Ω	-	-	-
C _{hc}	nF	-	-	-
R _{h2}	Ω	-	-	-
C _{h2}	μF	-	-	-
L _{h2}	mH	-	-	-
R _s	Ω	45,0	-	45,0
L _{h3}	mH	-	-	-
f _{applied}	Hz	-	-	-

Description of the three-phase synthetic circuit for synthetic make

The circuit is composed of:

a) **A three-phase current circuit**b) **Two single-phase voltage circuits**

This voltage is used to ascertain that the duration of pre-arcing of the making device is correct, to set the pre-arcing time as determined by direct pre-arcing tests at full applied voltage.

The first and the second pre-arcing phases are connected to a dc voltage source with a steep rate of rise, in the test circuit phases T and S. The voltage distribution between these phases is made by capacitance C_{hd}. Connecting the two phases to the same voltage source, correct interaction is achieved between the first and second pre-arcing phase as in a three-phase system.

The third pre-arcing phase is connected to an independent third voltage with a steep rate of rise, in the test circuit phase R.

The evolving fault current is regulated by the dependent triggered gap GP.

The delay between the commencement of the pre-arcing and the evolving fault current is the transfer time.

Remarks: -

29.3 Test results and oscillograms

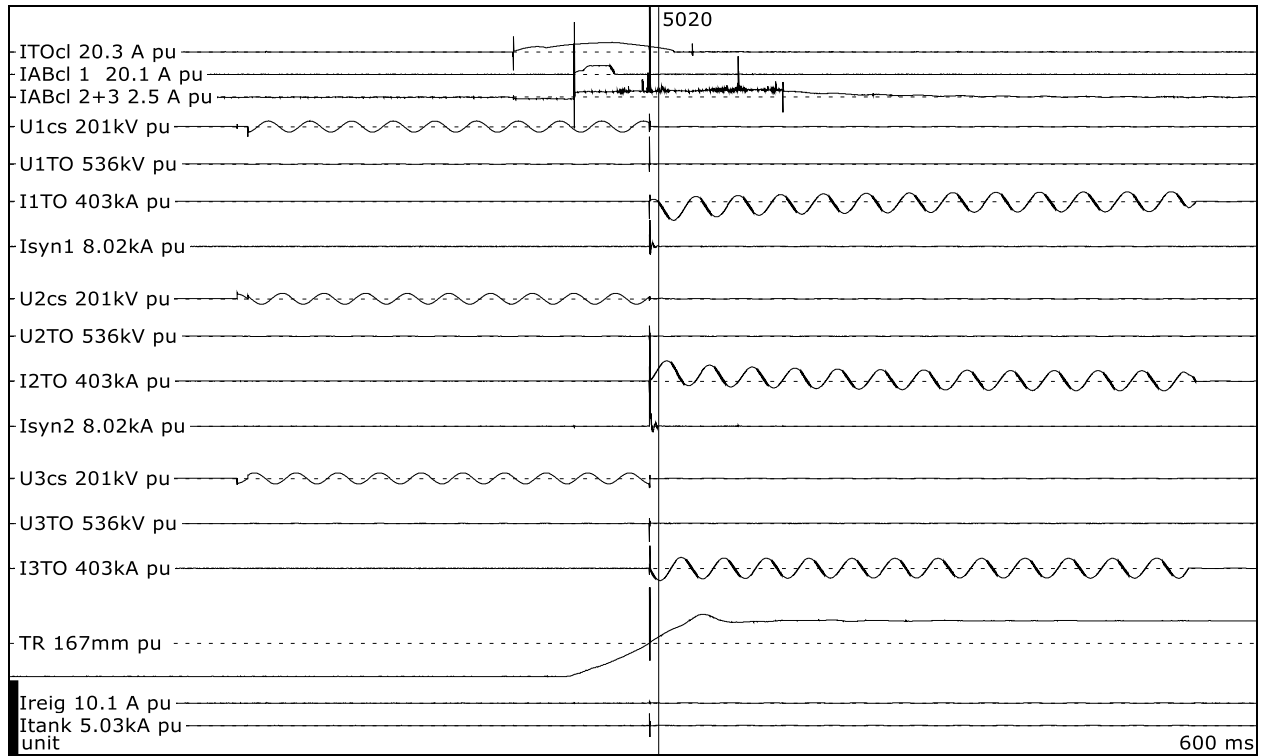
Overview of test numbers

170609-5020

Remarks

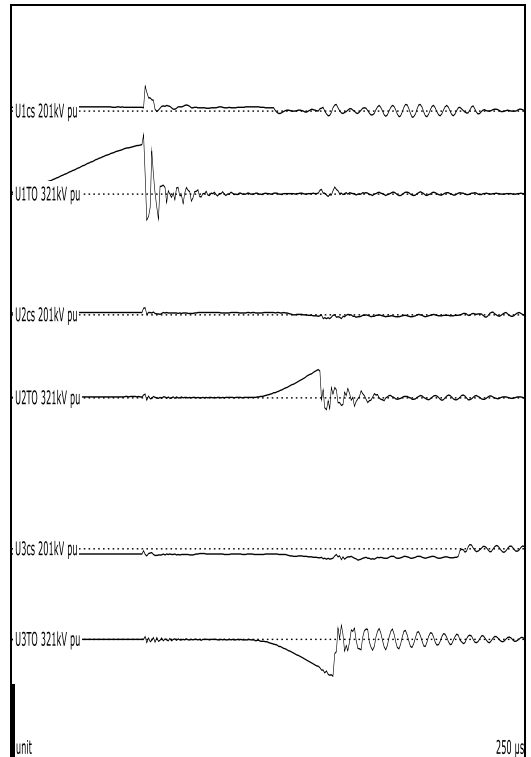
-

T100s(a)



Test number: 170609-5020

Time interval since previous test	min	-		
Operation		C		
Phase		A	B	C
Applied voltage, current source, phase value	kV	18,0	18,0	18,0
Charging voltage capacitor bank, DC value	kVd.c.	107	100	100
Applied voltage test object, phase value	kV	208	119	-158
Making current, peak	kA	-101	108	-66,0
Symmetrical current, begin	kA	-		
Make time	ms	69,0	65,5	65,6
Transfer time	µs	63,0	66,0	60,0
Pre-arcing time	ms	4,6	4,5	4,4
Current duration	ms	260	263	259



Voltage closing coil	242 Vd.c.	Gas pressure at 20 °C	0,60 MPa
		Operating pressure	- MPa

Remarks: Breaker closed.

30 T100s(b)

Standard and date

Standard	IEC 62271-100
Test date	9 June 2017

30.1 Condition before test

Breaker (Serial No 17101) in same condition.
Supply to fixed contacts.
Short-circuit on moving contacts.
Frame earthed via a CT.

Auxiliary breaker:

An SF₆ breaker, provided by KEMA Laboratories.
Number of elements: 1 per breaker.

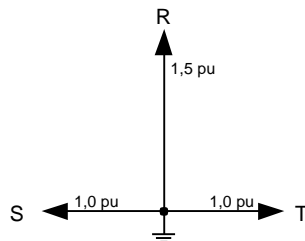
Values

Supply		
Power	MVA	2494
Frequency	Hz	50
Phase(s)		3
Voltage	kV	36,0
Current	kA	40,0
Impedance	Ω	0,52
Power factor		< 0,1
Neutral		not earthed

Load	
Short-circuit point	earthed

TRV control elements added (supply)		
C ₁	μF	0,30
R ₁	Ω	-
R1 (in series)	Ω	50,0
C _d	nF	15,0

Injection circuit					
		First phase	Second and third phase		
		R	T	Between phases	S
C _{h0}	μF	8,00	-	8,00	-
U _{h0}	kVd.c.	194	-	260	-
L _{h1}	mH	10,5	-	15,56	-
f _h	Hz	526	-	442	-
R _{h1}	Ω	108	102	-	102
C _{h1}	μF	0,20	0,22	-	0,24
C _{hd}	nF	14,0	15,0	-	15,0
R _{hc}	Ω	-	-	-	-
C _{hc}	nF	-	-	-	-
R _{h2}	Ω	58,8	-	167	-
C _{h2}	nF	444	-	556	-
L _{h2}	mH	8,40	-	9,80	-
R _{hp}	k Ω	-	-	-	-
L _{h3}	H	1,20	-	1,20	-
f _{RV}	Hz	48,2	-	48,3	-

Voltage distribution in FPTC 1,5 test-circuit

Prospective TRV of supply				
		First phase	Second phase	Third phase
		R	T	S
U _{recovery}	kVa.c.	126	83,7	83,7
u ₁	kV	133	76,5	76,5
u _c	kV	249	143,	143
t _d	μs	2,00	2,00	2,00
t ₁	μs	67,0	55,0	55,0
t ₂	μs	266	280	280
RRRV	kV/ μs	2,00	1,40	1,40

The circuit is composed of:

a) **A three-phase current source**

The neutral point of the supply circuit is isolated and the short-circuit-point is earthed.

b) **Two parallel current injection circuits**

One of the two circuits is used for the test of the first-pole-to-clear conditions. This circuit, one side of which is earthed and based on a fptc-factor of 1,5, is applied to the terminals of the first clearing pole, phase R.

The second circuit is used to obtain the conditions of the second and third clearing poles. This circuit, which is floating in relation to earth, is applied across these two poles, phase S and phase T. The voltage is divided at 50% / 50% between the two poles by means of capacitors

The recovery voltage for both circuits is transformed in a decaying power-frequency voltage by the use of air-cored reactors.

c) **Multi-loop reignition circuits**

For all poles standard RC-reignition circuits have been used.

The phases R, S and T relate to the diagram, presented on the previous page.

Remarks: -

30.3 Test results and oscillograms

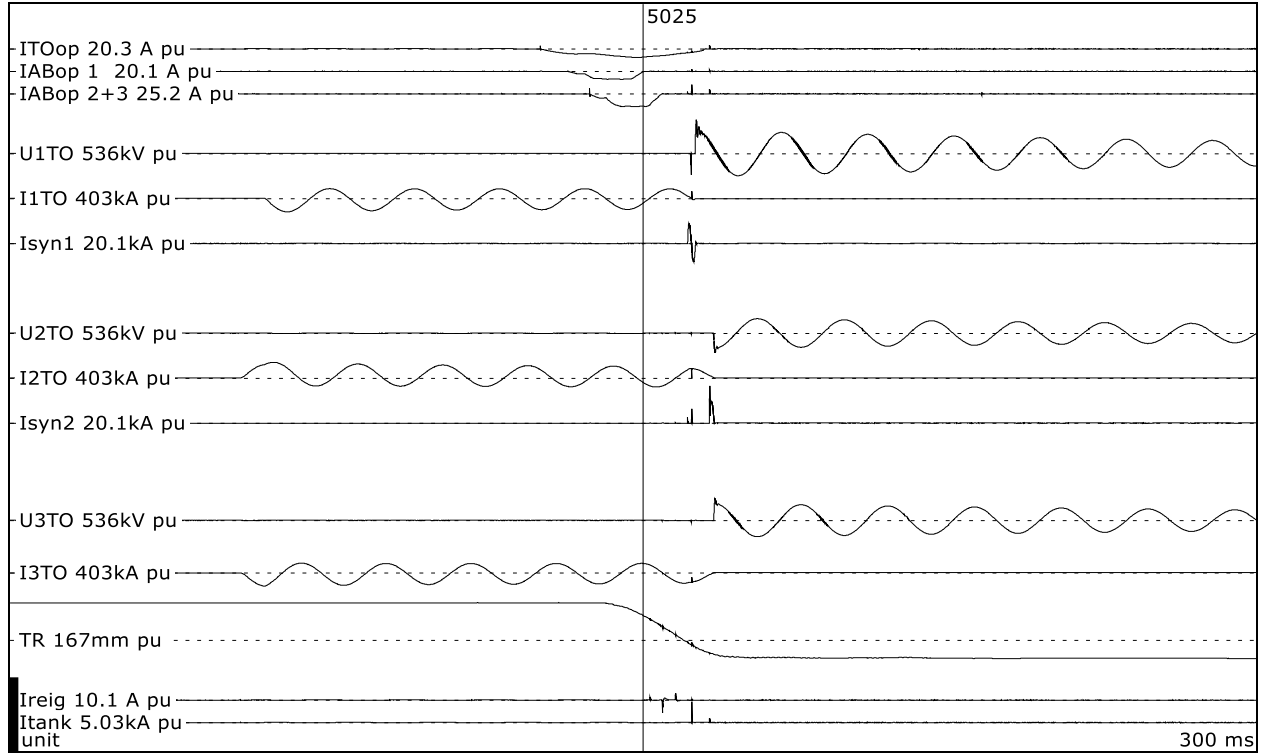
Overview of test numbers

170609-5025, 5026, 5029 to 5031

Remarks

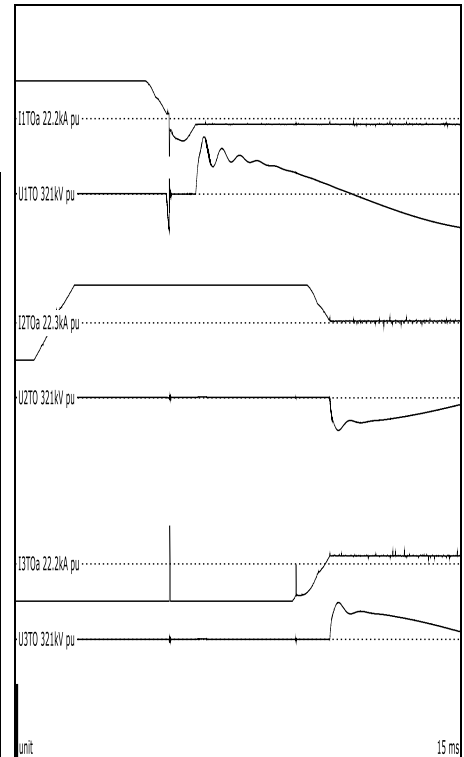
-

T100s(b)



Test number: 170609-5025

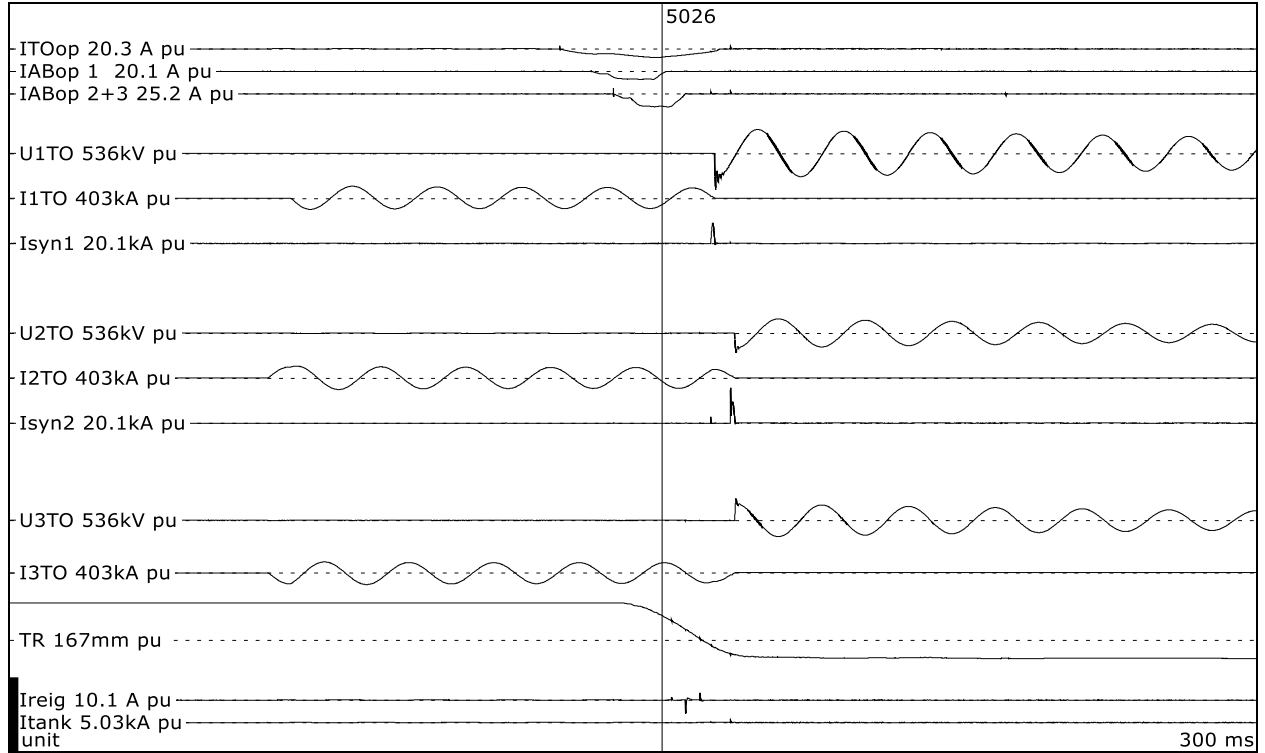
Time interval since previous test	min	-		
Operation		O _s		
Phase		A	B	C
Applied voltage, current source, phase value	kV	19,3	20,7	19,5
Charging voltage capacitor bank, DC value	kVd.c.	191	130	130
Breaking current, symmetrical, phase value	kA	40,0	40,2	40,0
Breaking current, DC-component	%	7	14	6
di/dt at last current zero	A/μs	17,8	15,7	15,4
TRV, peak	kV	-	-144	152
Recovery voltage, phase value	kV	-	84,0	87,0
Arc duration	ms	(1)	17,1	16,9
Opening time	ms	24,7		
Break time	ms	-	41,8	41,6
t _h	μs	398	426	427
Current last loop, peak	kA	50,4	51,6	-56,5



Voltage opening coil	242 Vd.c.	Gas pressure at 20 °C	0,60 MPa
		Operating pressure	- MPa

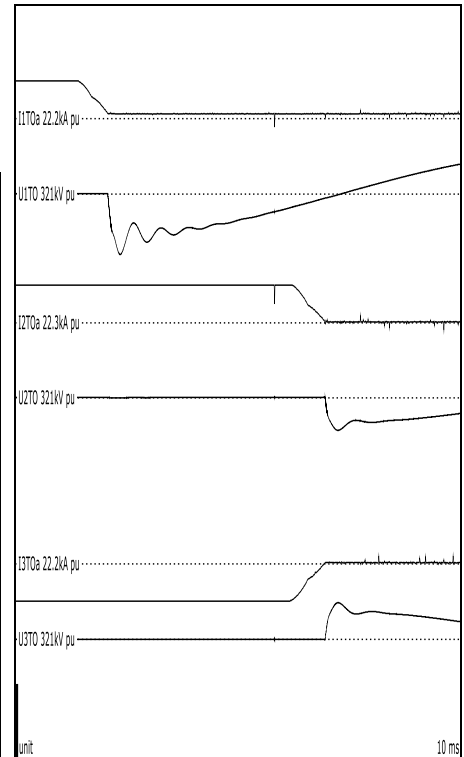
Remarks: Test to verify the correct reignition behaviour of the breaker (subclause 6.102.10 of IEC 62271-101).
 (1) Arcing time set for 11,6 ms.
 O_s = Operation in a synthetic circuit.

T100s(b)



Test number: 170609-5026

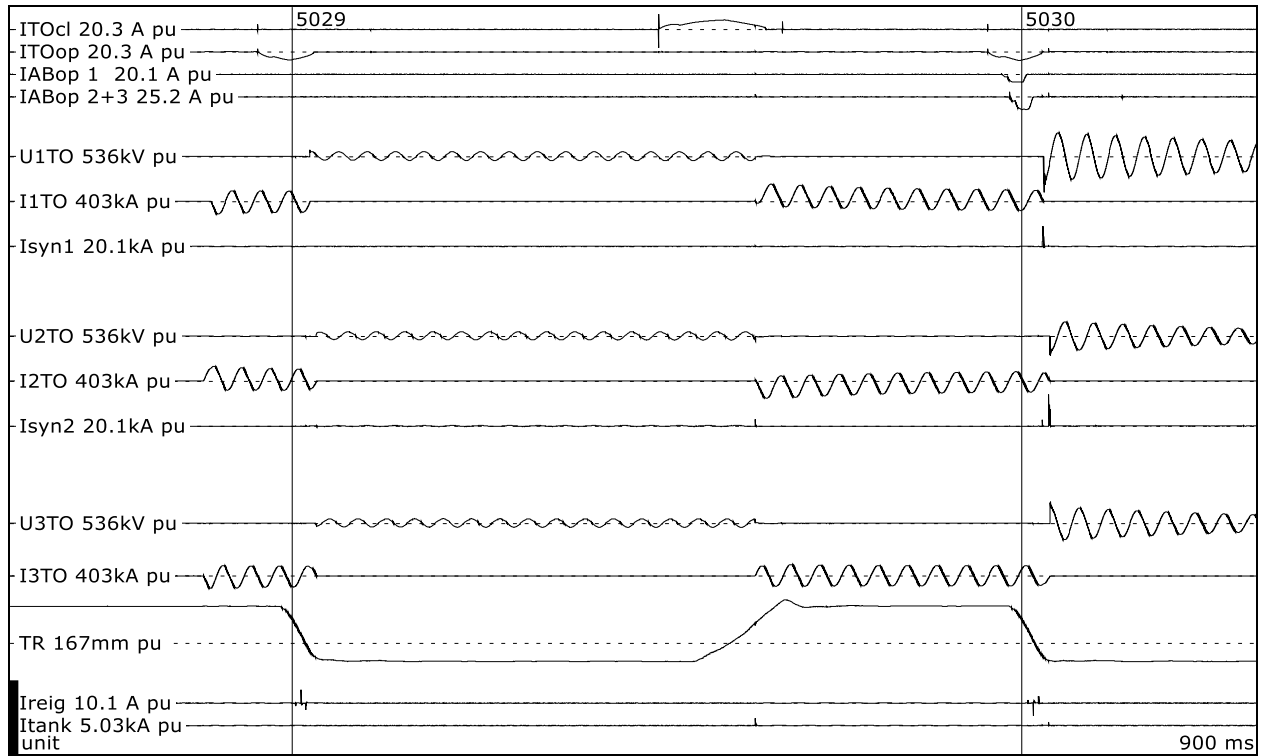
Time interval since previous test	min	-		
Operation		O _s		
Phase		A	B	C
Applied voltage, current source, phase value	kV	19,4	20,3	19,7
Charging voltage capacitor bank, DC value	kVd.c.	194	129	128
Breaking current, symmetrical, phase value	kA	40,3	40,5	40,3
Breaking current, DC-component	%	2	1	2
di/dt at last current zero	A/μs	17,8	15,6	15,4
TRV, peak	kV	-261	-144	143
Recovery voltage, phase value	kV	126	84,0	86,8
Arc duration	ms	12,6	17,6	17,6
Opening time	ms	24,6		
Break time	ms	37,2	42,2	42,2
t _h	μs	391	407	403
Current last loop, peak	kA	55,8	48,1	-55,0



Voltage opening coil	242 Vd.c.	Gas pressure at 20 °C	0,60 MPa
		Operating pressure	- MPa

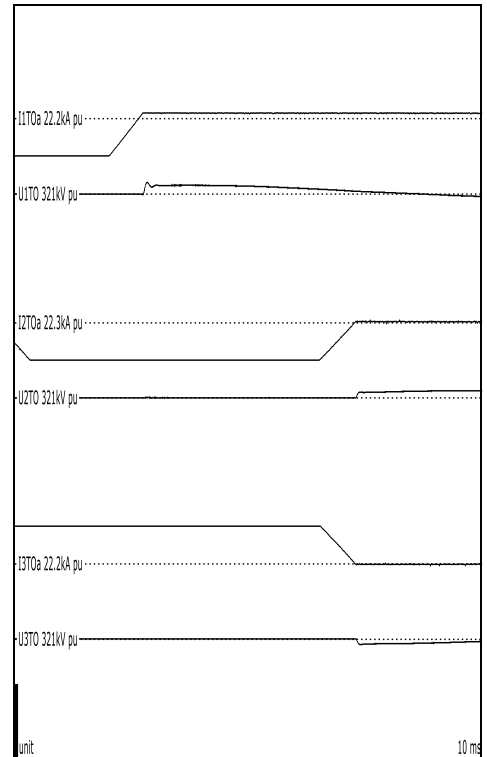
Remarks: Breaker cleared.
O_s = Operation in a synthetic circuit.

T100s(b)



Test number: 170609-5029

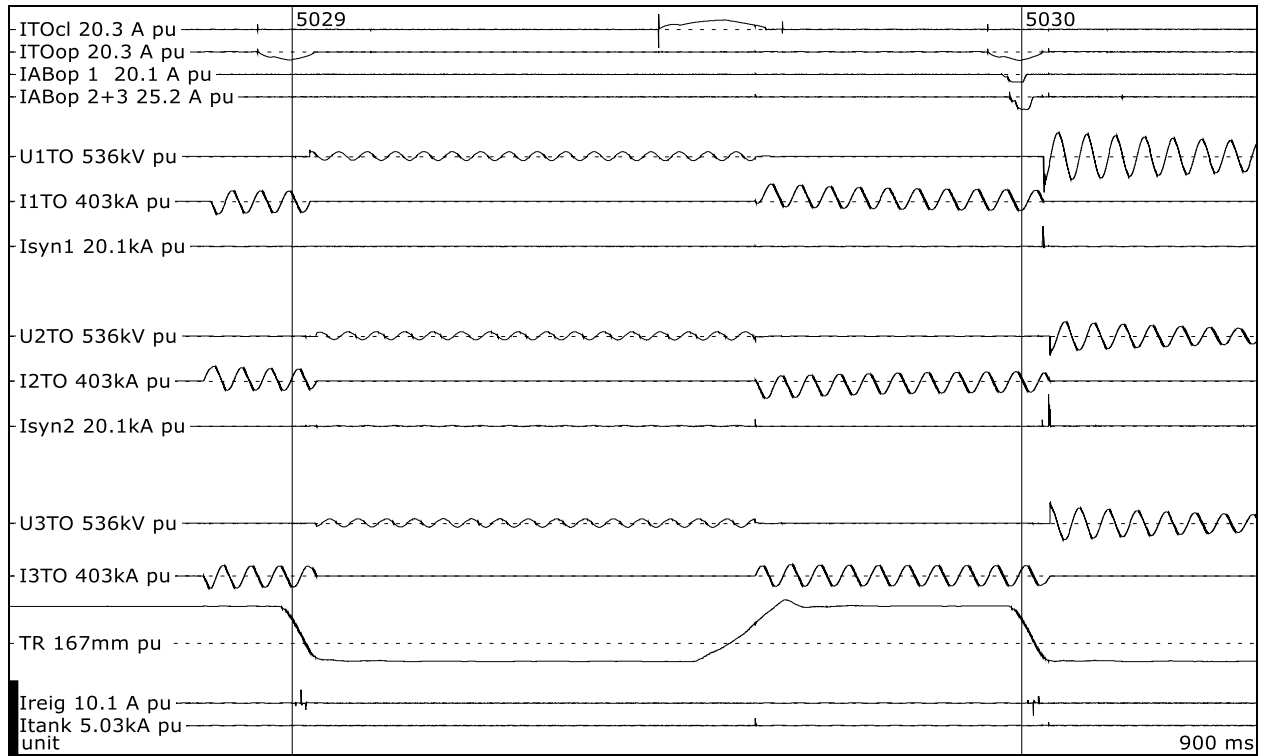
Time interval since previous test	min	-		
Operation		O _D		
Phase		A	B	C
Breaking current, symmetrical, phase value	kA	41,3	41,6	41,4
Breaking current, DC-component	%	7	15	9
Recovery voltage, phase value	kV	22,0	19,7	20,9
Arc duration	ms	13,1	17,7	17,7
Opening time	ms	24,8		
Break time	ms	37,9	42,5	42,5



Voltage opening coil	242 Vd.c.	Gas pressure at 20 °C	0,60 MPa
		Operating pressure	- MPa

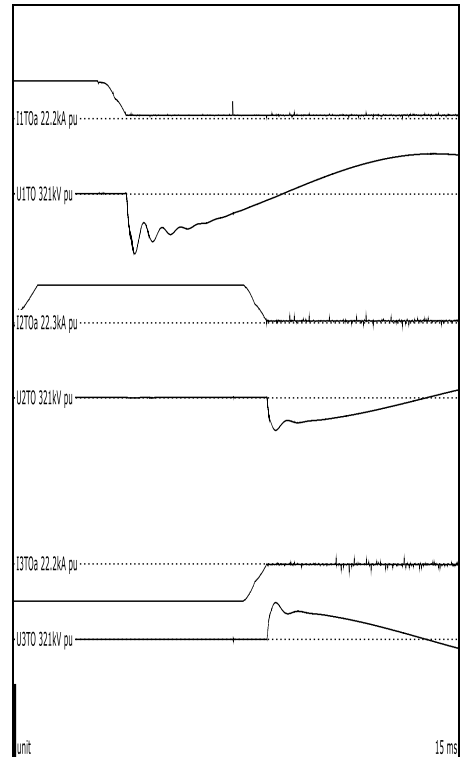
Remarks: Breaker cleared.
O_D = Operation with current source only.

T100s(b)



Test number: 170609-5030

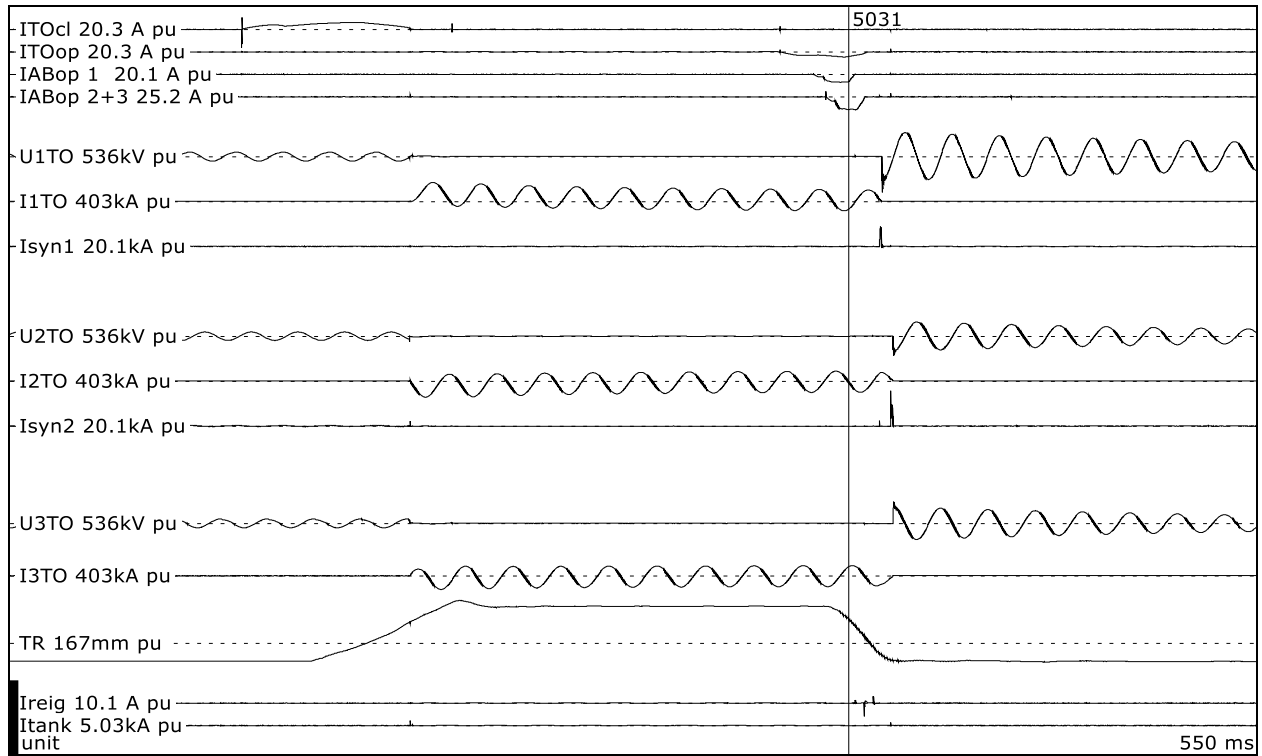
Time interval since previous test	min	-		
Time interval between operations	s	0,316		
Operation		CbOs		
Phase		A	B	C
Applied voltage, current source, phase value	kV	22,8	20,5	21,5
Charging voltage capacitor bank, DC value	kVd.c.	193	129	130
Making current, peak	kA	92,8	-94,1	61,2
Breaking current, symmetrical, phase value	kA	40,2	40,1	40,0
Breaking current, DC-component	%	10	9	1
di/dt at last current zero	A/μs	17,8	15,6	15,4
TRV, peak	kV	-252	-138	164
Recovery voltage, phase value	kV	124	84,3	87,1
Make time	ms	69,7	70,3	69,8
Arc duration	ms	15,7	20,7	20,7
Opening time	ms	24,7		
Break time	ms	40,4	45,4	45,4
t _h	μs	406	418	415
Current last loop, peak	kA	58,7	44,6	-52,8



Voltage closing coil	242 Vd.c.	Gas pressure at 20 °C	0,60 MPa
Voltage opening coil	242 Vd.c.	Operating pressure	- MPa

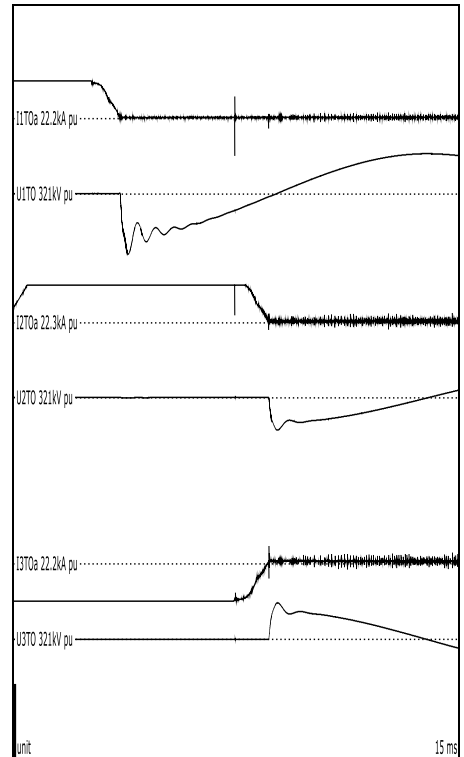
Remarks: Breaker closed and cleared.
 C_D = Operation with current source only. O_S = Operation in a synthetic circuit.

T100s(b)



Test number: 170609-5031

Time interval since previous test	min	19		
Operation		CbOs		
Phase		A	B	C
Applied voltage, current source, phase value	kV	23,1	21,3	21,9
Charging voltage capacitor bank, DC value	kVd.c.	194	129	129
Making current, peak	kA	102	-87,5	-74,9
Breaking current, symmetrical, phase value	kA	40,7	40,9	40,6
Breaking current, DC-component	%	11	7	4
di/dt at last current zero	A/μs	17,8	15,5	15,0
TRV, peak	kV	-267	-144	153
Recovery voltage, phase value	kV	125	84,0	86,8
Make time	ms	75,4	74,1	74,1
Arc duration	ms	14,6	19,6	19,6
Opening time	ms	30,2		
Break time	ms	44,8	49,8	49,8
t _h	μs	393	418	411
Current last loop, peak	kA	61,4	47,3	-56,4



Voltage closing coil	187 Vd.c.	Gas pressure at 20 °C	0,60 MPa
Voltage opening coil	154 Vd.c.	Operating pressure	- MPa

Remarks: Breaker closed and cleared.
 C_D = Operation with current source only. O_S = Operation in a synthetic circuit.

31 NO-LOAD TESTS

Standard and date

Standard IEC 62271-100

Test date 9 June 2017

31.1 Condition before test

Breaker (Serial No 17101) in same condition.

31.2 Test results and oscillograms

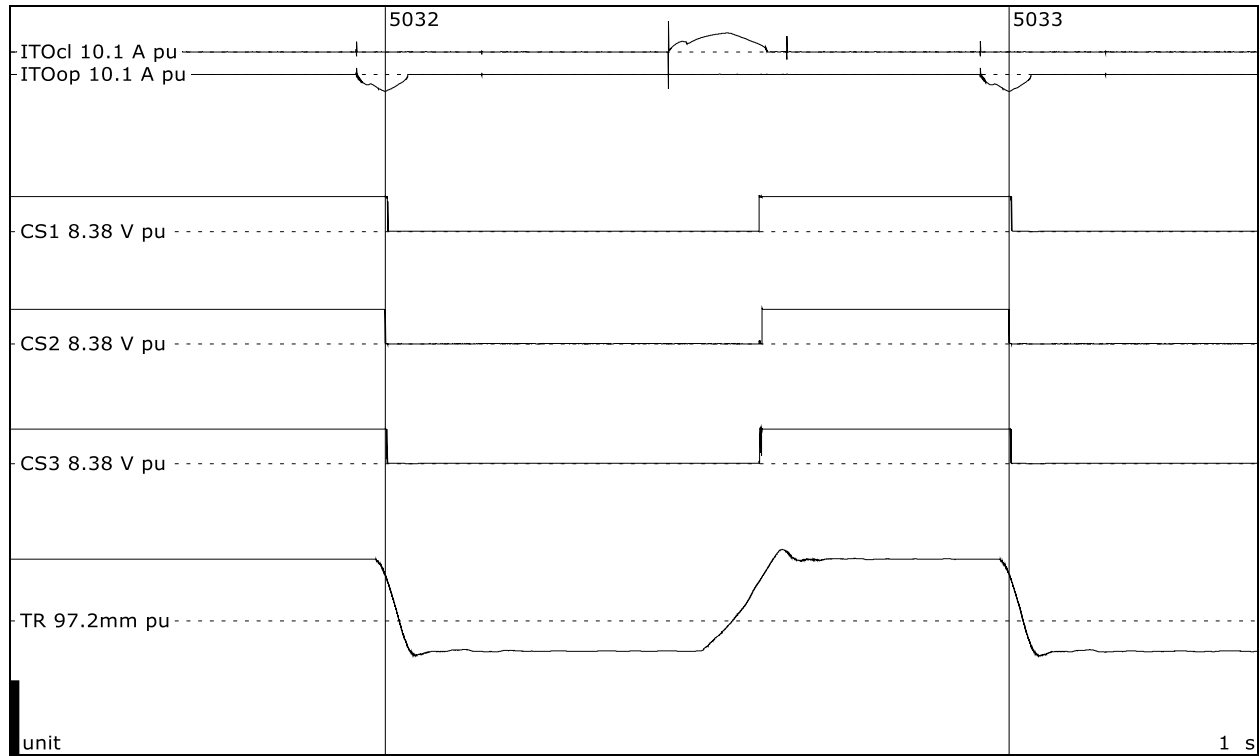
Overview of test numbers

170609-5032 to 5037

Remarks

-

No-load test



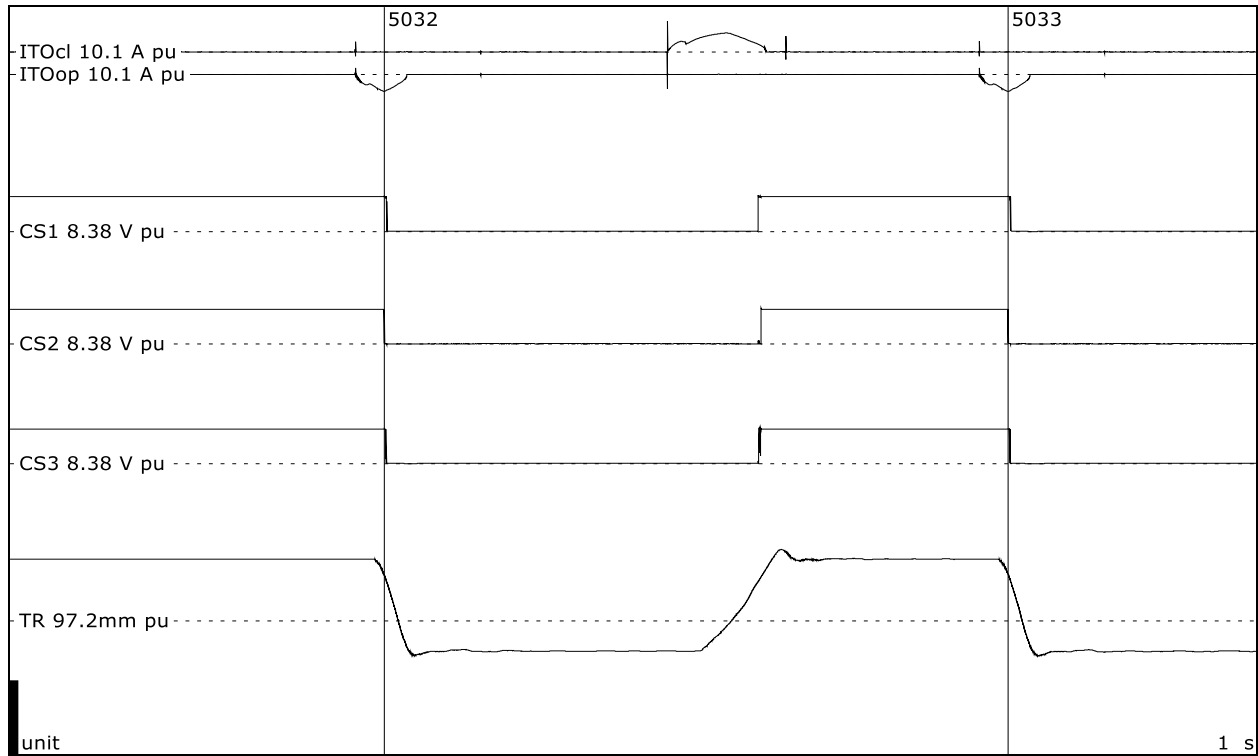
Test number: 170609-5032

Operation		O		
Phase		A	B	C
Current opening coil	A	-2,31		
Opening time	ms	25,0	23,1	24,5

Voltage opening coil	242 Vd.c.	Gas pressure at 20 °C	0,60 MPa
		Operating pressure	- MPa

Remarks: -

No-load test



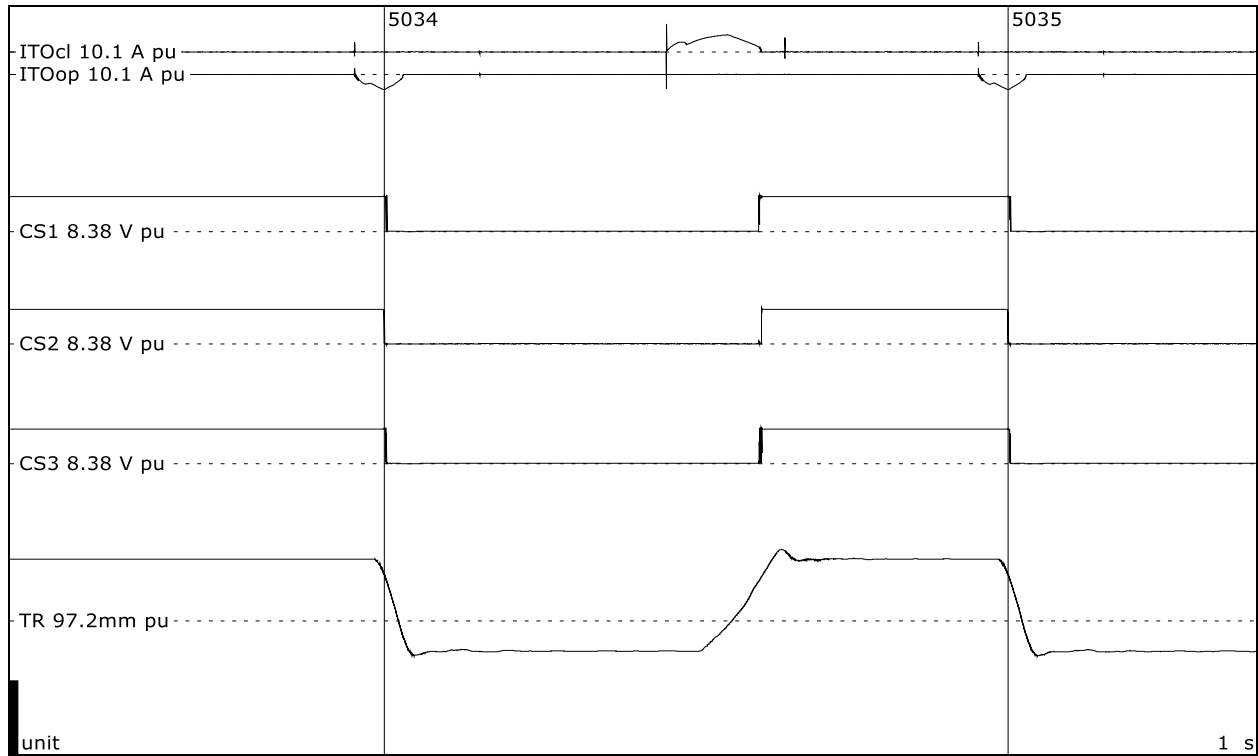
Test number: 170609-5033

Time interval between operations	s	0,300		
Operation		CO		
Phase		A	B	C
Current closing coil	A	2,53		
Closing time	ms	72,6	75,1	73,2
Current opening coil	A	-2,30		
Opening time	ms	25,0	23,1	24,6

Voltage closing coil	242 Vd.c.	Gas pressure at 20 °C	0,60 MPa
Voltage opening coil	242 Vd.c.	Operating pressure	- MPa

Remarks: -

No-load test



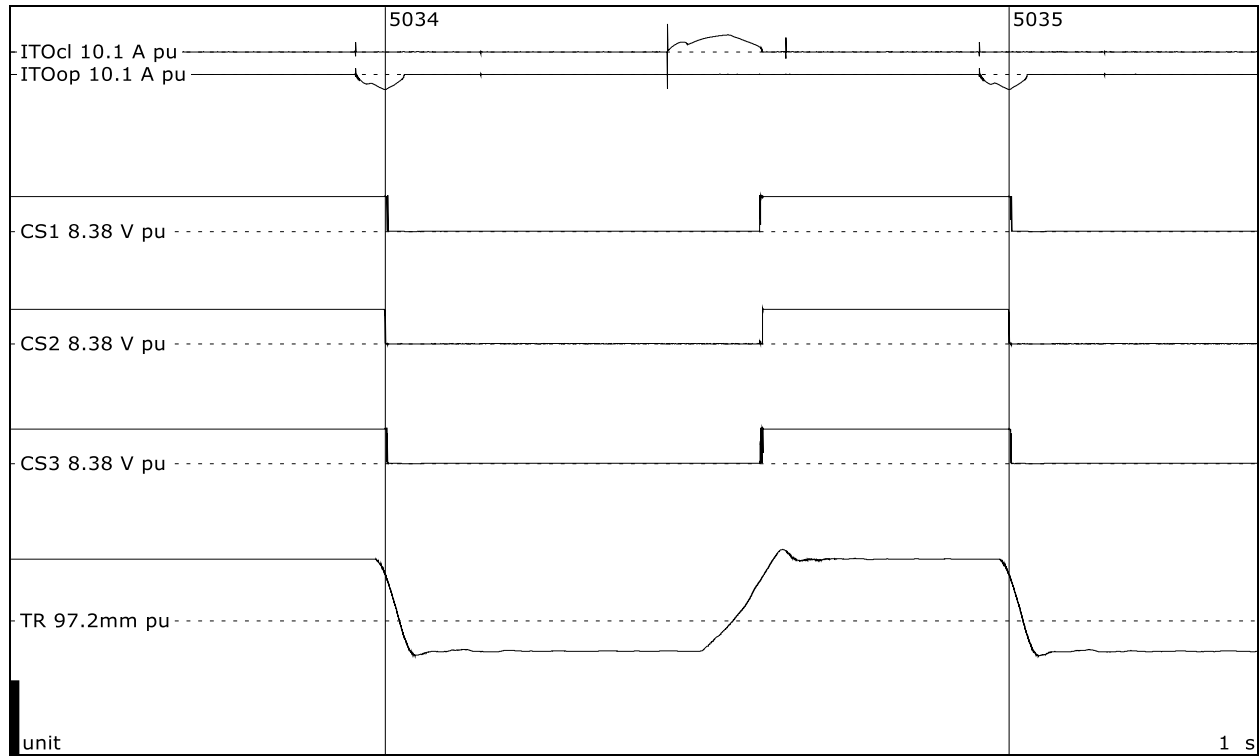
Test number: 170609-5034

Operation		O		
Phase		A	B	C
Current opening coil	A	-2,08		
Opening time	ms	25,6	23,9	25,1

Voltage opening coil	220 Vd.c.	Gas pressure at 20 °C	0,60 MPa
		Operating pressure	- MPa

Remarks: -

No-load test



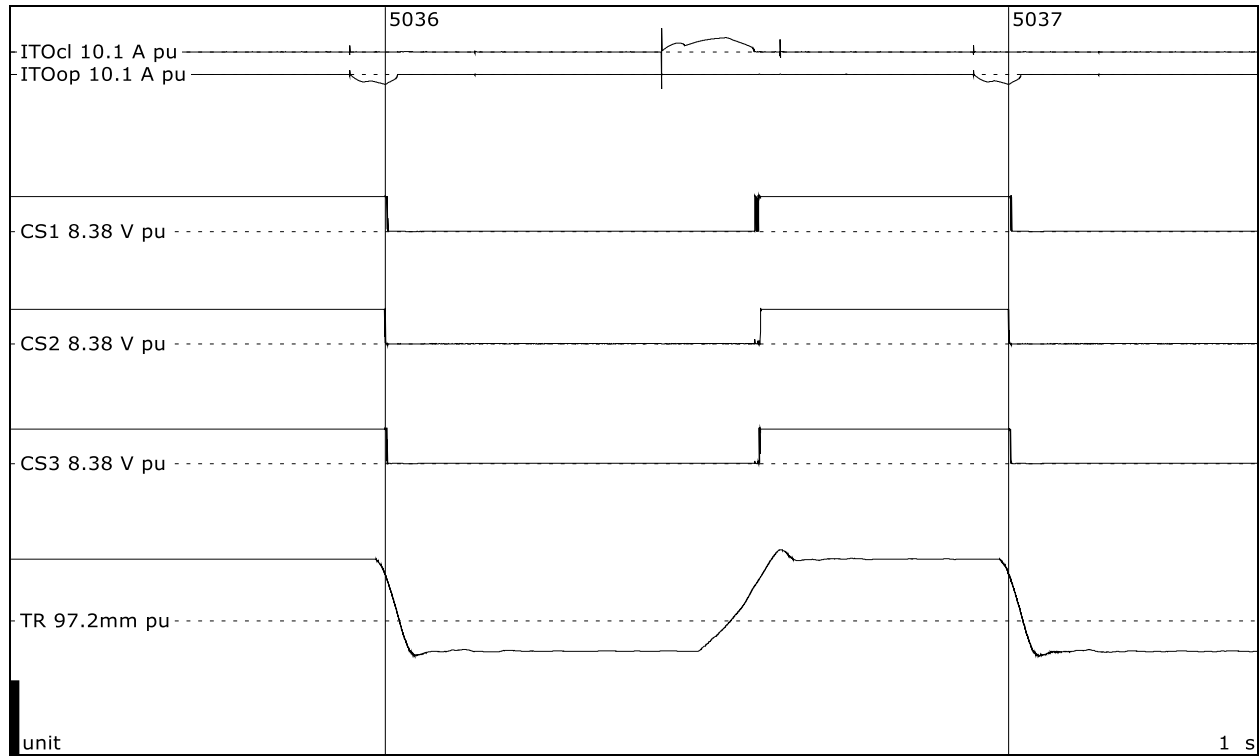
Test number: 170609-5035

Time interval between operations	s	0,300		
Operation	CO			
Phase		A	B	C
Current closing coil	A	2,27		
Closing time	ms	73,8	76,2	74,4
Current opening coil	A	-2,06		
Opening time	ms	25,4	23,7	25,2

Voltage closing coil	220 Vd.c.	Gas pressure at 20 °C	0,60 MPa
Voltage opening coil	220 Vd.c.	Operating pressure	- MPa

Remarks: -

No-load test



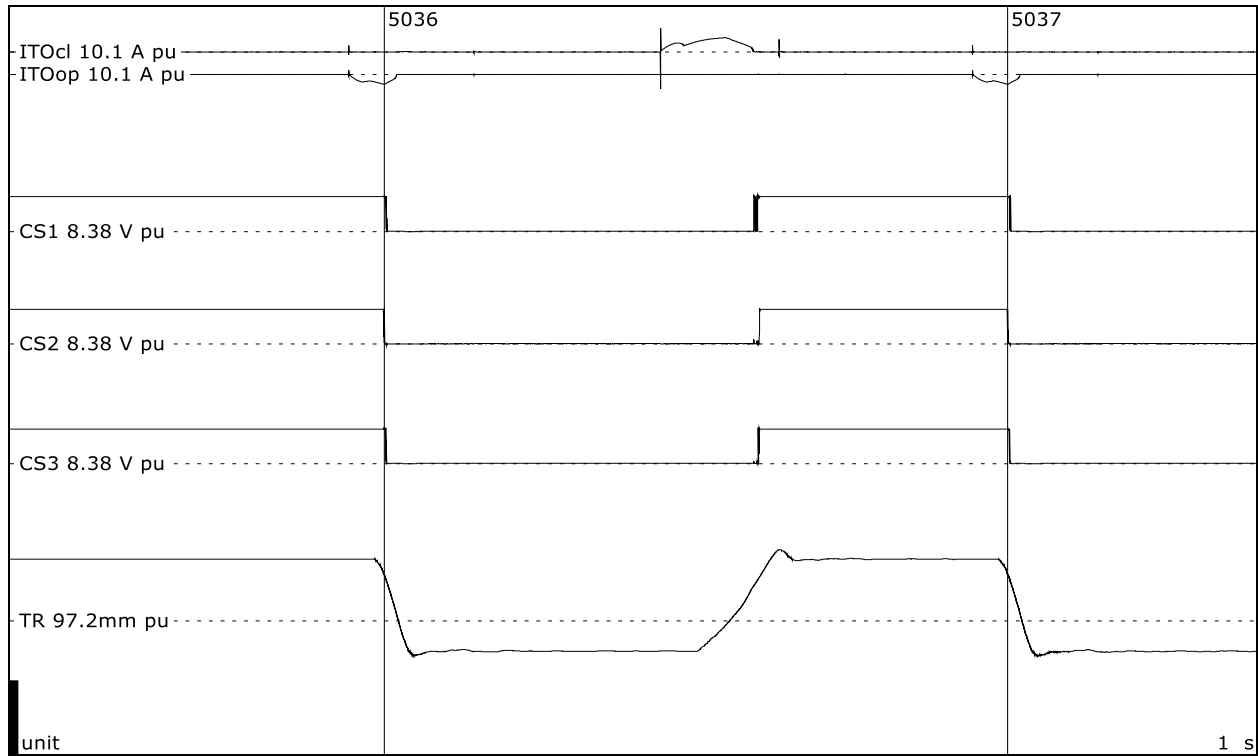
Test number: 170609-5036

Operation		O		
Phase		A	B	C
Current opening coil	A	-1,37		
Opening time	ms	30,2	28,4	29,8

Voltage opening coil	154 Vd.c.	Gas pressure at 20 °C	0,60 MPa
		Operating pressure	- MPa

Remarks: -

No-load test



Test number: 170609-5037

Time interval between operations	s	0,296		
Operation	CO			
Phase		A	B	C
Current closing coil	A	1,90		
Closing time	ms	74,6	79,0	77,9
Current opening coil	A	-1,35		
Opening time	ms	730	728	730

Voltage closing coil	187 Vd.c.	Gas pressure at 20 °C	0,60 MPa
Voltage opening coil	154 Vd.c.	Operating pressure	- MPa

Remarks: -

31.3 Condition / inspection after test

Externally no visible change.

Inspection of contacts:

Fixed arcing contact moderately burnt.

Moving arcing contact moderately burnt.

Fixed main contact finger tips showed locally moderate commutation marks. Silver layer on main contact area intact.

Moving main contact rim showed locally moderate commutation marks. Silver layer on main contact area intact.

Nozzle moderately eroded.

Auxiliary nozzle moderately eroded.

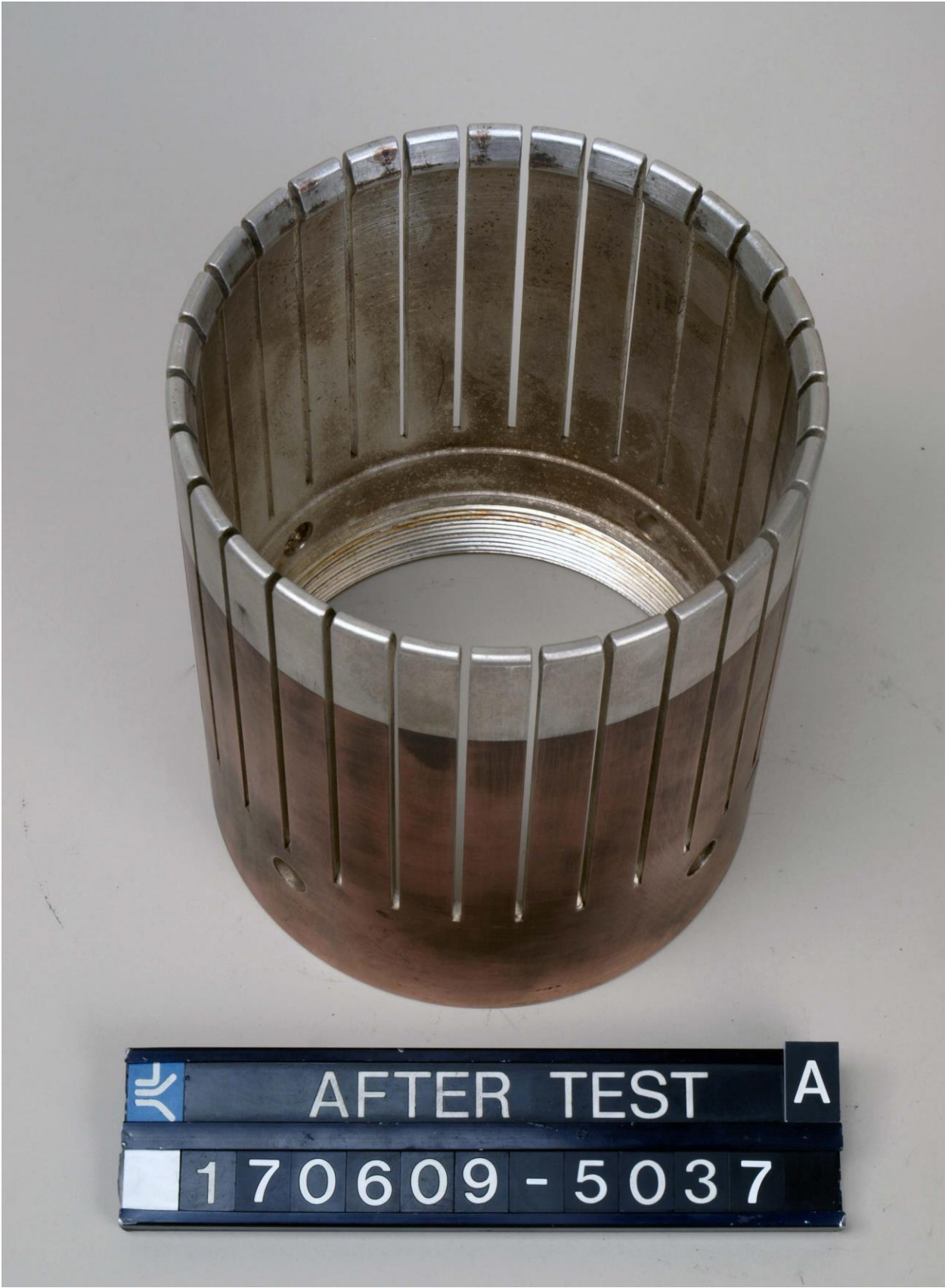
31.4 Photographs after test













































32 DRAWING

