Engineering Report
EB-16242-22

Title:	Stress-Strain Test of a sample of conductor 242-AL1/39-ST1A (LA 280 HAWK)
At the request of:	EMTA KABLO SANAYI VE TİCARET A.Ş. İstasyon Mahallesi İbişağa Caddesi No:4 34940 Tuzla – İstanbul, Turkey
Test standard:	EN 50182:2001
Place of test:	RIBE Test Laboratory Werk 2 Industriestr. 5 91126 Schwabach, Germany

Internal request for test: VA 16242 File: 1.2 Contents: 16 pages

Summary:

A Stress-Strain Test was carried out with a sample of conductor 242-AL1/39-ST1A (LA 280 HAWK) provided by the purchaser. The results are documented in this report.

Mario Dansachmüller
RIBE Engineering

Hans-Jörg Krispin
RIBE Engineering

Schwabach, 6 July 2016

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1. Test set-up for composite conductor

The length of the conductor sample was 20,68 m (between eyes of dead-end clamps). The gauge length was 15,000 m. The conductor sample was prepared in line with instructions given in EN 50182. Epoxy type end fittings were used.

Measuring devices (calibration protocol see Appendices 2 to 5):

Tensile load	Load cell 200 kN Lorenz K11, S.No. 28261
Displacement	Inductive sensor HBM W100 S.No. 113.04 Data Acquisition Delphin AMDT CH5
Displacement	Inductive sensor HBM W50 S.No. 92410224 Data Acquisition Delphin AMDT CH6

2. Test loads for composite conductor

Loading conditions for stress-strain test for conductor 242-AL1/39-ST1A (LA 280 HAWK) with a rated tensile strength (RTS) of 84,89 kN as specified by the purchaser:

Tensile load (% RTS)	Tensile load (kN)	Hold time (h)	Remark
2	1,7	-	Initial load to straighten the conductor
0	0	-	Set the strain gauges to zero
30	25,5	0,5	Readings after 5, 10, 15 and 30 minutes, release to initial load
2	1,7	-	
50	42,4	1	Readings after 5, 10, 15, 30, 45 and 60 minutes, release to initial load
2	1,7	-	
70	59,4	1	Readings after 5, 10, 15, 30, 45 and 60 minutes, release to initial load
2	1,7	-	
85	72,2	1	Readings after 5, 10, 15, 30, 45 and 60 minutes, release to initial load
2	1,7	-	
85	72,2	-	Remove strain gauges and increase tension until breakage of conductor

3. Results for composite conductor

A screw-type tension device was used (constant rate of displacement per time). The rate of increase of load was such that 30 % RTS were reached after 1 minute 30 seconds. The respective rate of loading was approximately 17,0 kN/min. Stress was calculated on the basis of tensile load and total cross-sectional area of conductor (281,1 mm²).

Date of test: 5 July 2016

Tensile load % RTS	Tensile load kN	Stress MPa	Elongation mm	Strain %	Temperature beginning/end of hold period °C	Remark
0	0	0	0	0	23,4	Set the strain gauges to zero
30	25,5	90,6	19,6	0,131	23,4	Reading after 0 minutes
			20,4	0,136	-	Reading after 5 minutes
			20,5	0,137	-	Reading after 10 minutes
			20,6	0,138	-	Reading after 15 minutes
			20,8	0,139	23,5	Reading after 30 minutes
50	42,4	151,0	36,8	0,246	23,5	Reading after 0 minutes
			38,1	0,254	-	Reading after 5 minutes
			38,4	0,256	-	Reading after 10 minutes
			38,6	0,257	-	Reading after 15 minutes
			38,9	0,259	-	Reading after 30 minutes
			39,1	0,261	-	Reading after 45 minutes
			39,3	0,262	24,0	Reading after 60 minutes
70	59,4	211,4	58,7	0,392	24,0	Reading after 0 minutes
			61,6	0,411	-	Reading after 5 minutes
			62,2	0,415	-	Reading after 10 minutes
			62,6	0,417	-	Reading after 15 minutes
			63,3	0,422	-	Reading after 30 minutes
			63,7	0,425	-	Reading after 45 minutes
			64,0	0,427	24,4	Reading after 60 minutes
85	72,2	256,7	80,4	0,536	24,4	Reading after 0 minutes
			84,5	0,563		Reading after 5 minutes
			85,4	0,569	-	Reading after 10 minutes
			86,0	0,573	-	Reading after 15 minutes
			87,0	0,580	-	Reading after 30 minutes
			87,6	0,584	-	Reading after 45 minutes
			88,1	0,587	24,6	Reading after 60 minutes
30	25,5	90,6	54,0	0,360	-	Readings during 5th application of load
50	42,4	151,0	65,8	0,439	-	
70	59,4	211,4	78,1	0,521	-	
85	72,2	256,7	88,1	0,587	-	

The conductor broke at a load of 85,1 kN (100,2 % RTS based on an RTS value of 84,89 kN) at the exit of one tension clamp in the fifth application of load.

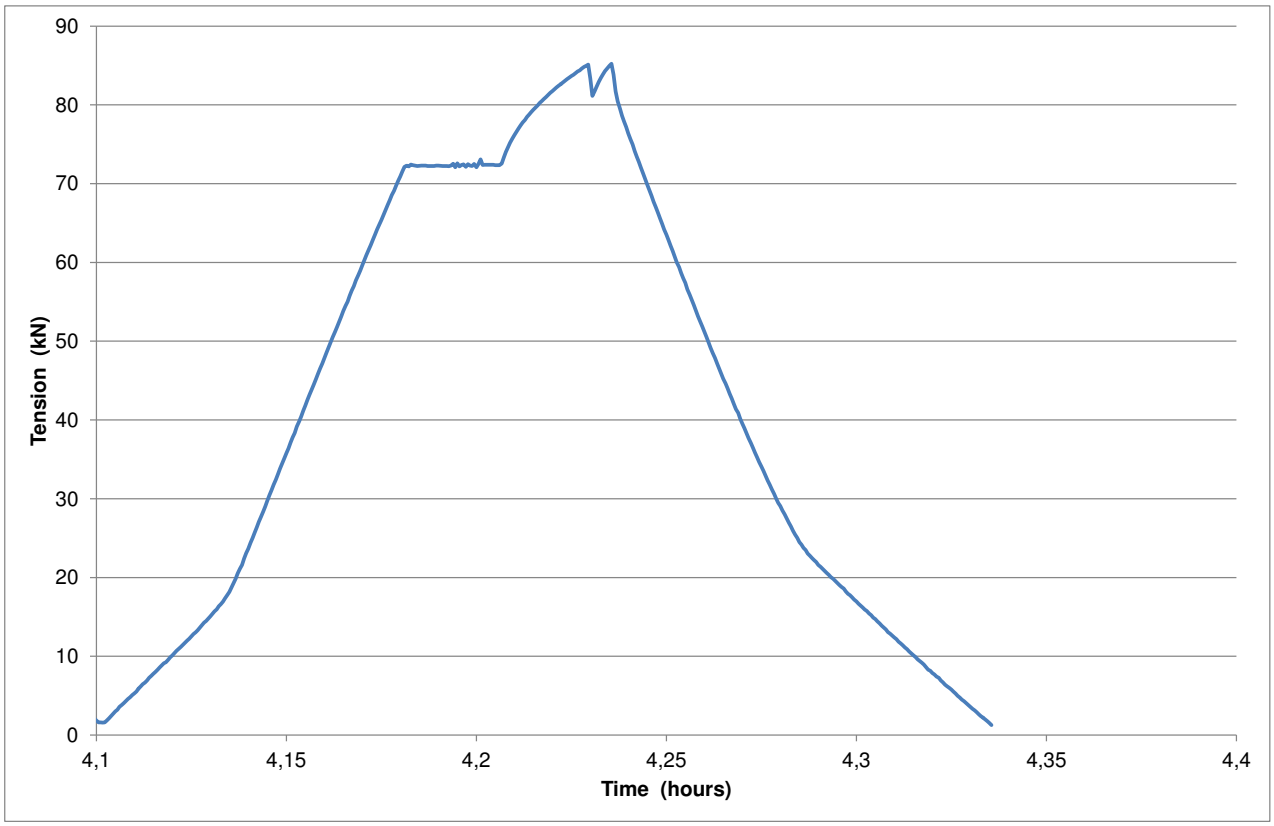

Fig. 1: Diagram load vs. time: Fifth application of load

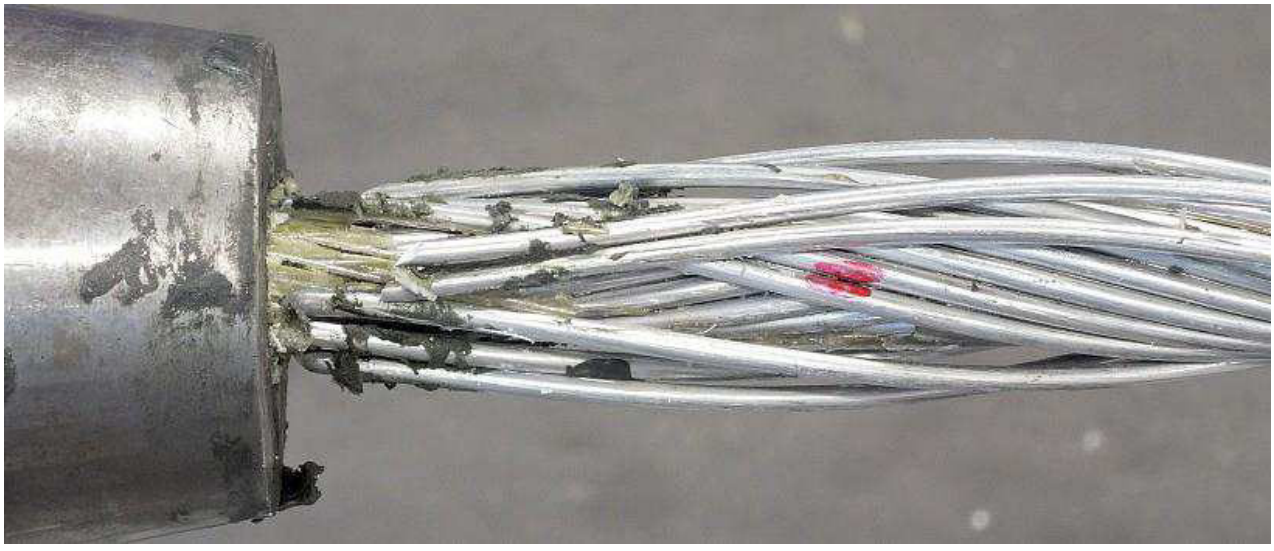

Fig. 2: Breakage of outer layer aluminium wires in one end clamp

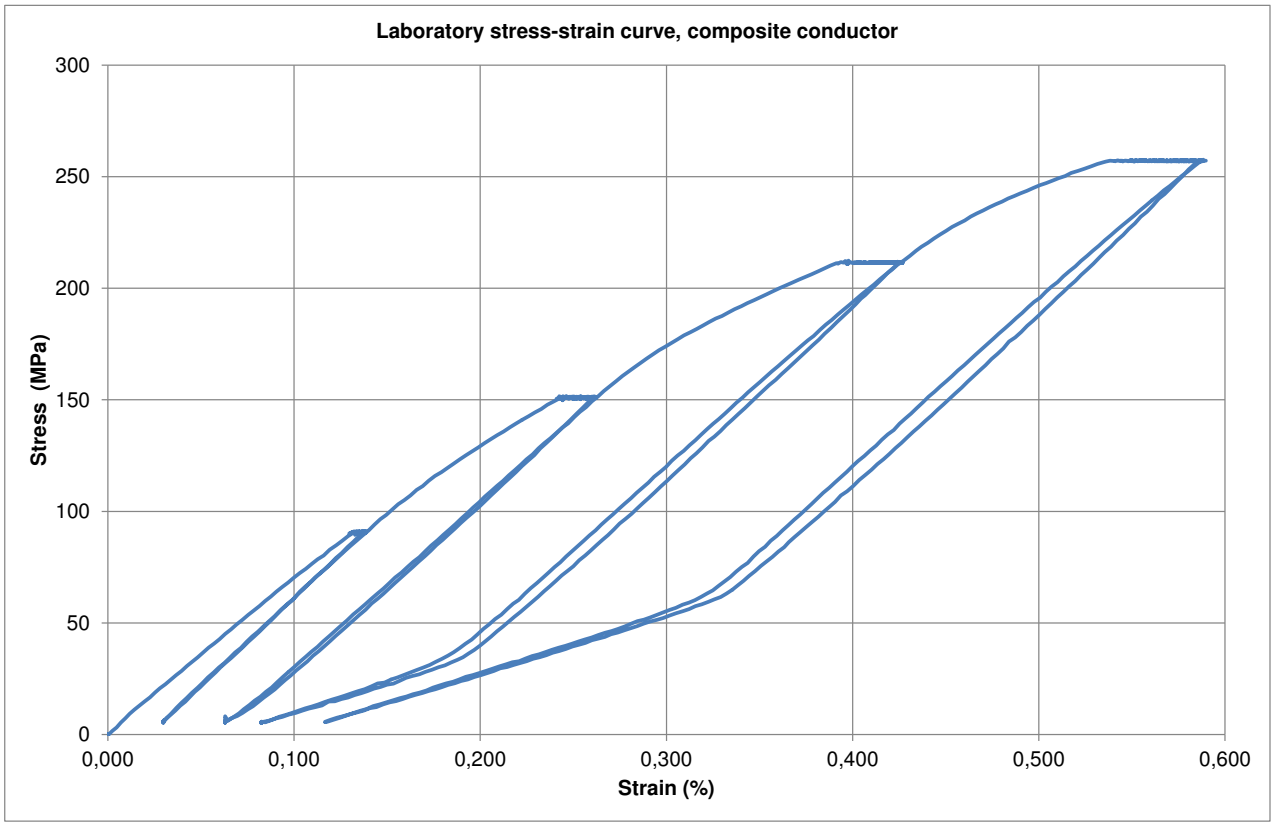

Fig. 3: Laboratory stress-strain curve, composite conductor

4. Test set-up for steel core only

The length of the steel core was 21,18 m (between eyes of compression dead-end clamps). The gauge length was 15,004 m. The steel core sample was prepared in line with instructions given in EN 50182, and the required methodology for installation of the compression dead-end clamps was used.

Measurement devices see paragraph 1.

5. Test loads for steel core only

The steel core was loaded until the elongation at the beginning of each hold period corresponded to that obtained on the conductor at 30, 50, 70, and 85 % RTS, respectively:

Load level (% RTS)	Strain (%)	Tensile load (kN)	Hold time (h)	Remark
-	-	1	-	Initial load to straighten the steel core
-	0	0	-	Set the strain gauges to zero
30	0,131	9,1	0,5	Readings after 5, 10, 15 and 30 minutes, release to initial load
-	-	1	-	
50	0,246	17,2	1	Readings after 5, 10, 15, 30, 45 and 60 minutes, release to initial load
-	-	1	-	
70	0,392	27,3	1	Readings after 5, 10, 15, 30, 45 and 60 minutes, release to initial load
-	-	1	-	
85	0,536	36,1	1	Readings after 5, 10, 15, 30, 45 and 60 minutes, release to initial load
-	-	1	-	
85	-	36,1	-	Remove strain gauges and increase tension until breakage of conductor

6. Results for steel core only

Stress was calculated on the basis of actual tensile load and cross-sectional area of steel core (39,5 mm²).

Date of test: 6 July 2016

Tensile load step % RTS	Actual tensile load kN	Stress MPa	Elongation mm	Strain %	Temperature °C	Remark
0	0	0	0	0	-	Set the strain gauges to zero
30	9,1	231,2	19,7	0,132	22,8	Reading after 0 minutes
			19,9	0,133	-	Reading after 5 minutes
			20,0	0,133	-	Reading after 10 minutes
			20,0	0,133	-	Reading after 15 minutes
			20,0	0,133	22,9	Reading after 30 minutes
50	17,3	437,0	36,9	0,246	22,9	Reading after 0 minutes
			37,4	0,249	-	Reading after 5 minutes
			37,5	0,250	-	Reading after 10 minutes
			37,6	0,250	-	Reading after 15 minutes
			37,6	0,251	-	Reading after 30 minutes
			37,7	0,251	-	Reading after 45 minutes
			37,7	0,251	23,0	Reading after 60 minutes
70	27,3	690,5	58,9	0,393	23,0	Reading after 0 minutes
			59,6	0,397		Reading after 5 minutes
			59,8	0,398	-	Reading after 10 minutes
			59,8	0,399	-	Reading after 15 minutes
			60,0	0,400	-	Reading after 30 minutes
			60,1	0,400	-	Reading after 45 minutes
			60,2	0,401	23,3	Reading after 60 minutes
85	36,2	914,3	80,7	0,538	23,3	Reading after 0 minutes
			81,8	0,545		Reading after 5 minutes
			82,1	0,547	-	Reading after 10 minutes
			82,3	0,549	-	Reading after 15 minutes
			82,6	0,551	-	Reading after 30 minutes
			82,9	0,552	-	Reading after 45 minutes
			83,0	0,553	23,5	Reading after 60 minutes
30	9,2	233,7	27,1	0,181	-	Readings during 5th application of load
50	17,4	441,4	43,8	0,292	-	
70	27,4	693,6	64,2	0,428	-	
85	36,3	919,2	82,8	0,552	-	

The test was terminated at a load of 50,0 kN in the fifth application of load without breakage of the steel core, in order to prevent damage of the testing equipment.

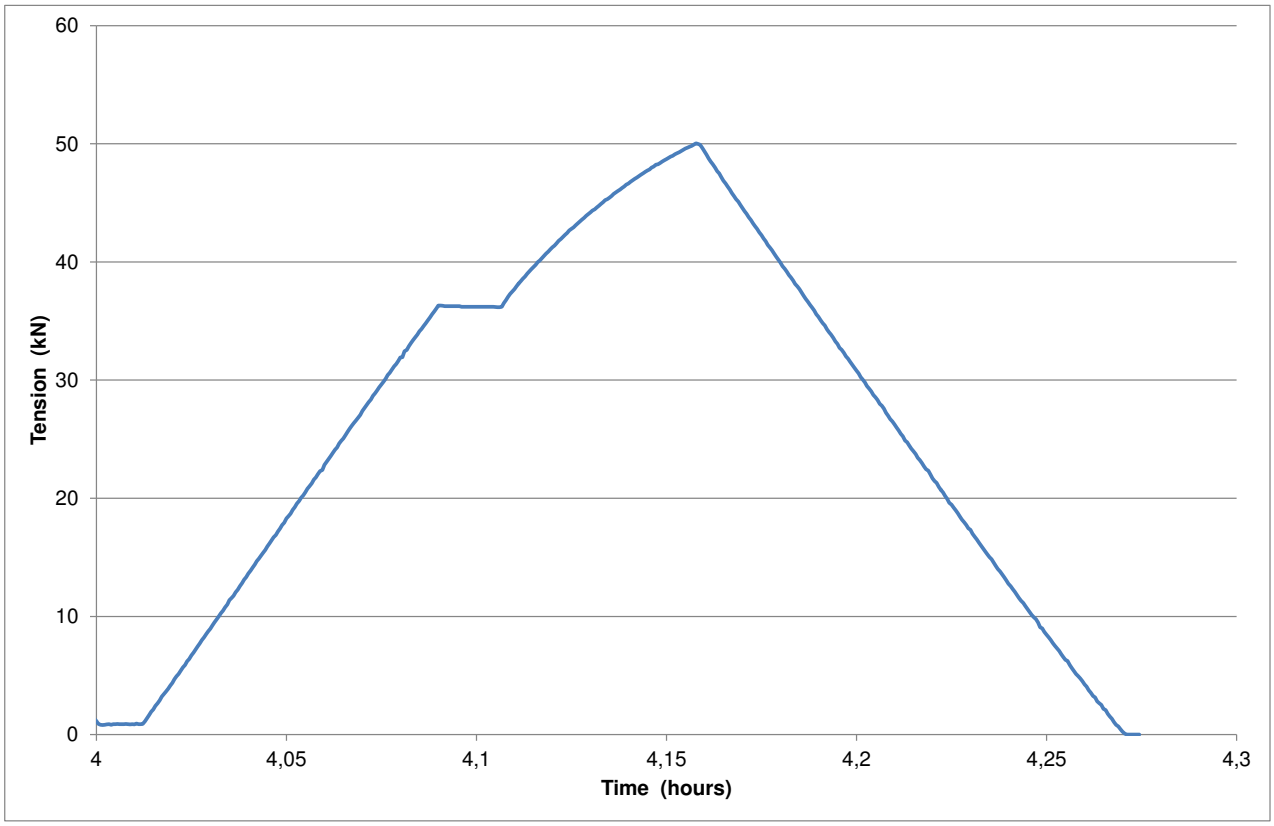

Fig. 4: Diagram load vs. time: Fifth application of load

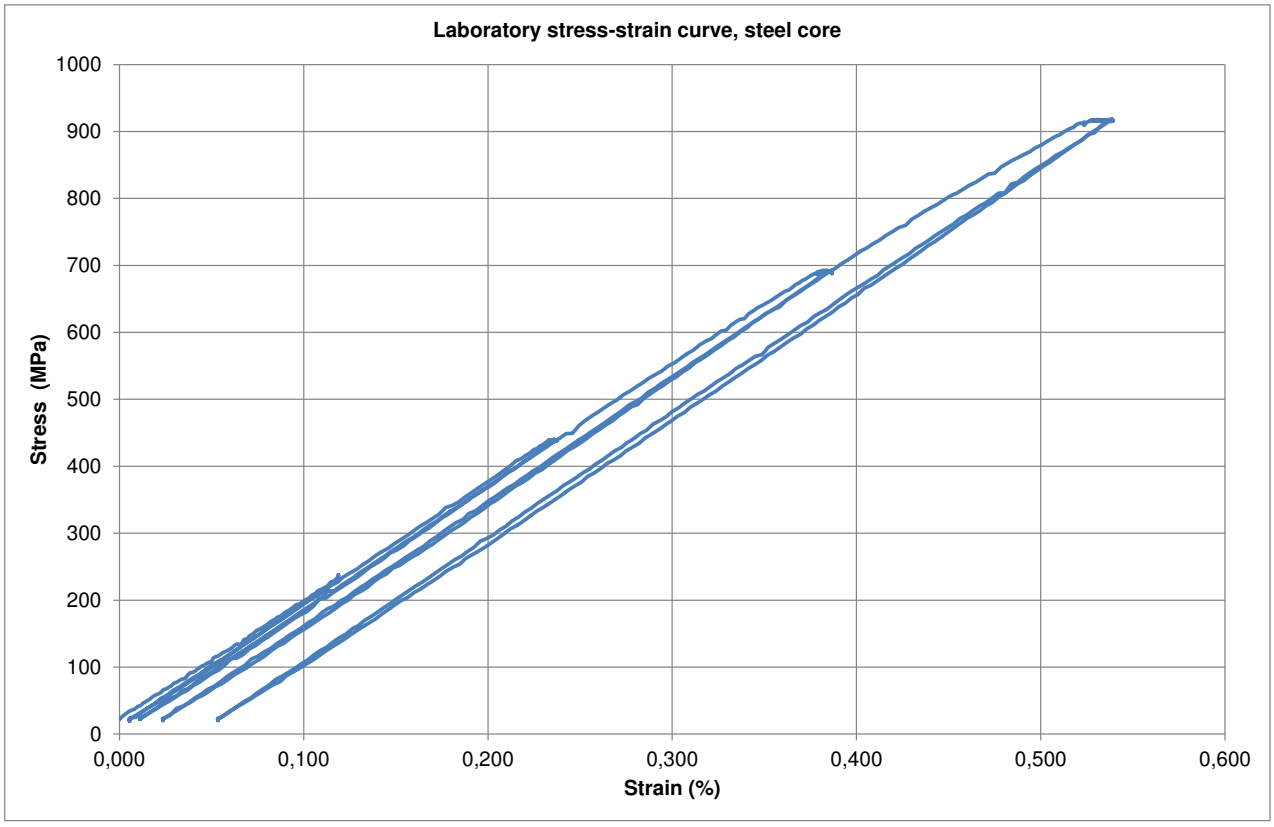

Fig. 5: Laboratory stress-strain curve, steel core

7. Evaluation of stress-strain curves

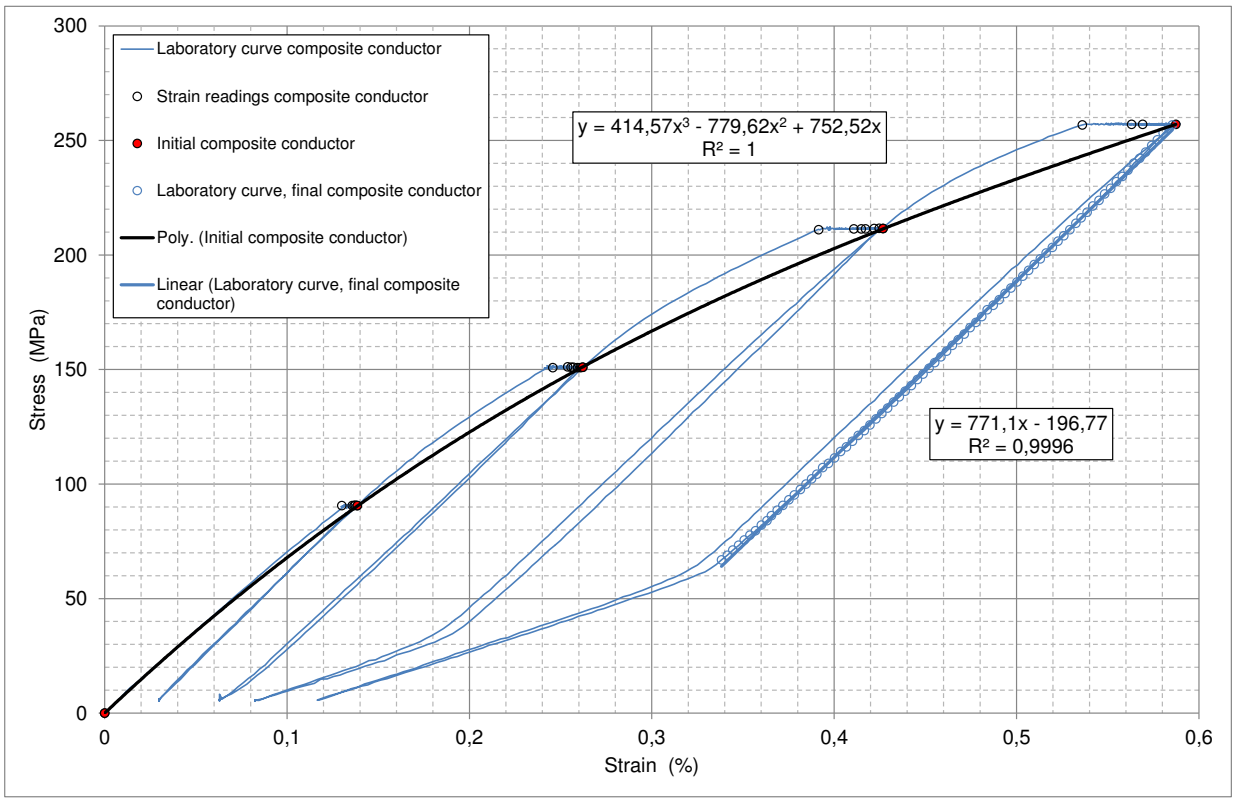

Fig. 6: Initial stress-strain curve and final modulus of composite conductor

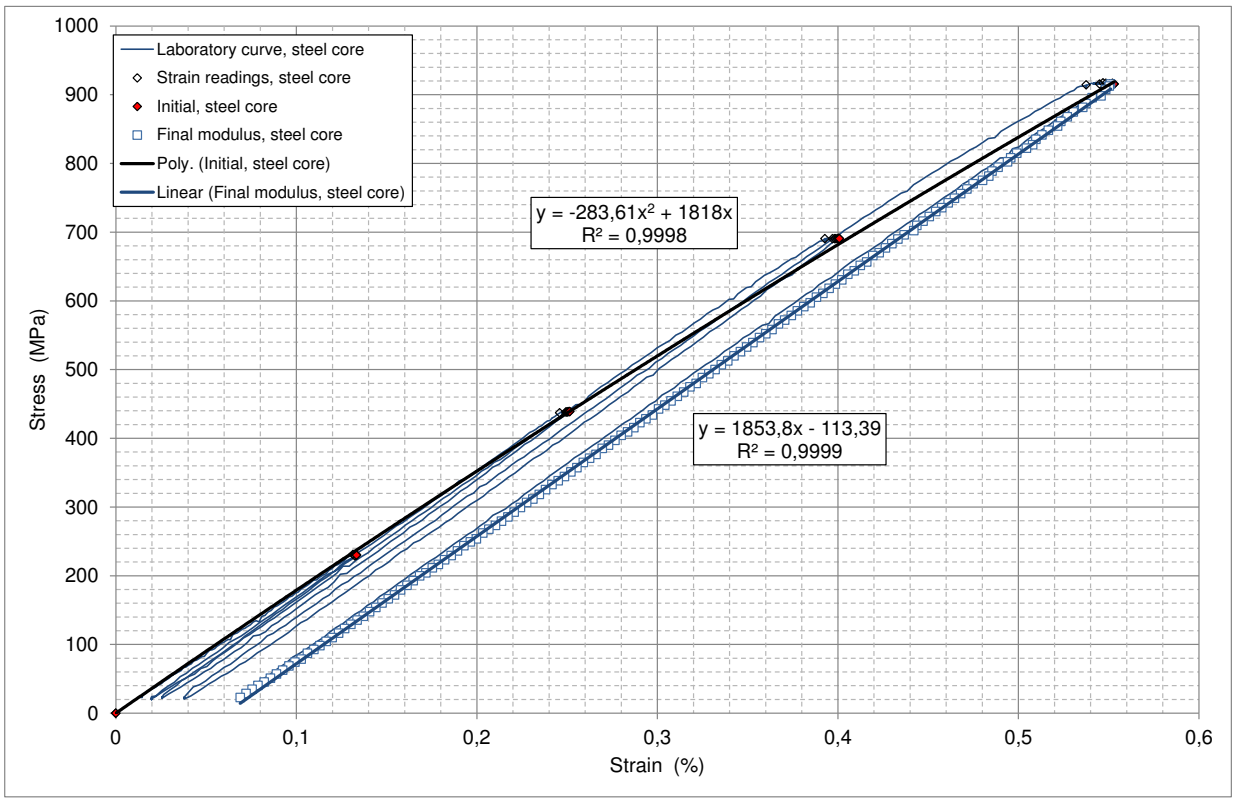

Fig. 7: Initial stress-strain curve and final modulus of steel core

Appendix 1: Conductor data

EMTA
CONDUCTOR & CABLE

CODE NAME			**242-AL1/39-ST1A**					
OLD CODE			**LA 280 HAWK**					
STANDARD			**BS EN 50182_2001**					
Aluminium Conductor Steel Reinforced	Size/nominal sectional area		mm²	240				
	Aluminum strand		Number	26		Diameter	3,44	mm
	Steel strand(for ACSR only)			7			2,68	
	Calculated area		Alum.	241,6	mm²	Total	281,1	mm²
			Steel	39,5				
	Minumum breaking strength		kN	84,89				
	Outside diameter		mm	21,80				
	Standard weight		Alum.	667,4	kg/km	Total	976,2	kg/km
			Steel	308,8	kg/km			
	Calculated resistance 20°C		D.C.	0,1195			Ohm/km	
	Modulus of elasticity		Final	77.000			N/mm²	
	Coefficient of linear expansion		Per °C	18.9 * 10⁻⁶				
				Outer		Second		Third
	Lay ratio and Direction of lay	Alum.	10 - 14	Right	10 - 16	Left		
		Steel	16 - 26	Right				
	Length of each reel		m (+/- %2)	1.750				
	Reel type		mm*mm*mm	1500 * 700 * 750 (890)				
	Net weight per drum (without grease)		kg	1.708				
	Gross weight per drum		kg	1.928				
	Grease weight Acc. To BS EN 50182_2001*		kg/km (+/-%20)					
	Grease type							
ALUMINUM WIRE	Diameter		mm	3,44				
	Ultimate tensile strength		N/mm²	165				
	Conductivity at 20°C		% IACS	61				
STEEL CORE WIRE	Diameter		mm	2,68				
	Ultimate tensile strength		N/mm²	1.350				
	Stress at 1% extension		N/mm²	1.140				
	Elongation in 250 mm		%	3,0				
	Galvanizing weight of coating		g/m²	230				
	Torsion		turns	16				

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Appendix 2: Calibration certificate load cell

Zentrum für Konstruktionswerkstoffe
Staatliche Materialprüfungsanstalt Darmstadt
Fachgebiet und Institut für Werkstoffkunde
Prof. Dr.-Ing. Matthias Oechsner

TECHNISCHE UNIVERSITÄT DARMSTADT

akkreditiert durch die / *accredited by the*

Deutsche Akkreditierungsstelle GmbH

als Kalibrierlaboratorium im / *as calibration laboratory in the*

DAkkS Deutsche Akkreditierungsstelle D-K-11048-01-00

Deutschen Kalibrierdienst DKD

Kalibrierschein *Calibration certificate*	**W 160272.3** **1. Ausfertigung**	Kalibrierzeichen *Calibration mark*	L 1938 D-K-11048-01-00 2016-02

Gegenstand *Object*	**liegende 200 kN Zugprüfmaschine**
Hersteller *Manufacturer*	**Lorenz**
Typ *Type*	**K11**
Fabrikat/Serien-Nr. *Serial number*	**28261**
Auftraggeber *Customer*	**RIBE, Richard Bergner Elektroarmaturen GmbH & Co. KG** **Bahnhofstraße 8 - 16** **91126 Schwabach**

Auftrags-, Vertragsnummer	**310513 vom 20.1.14 / W 620**
Anzahl der Seiten des Kalibrierscheines *Number of pages of the certificate*	**7**
Datum der Kalibrierung *Date of calibration*	**15.02.2016**

Dieser Kalibrierschein dokumentiert die Rückführung auf nationale Normale zur Darstellung der Einheiten in Übereinstimmung mit dem Internationalen Einheitensystem (SI).
Die DAkkS ist Unterzeichner der multilateralen Übereinkommen der European co-operation for Accreditation (EA) und der International Laboratory Accreditation Cooperation (ILAC) zur gegenseitigen Anerkennung der Kalibrierscheine.
Für die Einhaltung einer angemessenen Frist zur Wiederholung der Kalibrierung ist der Benutzer verantwortlich.
This calibration certificate documents the traceability to national standards, which realize the units of measurement according to the International System of Units (SI).
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The user is obliged to have the object recalibrated at appropriate intervals.

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Stempel *Seal*	Datum *Date*	Stellv. Leiter des Kalibrierlaboratoriums *Deputy head of the calibration laboratory*	Bearbeiter *Person in charge*
	16.02.2016	Dipl.-Ing. (FH) A. Hecht	Dipl.-Ing. V. Marzian

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Appendix 3: Calibration certificate displacement sensor 1

RIBE

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EEK Page 1/2 Protocol Cert_W50_092410224_2016-06-16 16/06/2016

Calibration protocol according to DIN ISO 10012

Calibration protocol code **Cert_W50_092410224_2016-06-16**

Devices calibrated:

Device 1:	Displacement Sensor HBM W50
Serial No.:	092410224
Device 2:	HBM Measurement Amplifier MGCplus / ML55B
Serial No.:	801197960/1
Device 3:	Delphin Data acquisition system, AMDT CH3
Serial No.:	without

Calibration reference device

Device 1:	Gauge blocks Johansson Type 11
Serial No.:	11, 25463 DKD-K-17301 2010-11

Measurement data:	Page 2
Date of calibration:	16/06/2016
Calibration carried out by:	H. Jung

H. Jung

CERT_W50_092410224_2016-06-16.xlsx

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Page 2/2 Protocol Cert_W50_092410224_2016-06-16 16/06/2016

Devices calibrated:

Device 1: Displacement Sensor HBM W50
Serial No.: 092410224
Settings: none

Device 2: HBM Measurement Amplifier MGCplus / ML55B
Settings: Channel 2, sensitivity 80,10 mV/V
Serial No.: 801197960/1

Device 3: Data acquisition system Delphin, AMDT CH4
Serial No.: without
Settings: Sensitivity 10 V / 50 mm

Calibration reference device

Device 1: Gauge blocks Johansson Type 11
Serial No.: 11, 25463 DKD-K-17301 2010-11

Relative displacement reference mm	Displacement reading mm	Relative displacement mm	Deviation relative displacement %
0	0,000	0,00	-
5	4,993	4,99	-0,14
10	9,993	9,99	-0,07
15	14,992	14,99	-0,05
20	19,985	19,99	-0,08
25	24,966	24,97	-0,14
30	29,989	29,99	-0,04
35	35,002	35,00	0,01
40	40,013	40,01	0,03
45	45,025	45,03	0,06
50	50,000	50,00	0,00

CERT_W50_092410224_2016-06-16.xlsx

Appendix 4: Calibration certificate displacement sensor 2

RIBE **Richard Bergner Elektroarmaturen GmbH + Co. KG**

EEK Page 1/2 Protocol Cert_W100_113-04_2016-06-16 16/06/2016

Calibration protocol according to DIN ISO 10012

Calibration protocol code **Cert_W100_113-04_2016-06-16**

Devices calibrated:

Device 1: Displacement Sensor HBM W100
Serial No.: 113.04 / 3799

Device 2: Measurement Amplifier HBM MGC / MC55
Serial No.: 199144B

Device 3: Data acquisition system Delphin, AMDT CH5
Serial No.: none

Calibration reference device

Device 1: Gauge blocks Johansson Type 11
Serial No.: 11, 25463 DKD-K-17301 2010-11

Measurement data: Page 2
Date of calibration: 16/06/2016
Calibration carried out by: H. Jung

H. Jung

CERT_W100_113-04_2014-10-10.xlsx

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Page 2/2 Protocol Cert_W100_113-04_2016-06-16 16/06/2016

Devices calibrated:

Device 1: Displacement Sensor HBM W100
Serial No.: 113.04 / 3799
Settings: none

Device 2: Measurement Amplifier HBM MGC / MC55
Serial No.: 199144B
Settings: Channel 1, sensitivity 82,08 mV/V, Filter AC

Device 3: Data acquisition system Delphin, AMDT CH5
Serial No.: none
Sensitivity 10 V / 100 mm

Calibration reference device:

Device 1: Gauge blocks Johansson Type 11
Serial No.: 11, 25463 DKD-K-17301 2010-11

Relative displacement reference mm	Displacement reading mm	Relative displacement mm	Deviation relative displacement %
0	-99,75	0,00	
10	-90,29	9,46	-5,43
20	-80,30	19,44	-2,79
30	-70,31	29,44	-1,88
40	-60,39	39,36	-1,60
50	-50,34	49,40	-1,19
60	-40,39	59,36	-1,07
70	-30,42	69,32	-0,97
80	-20,39	79,35	-0,81
90	-10,33	89,41	-0,65
100	-0,44	99,31	-0,69
110	9,62	109,36	-0,58
120	19,80	119,55	-0,38
130	29,96	129,70	-0,23
140	40,50	140,24	0,17
150	50,40	150,14	0,09
160	60,64	160,39	0,24
170	70,72	170,47	0,28
180	80,64	180,39	0,22
190	90,16	189,90	-0,05
200	99,67	199,42	-0,29

CERT_W100_113-04_2014-10-10.xlsx