TYPE TEST REPORT

Test object:	All Aluminium Alloy Conductor (AAAC)
Designation:	181 mm^2 All Aluminium Alloy Conductor (Code: 181-AL3)
Manufacturer:	**BMET Energy Telecom Industry and Trade LLC.** Region: Oromia Subcity: Finfine Special Zone City: Sebeta Woreda: Sebeta-Hawas Kebele: Dima Guranda P.O Box No: 20206/1000 ETHIOPIA
Tested for:	**BMET ENERJİ TELEKOM SAN. VE TİC. A.Ş.** Yeşilyurt Mah. Orkide Cad. Eresin Apt. No : 12 Daire No :11 , Kat 5 34149-Bakırköy İSTANBUL/TURKEY
Date of tests:	21st January 2015 – 05th February 2015
Tested by:	VEIKI-VNL Ltd. – Budapest – HUNGARY
Project ID:	NAL-33/2014
Order/Contract:	1066/2014, 19th November 2014
Test specification:	**EN 50182: 2001** **Conductors for overhead lines - Round wire concentric lay stranded conductors**
Tests performed:	The test object, constructed in accordance with the description, drawings and photographs incorporated in this report has been subjected to the following tests: – Stress-Strain curves (Clause 6.4.7 and Annex C) – Tensile breaking strength (Clause 6.4.8 and Annex C) – DC resistance measurement at 25 °C, 50 °C and 75 °C conductor temperatures
Test results:	**The tested conductor type AAAC 181 mm^2 (Code: 181-AL3) fulfilled the requirements of the relevant standards.**

This Type Test Report has been issued by VEIKI-VNL Ltd. in accordance with above mentioned specification.

The Report applies only to the test object. The responsibility for conformity of any product having the same designations with that tested rests with the Manufacturer.

This Report comprises 14 sheets in total (13 numbered pages and 1 datasheet).

VEIKI-VNL Ltd. is an independent testing laboratory. Member of Short-circuit Testing Liaison (STL).

VEIKI-VNL Ltd. is a testing laboratory, accredited by NAT (Hungarian Accreditation Board) under registration number NAT-1-1251/2011.

Budapest, 13th February 2015	Lajos Tóth responsible for the test	Norbert Menyhért supervised by	Dr. László Varga managing director

TEST CERTIFICATES OR REPORTS ISSUED BY VEIKI-VNL LTD.

Type Test Certificate of Complete Type Test
This certificate provides the verification of all the rated characteristics of the equipment as assigned by the manufacturer, by means of the performance of all type tests specified by the standards.

Type Test Certificate of Dielectric Performance
This certificate provides the verification of all dielectric ratings, by means of the performance of the appropriate type tests specified by the standards.

Type Test Certificate of Temperature-Rise Performance
This certificate provides the verification of temperature-rise limits together with measurement of the main circuit resistance, by means of the performance of the appropriate type tests specified by the standards.

Type Test Certificate of Short-Circuit / Making and Breaking Performance
This certificate provides the verification of rated characteristics with respect short-circuit and/or making and breaking performance, by means of the performance of the appropriate type tests specified by the standards.

Type Test Certificate of Switching Performance
This certificate provides the verification of the switching ratings (e.g. capacitive current), by means of the performance of the appropriate type tests specified by the standards.

Prototype Test Report
Prototype tests are required to verify the suitability of the materials and method of manufacture for composite insulators defined by relevant ANSI standards.

Design Test Report

According to IEC standard: The design tests are intended to verify the suitability of the design, materials and method of manufacture (technology) of composite insulators.

According to ANSI standard: The design tests are intended to verify the insulators electrical and mechanical characteristics that depend on its size and shape.

Type Test Report
This report provides the verification of the rated characteristics of the equipment as assigned by the manufacturer, by means of the performance of the appropriate type tests specified by the standards, for type tests not indicated above.

Development Test Report
This report is issued when the test is intended only to provide the Client with information about the performance of the equipment. The tests are performed in accordance with relevant standards, but are not intended to verify compliance of the equipment.

Control Test Report
This report is issued for tests performed on equipment in service, or removed from service. Tests are performed, and compliance is evaluated in accordance with relevant standards.

Test Report
Test report is issued in all cases not listed above.

Ratings/characteristics assigned by the manufacturer:

Test object:	All Aluminium Alloy Conductor (AAAC)
Designation:	181 mm^2 All Aluminium Alloy Conductor (Code: 181-AL3)
Manufacturer:	BMET
Structure:	
Centre:	1 × Ø3.48mm Aluminium Alloy wire (Al-Mg-Si)
Layer 1:	6 × Ø3.48mm Aluminium Alloy wire (Al-Mg-Si)
Layer 2:	12 × Ø3.48mm Aluminium Alloy wire (Al-Mg-Si)
Cross-sectional area:	180.7 mm^2
Conductor Diameter:	17.4 mm
Rated Tensile Strength (RTS):	53.31 kN
Modulus of Elasticity (E):	57 kN/mm^2
Nominal conductor mass:	496.1 kg/km
DC resistance at 20 °C:	0.1830 Ω/km

The tests were carried out in accordance with the following standards:

EN 50182: 2001	Conductors for overhead lines – Round wire concentric lay stranded conductors

Requirements of manufacturer or purchaser:

DC resistance measurement at 25 °C, 50 °C and 75 °C conductor temperatures

List of manufacturer's drawings for identification of the test object:

Technical Datasheet - 181 mm^2 All Aluminium Alloy Conductor

Present at the test in charge of manufacturer or purchaser:

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TESTS PERFORMED ON THE APPARATUS

No.	Description	Relevant clauses of the standard
1	Stress-Strain curves	EN 50182: 2001 Clause 6.4.7, Annex C
2	Tensile breaking strength	EN 50182: 2001 Clause 6.4.8, Annex C
3	DC resistance measurement	Client's requirement

DESCRIPTION OF THE TESTS

1. Stress-Strain curves

1.1. Test method and parameters

Stress–strain test was carried out on overhead line conductor type AAAC 181 mm^2 (Photo 1) in accordance with standard EN 50182 Clause 6.4.7 and Annex C. The ends of the conductor specimens were terminated with epoxy-resin dead-end and fixed in the end fittings (Photo 3). The test was performed in a tensile machine; with gauge length of 10.08 m. The conductor was tensioned according to the following table:

Table 1: Loading schedule for stress-strain test

Initial load (5% of RTS):	2.7 kN	To straighten the conductor and set the strain gage to zero.
Load (30% of RTS):	16.0 kN	30 min, then released to initial load.
Load (50% of RTS):	26.7 kN	60 min, then released to initial load.
Load (70% of RTS):	37.3 kN	60 min, then released to initial load.
Load (85% of RTS):	45.3 kN	60 min, then released to initial load.

During the test the conductor sample was supported along its length to keep the conductor straight and minimize the sag. The test set-up for the stress-strain test is shown in Figure 1 and on Photo 2. The test was carried out in a temperature-controlled laboratory at 20°C±2°C.

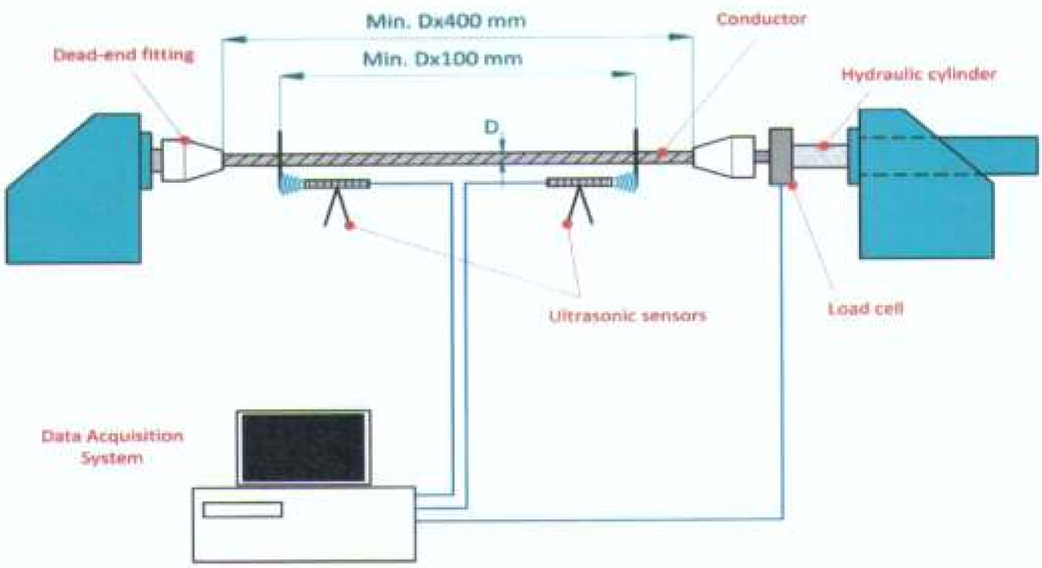

Figure 1
Test arrangement

1.2. Test results

The modulus of elasticity of the conductor was determined from the Force-Elongation curve by simple linear regression. Figure 2 shows the lines of best fit placed on the unloading segments of the curve.

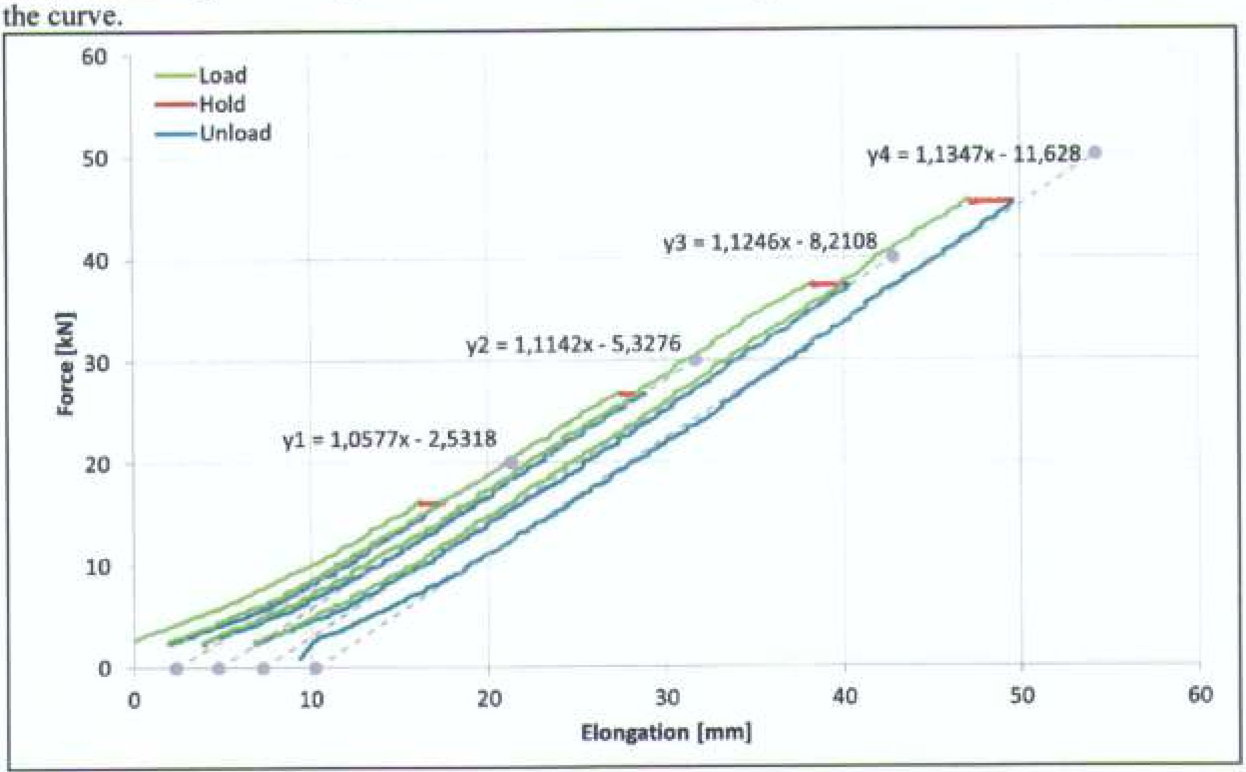

Figure 2
Lines of best fit placed on the unloading segments

The Modulus of Elasticity obtained at 30, 50, 70 and 85% RTS are summarised in Table 2.

Table 2: Modulus of elasticity

Load	Line of best fit ($y = m \cdot x + b$)	Slope (m)	Modulus of Elasticity ($E = m \cdot \frac{l_0}{A}$)
30% RTS	$y_1 = 1.0577 \cdot x - 2.5318$	1.0577	58.36 $\frac{kN}{mm^2}$
50% RTS	$y_2 = 1.1142 \cdot x - 5.3276$	1.1142	61.48 $\frac{kN}{mm^2}$
70% RTS	$y_3 = 1.1246 \cdot x - 8.2108$	1.1246	62.05 $\frac{kN}{mm^2}$
85% RTS	$y_4 = 1.1347 \cdot x - 11.628$	1.1347	62.61 $\frac{kN}{mm^2}$

The measured curves were corrected to cross zero by 0.03662% strain for the conductor. The corrected force-strain curves of the conductor are plotted in Figure 3.

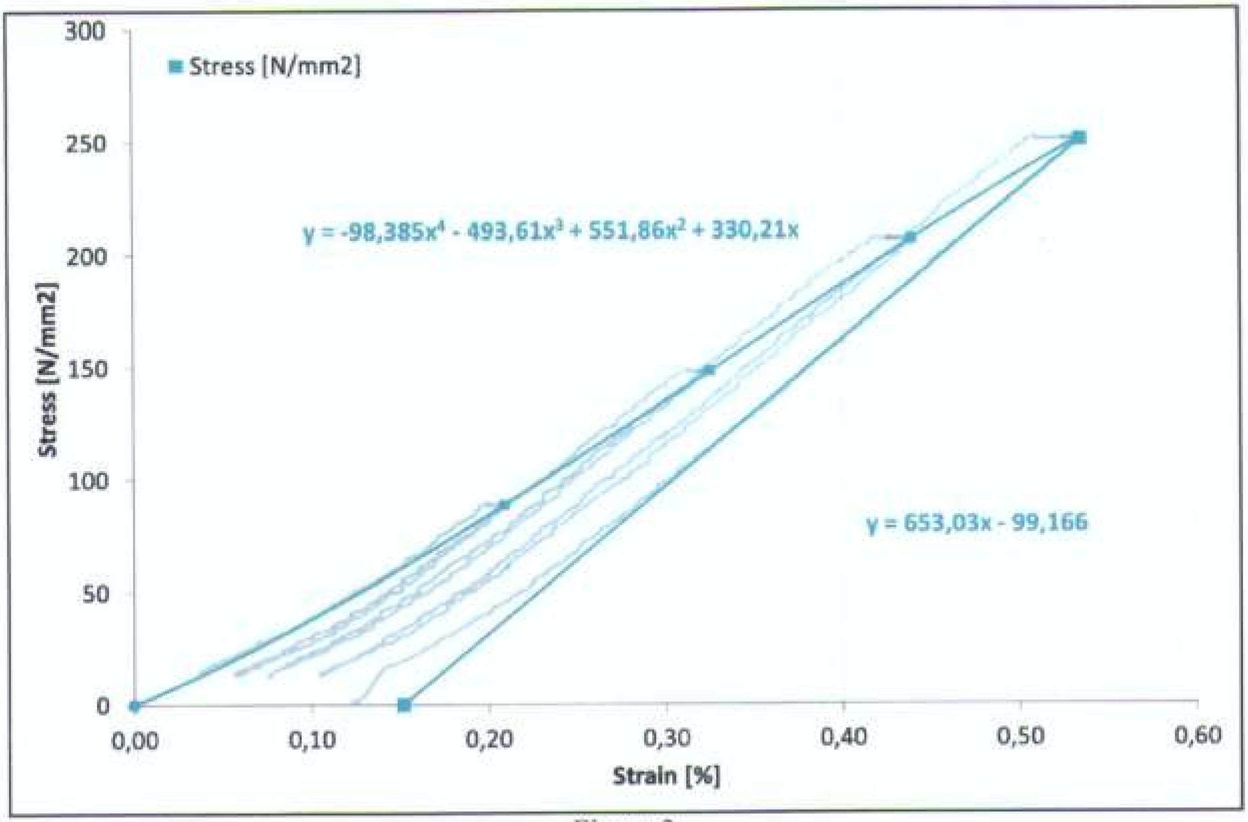

Figure 3
Stress-Strain curve (Conductor)

The stress-strain values obtained at the end of each hold period are summarized in Table 3.

Table 3: Stress and strain of the conductor

Load	Strain [%]	Stress of Conductor [N/mm^2]
30% RTS	0.2091	88.4837
50% RTS	0.3255	147.8085
70% RTS	0.4398	206.3033
85% RTS	0.5341	250.5755

The initial curve was obtained by fitting 4th order polynomial curve to above points. The coefficients are as follows:

- Conductor: $y = -98.385x^4 - 493.61x^3 + 551.86x^2 + 330.21x$

where:
x: strain [%]
y: stress [N/mm^2], calculated with the cross-sectional area of the whole conductor

The coefficients of the regression line fitted to the unloading segment of the stress-strain curves are as follows:

- Conductor: $y = 653.03x - 99.166$

where:
x: strain [%]
y: stress [N/mm^2], calculated with the cross-sectional area of the whole conductor

2. Tensile breaking strength

2.1. Test method and parameters

The verification of tensile breaking strength was carried out on overhead line conductor type AAAC 181 mm^2 in accordance with standard EN 50182 Clause 6.4.8 and Annex C. The test was carried on the same conductor specimen, which was subjected to stress-strain test.

2.2. Test results

The tensile specimen broke at the load of 61.74 kN. This value is higher than 50.6 kN (95 % of the 53.31 kN RTS), which is the acceptance criterion of the relevant standard. Based on the test results; the conductor AAAC 181 mm^2 fulfilled the requirements of tensile breaking strength.

The obtained Force-Elongation curve is shown in Figure 4. The fractured wires are shown on Photo 4.

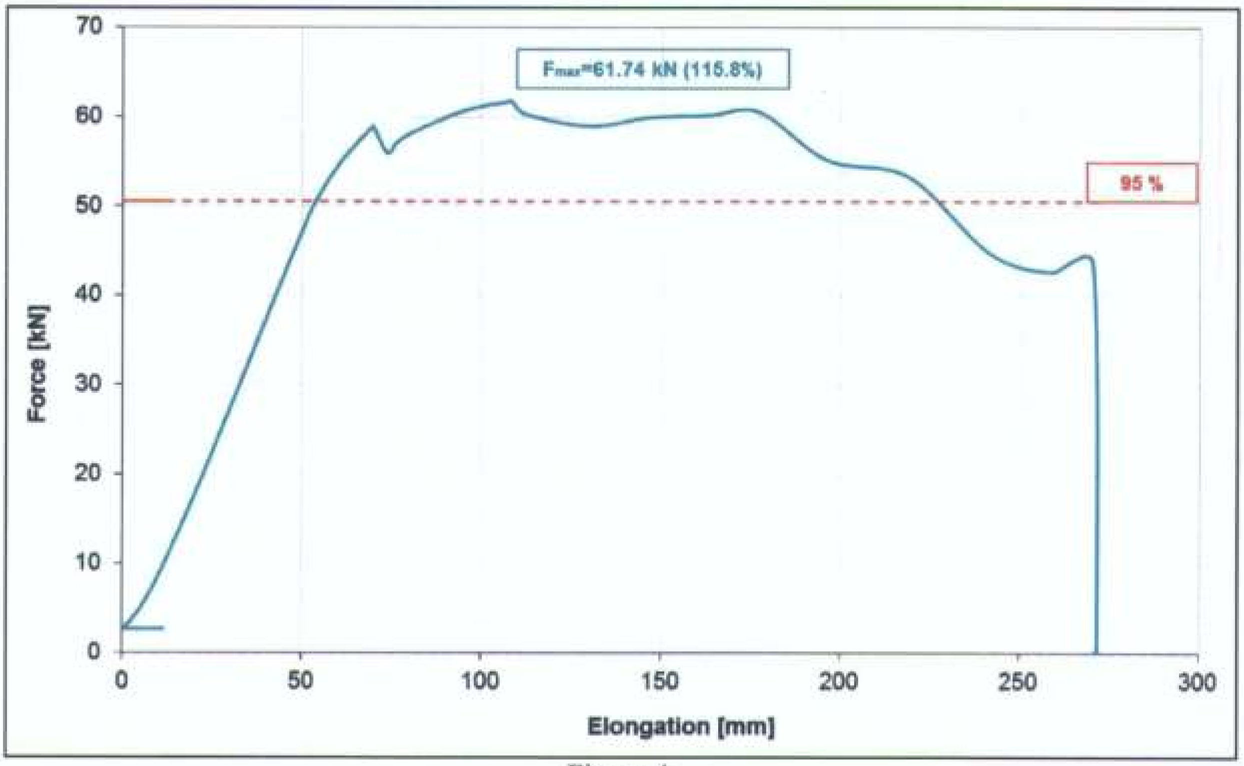

Figure 4
Tensile test of the conductor

3. DC resistance measurement

3.1. Test method and parameters

The DC resistance measurement was carried out on overhead line conductor type AAAC 181 mm^2 according to the test procedure agreed with Client. The conductor was placed in a 6 m long test span. The conductor was fixed by electrically ant thermally isolated fittings; the applied force was 10.7 kN (20% of RTS). The ends of the conductor were led to the power transformer and connected by bolted current clamps. The current was measured by CT and a data logger. Conductor temperature was measured by thermocouples installed under the outer layer at ends and middle of the tested section. The currents were applied to the conductor until its temperature reached steady state condition. The DC resistance measurement was made by a DC micro-ohmmeter (4-wire method). The voltage drop was measured in a 3 m long section at the middle of the span. The DC resistance measurement was performed at 25°C, 50°C and 75°C conductor temperature. The test arrangement is shown in Figure 5.

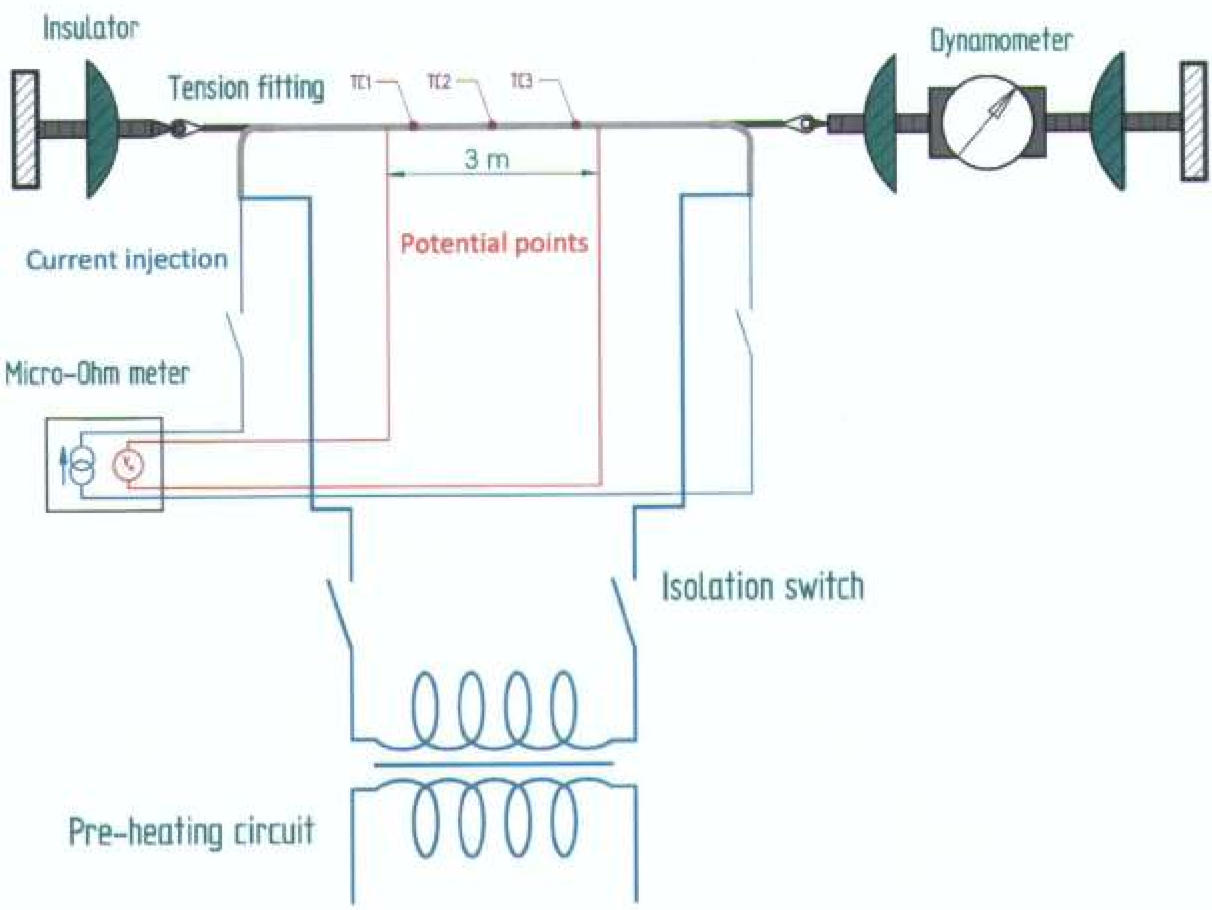

Figure 5
Test circuit diagram for DC resistance measurement

3.2. Test results

The DC resistance of the conductor measured at the temperature of 20.2°C was as the following:

$$R_{\theta\_3m} = 541.8\mu\Omega \Rightarrow R_\theta = \frac{541.8\mu\Omega}{3m} = 180.6\frac{\mu\Omega}{m} = 0.1806\frac{\Omega}{km}$$

The resistance value obtained was corrected to 20°C by the following formula:

$$R_{20} = \frac{R_\theta}{1+\alpha_{20}(\theta-20)} = \frac{0.1806}{1+3.6\times10^{-3}(20.4-20)} = 0.1803\frac{\Omega}{km}$$

where

R_θ is the measured resistance

θ is the temperature in degree Celsius

α_{20} is the thermal coefficient of resistance ($\alpha_{20} = 3.6\ x10^{-3}\frac{1}{°C}$)

The measured resistance of the conductor (0.1803 Ω/km) was lower than the specified maximum 0.1830 Ω/km; therefore the conductor met the DC resistance requirement of the data sheet. The DC resistances measured at 25°C, 50°C and 75°C conductor temperatures are summarized in Table 4.

Table 4: Results of DC resistance measurement

Average Temperature [°C]	Heating Current [A]	Measured DC-Resistance [μΩ]	DC-Resistance [Ω/km]
20.4	-	541.80	0.1806
26.1	112.5	550.67	0.1836
50.6	289.3	600.01	0.2000
74.7	396.8	648.14	0.2160

The conductor temperature and the heating current are plotted in Figure 6.

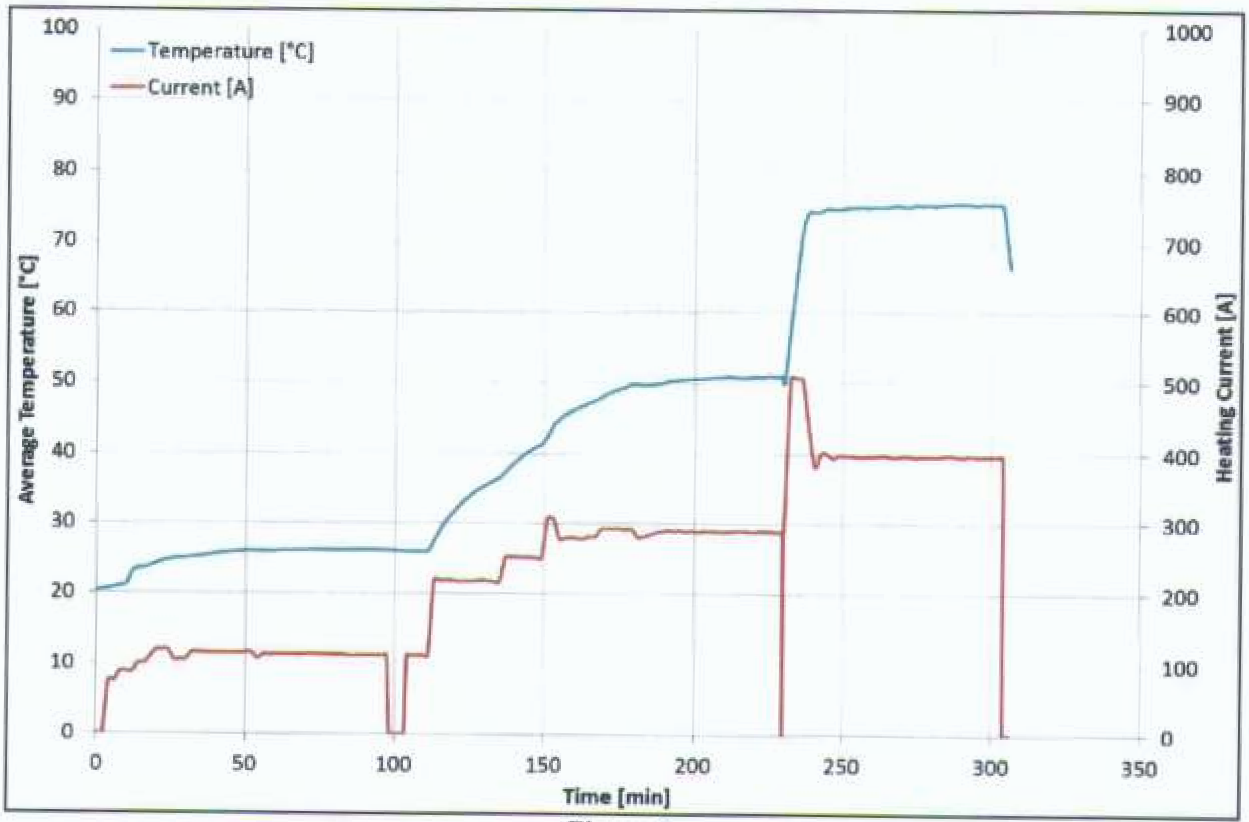

Figure 6
Conductor temperature and heating current

Uncertainty of measurements

Current measurement: ± 1 %
Temperature measurement: ± 2 °C
Tensile force measurement: ± 1 %
Resistance measurement: ± 0.2 %

The uncertainty values given in this report are the standard deviation values multiplied by k=2. Measurement uncertainty was estimated according to the method described in the EA-4/02 document.

Measuring devices used for the tests:

Designation	Manufacturer	Type	S/N:
Data Logger	FLUKE	2635A	2443009
Current Transformer	TETTEX	4724	103361
DC Microohm-meter	VEIKI-VNL	MO-1	001
Power Analyser	HIOKI	3193	05021 4964
Load Cell	TENZI	TCD-S-100kN	101102
Tensile test machine (300 kN)	BARABÁS Mérnökiroda Kft.	KSZ	001/2011

PHOTOS

Photo 1
Cross-sectional view of the tested conductor

Photo 2
Stress-Strain test arrangement

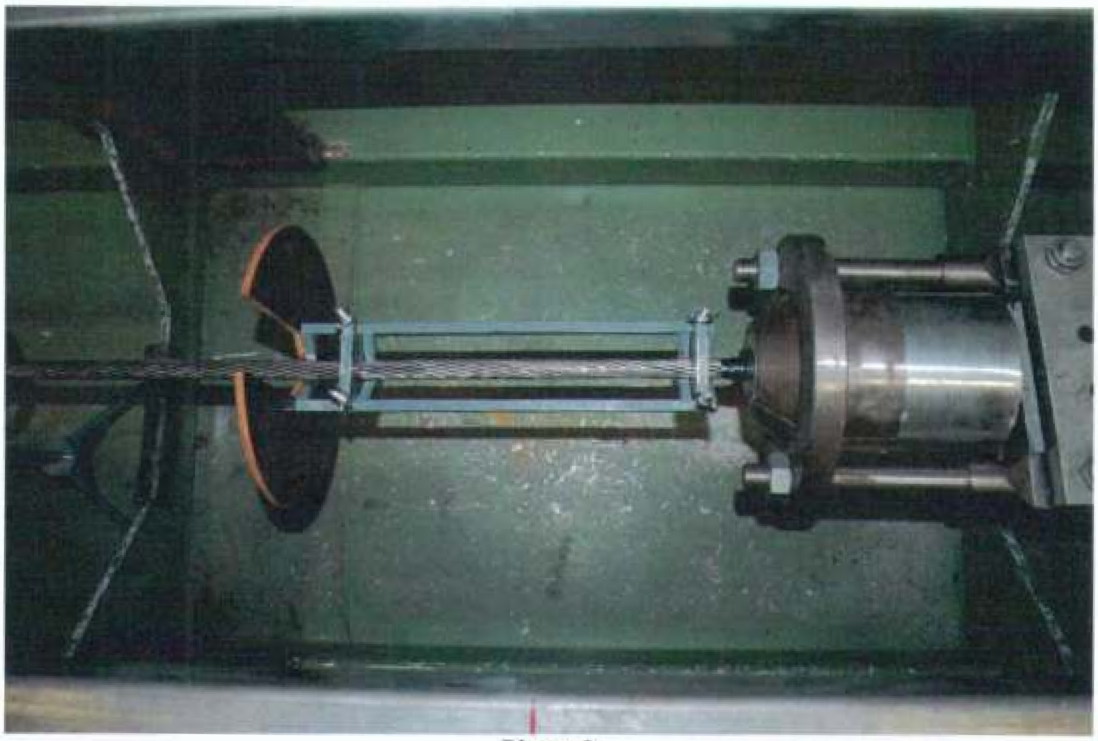

Photo 3
Dead-end fitting

Photo 4
Fractured wires after the tensile breaking test

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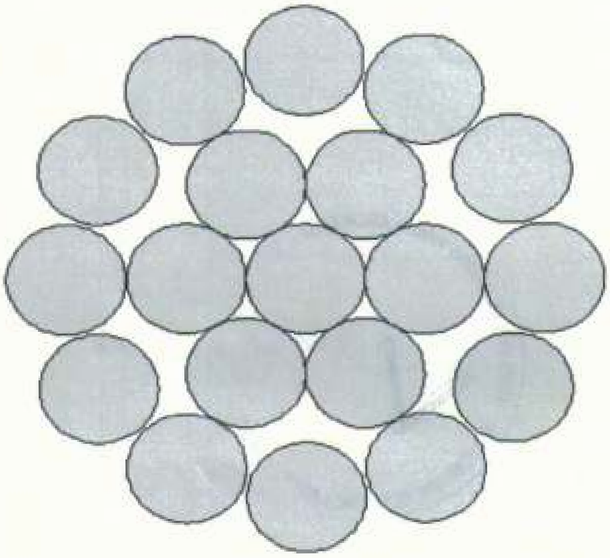
TECHNICAL DATASHEET

181 mm^2 All Aluminum Alloy Conductor



Type		AAAC
Code		181-AL3
Old Coed		ASH
According to regulation		BS EN 50182_2001
Size/nominal sectional area	mm^2	181
Number of Wires		19
Wire Diameter	mm^2	3.48
Ultimate tensile strength (before stranding)	N/mm^2	295
Conductivity at 20°C	% IACS	53
Calculated Area	mm^2	180.7
Minumum breaking strength	kN	53.31
Conductor Diameter	mm	17.4
Standard weight	kg/km	496.1
Calculated resistance 20°C (DC)	Ohm/km	0.1830
Modulus of elasticity (Final)	N/mm^2	57000
Coefficient of linear expansion	per °C	23*10^-6
Lay Ratio		Outer: 10-14 Second:10-16
Direction of Lay		Outer: Right Second:Left
Length of each reel	m	2000
Reel Type	mm	1300 * 650 * 880
Net weight per drum (without grease)	kg	992
Gross weight per drum	kg	1252

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Tóth Lajos