

Test Report

Report No.: 14253 Bs - 1

Copy No.: 0

Contents: 21 Sheets

Test object: Three-pole operated outdoor circuit-breaker
Designation: 3AP1FG - 145 kV - 3150 A - 40 kA - 50/60 Hz
Rated voltage: 145 kV Rated normal current: 3150 A Rated frequency: 50/60 Hz
Manufacturer: Siemens AG, EM HP CB, Berlin
Tested for: Siemens AG, EM HP CB R&D EN, Berlin
Testing station: PEHLA-Testing Laboratory Berlin-Siemensstadt
Date of test: December 01 - 05, 2014

Applied test specifications:

IEC Publication 62271-1, Edition 1.1 (2011)
IEC Publication 62271-100, Edition 2.1 (2012)

Tests performed:

Dielectric type tests including:

- Power-frequency withstand voltage test
- Power-frequency withstand voltage test, wet
- Lightning impulse withstand voltage test

Radio interference voltage test

Test results:

The test object passed the tests performed in accordance with the applied test specifications.



Mannheim, May 05, 2015

GESELLSCHAFT FÜR ELEKTRISCHE
HOCHLEISTUNGSPRÜFUNGEN


Dr. H. Jahn

Management Committee



Technical Committee


M. Bahr

The test results relate only to the items tested.

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Deutsche
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D-PL-12072-04-01

Notes

Accreditation

The PEHLA GbR, PEHLA-Testing Laboratory Berlin-Siemensstadt has been approved by the Deutsche Akkreditierungsstelle GmbH (DAkkS) according to EN ISO/IEC 17025 for tests in the field of high-voltage switchgear and controlgear and power engineering equipment (Registration-No. D-PL-12072-04).

STL-Member

PEHLA is founder member of the SHORT-CIRCUIT TESTING LIAISON (STL) which has been established in 1969. STL is a forum for the international cooperation of the testing organisations with the further full members ASTA (GB), CESI (IT), CPRI (IN), ESEF (FR), JSTC (JP), KEMA (NL), KERI (KR), SATS (FI, NO, SE) and STLNA (CA, MX, US). In the frame-work of EC, STL (EU) has been recognised in 1992 by EOTC as agreement group.

PEHLA-Documents

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is issued for type tests which have successfully been carried out in full compliance with the relevant specifications or standards and STL Guides valid at the time of the test. For these tests the test object must be clearly identified by technical description, drawings and additional specifications.

A Test Document

is issued for parts of type tests which have successfully been carried out in full compliance with the relevant specifications or standards and STL Guides valid at the time of test. For these tests the test object must be clearly identified by technical description, drawings and additional specifications.

A Test Report

is issued for all other tests which have been carried out according to specifications, standards or "PEHLA-Richtlinien" (PEHLA Guides) and/or clients' instructions. Similarly, this test report contains all test results, details of the conditions under which the tests were carried out, also details relating to the behaviour of the test object, and its condition after the tests.

A Test Confirmation

is issued immediately after the tests. It confirms that the tests have been conducted and is valid only until publishing the detailed results in an entire document.

Uncertainty of the measurement systems

The PEHLA - Testing Laboratories apply the PEHLA Guide No. 12 for determining the uncertainties of measurement, based on ENV 13005 (Guide to the expression of uncertainty in measurement). As long as no explicit statements are made, the uncertainties required by the relevant standards have been complied with.

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Tested for: Siemens AG
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List of Test Participants

Representatives of Technical Committee:

Mr. Schrader	PEHLA-Testing Laboratory Berlin-Siemensstadt
Dr. Jahn	PEHLA-Testing Laboratory Mannheim-Rheinau

Test Engineer / Test Operator:

Mr. Schrader	PEHLA-Testing Laboratory Berlin-Siemensstadt
Mr. Rossa	PEHLA-Testing Laboratory Berlin-Siemensstadt
Mr. Theil	PEHLA-Testing Laboratory Berlin-Siemensstadt

Representatives of Manufacturer:

Mr. Scharschmidt	Siemens AG, EM HP CB R&D EN, Berlin
Mr. Wolf	Siemens AG, EM HP CB R&D M CP, Berlin

Further Participants:

-

Technical Data of Test Object Circuit-breaker

Test object: Three-pole operated outdoor circuit-breaker
Designation: 3AP1FG - 145 kV - 3150 A - 40 kA - 50/60 Hz
Manufacturer: Siemens AG, EM HP CB, Berlin
Serial No.: 35139502
Year of manufacture: 2014
Serial No. of drive: -
Drawing No.: 3HM 427-44102-008 / 1HZ 427-44700-814

Ratings assigned by the manufacturer:

Rated voltage [U]	145	kV	
Rated normal current [I]	3150	A	
Rated frequency [f]	50/60	Hz	
Rated lightning impulse withstand voltage [U_p]	650	kV	
Rated switching impulse withstand voltage [U_s]	-	kV	
Rated power-frequency withstand voltage [U_d]	275	kV	
Rated peak withstand current [I_p]	108	kA	
Rated short-time withstand current [I_k]	40	kA	
Rated duration of short-circuit [t_k]	3	s	
Rated short-circuit breaking current [I_{sc}]	40	kA	
DC component of the rated short-circuit breaking current [ρ_{cs}]	50	%	
Rated short-circuit making current [I_{ma}]	108	kA	
Rated transient recovery voltage	249	kV	
Rate of rise of transient recovery voltage	2.0	kV/ μ s	
First-pole-to-clear factor	1.3/1.5	p.u.	
Rated operating sequence	O - 0.3 s - CO - 3 min - CO		
Arc extinguishing medium	SF ₆		
Rated filling pressure for interruption [p_{rm}]	0.70	MPa	abs. at 20 °C
Minimum functional pressure for interruption [p_{mm}]	0.60	MPa	abs. at 20 °C
Insulating medium	SF ₆		
Rated filling pressure for insulation [p_{re}]	0.70	MPa	abs. at 20 °C
Minimum functional pressure for insulation [p_{me}]	0.60	MPa	abs. at 20 °C
Driving mechanism (type)	spring drive		
Number of poles	3		
Number of units per pole	1		
Rated opening time	23	ms	
Rated closing time	54	ms	
Rated supply voltage of opening device [U_{op}]	110	V	d.c.
Rated supply voltage of closing device [U_{op}]	110	V	d.c.
Rated supply voltage of auxiliary circuits [U_a]	400	V	a.c.
Rated frequency of supply voltage	50	Hz	
Rated line-charging breaking current	50	A	
Rated cable-charging breaking current	160	A	
Rated single capacitor bank breaking current	400	A	

Further data:

Range of ambient air temperature -30 ... +40 °C
 Classification M2; C2

Essential characteristics: -

Remarks: -

List of Identified Drawings

The manufacturer has submitted to the testing laboratory drawings and other data containing sufficient information to unambiguously identify by type the essential details and parts of the test object presented for test.

The drawings have been stamped and signed by the manufacturer in order to guarantee that the drawings or data schedules truly represent the test object to be tested.

Further these drawings have been stamped and signed by PEHLA representatives and are kept

at the manufacturer.

with the test documents at the test laboratory.

The testing laboratory has checked that drawings and data schedules adequately represent the essential details and parts of the test object to be tested, but is not responsible for the accuracy of the detailed information.

The drawing(s) contained in this document are identical with the checked, stamped and signed drawings.

Drawing No.	Rev.	P/D ^{*)}	Title	Additional remarks
3HM 427-44102-008	-	D	Triple-pole circuit-breaker 145 kV	Sheet 1 ¹⁾
1HZ 427-44700-814	T	D	Triple-pole circuit-breaker	Sheet 1-3
1HZ 427-44700-814	W	P	Triple-pole circuit-breaker	Sheet 1, 5, 6, 8
1HG 427-44704-001	K	D	Interrupter unit 145 kV	Sheet 1
1HG 427-44704-001	K	P	Interrupter unit 145 kV	Sheet 1, 2, 4
2HG 427-44860-001	E	D	Base, top, cpl.	Sheet 1
2HG 427-44860-001	E	P	Base, top, cpl.	Sheet 1-4
2HG 427-44880-001	H	D	Base, bottom, cpl.	Sheet 1
2HG 427-44880-001	I	P	Base, bottom, cpl.	Sheet 1-3
1HG 427-44900-001	F	D	Moving contact	Sheet 1
1HG 427-44900-001	G	P	Moving contact	Sheet 1-3
1HG 427-44703-011, -012	O	D	Column	Sheet 1
1HG 427-44703-011, -012	Q	P	Column	Sheet 1-3, 7
2HG 427-08910-002	E	D	Operating rod, cpl.	Sheet 2
2HG 427-08910-002	E	P	Operating rod, cpl.	Sheet 1-3
2HG 427-44928-001	E	D	Cover, cpl.	Sheet 1
2HG 427-44928-001	F	P	Cover, cpl.	Sheet 1-3
1HT 427-44925-001	E	D	Cover	Sheet 1-2
1HG 427-44701-001	P	D	Breaker base	Sheet 1
1HG 427-44701-001	N	P	Breaker base	Sheet 1, 2, 4
1HG 427-44702-001	K	D	Operating mechanism unit	Sheet 1
1HG 427-44702-001	L	P	Operating mechanism unit	Sheet 1-4
1HF 525-22023-950	-	D	145kV Composite Hollow Insulator	Sheet 1
1HF 526-22023-950	-	D	145kV Composite Hollow Insulator	Sheet 1
2HT 427-44720-001	E	D	Terminal	Sheet 1

*) P: Parts list, D: Drawing

Remarks: ¹⁾ Included in this document

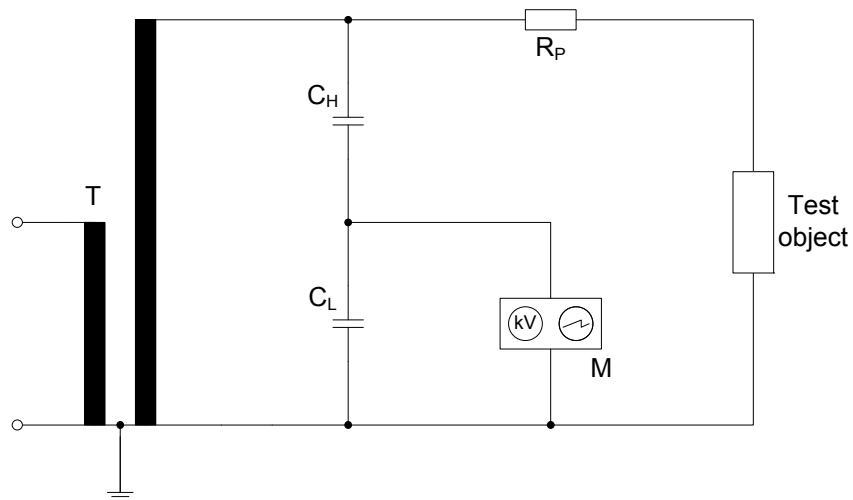
List of Identified Drawings

Drawing No.	Rev.	P/D ^{*)}	Title	Additional remarks
433-02020-014	0	D	cb-support	Sheet 2
4FR 950-34812	-	D	contact lamination LA-CU/0,15-0,5 Ø124	Sheet 1
3HG 427-44905-001	B	D	Heating cylinder, cpl.	Sheet 1
3HG 427-44905-001	B	P	Heating cylinder, cpl.	Sheet 1-2
2HT 427-44914-001	C	D	Heating cylinder	Sheet 1
3HT 427-44907-001	D	D	Pipe	Sheet 1
3HT 427-08932-004	G	D	Auxiliary nozzle	Sheet 4
2HT 427-44915-001	D	D	Nozzle	Sheet 1
3HG 427-44766-007	G	D	Pin	Sheet 3
3HG 427-44766-007	F	P	Pin	Sheet 1-2
2HT 427-44764-003	D	D	Contact cage	Sheet 3
2HG 427-44775-001	A	D	Tube contact	Sheet 1
4HT 428-00288-001	N	D	Contact lamination	Sheet 1
2HT 427-44923-001	E	D	Contact support	Sheet 1-5

*) P: Parts list, D: Drawing

Remarks: -

Circuit Diagram Power-frequency Voltage Test



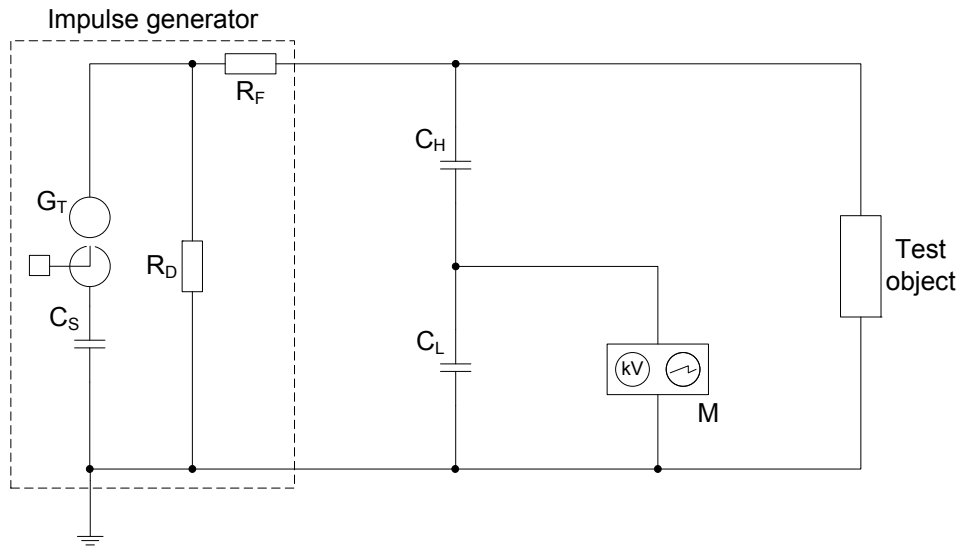
Essential elements of the test circuit:

T	Transformer
R _P	Protective resistance

Measuring system:

C _H , C _L	Voltage divider
M	Measuring device MIAS 100-14/4B

Circuit Diagram Standard Lightning Impulse Voltage Test



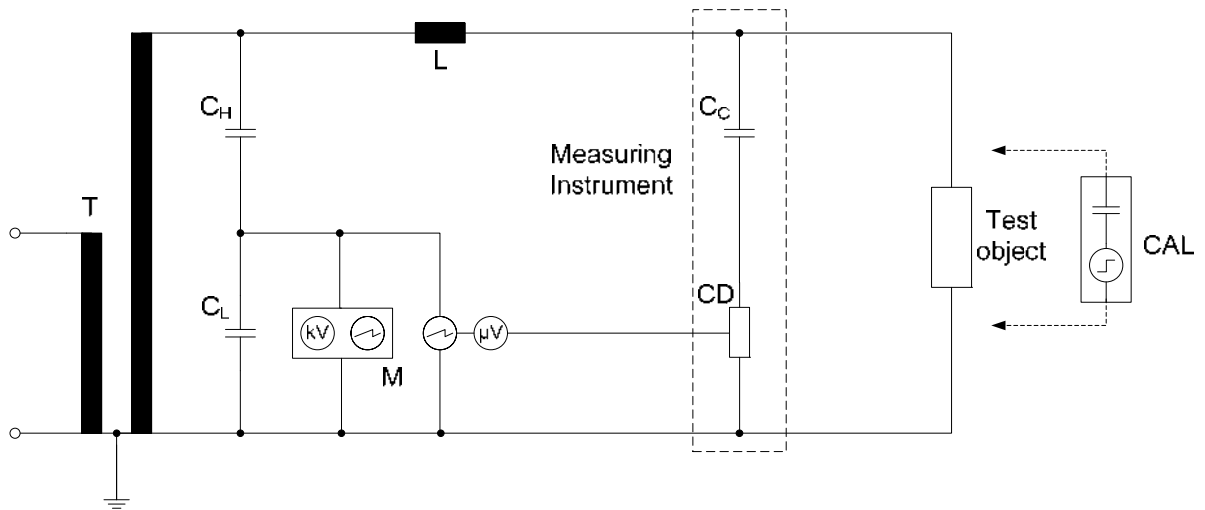
Essential elements of the test circuit:

- C_S Surge capacitance
- R_F Front resistance
- R_D Discharge resistance
- G_T Trigger gap

Measuring system:

- C_H, C_L Voltage divider
- M Measuring device MIAS 100-14/4B

Circuit Diagram Radio Interference Voltage Test





Essential elements of the test circuit:

- T Transformer
- L Filter

Measuring system:

- C_H, C_L Voltage divider
- M Measuring device MIAS 100-14/4B

Measuring system:

- C_C Coupling capacitance
-  Oscilloscope Tektronix TDS 320
-  EMI Test Receiver Rohde & Schwarz ESHS 10
- CD Coupling device

Test Conditions and Results

General:

Condition of test object before tests:

All components were in a factory new condition and completely assembled as in service.

Connections of test object:

Conductors at the high-voltage terminals were simulated by rods. The connection to the high-voltage sources was performed by copper wire. For radio interference voltage tests the copper wire was replaced by tubes.

The enclosure (designated with F) was earthed during all tests (sheets 20 and 21).

The test object was filled with SF₆-gas at minimum

functional gas pressure for interruption and insulation:

0.60 MPa abs. at 20 °C

Tested values:

Rated short-duration power-frequency withstand voltage
(phase-to-earth, between phases and across open switching
device)

275 kV

Rated short-duration power-frequency withstand voltage, wet
(phase-to-earth, between phases and across open switching
device)

275 kV

Rated lightning impulse withstand voltage
(phase-to-earth, between phases and across open switching
device)

650 kV

Radio interference voltage test $1.1 \times U_r / \sqrt{3} = 92 \text{ kV}$

≤ 2500 μV

Evaluation:

The test object passed all tests without any objection.

Remarks: -

Ambient Air Conditions and Atmospheric Correction Factors

Date of test: December 03, 2014 Power-frequency voltage test (test arrangement No. 1-2)

Atmospheric correction factors					
Input data			Calculated correction factors ¹⁾		
Air temperature	<i>t</i>	18.2 °C	Air density	<i>k</i> ₁	1.006
Air pressure	<i>p</i>	1019.3 hPa	Humidity	<i>k</i> ₂	0.952
Air humidity	<i>h</i>	3.3 g/m ³	Atmospheric correction	<i>K</i> _t	0.958
50% disruptive-discharge voltage	<i>U</i> ₅₀	1.1 x 275 kV	Applied correction factor	<i>K</i>_t	1.000
Minimum discharge path	<i>L</i>	1.200 m			

Date of test: December 03, 2014 Power-frequency voltage test (test arrangement No. 3)

Atmospheric correction factors					
Input data			Calculated correction factors ¹⁾		
Air temperature	<i>t</i>	18.2 °C	Air density	<i>k</i> ₁	1.006
Air pressure	<i>p</i>	1019.3 hPa	Humidity	<i>k</i> ₂	0.957
Air humidity	<i>h</i>	3.3 g/m ³	Atmospheric correction	<i>K</i> _t	0.962
50% disruptive-discharge voltage	<i>U</i> ₅₀	1.1 x 275 kV	Applied correction factor	<i>K</i>_t	1.000
Minimum discharge path	<i>L</i>	1.261 m			

Date of test: December 05, 2014 Power-frequency voltage test, wet (test arrangement No. 1-2)

Atmospheric correction factors					
Input data			Calculated correction factors ¹⁾		
Air temperature	<i>t</i>	18.3 °C	Air density	<i>k</i> ₁	1.003
Air pressure	<i>p</i>	1014.0 hPa	Humidity	<i>k</i> ₂	1.000
Air humidity	<i>h</i>	7.6 g/m ³	Atmospheric correction	<i>K</i> _t	1.003
50% disruptive-discharge voltage	<i>U</i> ₅₀	1.1 x 275 kV	Applied correction factor	<i>K</i>_t	1.003
Minimum discharge path	<i>L</i>	1.200 m			

Remarks: ¹⁾ Calculation according to the convers procedure

Ambient Air Conditions and Atmospheric Correction Factors

Date of test: December 05, 2014 Power-frequency voltage test, wet (test arrangement No. 3)

Atmospheric correction factors					
Input data			Calculated correction factors ¹⁾		
Air temperature	<i>t</i>	18.3 °C	Air density	<i>k</i> ₁	1.003
Air pressure	<i>p</i>	1014.0 hPa	Humidity	<i>k</i> ₂	1.000
Air humidity	<i>h</i>	7.6 g/m ³	Atmospheric correction	<i>K</i> _t	1.003
50% disruptive-discharge voltage	<i>U</i> ₅₀	1.1 x 275 kV	Applied correction factor	<i>K</i>_t	1.003
Minimum discharge path	<i>L</i>	1.261 m			

Date of test: December 02, 2014 Lightning impulse voltage test (test arrangement No. 1)

Atmospheric correction factors					
Input data			Calculated correction factors ¹⁾		
Air temperature	<i>t</i>	19.6 °C	Air density	<i>k</i> ₁	1.002
Air pressure	<i>p</i>	1014.0 hPa	Humidity	<i>k</i> ₂	0.920
Air humidity	<i>h</i>	3.0 g/m ³	Atmospheric correction	<i>K</i> _t	0.922
50% disruptive-discharge voltage	<i>U</i> ₅₀	1.1 x 650 kV	Applied correction factor	<i>K</i>_t	1.000
Minimum discharge path	<i>L</i>	1.200 m			

Date of test: December 01, 2014 Lightning impulse voltage test (test arrangement No. 2)

Atmospheric correction factors					
Input data			Calculated correction factors ¹⁾		
Air temperature	<i>t</i>	20.0 °C	Air density	<i>k</i> ₁	1.004
Air pressure	<i>p</i>	1016.9 hPa	Humidity	<i>k</i> ₂	0.920
Air humidity	<i>h</i>	3.0 g/m ³	Atmospheric correction	<i>K</i> _t	0.924
50% disruptive-discharge voltage	<i>U</i> ₅₀	1.1 x 650 kV	Applied correction factor	<i>K</i>_t	1.000
Minimum discharge path	<i>L</i>	1.200 m			

Remarks: ¹⁾ Calculation according to the convers procedure

Ambient Air Conditions and Atmospheric Correction Factors

Date of test: December 02, 2014 Lightning impulse voltage test (test arrangement No. 3)

Atmospheric correction factors					
Input data			Calculated correction factors ¹⁾		
Air temperature	t	19.6 °C	Air density	k_1	1.002
Air pressure	p	1014.0 hPa	Humidity	k_2	0.920
Air humidity	h	3.0 g/m ³	Atmospheric correction	K_t	0.922
50% disruptive-discharge voltage	U_{50}	1.1 x 650 kV	Applied correction factor	K_t	1.000
Minimum discharge path	L	1.261 m			

Date of test: December 04, 2014 Radio interference voltage test (test arrangement No. 1-3)

Atmospheric correction factors					
Input data			Calculated correction factors		
Air temperature	t	18.8 °C	Air density	k_1	-
Air pressure	p	1017.1 hPa	Humidity	k_2	-
Air humidity	h	3.8 g/m ³	Atmospheric correction	K_t	-
50% disruptive-discharge voltage	U_{50}	-	Applied correction factor	K_t	-
Minimum discharge path	L	-			

Remarks: ¹⁾ Calculation according to the convers procedure

Test Results

Power-frequency Voltage Test

Test performed: Withstand voltage test
(phase-to-earth, between phases and across open switching device)

Date of test: December 03, 2014

Gas pressure (abs. at 20 °C): 0.60 MPa

Test frequency: 50 Hz

Atmospheric correction factors K_t listed in "Ambient Air Conditions and Atmospheric Correction Factors" have to be considered for the external insulation.

Test arrangement				Test voltages	Result
No.	Condition	Voltage applied to	Earthed	kV	Test duration / disruptive discharges
1	Open	b	acABCF	275	1 min / 0
2	Open	B	abcACF	275	1 min / 0
3	Closed	bB	acACF	275	1 min / 0

Remarks: -

Test Results

Power-frequency Voltage Test, wet

Test performed: Withstand voltage test
(phase-to-earth, between phases and across open switching device)

Date of test: December 05, 2014

Gas pressure (abs. at 20 °C): 0.60 MPa

Test frequency: 50 Hz

Precipitation conditions:

		“Breaking chamber insulator”	“Post insulator”
Precipitation rates:	[units]		
- vertical component:	mm/min	1.7	2.0
- horizontal component:	mm/min	1.3	1.3
Temperature of water:	°C	16.7	16.7
Conductivity of water:	µS/cm	93.1	93.1
Pre-wetting time:	min	> 15	> 15

Atmospheric correction factors K_f listed in “Ambient Air Conditions and Atmospheric Correction Factors” have to be considered for the external insulation.

Test arrangement				Test voltages	Result
No.	Condition	Voltage applied to	Earthed	kV	Test duration / disruptive discharges
1	Open	b	acABCF	275	1 min / 0
2	Open	B	abcACF	275	1 min / 0
3	Closed	bB	acACF	275	1 min / 0

Remarks: -

Test Results

Lightning Impulse Voltage Test

Test performed: Withstand voltage test
(phase-to-earth, between phases and across open switching device)

Date of test: December 01 - 02, 2014

Gas pressure (abs. at 20 °C): 0.60 MPa

Test arrangement:	1	2	3		
Date of test:	Dec. 02	Dec. 01	Dec. 02		
Front time T_1 :	0.97 μ s	1.11 μ s	1.11 μ s		
Time to half-value T_2 :	51.7 μ s	52.3 μ s	52.0 μ s		

Atmospheric correction factors K_t listed in "Ambient Air Conditions and Atmospheric Correction Factors" have to be considered for the external insulation.

Test arrangement				Test voltages	Result
No.	Condition	Voltage applied to	Earthed	kV	Number of impulses / disruptive discharges
1	Open	b	acABCF	+650	15 / 0
				-650	15 / 0
2	Open	B	abcACF	+650	15 / 0
				-650	15 / 0
3	Closed	bB	acACF	+650	15 / 0
				-650	15 / 0

Remarks: -

Test Results

Radio Interference Voltage Test

Test performed: Radio interference voltage measurement

Date of test: December 04, 2014

Gas pressure (abs. at 20 °C): 0.60 MPa

Test frequency: 50 Hz

Measuring frequency: 500 kHz

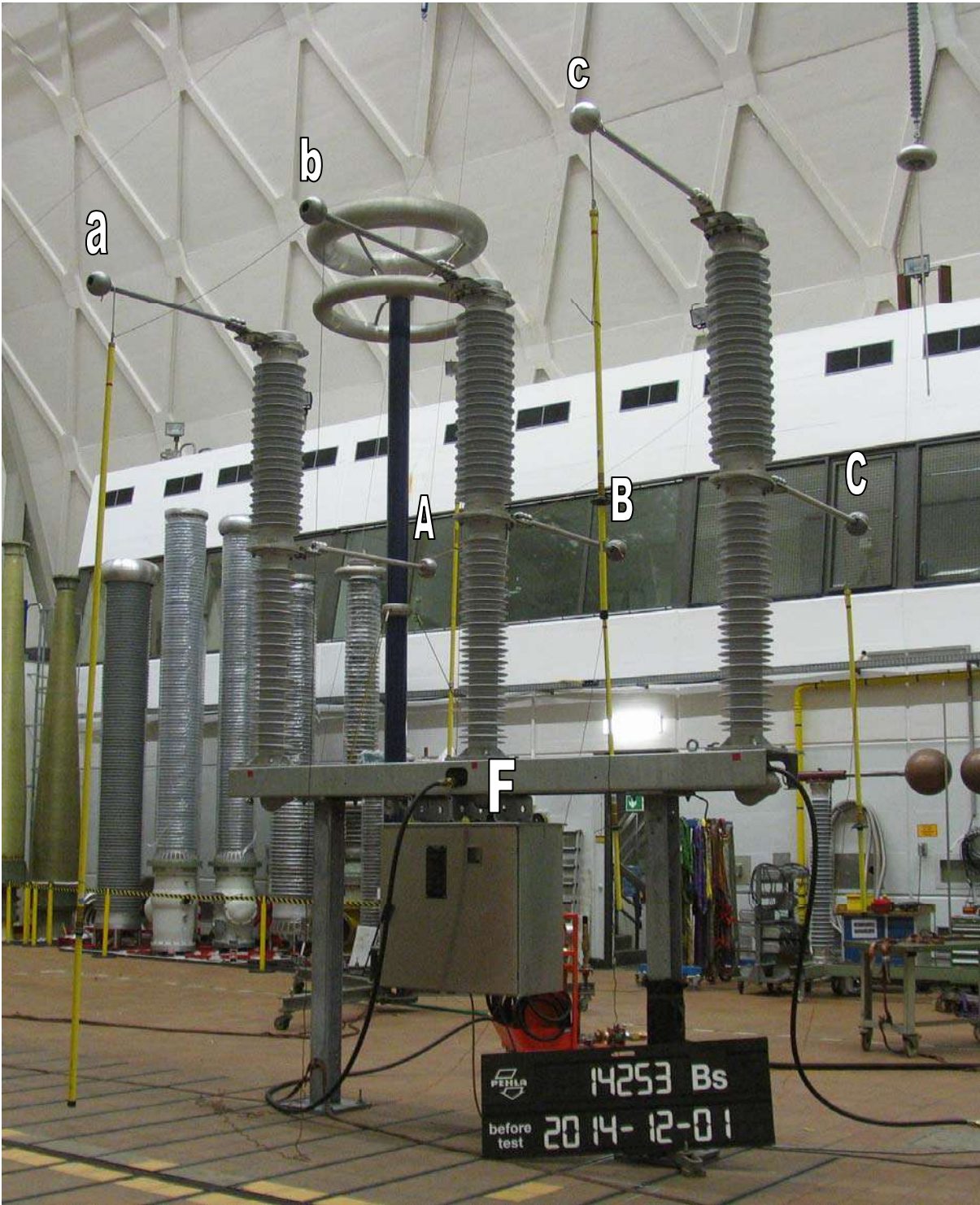
Background level: 10 μ V

An atmospheric correction of the test voltage values was not performed during these tests.

Test arrangement				Test voltages	Results of RIV-measurement at 300 Ω
No.	Condition	Voltage applied to	Earthed	kV	μ V
1	Open	b	acABCF	92	10
2	Open	B	abcACF	92	10
3	Closed	bB	acACF	92	10

Remarks: -

**Photo of Test Setup
Before Test**



**Photo of Test Setup
After Test**

