Test Report
No B25-19-AY-02E

ilac-MRA ENAC ENSAYOS Nº 4/LE148

Dielectrics, Temperature-rise, Degree of protection and Mechanical operation tests

TEST OBJECT	CAPACITOR BANK OF 6,3 kV
DESIGNATION	EARC 12kV
MANUFACTURER	CYDESA
CLIENT	CYDESA
	Pol. Ind. Sant Antoni, Parcela 2, Nave A 08620 Sant Vicenç dels Horts Barcelona
STANDARD	IEC 62271-200:2011
RECEPTION DATE	May 20th 2019
TEST DATE	May 21st -28th 2019
ISSUE DATE	June 27th 2019

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INDEX

1. TEST OBJECT IDENTIFICATION

CAPACITOR BANK OF 6.3 KV.

Characteristics of the test equipment are the following:

Manufacturer:	CYDESA
Designation:	EARC 12 kV
Serial no:	33097
Nominal voltage:	6.3 kV
Rated insulating voltage:	12 kV
Rated power frequency withstand voltage:	28 kV
Rated lightning impulse withstand voltage:	75 kV
Rated short-time withstand current:	31.5 kA, 1 s
Rated output:	1 MVAR
Frequency:	50 Hz

See photographs and drawings of the test object in the annex.

2. TESTS PLACE

Tests have been performed at TECNALIA'S Electrical Equipment Laboratories, located at the Scientific and Technological Park of Bizkaia, building 413–INGRID (Zamudio-Spain).

3. TESTS PERFORMED. STANDARD

- Dielectric tests
    - Lightning impulse test
    - Power frequency voltage test
- Temperature-rise test
- Degree of protection test IP 41
- Mechanical operation tests

Tests have been performed according to the following standards:

IEC 62271-200: 2011, “High-voltage switchgear and controlgear – Part 200: AC metal-enclosed switchgear and controlgear for rated voltages above 1 kV and up to and including 52 kV”.

Quoted standard:
IEC 62271-1:2011, “High-voltage switchgear and controlgear – Part 1: Common specifications”
IEC 60529:1989+A1:1999+A2:2013 “Degrees of protection provided by enclosures (IP Code)”

The calculation of the uncertainties of the measurements is available.

4. DIELECTRIC TESTS

4.1. Test configurations

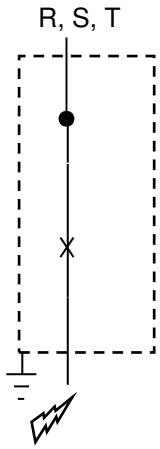
Full insulation withstand tests were performed for the following parts:

A. Adjacent insulation components and equipment
B. For capacitors insulated from ground, all insulation paths between any energized part of the capacitor and ground.

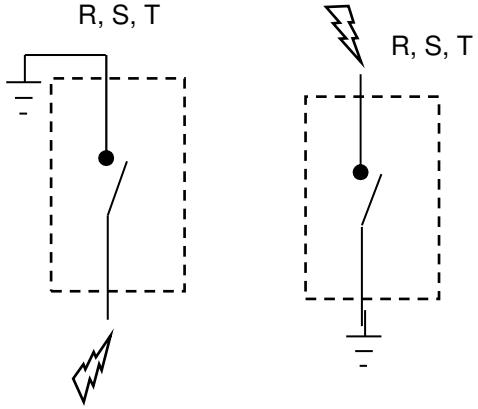
Tests A.

Tests have been performed according to IEC 62271-200, for insulation between phases, phase to ground and across the isolating distance (disconnector)

1- Between phases and phase to ground. With the contactor and the disconnector closed and the capacitor bank not connected, tests voltages of 75 kV lightning impulse and 28 kV power frequency have been applied.

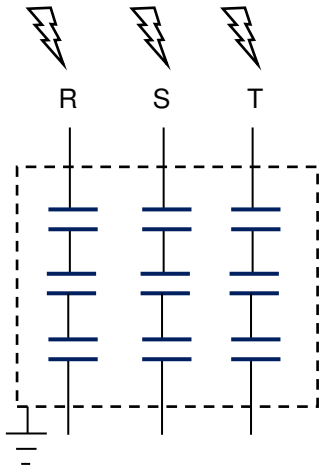


2- Across the isolating distance. With the disconnector opened to test the isolating distance. In this conditions and taking into account the isolation voltage, 85 kV lightning impulse and 32 kV power frequency, were applied phase by phase with the others earthed.



Test B

The voltage was applied in all phases together (including the capacitors) with the enclosure earthed. In this condition 75 kV lightning impulse and 28 kV power frequency were applied.



The configurations are listed in the table below:

Test configuration	Voltage applied to	Earth connected to	Voltage applied 50 Hz / Impulse	Result
1	Rr	SsTtF	28 kV / 75 kV	OK
	Ss	RrTtF	28 kV / 75 kV	OK
	Tt	RrSsF	28 kV / 75 kV	OK
2	R	SsTtF	32 kV / 85 kV	OK
	S	RrTtF	32 kV / 85 kV	OK
	T	RrSsF	32 kV / 85 kV	OK
	r	SsTtF	32 kV / 85 kV	OK
	s	RrTtF	32 kV / 85 kV	OK
	t	RrSsF	32 kV / 85 kV	OK
3	RST	F	28 kV / 75 kV	OK

F = frame

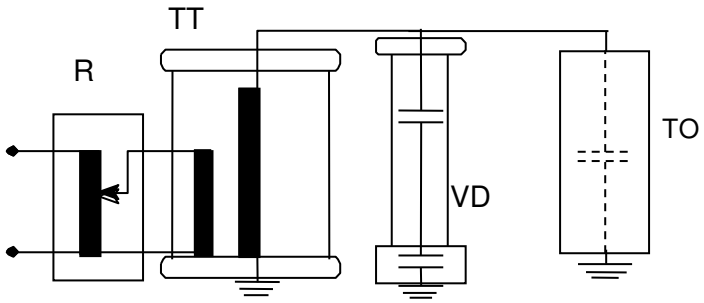
- *The isolating distance has been tested with the enclosure of the test object isolated from earth, and with the other phase to the same potential of the enclosure.*

4.2. Power-frequency voltage tests

Test voltage is raised for each test condition to the test value and maintained for 1 min.
Rated short- duration power-frequency withstands voltages have been:

- Phase-to-earth and between phases: **28 kV** (r.m.s. value)
- Across the isolating distance: **32 kV** (r.m.s. value)
- Test frequency: **50 Hz**

Test scheme



R: Regulator
TT: Test transformer
VD: Voltage divider
TO: Object test

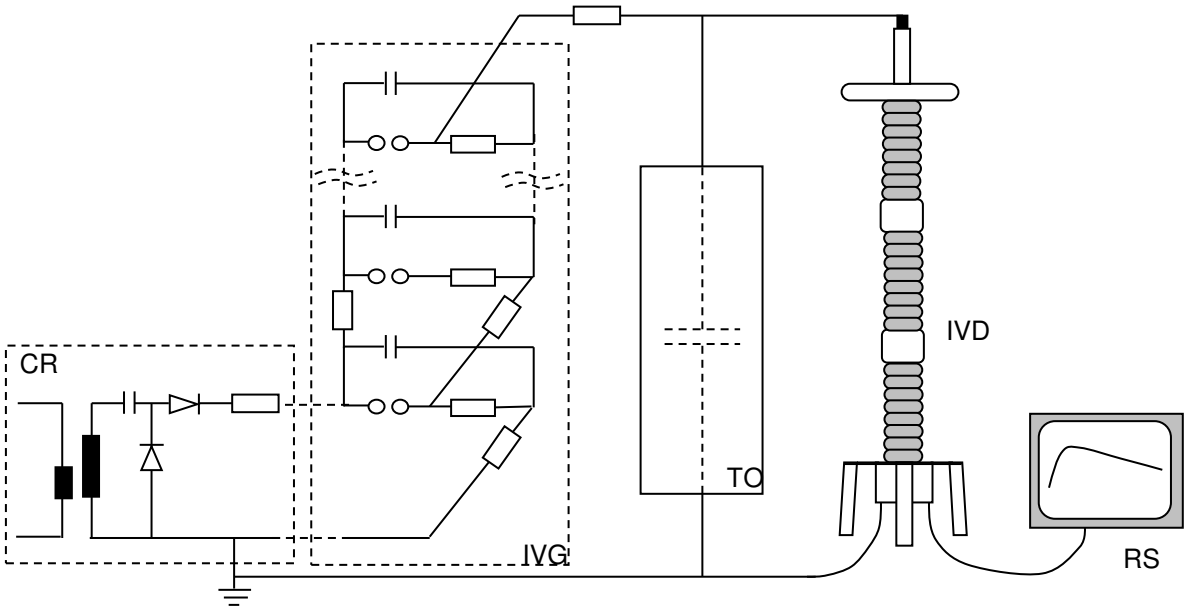
4.3. Lightning impulse voltage tests

Tests have been performed with voltages of both polarities using the standard lightning impulse 1.2/50 µs. 15 consecutive lightning impulses at the rated withstand voltage have been applied for each test condition and each polarity. Rated lightning impulse withstands voltage are the following:

- Phase-to-earth and between phases: **75 kV** (peak value)
- Across the isolating distance: **85 kV** (peak value)

Test is considered as passed if no more than two disruptive discharges occur in each of the tested series.

Test scheme:



CR:	Charging Rectifier
IVG:	Impulse voltage generator
TO:	Test object
IVD:	Impulse voltage divider
RS:	Recording system

4.4. Ambient air conditions

- Ambient temperature: 18 ºC
- Atmospheric pressure: 1011 mbar
- Relative humidity: 55 %

Calculated ambient air correction factor:1,00

4.5. Results

CORRECT. Test object satisfied dielectric tests.

4.5.1. Power-frequency voltage tests

CORRECT. No disruptive discharges occurred in any of the test configurations.

4.5.2. Lightning impulse voltage tests

CORRECT. No disruptive discharges occurred in any of the test configurations.

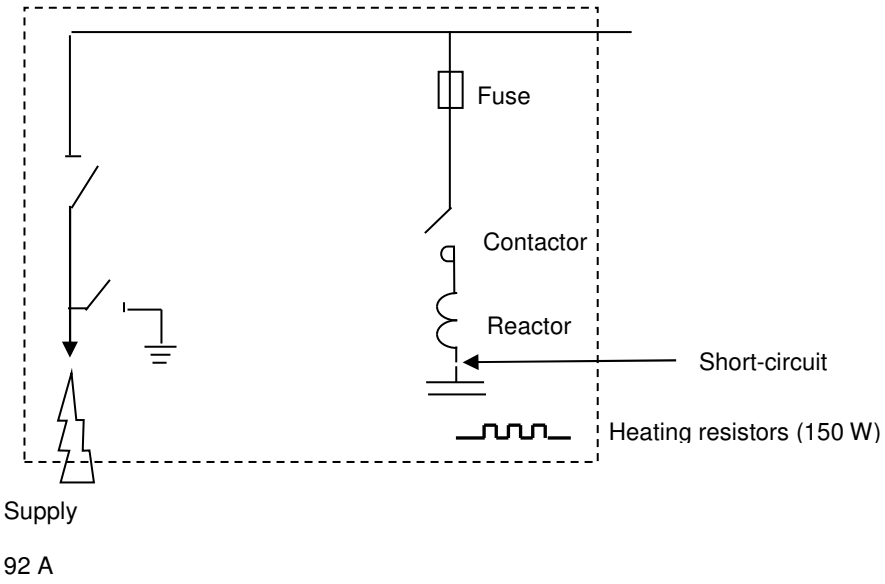
5. TEMPERATURE-RISE TEST

5.1. Test method

The test is performed indoor with an ambient substantially free from air currents, except those generated by the heat of the switch-disconnectors.

Time interval is long enough to achieve a stable value of temperature rise. This condition is assumed to be fulfilled when the variation of the air ambient temperature has not exceeded 1K in 1 h.

The test was performed as indicated in the following scheme:



The capacitors were disconnected for the test and replaced by resistors of equivalent power consumption. The capacitor was replaced by a resistor of 150 W.

The output of the exhausting duct is maintained open as in normal service.

The cross section of supply cables was 35 mm^2 (copper).

The temperature of each element for which limits are specified has been measured with thermocouples.

The ambient air temperature is the average temperature of the air around the panel. It is measured by means of three thermocouples equally distributed around the object, at a height approximately equal to the average height of its current-carrying parts and at a distance of about 1 m from the object. The thermocouples are protected against air currents and abnormal effects of heat.

In order to avoid reading errors due to sudden changes of temperature, thermocouples have been put into small bottles containing about 0.5 l of oil. In the last quarter of the whole period of test, the variation of the air ambient temperature has not exceeded 1K in 1 h.

The temperature-rise of each component refers to the air ambient temperature must not exceed the specified limits.

The location of the thermocouples is as follows (see also photographs in the annex):

Thermoc.	Location	Nature of the part	Material
1	Terminal for incoming conductors, phase R	Terminals for external conductors	Silver-coated
2	Terminal for incoming conductors, phase S	Terminals for external conductors	Silver-coated
3	Terminal for incoming conductors, phase T	Terminals for external conductors	Silver-coated
4	Upper bolted connection of disconnector, phase R	Bolted connections	Silver-coated
5	Upper bolted connection of disconnector, phase S	Bolted connections	Silver-coated
6	Upper bolted connection of disconnector, phase T	Bolted connections	Silver-coated
7	Moving contact of disconnector, phase R	Contacts	Silver-coated
8	Moving contact of disconnector, phase S	Contacts	Silver-coated
9	Moving contact of disconnector, phase T	Contacts	Silver-coated
10	Internal ambient, disconnector compartment	-	-
11	Bolted connection vertical to horizontal busbar, phase R	Bolted connections	Copper
12	Bolted connection vertical to horizontal busbar, phase S	Bolted connections	Copper
13	Bolted connection vertical to horizontal busbar, phase T	Bolted connections	Copper
14	Upper connection of the fuse, phase R	Bolted connections	Tin-coated
15	Upper connection of the fuse, phase S	Bolted connections	Tin-coated
16	Upper connection of the fuse, phase T	Bolted connections	Tin-coated
17	Lower connection of the fuse, phase R	Bolted connections	Tin-coated
18	Lower connection of the fuse, phase S	Bolted connections	Tin-coated
19	Lower connection of the fuse, phase T	Bolted connections	Tin-coated
20	Fuse surface	-	-
21	Input connection to contactor, phase R	Bolted connections	Silver-coated

Thermoc.	Location	Nature of the part	Material
22	Input connection to contactor, phase S	Bolted connections	Silver-coated
23	Input connection to contactor, phase T	Bolted connections	Silver-coated
24	Output connection to contactor, phase R	Bolted connections	Silver-coated
25	Output connection to contactor, phase S	Bolted connections	Silver-coated
26	Output connection to contactor, phase T	Bolted connections	Silver-coated
28	Enclosure of the contactor	-	-
29	Connection to the insulator of the capacitor, phase R	Bolted connections	Tin-coated
30	Connection to the insulator of the capacitor, phase S	Bolted connections	Tin-coated
31	Connection to the insulator of the capacitor, phase T	Bolted connections	Tin-coated
33	Lower connection of reactor, phase R	Bolted connections	Bare-copper
34	Upper connection of reactor, phase R	Bolted connections	Bare-copper
35	Reactor surface	Materials used as insulation	Class F
36	Enclosure, front	Accessible parts	Need not to be touched in normal op.
37	Enclosure, right	Accessible parts	Need not to be touched in normal op.
38	Enclosure, left	Accessible parts	Need not to be touched in normal op.
39	Enclosure, rear	Accessible parts	Need not to be touched in normal op.
40	Enclosure, top	Accessible parts	Need not to be touched in normal op.

5.2. Test parameters

Test current: 92 A

Capacitor power dissipation: 150 W

5.3. Results

Thermoc.	Location	Measured values		Limits	
		ºC	K	ºC	K
1	Terminal for incoming conductors, phase R	28	8	105	**65**
2	Terminal for incoming conductors, phase S	27	7	105	**65**
3	Terminal for incoming conductors, phase T	28	8	105	**65**
4	Upper bolted connection of disconnector, phase R	26	6	115	**75**
5	Upper bolted connection of disconnector, phase S	26	6	115	**75**
6	Upper bolted connection of disconnector, phase T	26	6	115	**75**
7	Moving contact of disconnector, phase R	26	6	105	**65**
8	Moving contact of disconnector, phase S	26	6	105	**65**
9	Moving contact of disconnector, phase T	26	6	105	**65**
10	Internal ambient, disconnector compartment	29	8	-	**-**
11	Bolted connection vertical to horizontal busbar, phase R	37	17	90	**50**
12	Bolted connection vertical to horizontal busbar, phase S	35	15	90	**50**
13	Bolted connection vertical to horizontal busbar, phase T	34	14	90	**50**
14	Upper connection of the fuse, phase R	42	22	105	**65**
15	Upper connection of the fuse, phase S	43	23	105	**65**
16	Upper connection of the fuse, phase T	44	24	105	**65**
17	Lower connection of the fuse, phase R	49	29	105	**65**
18	Lower connection of the fuse, phase S	50	30	105	**65**
19	Lower connection of the fuse, phase T	50	30	105	**65**
20	Fuse surface	85	65	110	**70**
21	Input connection to contactor, phase R	39	19	115	**75**
22	Input connection to contactor, phase S	39	19	115	**75**
23	Input connection to contactor, phase T	39	19	115	**75**
24	Output connection to contactor, phase R	39	19	115	**75**
25	Output connection to contactor, phase S	41	21	115	**75**
26	Output connection to contactor, phase T	39	19	115	**75**
28	Enclosure of the contactor	36	16	115	**75**
29	Connection to the insulator of the capacitor, phase R	40	20	105	**65**
30	Connection to the insulator of the capacitor, phase S	40	20	105	**65**

Thermoc.	Location	Measured values		Limits	
		ºC	K	ºC	K
31	Connection to the insulator of the capacitor, phase T	41	21	105	**65**
33	Lower connection of reactor, phase R	34	14	90	**50**
34	Upper connection of reactor, phase R	41	21	90	**50**
35	Reactor surface	50	30	155	**115**
36	Enclosure, front	44	24	70	**30**
37	Enclosure, right	28	8	80	**40**
38	Enclosure, left	23	3	80	**40**
39	Enclosure, rear	29	9	80	**40**
40	Enclosure, top	29	9	80	**40**

Ambient temperature: 20 ºC

Result: **CORRECT.** All the values fulfil the specified limits and the resistance of the contacts was not increased by more than 20 %.

The measurement of the contacts resistance was the following (in μΩ):

Measuring point: Between the input terminals and the upper terminals of the fuses.

PHASE	BEFORE (20 ºC)	AFTER (21 ºC)	DIFFERENCE
R	160	165	3.1
S	159	151	- 5.0
T	137	139	1.5

Measuring point: Between the lower terminals of the fuses and the star point.

PHASE	BEFORE (20 ºC)	AFTER (21 ºC)	DIFFERENCE
R	5577	5861	5.1
S	5778	6086	5.3
T	5620	5925	5.4

6. DEGREE OF PROTECTION (IP41)

6.1. Protection against access to dangerous areas (IP4X)

To meet the requirements according to the first characteristic 4 the access probe of 1 mm Ø applied with a force of 1 N ± 10% shall not penetrate into the enclosure.

Ambient air conditions: 19 ºC – 66% HR – 1011 mbar.

Result. **CORRECT.** The test gauge did not penetrate into the enclosure.

6.2. Protection against access of foreign particles (IP4X)

To meet the requirements according to the first characteristic 4, the object probe, of 1 mm Ø applied with a force of 1 N ± 10% no penetration is permitted (the whole diameter of the test probe shall not pass through any opening of the enclosure).

Atmosphere air conditions: 19 ºC – 66% HR – 1011 mbar.

Result: **CORRECT**. The object probe does not penetrate into the enclosure.

6.3. Protection against water (IPX1) for outdoor

The test is carried out spraying the test sample for 10 minutes, using a drip box that produces a uniform flow of water droplets on the entire surface of the enclosure. The application distance is 200 mm above the highest part of the sample and the water flow rate of 1 mm / minute.

Ambient air conditions: 19 ºC – 66% HR – 1011 mbar.

Water temperature: 16 ºC.

Result: **CORRECT.** No water entry was observed inside the sample.

7. MECHANICAL OPERATION TESTS

7.1. Switching devices and removable parts

The contactor, the incoming disconnector and the earthing switch must be operated 50 times (CO) when installed in the metal enclosed switchgear.

Result: **CORRECT**. The 50 operations on the switching devices were satisfactorily performed.

7.2. Mechanical interlocks

The interlocks must be set in all positions intended to prevent the operation of the switching devices and the access to operation interfaces.

1) 25 attempts to open any interlocked door or cover

With the handle of the front door in open position and the locking key blocking the opening of the door 25 opening attempts were performed.

Result: **CORRECT**

With the handle blocked by its key, 25 attempts of spinning the handle were performed.

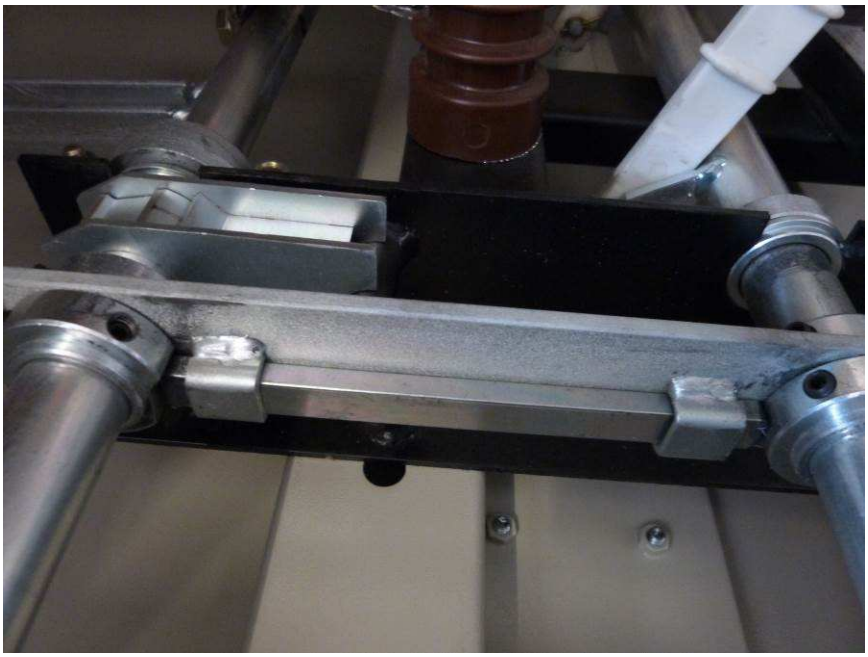
Result: **CORRECT**

2) 50 Attempts to operate the switching devices manually

With the earthing-switch closed 50 attempts to close the disconnector were performed.

With the disconnector closed 50 attempts of closing the earthing switch were performed.

As there is an interlock blocking the operating shaft a force of 750 N was applied to the operating handle:



Interlock blocking the shaft

750 N applied

Result: **CORRECT**. The switching devices cannot be operated during the test attempts and after the tests they continue being operative with no significative damages.

3) 10 Attempts to operate the switching device manually in the wrong direction

The disconnector and the earthing switch are tested.

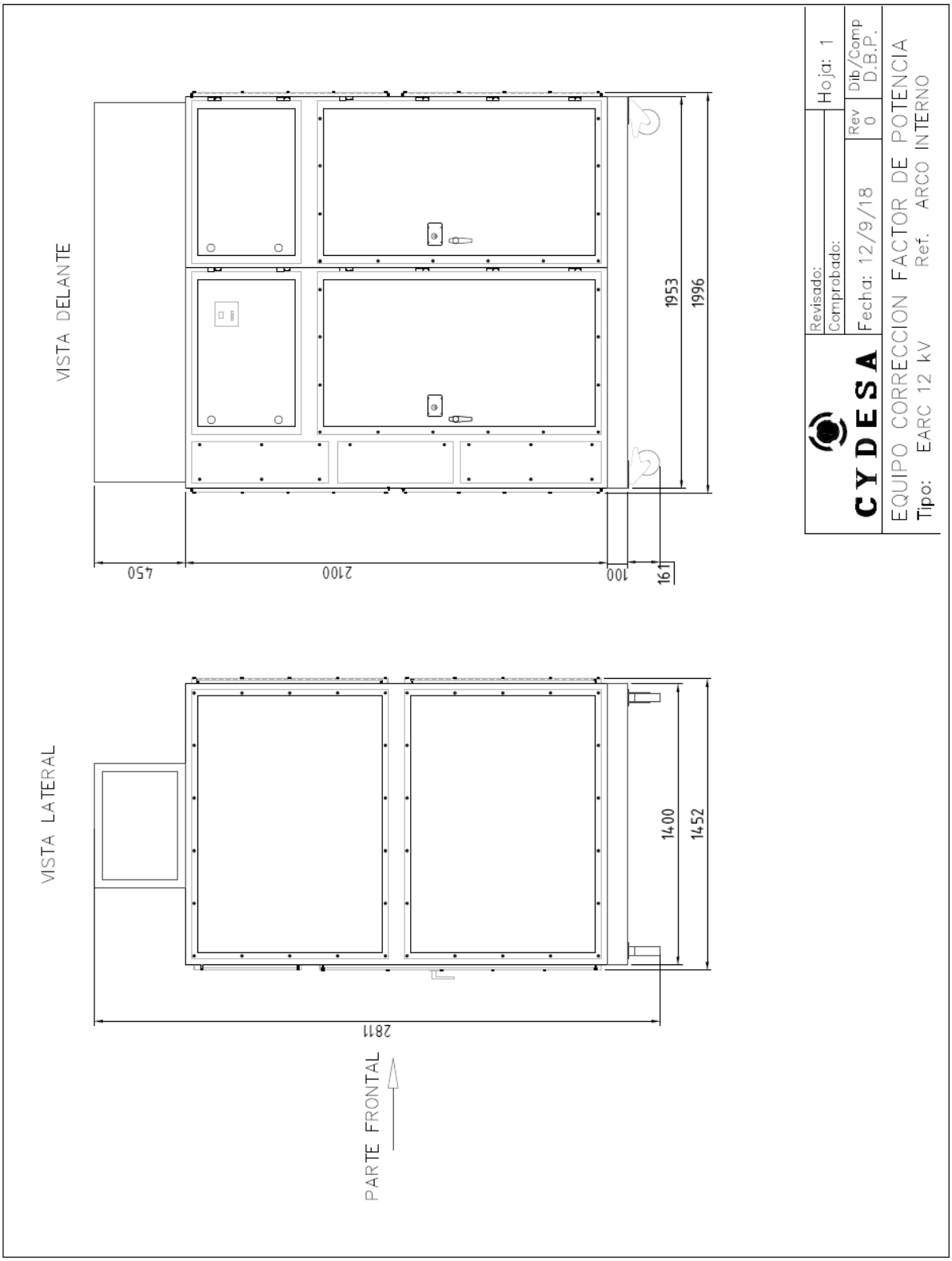
Result: **CORRECT**. The switching devices cannot be operated in the wrong direction.

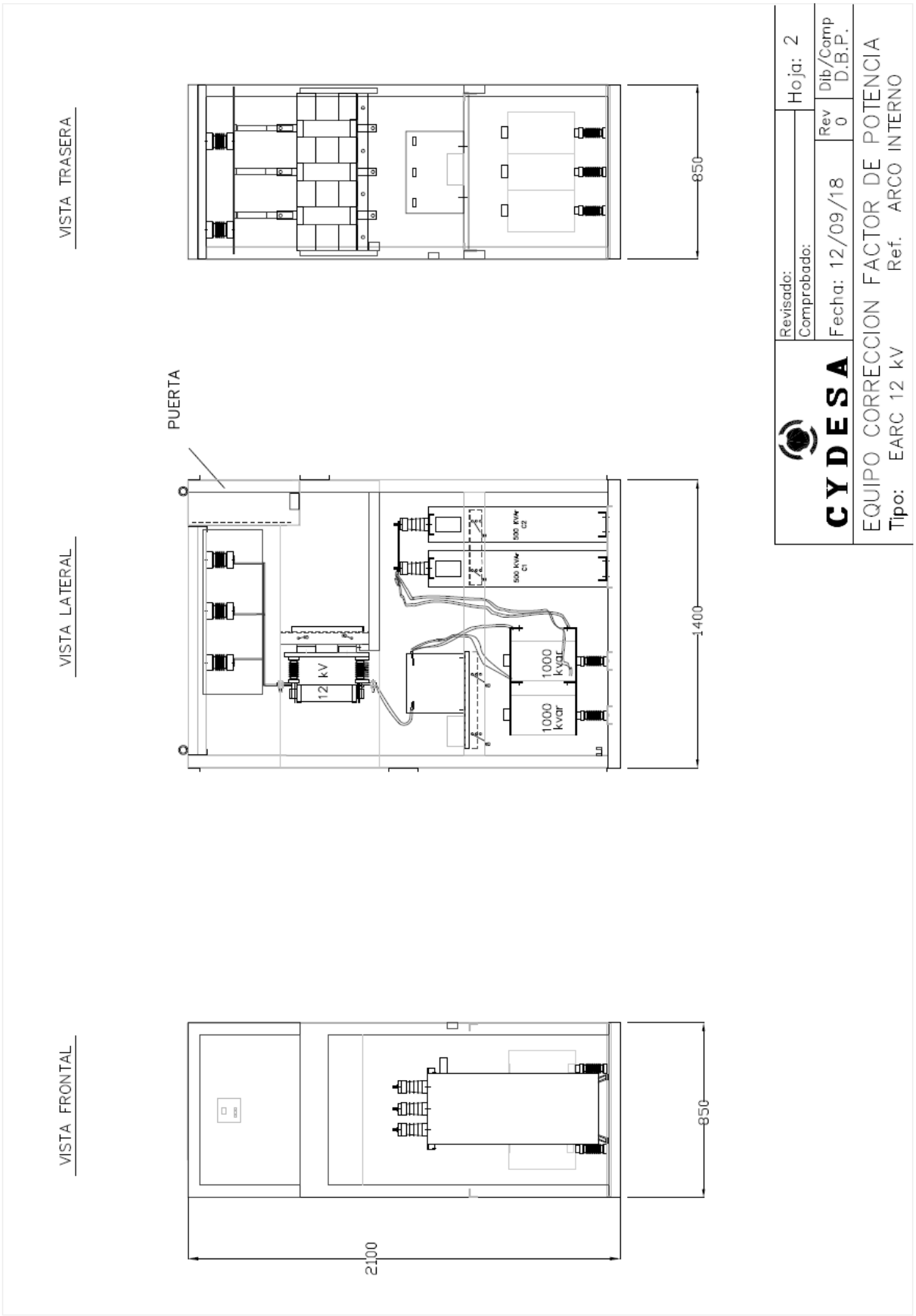
4) 50 Attempts to access to the operation interface with the earthing switch closed and the locking key removed.

The same 50 access attempts with the disconnector closed.

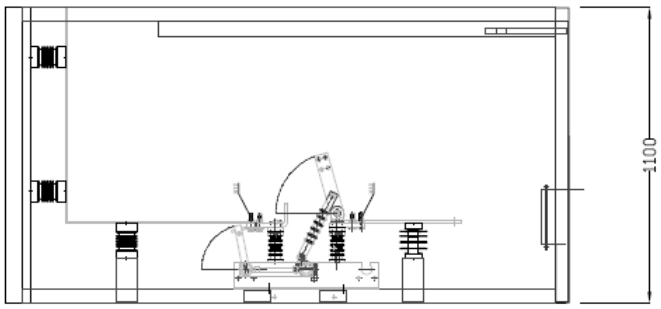
Result: **CORRECT**.

8. ANNEX 1. DRAWINGS

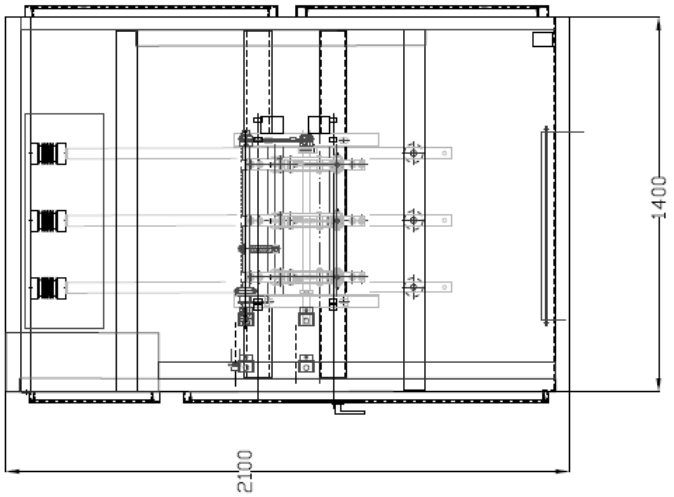



VISTA TRASERA
850
PUERTA
VISTA LATERAL
1400
500 KVAr C2
500 KVAr C1
1000 kvar
1000 kvar
12 kV
VISTA FRONTAL
850
2100
Revisado:
Comprobado:
Hoja: 2
CYDESA
Fecha: 12/09/18
Rev 0
Dib/Comp D.B.P.
EQUIPO CORRECCION FACTOR DE POTENCIA
Tipo: EARC 12 kV
Ref. ARCO INTERNO

VISTA FRONTAL



VISTA LATERAL



CYDESA	Revisado:	Hoja: 3	
	Comprobado:		
	Fecha: 12/9/18	Rev 0	Dib/Comp D.B.P.

EQUIPO CORRECCION FACTOR DE POTENCIA
Tipo: EARC 12 kV Ref. ARCO INTERNO

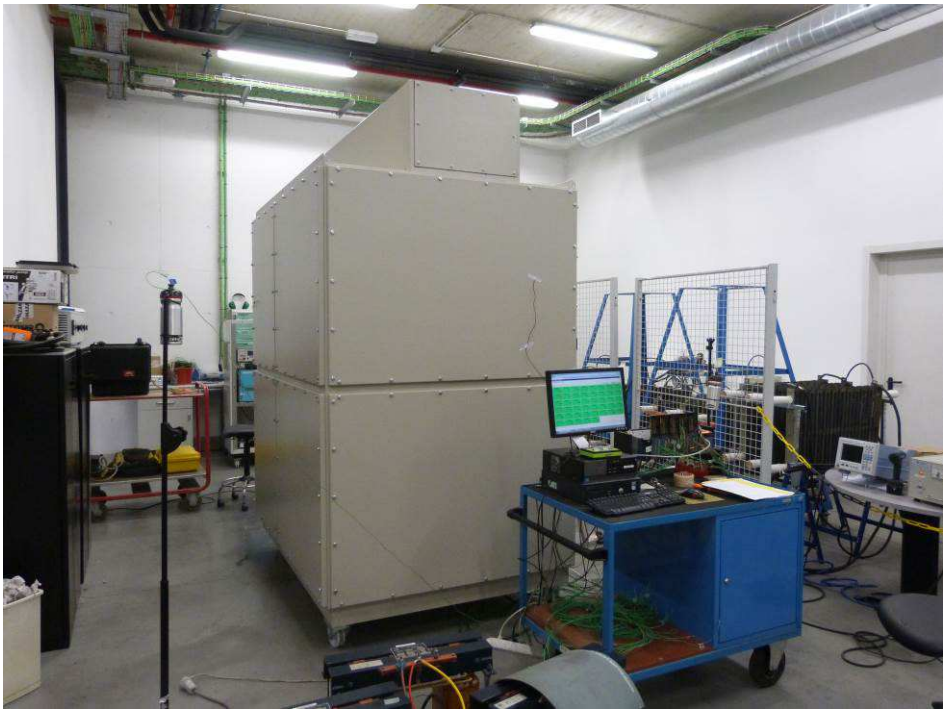
9. ANNEX 2. PHOTOGRAPHS

Test object

Rating plate

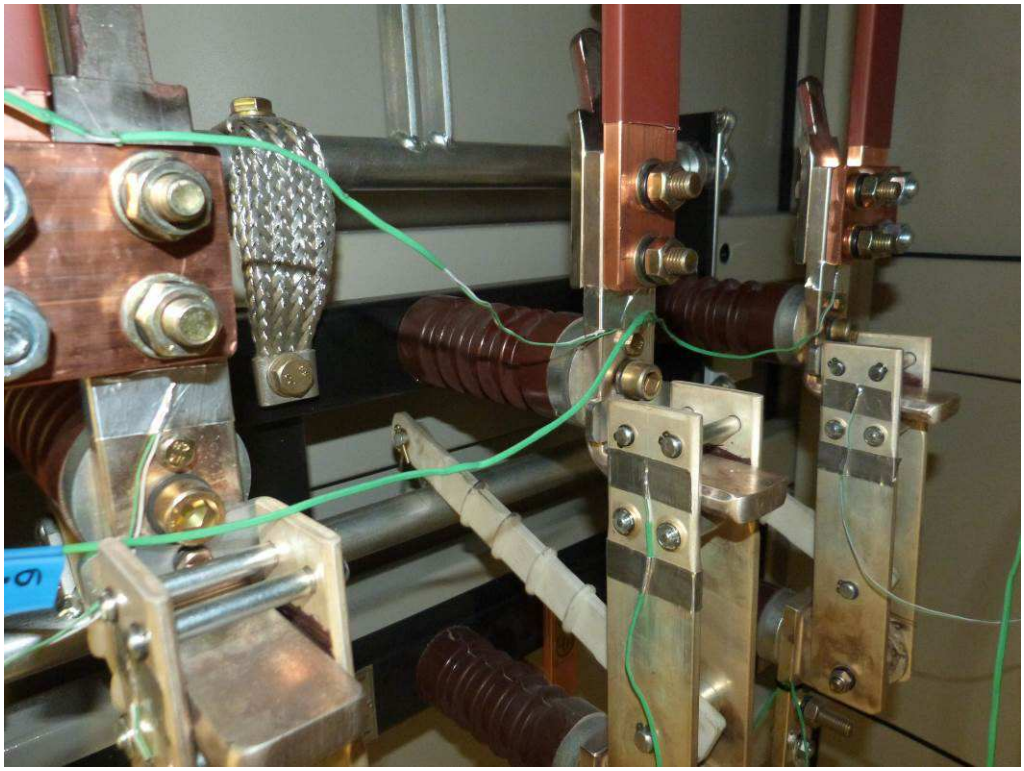
Dielectric tests arrangement

Incoming disconnector



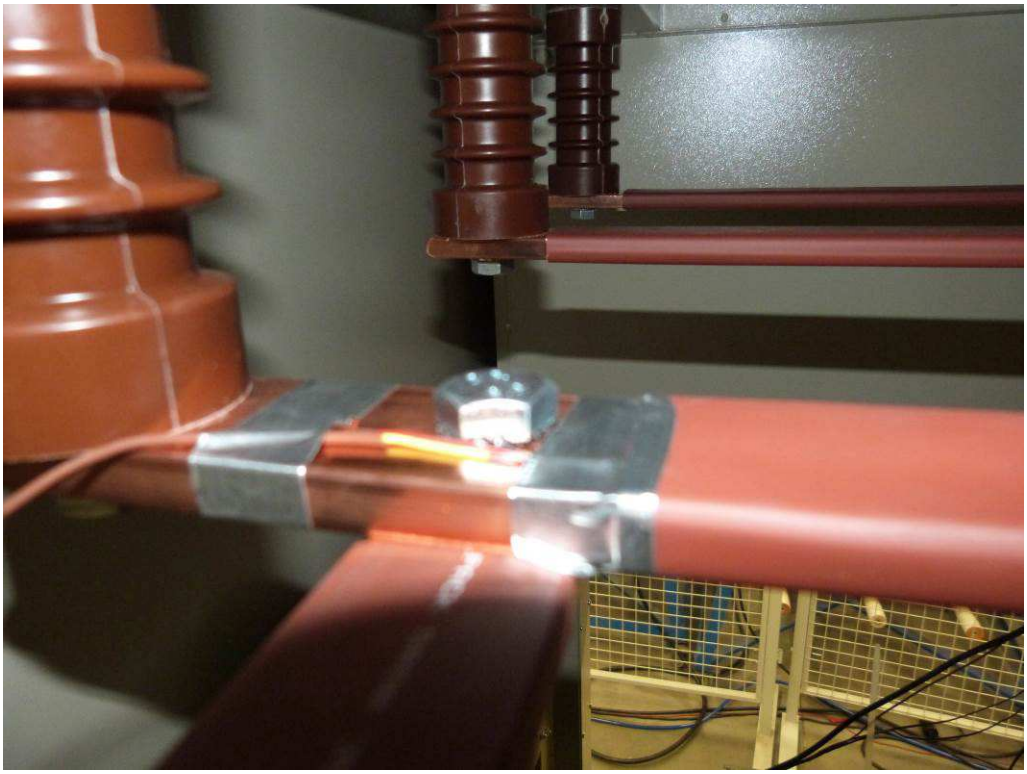
Temperature-rise test arrangement

Thermocouples placed in the incoming disconnector



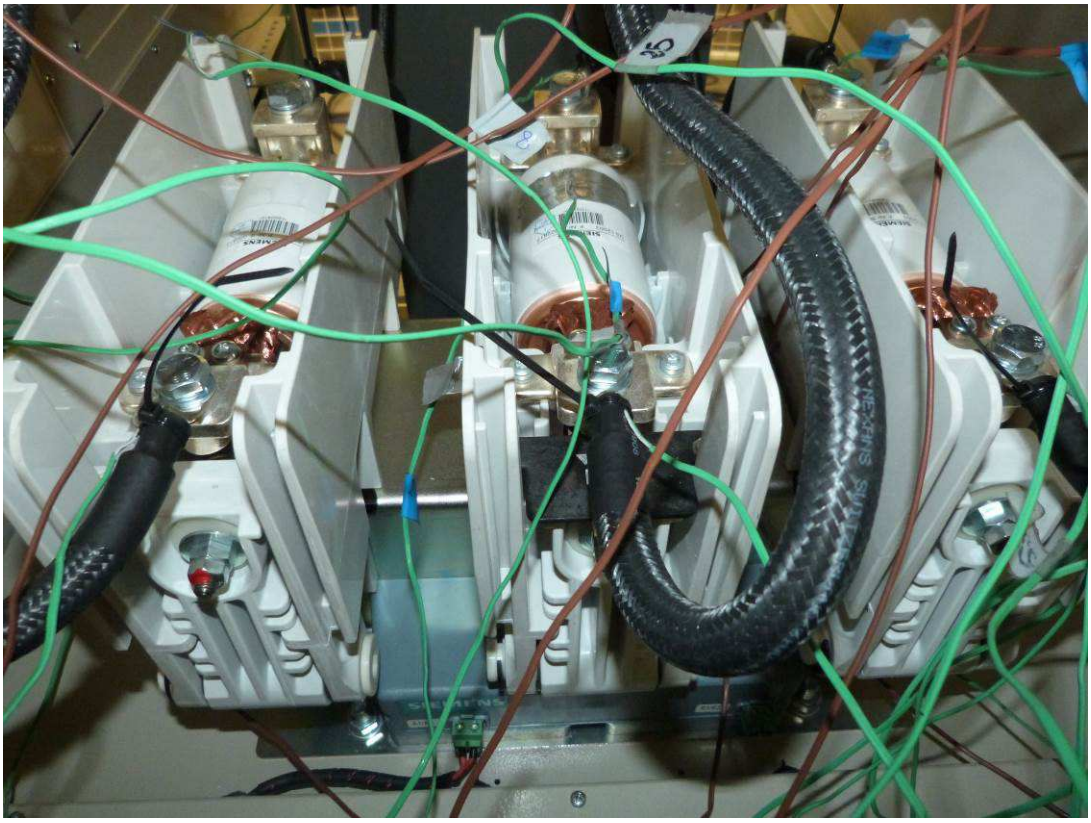
Detail of Thermocouples in the incoming disconnector

Heating resistor

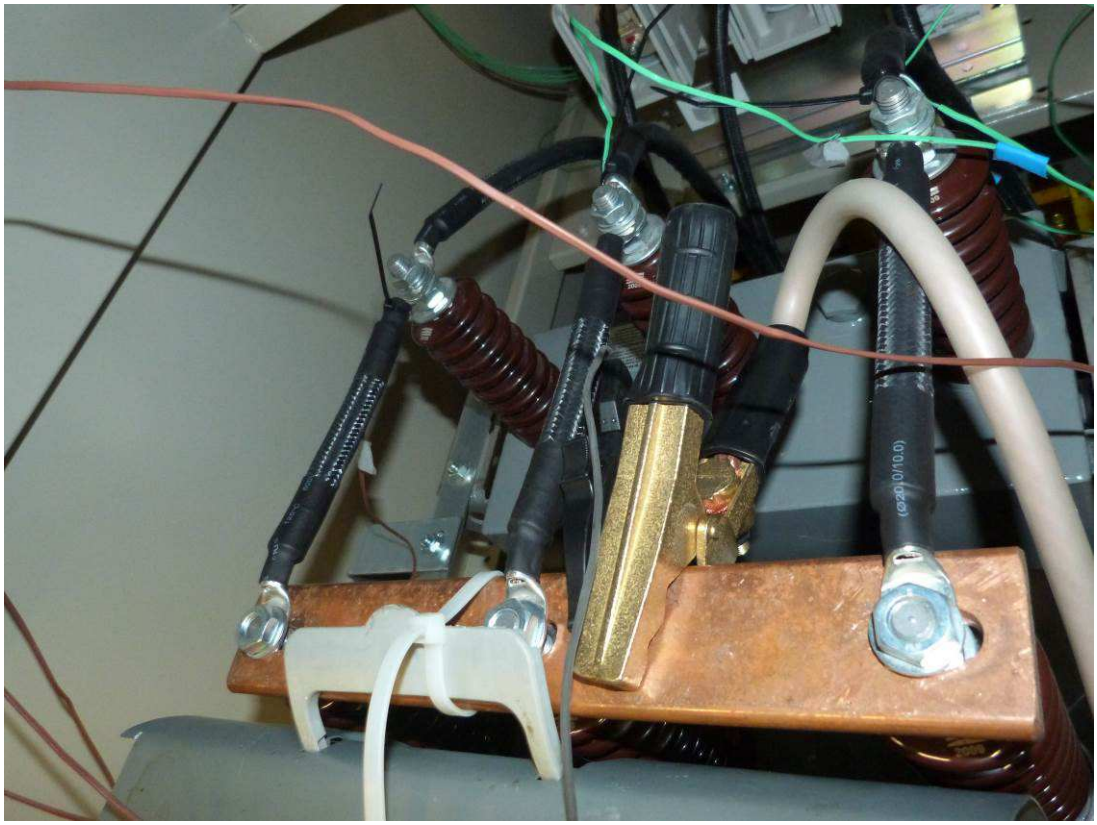


Thermocouple in the connection between bars

Thermocouples in the fuses area

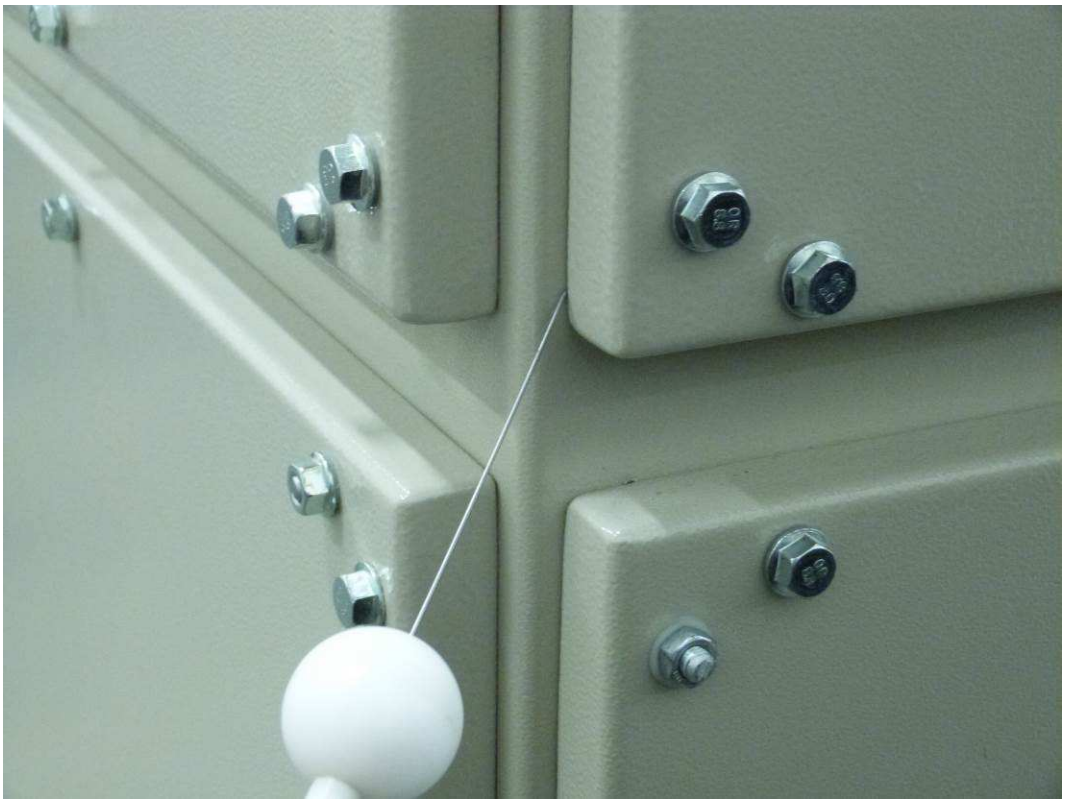


Thermocouples in the contactor area



Star point with the capacitor short-circuited (during contact resistance measurement)

Thermocouples in the reactor



IP 4X

IP X1 Test

IP X1 Test