ВИПРОБУВАЛЬНА ЛАБОРАТОРІЯ
ТзОВ ВКФ «ЛІЗО»

TESTING LABORATORY
of the "LIZO Ltd."

201383
Випробування / Testing

Атестат акредитації
№ 201383
Дійсний до
25 листопада 2026 року

79035, Україна, м. Львів
вул. М.Пимоненка, 3
тел.:(032) 294-82-87,
e-mail: lablizo@ukr.net

Accreditation certificate
№ 201383
Expiry date:
25 November, 2026

79035, Ukraine, Lviv
st. Pymonenka, 3
Tel. :(032) 294-82-87,
e-mail: lablizo@ukr.net

Approved by
The head of the
testing laboratory of "LIZO Ltd."
D.R. Dovgun
«01» 07 2024

TESTING REPORT № 07/24

of the mechanical cable connectors ZSSN 150-240/6S 36kV

Requirements: IEC 61238-1-3:2018, manufacturer specifications

The test methods: IEC 61238-1-3:2018.

Product name:	**Mechanical cable connector**
Model and type:	**ZSSN 150-240/6S 36kV**
Manufacturer:	**Company RADPOL S.A** **Poland, Człuchow (27-300), st. Batorego 14**
Customer:	**PE "VKF "Soznanie"** **Ukraine, Kyiv region, Obukhiv district, Ukrainka, Dniprovskyi avenue, building 20, office 55 by proxy of the company RADPOL S.A. from January 11, 2024**
Reason:	**Contract № 3-02-24 of 08.02.2024**
Testing results:	***Mechanical cable connectors ZSSN 150-240/6S 36kV with copper – copper, aluminum – aluminum, aluminium –copper conductor combinations have passed the tests, satisfy requirements of IEC 61238-1-3:2018 and manufacturer specifications.*** *(the testing results are given at the additional testing reports №№ 07/24-1 … 07/24-2, which is the integral part of this testing report)*

Lviv - 2024

List and numbers of the testing reports where the testing results are given

Test	Testing report
1. Electrical tests (IEC 61238-1-3:2018 clause 6)	07/24-1
2. Mechanical tests (IEC 61238-1-3:2018 clause 7)	07/24-2

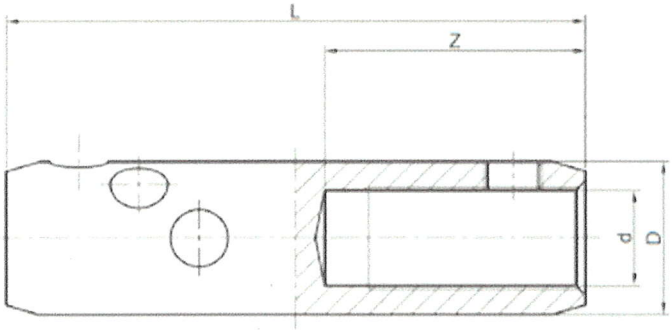
ВИПРОБУВАЛЬНА ЛАБОРАТОРІЯ "ЛІЗО"

CHARACTERISTICS

Name:	Mechanical cable connector.
Manufacturer:	Company RADPOL S.A
Model and type:	ZSSN 150-240/6S 36kV.
Purpose:	They are used to connect aluminum, copper, as well as a combination of copper-aluminum, round and sector, solid and multi-wire cable conductors, for voltages up to 36kV.

Technical characteristics

Class:	A1.
Conductor cross-sections:	(150 – 240) mm^2.
The bolt tightening torque:	(34 ± 2) Nm.
Batch number:	03/24.
Dimensions (L / Z / D / d):	(120 / 54 / 32 / 20) mm.



The tests were performed by:

Deputy Head of the testing laboratory:	_____	S. S. Lakhovskyi
Engineer:	_____	O. O. Nepyivoda
Engineer:	_____	D. S. Denys
Engineer:	_____	A. S. Shevtsiv

ВИПРОБУВАЛЬНА ЛАБОРАТОРІЯ "ЛІЗО"

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testing laboratory of "LIZO Ltd."

_____ D. R. Dovgun
«_____» _____ 2024

TESTING REPORT № 07/24-1

Electrical tests of the mechanical cable connectors ZSSN 150-240/6S 36kV

Requirements: IEC 61238-1-3:2018 clause 6.6.

The test methods: IEC 61238-1-3:2018 clause 6.1…clause 6.5.

Product name:	**Mechanical cable connector**
Model and type:	**ZSSN 150-240/6S 36kV**
Manufacturer:	**Company RADPOL S.A** **Poland, Człuchow (27-300), st. Batorego 14**
Customer:	**PE "VKF "Soznanie"** **Ukraine, Kyiv region, Obukhiv district, Ukrainka, Dniprovskyi avenue, building 20, office 55 by proxy of the company RADPOL S.A. from January 11, 2024**
Reason:	**Contract № 3-02-24 of 08.02.2024**
Testing results:	***Mechanical cable connectors ZSSN 150-240/6S 36kV with copper – copper, aluminum – aluminum, copper – aluminum conductor combinations have passed the electrical tests, satisfies requirements of IEC 61238-1-3:2018 clause 6 and manufacturer's specifications.***

Lviv - 2024

Samples' receiving date:	26.03.2024.
Quantity of the tested samples:	36.
Identification numbers of the samples:	№1 … №36.
The testing dates:	28.03.2024 - 25.06.2024.
The testing place:	Testing laboratory of "LIZO Ltd" 3, Pymonenka str., Lviv
The environmental conditions:	
temperature:	(20 – 26) °C;
air pressure:	(96 – 101) kPa;
humidity:	(45 – 75) %.

1. Tested samples:

Mechanical cable connectors:

Manufacturer:	Company RADPOL S.A.
Model and type:	ZSSN 150-240/6S 36kV.
Class:	A1.
Main conductor cross-sections:	(150 – 240) mm^2.
The bolt tightening torque:	(34 ± 2) Nm.
Batch number:	03/24.

Conductors:

Conductor material:	Copper	Copper
Conductor cross-section:	240 mm^2	150 mm^2
Conductor diameter:	18,8 mm	15,2 mm
Shape:	Round	Round
Class in accordance with IEC 60228:	Stranded	Stranded
Compacted:	Uncompacted	Uncompacted
Number and placement of layers:	3	3
Type of coating:	No cover	No cover
Type of impregnation:	Without impregnation	Without impregnation

Conductor material:	Aluminum	Aluminum
Conductor cross-section:	240 mm^2	150 mm^2
Conductor diameter:	19,0 mm	15,4 mm
Shape:	Round	Round
Class in accordance with IEC 60228:	Stranded	Stranded
Compacted:	Uncompacted	Uncompacted
Number and placement of layers:	2	2
Type of coating:	No cover	No cover
Type of impregnation:	Without impregnation	Without impregnation

ВИПРОБУВАЛЬНА ЛАБОРАТОРІЯ "ЛІЗО"

2. Testing procedure:

The tests are performed in accordance with IEC 61238-1-3:2018 clause 6.

Circuits are mounted with the maximum cross-section of conductors and combinations of copper – copper, aluminum – aluminum, aluminum – copper and circuits with the minimum cross-section of conductors and similar combinations.

The conducting paths lengths and configuration are specified in accordance with Table 1 and Fig.2 in accordance with IEC 61238-1-3:2018.

Table 1 – The conducting paths lengths in circuit

№	The connecting paths lengths, mm			
	l_a	l_b	l_r	d
1	240	240	600	1240
2	190	190	500	980

Mechanical connectors are installed in accordance with manufacturer's installation instructions.

The temperature of the reference conductors and the connectors is measured by the resistive temperature transducer in the points which corresponds IEC 61238-1-3:2018 clause 6.2.3.

The electrical resistance of the connectors and the reference conductors are measured between two adjacent measurement points (points of the potential balancing) under the direct current. Measurements are performed by volt-ammeter method. The resistance is calculated by division of the voltage drop to the direct current value which is not more than 10 % of the heat cycle current value. Direct current and voltage drop measurement is performed with the precision of measurements within the range ± 0,5 %.

A total of 1000 heating-cooling cycles are performed during the tests. Heating-cooling is carried out in accordance with the thermal cycle profile presented in Fig. 1.

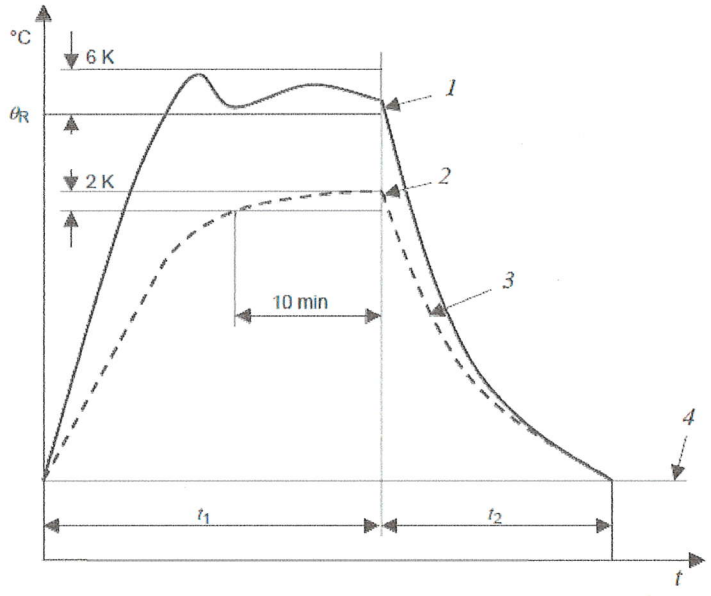
Measurements of the temperature and resistance valuation are made for the next cycles:

- 0 (before the heat cycle), only valuation of the resistance;
- 200, before short circuit;
- 200, after short circuit;
- 250;
- else after each 75 cycles (14 measurements in sum).

Temperature measurement and resistance valuation are provided for the reference conductors and for each connector. The results are documented. Maximum temperatures of the reference conductors and of each connector are fixed immediately before or after the heat cycle.

The resistance of each sample of the circuit is measured before the first heat cycle. The purpose of the first heat cycle is to determine the reference conductor temperature for its application in subsequent cycles and to identify the median temperature connector. When testing a circuit with a combination of aluminum - copper conductors, the control temperature is determined for the aluminum conductor.

Equilibrium is reached when the reference conductor and the connectors do not vary in temperature by more than ± 2 K.



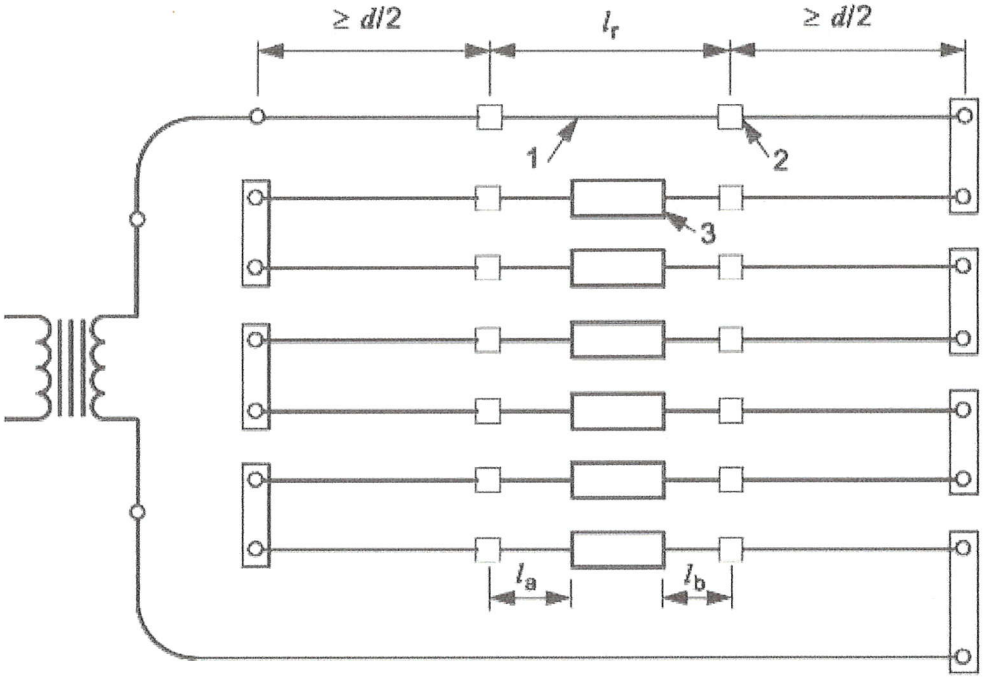
1. Reference conductor temperature;
2. Median connector temperature does not differ by more than 3 K compared to cycle 1 when equilibrium is reached;
3. Median connector temperature;
4. ≤35 °C for all connectors and reference conductor.

Fig.1 – Profile of the second heat cycle

Six short-circuits are applied for each connector from the testing loop after 200 cycles of heating and cooling. The short-circuit test is performed by short impulses. The short-circuit test current level shall be such, that it raises the reference conductor from a temperature ≤35 °C to a temperature between 250 °C and 270 °C. Calculated in accordance with Annex D IEC 61238-1-3:2018. The testing loop is cooled to the temperature ≤ 35 ^{0}C after each impulse.

The measurements results evaluation and the calculation of the following parameters are performed after 1000 cycles of heating-cooling in accordance with Annex F IEC 61238-1-3:2018:

- the connector resistance factor k for each of the six connectors at all the measurement intervals;
- the initial scatter δ, between six initial values of k_o, calculated before heat cycle;
- the mean scatter β, between the six values of k, averaged over the last 11 measurement intervals;
- the change in resistance factor D for each of the six connectors; D is the change in the value of k taken over the last 11 measurement intervals, calculated as a fraction of the mean value of k in this interval;
- the resistance factor ratio λ, calculated as the ratio between resistance factor for each connector found at any stage of the measurement series to the resistance factor of the same connector measured at cycle no. zero, calculated for last 11 measurements;
- the maximum temperature θ_{max} on each connector;



$d \geq 80\sqrt{A}$ or 500 mm, whichever is the greater;
A – cross section of the conductor (mm²);
$l_r \geq l_a + l_b + l_j$;
for stranded conductors:
l_a, $l_b = 15\sqrt{A}$ or 150 mm, whichever is the greater;

1. Reference conductor;
2. Equalizers (for stranded conductors);
3. Connectors

Fig.2 – Testing loop

3. Requirements:

Table 2 – Test requirements

№	Parameter	Maximum value
1	Initial scatter δ	0,3
2	Mean scatter β	0,3
3	Change in resistance factor D	0,15
4	Resistance factor ratio λ	2,0
5	Maximum temperature θ_{max}	θ_{ref}

ВИПРОБУВАЛЬНА ЛАБОРАТОРІЯ "ЛІЗО"

4. Testing results:

4.1. Connectors testing results in circuit with maximum conductor's cross-section 240 mm² and a combination of copper – copper (circuit 1)

Table 3 – Resistance factor k, resistance factor ratio λ and change in resistance factor D*

№	Cycle	Connector №1		Connector №2		Connector №3		Connector №4		Connector №5		Connector №6	
		Factor *k*	Factor ratio λ	Factor *k*	Factor ratio λ	Factor *k*	Factor ratio λ	Factor *k*	Factor ratio λ	Factor *k*	Factor ratio λ	Factor *k*	Factor ratio λ
1	0	0,549	-	0,605	-	0,531	-	0,576	-	0,612	-	0,556	-
2	200	0,587	1,07	0,684	1,13	0,571	1,08	0,658	1,14	0,694	1,13	0,602	1,08
3	200	0,595	1,08	0,701	1,16	0,580	1,09	0,674	1,17	0,697	1,14	0,613	1,10
4	250	0,609	1,11	0,733	1,21	0,589	1,11	0,713	1,24	0,733	1,20	0,639	1,15
5	325	0,616	1,12	0,777	1,29	0,607	1,14	0,739	1,28	0,755	1,23	0,658	1,18
6	400	0,632	1,15	0,793	1,31	0,619	1,17	0,769	1,33	0,771	1,26	0,671	1,21
7	475	0,644	1,17	0,797	1,32	0,634	1,19	0,775	1,35	0,780	1,27	0,687	1,24
8	550	0,656	1,20	0,817	1,35	0,638	1,20	0,791	1,37	0,789	1,29	0,717	1,29
9	625	0,664	1,21	0,832	1,38	0,645	1,21	0,793	1,38	0,799	1,31	0,735	1,32
10	700	0,666	1,21	0,842	1,39	0,652	1,23	0,811	1,41	0,805	1,31	0,739	1,33
11	775	0,673	1,23	0,859	1,42	0,668	1,26	0,811	1,41	0,807	1,32	0,760	1,37
12	850	0,678	1,24	0,870	1,44	0,666	1,25	0,825	1,43	0,818	1,34	0,758	1,36
13	925	0,693	1,26	0,879	1,45	0,675	1,27	0,835	1,45	0,825	1,35	0,771	1,39
14	1000	0,700	1,28	0,885	1,46	0,694	1,31	0,847	1,47	0,840	1,37	0,779	1,40
15	Change in resistance factor *D*	0,08		0,13		0,09		0,11		0,09		0,13	

* Value of the sample's resistance indicated for temperature 20 °C.

Thermal profile: I_N = 980 A, t_1 = 40 min, t_2 = 25 min, I = I_r = 20 A.
SC test: I_{sc} = 18896 A, t_{sc} = 5,0 s.

Table 4 – Maximum temperatures

№	Cycle	Reference conductor	Connector №1	Connector №2	Connector №3	Connector №4	Connector №5	Connector №6	In circuit
		θ_{ref} (°C)	θ_{max} (°C)	θ_{max} (°C)	θ_{max} (°C)	θ_{max} (°C)	θ_{max} (°C)	θ_{max} (°C)	θ_k (°C)
1	1	130,0	96,0	100,0	88,0	100,0	100,0	94,0	20,0
2	200	130,0	96,0	100,0	89,0	100,0	100,0	94,0	20,8
3	200	129,0	96,0	101,0	89,0	100,0	100,0	95,0	21,0
4	250	130,0	96,7	101,0	89,0	100,3	100,5	96,0	22,8
5	325	130,0	97,0	102,0	90,0	100,8	100,4	97,0	23,0
6	400	130,0	98,0	102,2	91,0	101,0	100,8	98,0	24,0
7	475	130,0	99,0	102,0	92,0	100,9	101,0	98,0	23,8
8	550	130,0	99,0	102,4	93,0	101,0	102,0	98,0	24,2
9	625	130,0	99,0	103,0	94,0	101,5	102,0	98,0	24,5
10	700	130,0	99,0	103,0	95,0	102,0	102,6	98,0	23,9
11	775	130,0	99,8	103,0	95,0	102,0	103,0	98,0	23,5
12	850	130,0	99,5	103,0	95,3	102,0	103,0	99,0	24,4
13	925	130,0	100,0	103,2	95,7	102,2	103,0	99,0	23,0
14	1000	130,0	100,0	103,0	96,0	102,4	103,0	99,5	23,6
15	Max value	130,0	100,0	103,2	96,0	102,4	103,0	99,5	24,5

ВИПРОБУВАЛЬНА ЛАБОРАТОРІЯ "ЛІЗО"

4.2. Connectors testing results in circuit with minimum conductor's, cross-section 150 mm² and a combination of copper – copper (circuit 2)

Table 5 – Resistance factor k, resistance factor ratio λ and change in resistance factor D*

№	Cycle	Connector №1		Connector №2		Connector №3		Connector №4		Connector №5		Connector №6	
		Factor *k*	Factor ratio λ	Factor *k*	Factor ratio λ	Factor *k*	Factor ratio λ	Factor *k*	Factor ratio λ	Factor *k*	Factor ratio λ	Factor *k*	Factor ratio λ
1	0	0,719	-	0,665	-	0,636	-	0,630	-	0,626	-	0,659	-
2	200	0,805	1,12	0,754	1,13	0,704	1,11	0,667	1,06	0,667	1,07	0,724	1,10
3	200	0,789	1,10	0,743	1,12	0,686	1,08	0,649	1,03	0,652	1,04	0,712	1,08
4	250	0,805	1,12	0,754	1,13	0,699	1,10	0,658	1,04	0,668	1,07	0,730	1,11
5	325	0,808	1,12	0,764	1,15	0,713	1,12	0,666	1,06	0,675	1,08	0,752	1,14
6	400	0,820	1,14	0,771	1,16	0,731	1,15	0,678	1,08	0,680	1,09	0,768	1,17
7	475	0,833	1,16	0,769	1,16	0,725	1,14	0,693	1,10	0,692	1,11	0,762	1,16
8	550	0,865	1,20	0,784	1,18	0,744	1,17	0,707	1,12	0,711	1,14	0,772	1,17
9	625	0,870	1,21	0,778	1,17	0,739	1,16	0,710	1,13	0,713	1,14	0,773	1,17
10	700	0,874	1,22	0,787	1,18	0,753	1,19	0,710	1,13	0,714	1,14	0,778	1,18
11	775	0,890	1,24	0,797	1,20	0,764	1,20	0,725	1,15	0,722	1,15	0,786	1,19
12	850	0,905	1,26	0,800	1,20	0,773	1,22	0,734	1,17	0,731	1,17	0,787	1,19
13	925	0,921	1,28	0,807	1,21	0,770	1,21	0,728	1,16	0,733	1,17	0,789	1,20
14	1000	0,952	1,33	0,812	1,22	0,786	1,24	0,742	1,18	0,741	1,18	0,803	1,22
15	Change in resistance factor *D*	0,13		0,05		0,08		0,08		0,07		0,06	

* Value of the sample's resistance indicated for temperature 20 °C.

Thermal profile: I_N = 700 A, t_1 = 35 min, t_2 = 22 min, I = I_r = 20 A.
SC test: I_{sc} = 11810 A, t_{sc} = 5,0 s.

Table 6 – Maximum temperatures

№	Cycle	Reference conductor	Connector №1	Connector №2	Connector №3	Connector №4	Connector №5	Connector №6	In circuit
		θ_{ref} (°C)	θ_{max} (°C)	θ_{max} (°C)	θ_{max} (°C)	θ_{max} (°C)	θ_{max} (°C)	θ_{max} (°C)	θ_k (°C)
1	1	135,0	102,0	101,0	99,0	98,0	98,0	100,0	20,0
2	200	135,0	103,0	101,0	100,0	98,6	99,0	100,6	25,0
3	200	135,0	103,0	101,6	100,0	98,8	99,0	101,0	24,0
4	250	135,0	103,4	102,0	101,0	99,0	99,2	101,0	25,0
5	325	135,0	103,7	102,0	101,0	99,0	99,6	101,8	24,6
6	400	135,0	104,0	102,4	101,5	99,5	99,9	102,0	24,2
7	475	135,0	104,0	102,3	102,0	99,6	100,0	102,0	20,0
8	550	135,0	104,0	102,8	102,0	99,9	100,2	102,0	25,0
9	625	135,0	105,0	103,0	102,3	100,0	100,6	103,0	25,5
10	700	135,0	105,0	103,0	102,7	100,0	101,0	103,0	23,4
11	775	135,0	106,0	103,2	103,0	101,0	101,0	103,3	22,4
12	850	135,0	106,8	103,3	103,0	101,4	102,0	103,5	23,0
13	925	135,0	106,6	103,6	103,5	102,0	102,0	103,3	23,2
14	1000	135,0	107,0	103,4	104,0	102,0	102,2	103,6	22,8
15	Max value	135,0	107,0	103,6	104,0	102,0	102,2	103,6	25,5

4.3. Connectors testing results in circuit with maximum conductor's cross-section 240 mm² and a combination of aluminum – aluminum (circuit 3)

Table 7 – Resistance factor k, resistance factor ratio λ and change in resistance factor D*

№	Cycle	Connector №1		Connector №2		Connector №3		Connector №4		Connector №5		Connector №6	
		Factor *k*	Factor ratio λ	Factor *k*	Factor ratio λ	Factor *k*	Factor ratio λ	Factor *k*	Factor ratio λ	Factor *k*	Factor ratio λ	Factor *k*	Factor ratio λ
1	0	0,549	-	0,605	-	0,531	-	0,576	-	0,612	-	0,556	-
2	200	0,587	1,07	0,684	1,13	0,571	1,08	0,658	1,14	0,694	1,13	0,602	1,08
3	200	0,595	1,08	0,701	1,16	0,580	1,09	0,674	1,17	0,697	1,14	0,613	1,10
4	250	0,609	1,11	0,733	1,21	0,589	1,11	0,713	1,24	0,733	1,20	0,639	1,15
5	325	0,616	1,12	0,777	1,29	0,607	1,14	0,739	1,28	0,755	1,23	0,658	1,18
6	400	0,632	1,15	0,793	1,31	0,619	1,17	0,769	1,33	0,771	1,26	0,671	1,21
7	475	0,644	1,17	0,797	1,32	0,634	1,19	0,775	1,35	0,780	1,27	0,687	1,24
8	550	0,656	1,20	0,817	1,35	0,638	1,20	0,791	1,37	0,789	1,29	0,717	1,29
9	625	0,664	1,21	0,832	1,38	0,645	1,21	0,793	1,38	0,799	1,31	0,735	1,32
10	700	0,666	1,21	0,842	1,39	0,652	1,23	0,811	1,41	0,805	1,31	0,739	1,33
11	775	0,673	1,23	0,859	1,42	0,668	1,26	0,811	1,41	0,807	1,32	0,760	1,37
12	850	0,678	1,24	0,870	1,44	0,666	1,25	0,825	1,43	0,818	1,34	0,758	1,36
13	925	0,693	1,26	0,879	1,45	0,675	1,27	0,835	1,45	0,825	1,35	0,771	1,39
14	1000	0,700	1,28	0,885	1,46	0,694	1,31	0,847	1,47	0,840	1,37	0,779	1,40
15	Change in resistance factor *D*	0,08		0,13		0,09		0,11		0,09		0,13	

* Value of the sample's resistance indicated for temperature 20 °C.

Thermal profile: I_N = 730 A, t_1 = 35 min, t_2 = 22 min, I = I_r = 20 A.
SC test: I_{sc} = 12489 A, t_{sc} = 5,0 s.

Table 8 – Maximum temperatures

№	Cycle	Reference conductor	Connector №1	Connector №2	Connector №3	Connector №4	Connector №5	Connector №6	In circuit
		θ_{ref} (°C)	θ_{max} (°C)	θ_{max} (°C)	θ_{max} (°C)	θ_{max} (°C)	θ_{max} (°C)	θ_{max} (°C)	θ_k (°C)
1	1	130,0	96,0	100,0	88,0	100,0	100,0	94,0	20,0
2	200	130,0	96,0	100,0	89,0	100,0	100,0	94,0	20,8
3	200	129,0	96,0	101,0	89,0	100,0	100,0	95,0	21,0
4	250	130,0	96,7	101,0	89,0	100,3	100,5	96,0	22,8
5	325	130,0	97,0	102,0	90,0	100,8	100,4	97,0	23,0
6	400	130,0	98,0	102,2	91,0	101,0	100,8	98,0	24,0
7	475	130,0	99,0	102,0	92,0	100,9	101,0	98,0	23,8
8	550	130,0	99,0	102,4	93,0	101,0	102,0	98,0	24,2
9	625	130,0	99,0	103,0	94,0	101,5	102,0	98,0	24,5
10	700	130,0	99,0	103,0	95,0	102,0	102,6	98,0	23,9
11	775	130,0	99,8	103,0	95,0	102,0	103,0	98,0	23,5
12	850	130,0	99,5	103,0	95,3	102,0	103,0	99,0	24,4
13	925	130,0	100,0	103,2	95,7	102,2	103,0	99,0	23,0
14	1000	130,0	100,0	103,0	96,0	102,4	103,0	99,5	23,6
15	Max value	130,0	100,0	103,2	96,0	102,4	103,0	99,5	24,5

4.4. Connectors testing results in circuit with minimum conductor's, cross-section 150 mm² and a combination of aluminum – aluminum (circuit 4)

Table 9 – Resistance factor k, resistance factor ratio λ and change in resistance factor D*

№	Cycle	Connector №1		Connector №2		Connector №3		Connector №4		Connector №5		Connector №6	
		Factor *k*	Factor ratio λ	Factor *k*	Factor ratio λ	Factor *k*	Factor ratio λ	Factor *k*	Factor ratio λ	Factor *k*	Factor ratio λ	Factor *k*	Factor ratio λ
1	0	0,719	-	0,665	-	0,636	-	0,630	-	0,626	-	0,659	-
2	200	0,805	1,12	0,754	1,13	0,704	1,11	0,667	1,06	0,667	1,07	0,724	1,10
3	200	0,789	1,10	0,743	1,12	0,686	1,08	0,649	1,03	0,652	1,04	0,712	1,08
4	250	0,805	1,12	0,754	1,13	0,699	1,10	0,658	1,04	0,668	1,07	0,730	1,11
5	325	0,808	1,12	0,764	1,15	0,713	1,12	0,666	1,06	0,675	1,08	0,752	1,14
6	400	0,820	1,14	0,771	1,16	0,731	1,15	0,678	1,08	0,680	1,09	0,768	1,17
7	475	0,833	1,16	0,769	1,16	0,725	1,14	0,693	1,10	0,692	1,11	0,762	1,16
8	550	0,865	1,20	0,784	1,18	0,744	1,17	0,707	1,12	0,711	1,14	0,772	1,17
9	625	0,870	1,21	0,778	1,17	0,739	1,16	0,710	1,13	0,713	1,14	0,773	1,17
10	700	0,874	1,22	0,787	1,18	0,753	1,19	0,710	1,13	0,714	1,14	0,778	1,18
11	775	0,890	1,24	0,797	1,20	0,764	1,20	0,725	1,15	0,722	1,15	0,786	1,19
12	850	0,905	1,26	0,800	1,20	0,773	1,22	0,734	1,17	0,731	1,17	0,787	1,19
13	925	0,921	1,28	0,807	1,21	0,770	1,21	0,728	1,16	0,733	1,17	0,789	1,20
14	1000	0,952	1,33	0,812	1,22	0,786	1,24	0,742	1,18	0,741	1,18	0,803	1,22
15	Change in resistance factor *D*	0,13		0,05		0,08		0,08		0,07		0,06	

* Value of the sample's resistance indicated for temperature 20 °C.

Thermal profile: I_N = 590 A, t_1 = 32 min, t_2 = 18 min, I = I_r = 20 A.
SC test: I_{sc} = 10077 A, t_{sc} = 3,0 s.

Table 10 – Maximum temperatures

№	Cycle	Reference conductor	Connector №1	Connector №2	Connector №3	Connector №4	Connector №5	Connector №6	In circuit
		θ_{ref} (°C)	θ_{max} (°C)	θ_{max} (°C)	θ_{max} (°C)	θ_{max} (°C)	θ_{max} (°C)	θ_{max} (°C)	θ_k (°C)
1	1	135,0	102,0	101,0	99,0	98,0	98,0	100,0	20,0
2	200	135,0	103,0	101,0	100,0	98,6	99,0	100,6	25,0
3	200	135,0	103,0	101,6	100,0	98,8	99,0	101,0	24,0
4	250	135,0	103,4	102,0	101,0	99,0	99,2	101,0	25,0
5	325	135,0	103,7	102,0	101,0	99,0	99,6	101,8	24,6
6	400	135,0	104,0	102,4	101,5	99,5	99,9	102,0	24,2
7	475	135,0	104,0	102,3	102,0	99,6	100,0	102,0	20,0
8	550	135,0	104,0	102,8	102,0	99,9	100,2	102,0	25,0
9	625	135,0	105,0	103,0	102,3	100,0	100,6	103,0	25,5
10	700	135,0	105,0	103,0	102,7	100,0	101,0	103,0	23,4
11	775	135,0	106,0	103,2	103,0	101,0	101,0	103,3	22,4
12	850	135,0	106,8	103,3	103,0	101,4	102,0	103,5	23,0
13	925	135,0	106,6	103,6	103,5	102,0	102,0	103,3	23,2
14	1000	135,0	107,0	103,4	104,0	102,0	102,2	103,6	22,8
15	Max value	135,0	107,0	103,6	104,0	102,0	102,2	103,6	25,5

4.5. Connectors testing results in circuit with maximum conductor's cross-section 240 mm² and a combination of aluminum – copper (circuit 5)

Table 11 – Resistance factor k, resistance factor ratio λ and change in resistance factor D*

№	Cycle	Connector №1		Connector №2		Connector №3		Connector №4		Connector №5		Connector №6	
		Factor *k*	Factor ratio λ	Factor *k*	Factor ratio λ	Factor *k*	Factor ratio λ	Factor *k*	Factor ratio λ	Factor *k*	Factor ratio λ	Factor *k*	Factor ratio λ
1	0	0,549	-	0,605	-	0,531	-	0,576	-	0,612	-	0,556	-
2	200	0,587	1,07	0,684	1,13	0,571	1,08	0,658	1,14	0,694	1,13	0,602	1,08
3	200	0,595	1,08	0,701	1,16	0,580	1,09	0,674	1,17	0,697	1,14	0,613	1,10
4	250	0,609	1,11	0,733	1,21	0,589	1,11	0,713	1,24	0,733	1,20	0,639	1,15
5	325	0,616	1,12	0,777	1,29	0,607	1,14	0,739	1,28	0,755	1,23	0,658	1,18
6	400	0,632	1,15	0,793	1,31	0,619	1,17	0,769	1,33	0,771	1,26	0,671	1,21
7	475	0,644	1,17	0,797	1,32	0,634	1,19	0,775	1,35	0,780	1,27	0,687	1,24
8	550	0,656	1,20	0,817	1,35	0,638	1,20	0,791	1,37	0,789	1,29	0,717	1,29
9	625	0,664	1,21	0,832	1,38	0,645	1,21	0,793	1,38	0,799	1,31	0,735	1,32
10	700	0,666	1,21	0,842	1,39	0,652	1,23	0,811	1,41	0,805	1,31	0,739	1,33
11	775	0,673	1,23	0,859	1,42	0,668	1,26	0,811	1,41	0,807	1,32	0,760	1,37
12	850	0,678	1,24	0,870	1,44	0,666	1,25	0,825	1,43	0,818	1,34	0,758	1,36
13	925	0,693	1,26	0,879	1,45	0,675	1,27	0,835	1,45	0,825	1,35	0,771	1,39
14	1000	0,700	1,28	0,885	1,46	0,694	1,31	0,847	1,47	0,840	1,37	0,779	1,40
15	Change in resistance factor *D*	0,08		0,13		0,09		0,11		0,09		0,13	

* Value of the sample's resistance indicated for temperature 20 °C.

Thermal profile: I_N = 730 A, t_1 = 35 min, t_2 = 22 min, I = I_r = 20 A.
SC test: I_{sc} = 12489 A, t_{sc} = 5,0 s.

Table 12 – Maximum temperatures

№	Cycle	Reference conductor	Connector №1	Connector №2	Connector №3	Connector №4	Connector №5	Connector №6	In circuit
		θ_{ref} (°C)	θ_{max} (°C)	θ_{max} (°C)	θ_{max} (°C)	θ_{max} (°C)	θ_{max} (°C)	θ_{max} (°C)	θ_k (°C)
1	1	130,0	96,0	100,0	88,0	100,0	100,0	94,0	20,0
2	200	130,0	96,0	100,0	89,0	100,0	100,0	94,0	20,8
3	200	129,0	96,0	101,0	89,0	100,0	100,0	95,0	21,0
4	250	130,0	96,7	101,0	89,0	100,3	100,5	96,0	22,8
5	325	130,0	97,0	102,0	90,0	100,8	100,4	97,0	23,0
6	400	130,0	98,0	102,2	91,0	101,0	100,8	98,0	24,0
7	475	130,0	99,0	102,0	92,0	100,9	101,0	98,0	23,8
8	550	130,0	99,0	102,4	93,0	101,0	102,0	98,0	24,2
9	625	130,0	99,0	103,0	94,0	101,5	102,0	98,0	24,5
10	700	130,0	99,0	103,0	95,0	102,0	102,6	98,0	23,9
11	775	130,0	99,8	103,0	95,0	102,0	103,0	98,0	23,5
12	850	130,0	99,5	103,0	95,3	102,0	103,0	99,0	24,4
13	925	130,0	100,0	103,2	95,7	102,2	103,0	99,0	23,0
14	1000	130,0	100,0	103,0	96,0	102,4	103,0	99,5	23,6
15	Max value	130,0	100,0	103,2	96,0	102,4	103,0	99,5	24,5

4.6. Connectors testing results in circuit with minimum conductor's, cross-section 150 mm² and a combination of aluminum – copper (circuit 6)

Table 13 – Resistance factor k, resistance factor ratio λ and change in resistance factor D*

№	Cycle	Connector №1		Connector №2		Connector №3		Connector №4		Connector №5		Connector №6	
		Factor *k*	Factor ratio λ	Factor *k*	Factor ratio λ	Factor *k*	Factor ratio λ	Factor *k*	Factor ratio λ	Factor *k*	Factor ratio λ	Factor *k*	Factor ratio λ
1	0	0,719	-	0,665	-	0,636	-	0,630	-	0,626	-	0,659	-
2	200	0,805	1,12	0,754	1,13	0,704	1,11	0,667	1,06	0,667	1,07	0,724	1,10
3	200	0,789	1,10	0,743	1,12	0,686	1,08	0,649	1,03	0,652	1,04	0,712	1,08
4	250	0,805	1,12	0,754	1,13	0,699	1,10	0,658	1,04	0,668	1,07	0,730	1,11
5	325	0,808	1,12	0,764	1,15	0,713	1,12	0,666	1,06	0,675	1,08	0,752	1,14
6	400	0,820	1,14	0,771	1,16	0,731	1,15	0,678	1,08	0,680	1,09	0,768	1,17
7	475	0,833	1,16	0,769	1,16	0,725	1,14	0,693	1,10	0,692	1,11	0,762	1,16
8	550	0,865	1,20	0,784	1,18	0,744	1,17	0,707	1,12	0,711	1,14	0,772	1,17
9	625	0,870	1,21	0,778	1,17	0,739	1,16	0,710	1,13	0,713	1,14	0,773	1,17
10	700	0,874	1,22	0,787	1,18	0,753	1,19	0,710	1,13	0,714	1,14	0,778	1,18
11	775	0,890	1,24	0,797	1,20	0,764	1,20	0,725	1,15	0,722	1,15	0,786	1,19
12	850	0,905	1,26	0,800	1,20	0,773	1,22	0,734	1,17	0,731	1,17	0,787	1,19
13	925	0,921	1,28	0,807	1,21	0,770	1,21	0,728	1,16	0,733	1,17	0,789	1,20
14	1000	0,952	1,33	0,812	1,22	0,786	1,24	0,742	1,18	0,741	1,18	0,803	1,22
15	Change in resistance factor *D*	0,13		0,05		0,08		0,08		0,07		0,06	

* Value of the sample's resistance indicated for temperature 20 °C.

Thermal profile: I_N = 590 A, t_1 = 32 min, t_2 = 18 min, I = I_r = 20 A.
SC test: I_{sc} = 10077 A, t_{sc} = 3,0 s.

Table 14 – Maximum temperatures

№	Cycle	Reference conductor	Connector №1	Connector №2	Connector №3	Connector №4	Connector №5	Connector №6	In circuit
		θ_{ref} (°C)	θ_{max} (°C)	θ_{max} (°C)	θ_{max} (°C)	θ_{max} (°C)	θ_{max} (°C)	θ_{max} (°C)	θ_k (°C)
1	1	135,0	102,0	101,0	99,0	98,0	98,0	100,0	20,0
2	200	135,0	103,0	101,0	100,0	98,6	99,0	100,6	25,0
3	200	135,0	103,0	101,6	100,0	98,8	99,0	101,0	24,0
4	250	135,0	103,4	102,0	101,0	99,0	99,2	101,0	25,0
5	325	135,0	103,7	102,0	101,0	99,0	99,6	101,8	24,6
6	400	135,0	104,0	102,4	101,5	99,5	99,9	102,0	24,2
7	475	135,0	104,0	102,3	102,0	99,6	100,0	102,0	20,0
8	550	135,0	104,0	102,8	102,0	99,9	100,2	102,0	25,0
9	625	135,0	105,0	103,0	102,3	100,0	100,6	103,0	25,5
10	700	135,0	105,0	103,0	102,7	100,0	101,0	103,0	23,4
11	775	135,0	106,0	103,2	103,0	101,0	101,0	103,3	22,4
12	850	135,0	106,8	103,3	103,0	101,4	102,0	103,5	23,0
13	925	135,0	106,6	103,6	103,5	102,0	102,0	103,3	23,2
14	1000	135,0	107,0	103,4	104,0	102,0	102,2	103,6	22,8
15	Max value	135,0	107,0	103,6	104,0	102,0	102,2	103,6	25,5

Table 15 – Testing results

№	Parameter	Result						Accepted value
		Circuit 1: max copper – copper	Circuit 2: min copper – copper	Circuit 3: max aluminum – aluminum	Circuit 4: min aluminum – aluminum	Circuit 5: max aluminum – copper	Circuit 6: min aluminum – copper	
1	Initial scatter δ	0,093	0,087	0,093	0,087	0,093	0,087	≤ 0,3
2	Mean scatter β	0,171	0,131	0,171	0,131	0,171	0,131	≤ 0,3
3	Change in resistance factor D	Table 3	Table 5	Table 7	Table 9	Table 11	Table 13	≤ 0,15
4	Resistance factor ratio λ	Table 3	Table 5	Table 7	Table 9	Table 11	Table 13	≤ 2,0
6	Maximum temperature θ_{max}	Table 4	Table 6	Table 8	Table 10	Table 12	Table 14	θ_{ref}

5. Conclusion:

After 1000 cycles of heating-cooling all tested samples of the mechanical cable connectors ZSSN 150-240/6S 36kV passed the test and correspond to class A in accordance with requirements of IEC 61238-1-3:2018 clause 6.6.

ВИПРОБУВАЛЬНА ЛАБОРАТОРІЯ "ЛІЗО"

6. Pictures:

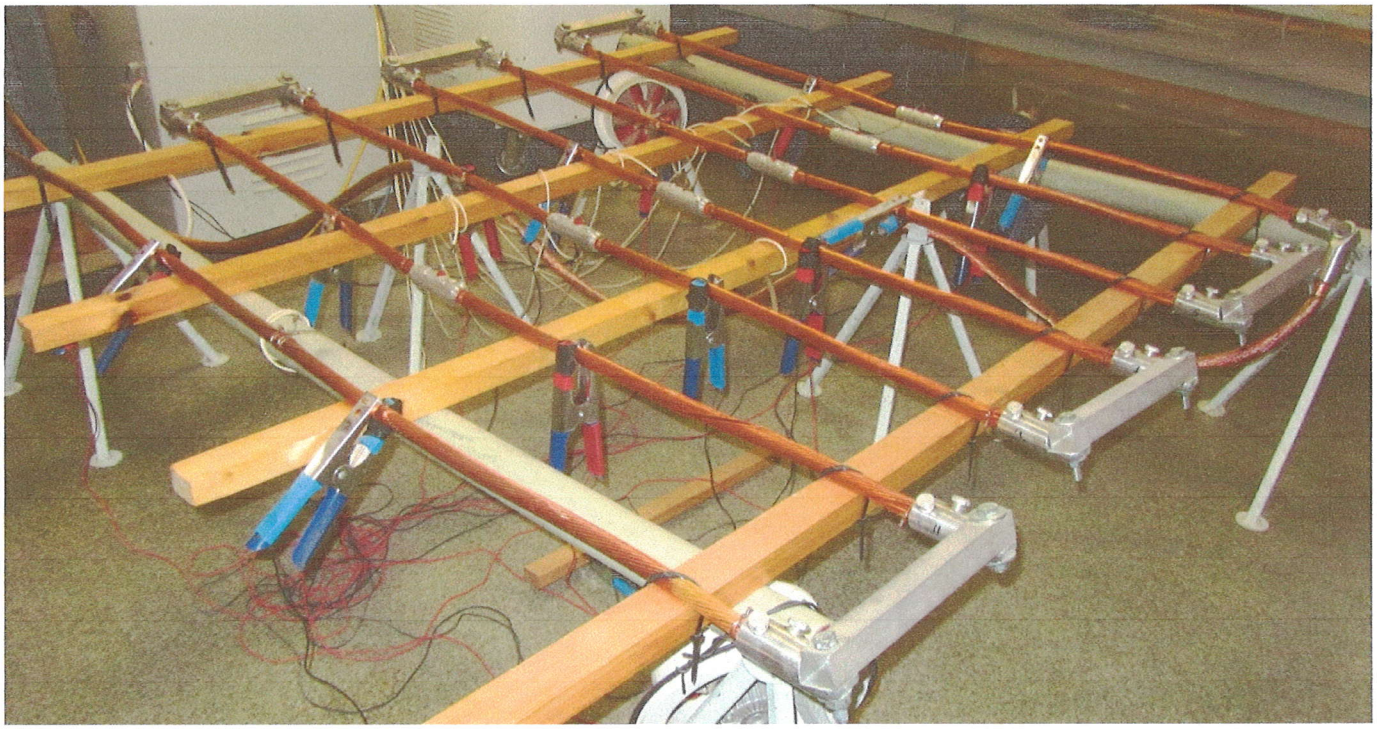


Fig.3 – The connectors during the tests in the circuit with maximum conductor's cross section 240 mm^2 and a combination of copper – copper

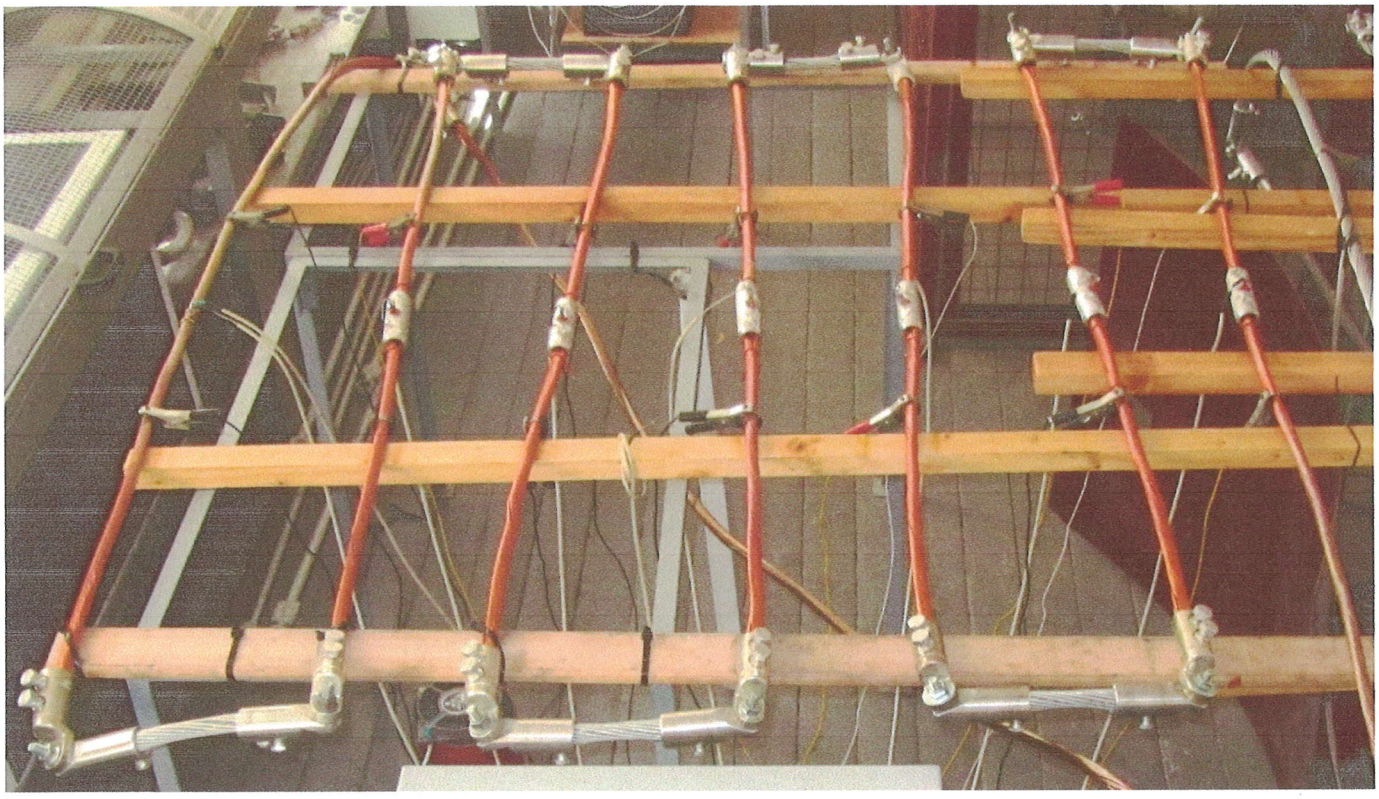


Fig.4 – The connectors during the tests in the circuit with minimum conductor's cross section 150 mm^2 and a combination of copper – copper

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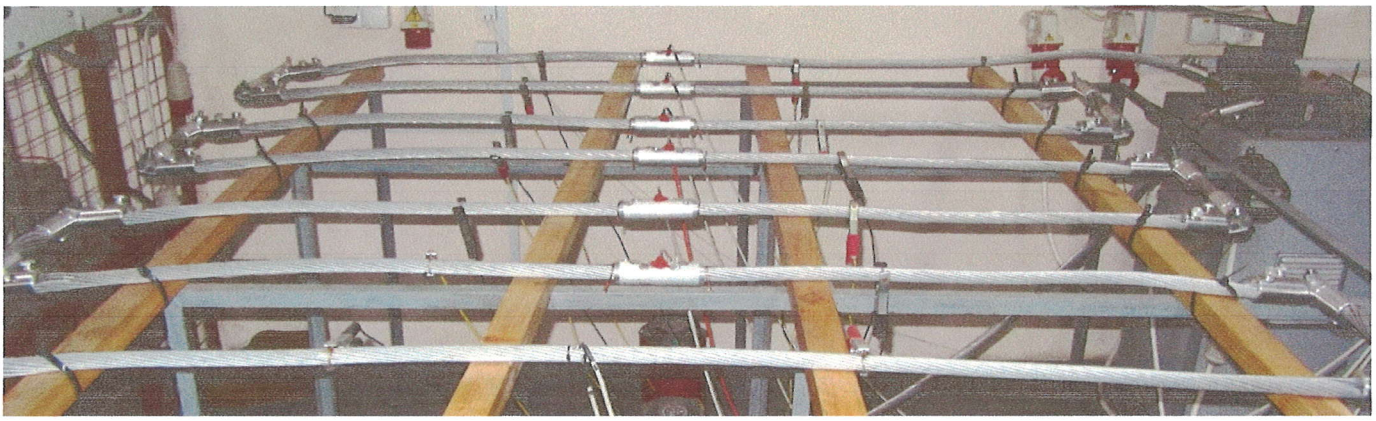

Fig.5 – The connectors during the tests in the circuit with maximum conductor's cross section 240 mm^2 and a combination of aluminum – aluminum

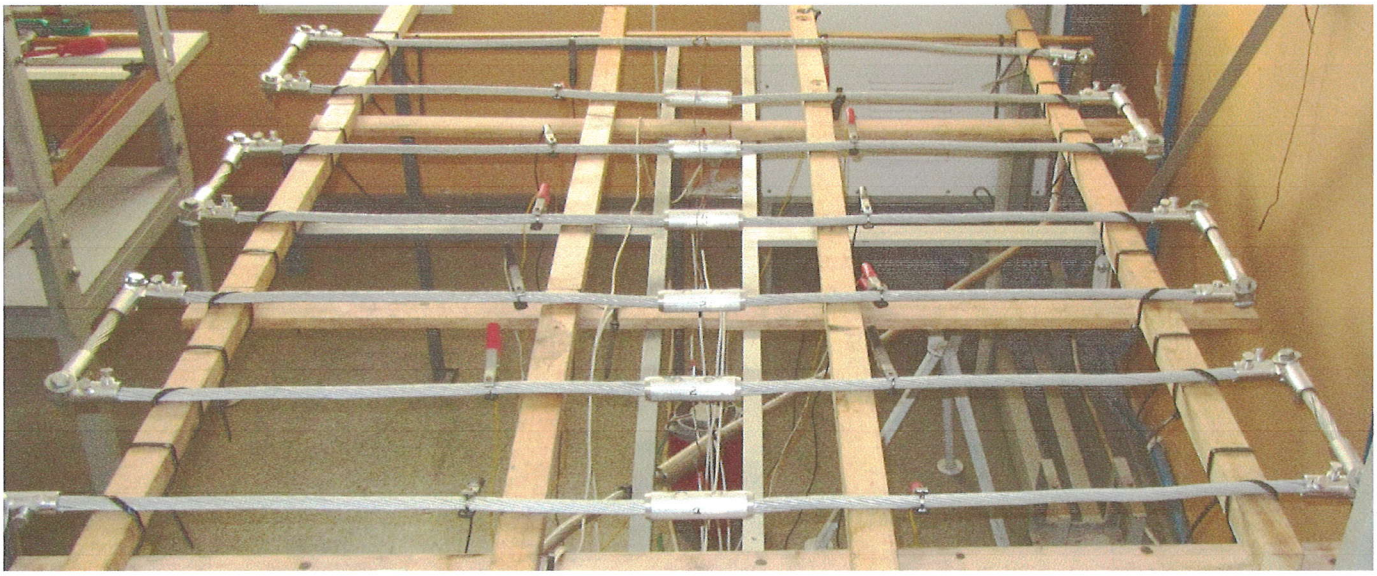

Fig.6 – The connectors during the tests in the circuit with minimum conductor's cross section 150 mm^2 and a combination of aluminum – aluminum

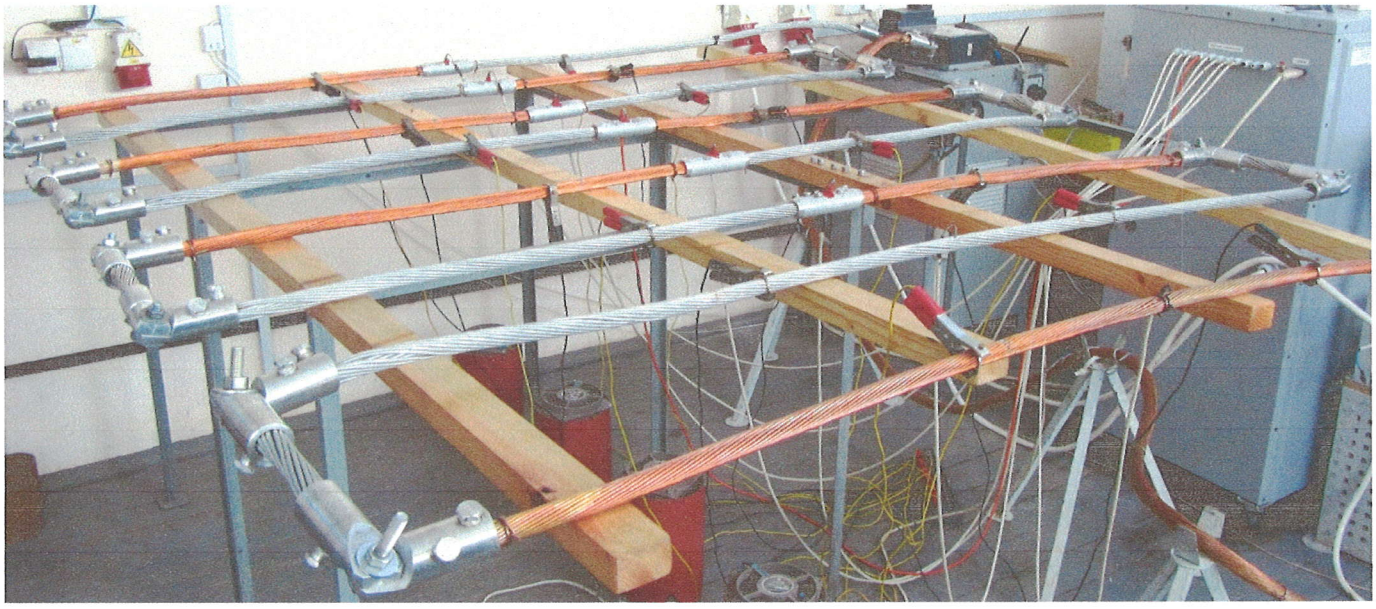

Fig.7 – The connectors during the tests in the circuit with maximum conductor's cross section 240 mm^2 and a combination of aluminum – copper

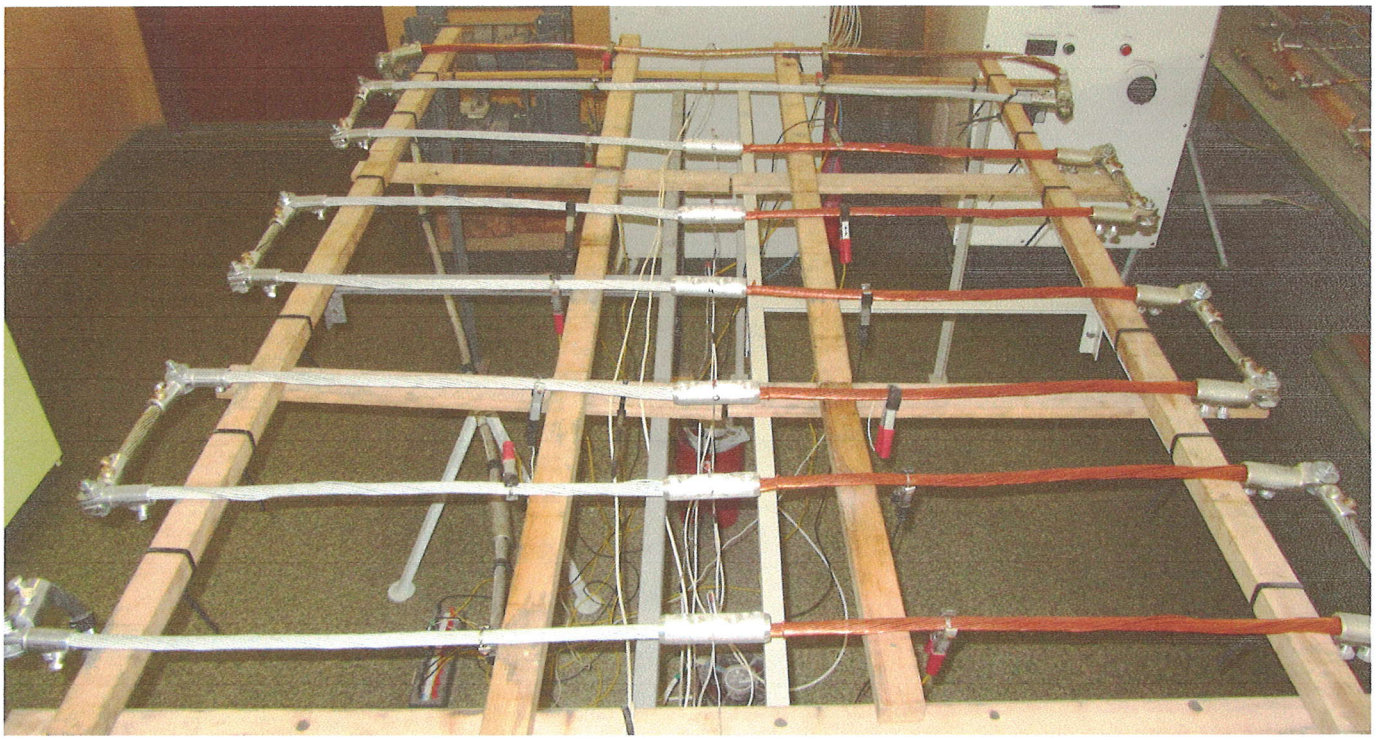

Fig.8 – The connectors during the tests in the circuit with minimum conductor's cross section 150 mm^2 and a combination of aluminum – copper

7. Test equipment:

№	Type	Model	Latest calibration date
1	Ruler 1m	VaGo-Tools №003	18.12.2023
2	Torque wrench	DT-030S2 №17000067	22.12.2023
3	Stopwatch	СОПпр-2а-3-000 №5353	19.12.2023
4	Digital eight-channel millivoltmeter	МВЦ-109-8 №15-10	22.12.2023
5	Amperemeter	Э514 №45541	16.09.2022
6	Heat chamber	ILKA T25/021 №20200113	Don't need calibration
7	Measurement and control device with resistive temperature transducer	РТ-0102 (В-БУК) №14-070 ТСП-1388 №№ 14-352, 14-355.	15.12.2023
8	Source of current	ДСЕС №005	Don't need calibration
9	Measurement and control device with resistive temperature transducer	РТ-0102-8 №18-001, ТСП-0287 № 18-001, 18-002, 18-003, 18-004, 18-005, 18-006, 18-007, 18-008.	12.12.2023
10	Measurement and control device with resistive temperature transducer	РТ-0102 №18-111 ТСП-0287 № 18-011	15.12.2023
11	Panel for electrical ageing test	СВЕС №003	Don't need calibration
12	Source of current	ДСЕС №006	Don't need calibration
13	Measurement and control device with resistive temperature transducer	ВР-10-8 №20-001, ТОП-109 №№ 19-197, 19-200, 19-204, 19-206, 19-208, 19-209, 19-210, 19-215.	12.12.2023
14	Measurement and control device with resistive temperature transducer	ВР-10 №20-001 ТОП-109 №19-206	19.12.2023
15	Panel for electrical ageing test	СВЕС №004	Don't need calibration
16	Source of current	ДСЕС №007	Don't need calibration
17	Measurement and control device with resistive temperature transducer	ВР-10-8 №20-002, ТОП-109 №№ 19-198, 19-201, 19-202, 19-205, 19-207, 19-210, 19-211, 19-212.	12.12.2023
18	Measurement and control device with resistive temperature transducer	ВР-10 №20-002 ТОП-109 № 19-209	19.12.2023
19	Panel for electrical ageing test	СВЕС №005	Don't need calibration
20	Source of current	ДСЕС №008	Don't need calibration
21	Measurement and control device with resistive temperature transducer	РТ-0102-8 №19-016 ТСП-0287 № 19-004, 19-008, 19-009, 19-010, 19-012, 19-013, 19-015, 19-027.	11.12.2023
22	Measurement and control device with resistive temperature transducer	РТ-0102К №19-013 ТСП-0287 №19-011	18.12.2023
23	Panel for electrical ageing test	СВЕС №006	Don't need calibration
24	Constant-current source	ДПС №001	Don't need calibration
25	Shunt	75ШСМОМ3 №375802	04.12.2020
26	Source of current for short-circuit testing	ДСКЗ №001	Don't need calibration
27	Oscilloscope	OWON SDS 7102E №SDS7102E2002011	16.09.2022

The tests were performed by:

Deputy Head of the testing laboratory: _____ S. S. Lakhovskyi

Engineer: _____ O. O. Nepyivoda

Engineer: _____ D. S. Denys

Engineer: _____ A. S. Shevtsiv

ВИПРОБУВАЛЬНА ЛАБОРАТОРІЯ "ЛІЗО"

ВИПРОБУВАЛЬНА ЛАБОРАТОРІЯ
ТзОВ ВКФ «ЛІЗО»

TESTING LABORATORY
of the "LIZO Ltd."

201383
Випробування / Testing

Атестат акредитації
№ 201383
Дійсний до
25 листопада 2026 року

79035, Україна, м. Львів
вул. М.Пимоненка, 3
тел.:(032) 294-82-87,
e-mail: lablizo@ukr.net

Accreditation certificate
№ 201383
Expiry date:
25 November, 2026

79035, Ukraine, Lviv
st. Pymonenka, 3
Tel. :(032) 294-82-87,
e-mail: lablizo@ukr.net

Approved by
The head of the
testing laboratory of "LIZO Ltd."
D.R. Dovgun

«_____» _____ 2024

TESTING REPORT № 07/24-2

Mechanical tests of the mechanical cable connectors ZSSN 150-240/6S 36kV

Requirements: IEC 61238-1-3:2018 clause 7.3.

The test methods: IEC 61238-1-3:2018 clause 7.2.

Product name:	**Mechanical cable connector**
Model and type:	**ZSSN 150-240/6S 36kV**
Manufacturer:	**Company RADPOL S.A Poland, Człuchow (27-300), st. Batorego 14**
Customer:	**PE "VKF "Soznanie" Ukraine, Kyiv region, Obukhiv district, Ukrainka, Dniprovskyi avenue, building 20, office 55 by proxy of the company RADPOL S.A. from January 11, 2024**
Reason:	**Contract № 3-02-24 of 08.02.2024**
Testing results:	***Mechanical cable connectors ZSSN 150-240/6S 36kV with copper – copper, aluminum – aluminum, aluminum – copper conductor combinations have passed the tests, satisfy requirements of IEC 61238-1-3:2018 clause 7 and manufacturer's specifications.***

Lviv - 2024

Samples' receiving date:	26.03.2024.
Quantity of the tested samples:	18.
Identification numbers of the samples:	№37 … №54.
The testing dates:	19.04.2024 - 20.04.2024.
The testing place:	Testing laboratory of "LIZO Ltd" 3, Pymonenka str., Lviv
The environmental conditions:	
temperature:	(22,4 – 24,6) °C;
air pressure:	(96,4 – 98,0) kPa;
humidity:	(66 – 70) %.

1. Tested samples:

Mechanical cable connectors:

Manufacturer:	Company RADPOL S.A.
Model and type:	ZSSN 150-240/6S 36kV.
Class:	A1.
Main conductor cross-sections:	(150 – 240) mm^2.
The bolt tightening torque:	(34 ± 2) Nm.
Batch number:	03/24.

Conductors:

Conductor material:	Copper	Copper
Conductor cross-section:	240 mm^2	150 mm^2
Conductor diameter:	18,8 mm	15,2 mm
Shape:	Round	Round
Class in accordance with IEC 60228:	Stranded	Stranded
Compacted:	Uncompacted	Uncompacted
Number and placement of layers:	3	3
Type of coating:	No cover	No cover
Type of impregnation:	Without impregnation	Without impregnation

Conductor material:	Aluminum	Aluminum
Conductor cross-section:	240 mm^2	150 mm^2
Conductor diameter:	19,0 mm	15,4 mm
Shape:	Round	Round
Class in accordance with IEC 60228:	Stranded	Stranded
Compacted:	Uncompacted	Uncompacted
Number and placement of layers:	2	2
Type of coating:	No cover	No cover
Type of impregnation:	Without impregnation	Without impregnation

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2. Testing procedure:

The tests were performed in accordance with IEC 61238-1-3:2018 clause 7.

Three samples are tested for maximum and minimum cross-section of conductors and copper – copper, aluminum – aluminum, aluminum – copper combinations are tested.

The samples are installed at the core in accordance with manufacturer's installation instruction.

The conductor length between connector and tensile test machine jaws is ≥ 500 mm. The rate of application of the load not exceed 10 N per square millimetre of nominal cross-sectional area and per second.

Tensile load 25 % of the value from Table 1 is applied to sample. The conductor is marking in the point where it leaves the connector. Then the load is increasing to the values, which is shown in the Table 1. and maintained for 1 min.

Table 1 – Tensile test load

№	Class	Conductor material	Nominal cross-section A (mm^2)	Testing load (N)
1	1	Aluminum	≤ 500	40 x A
2	1	Copper	≤ 300	60 x A

3. Requirements:

Not more than 3 mm slippage shall occur during the last minute of the test.

4. Testing results:

Table 2 – Testing results

№	Identification number of the sample	Conductor material	Conductor cross-section (mm^2)	Load during the marking, kN	Testing load during 1 min, kN	Slippage
1	37	copper – copper	240	3,60	14,40	Absent
	38					Absent
	39					Absent
2	40	copper – copper	150	2,25	9,00	Absent
	41					Absent
	42					Absent
3	43	aluminum – aluminum	240	2,40	9,60	Absent
	44					Absent
	45					Absent
4	46	aluminum – aluminum	150	1,50	6,00	Absent
	47					Absent
	48					Absent
5	49	aluminum – copper	240	2,40	9,60	Absent
	50					Absent
	51					Absent
6	52	aluminum – copper	150	1,50	6,00	Absent
	53					Absent
	54					Absent

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5. Conclusion:

There is no slippage occurs during the testing of the connectors ZSSN 150-240/6S 36kV. The samples passed the tests and satisfy requirements of IEC 61238-1-3:2018 clause 7.

6. Pictures:

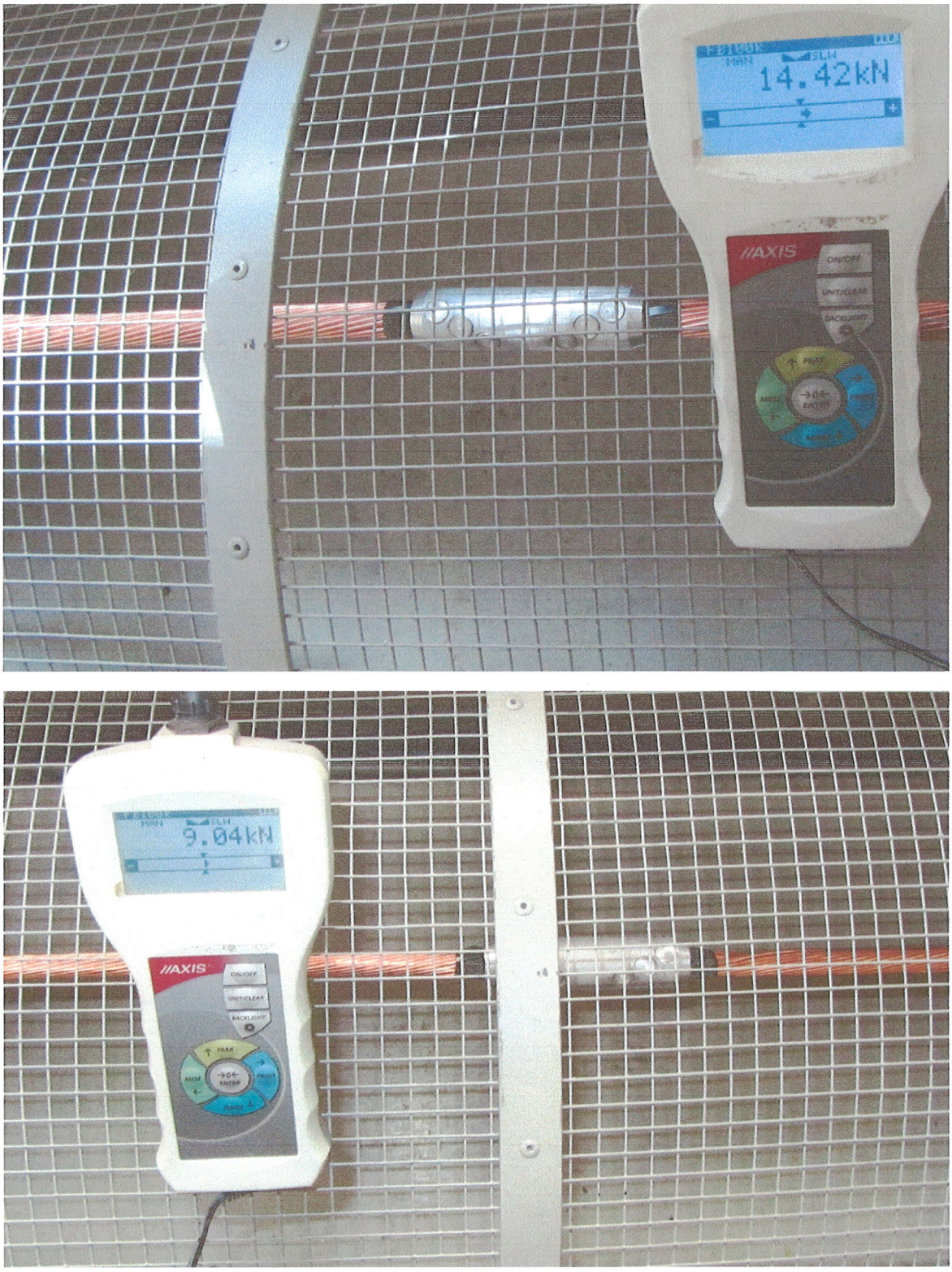

Fig.1.1 – A connector during the testing.

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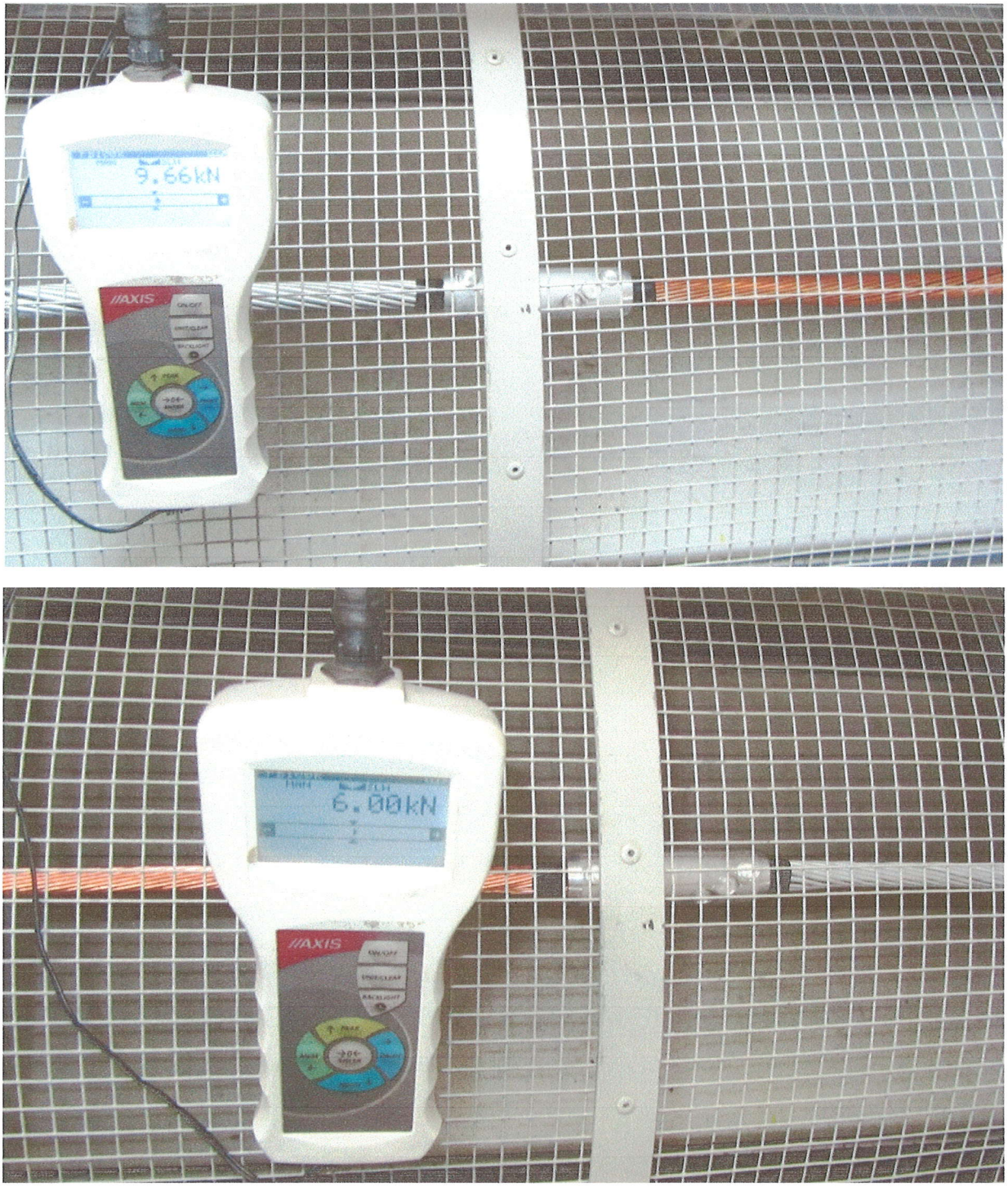

Fig.1.2 – A connector during the testing.

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Fig.1.3 – A connector during the testing.

7. Test equipment:

№	Type	Model	Latest calibration date
1	Ruler 1m	VaGo-Tools №003	18.12.2023
2	Torque wrench	DT-100N №319892	22.12.2023
3	Stopwatch	СОПпр-2а-3-000 №5353	19.12.2023
4	Tensile test machine, factory №001	ВРМ №001	Don't need calibration
5	Load cell	FB 20K №0048	22.12.2023

The tests were performed by:

Deputy Head of the testing laboratory: _____ S. S. Lakhovskyi

Engineer: _____ O. O. Nepyivoda

Engineer: _____ A. S. Shevtsiv

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