



DEHN Test Centre

Test report



No. 2582_SUJ

Test object:	2x Duraklick aluminum floor rail with Duraklick external profile connector; manufacturer Soltop Energie Uni – Earthingclamp (Art.-Nr. 540251); manufacturer DEHN SE
Applicant:	<i>Soltop Energie GmbH</i> <i>Lindauer Strasse 15</i> <i>88145 Hergatz</i> <i>Germany</i>
Type of testing:	• Verification of the lightning current carrying capacity for test class N (50 kA) based on the test methods of IEC 62561-1 (VDE 0185-561-1):2024-05, Section 6.5 and Section 6.6. • Evaluation of the PV mounting frame as a natural component of the derivation of a lightning protection system in accordance with IEC 62305-3 (VDE 0185-305-3):2011-10, clause 5.3.5.
Test result:	➤ The test of the lightning current carrying capacity of the Duraklick PV mounting system based on DIN EN IEC 62561-1 (VDE 0185-561-1):2024-05 was passed. ➤ The assessment of the photovoltaic mounting system according to IEC 62305-3:2010-12 (Edition 2.0); chapter 5.3.5, for the compliance with the minimum dimensions is made by the applicant, see Annex A.
Contents:	36 pages test report including 27 figures, 9 oscillograms and 1 annex.

Neumarkt, 19.09.2024

Revision: 0

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General Remarks

- This test report only provides information on the test samples submitted for the test and does not examine the lasting quality of the series production.
- This test report does not give the right to use any kind of approval symbol.

Laboratory

Name and address:

DEHN SE
DEHN Test Centre
Hans-Dehn-Str. 1
92318 Neumarkt
Germany

Measurement uncertainty:

The statements of conformity are made, considering the measurement uncertainty for the relevant measurement parameters on basis of ILAC G8:2019 cl. 4.2.1. The information on the measurement uncertainty can be provided on request.

DEHN Test Centre accreditation:



DEHN Test Centre is an accredited test laboratory by German Accreditation Body (DAkKS) according to DIN EN ISO/IEC 17025. The accreditation is valid for the scope listed in the annex of the accreditation certificate D-PL-20356-01-00. www.dakks.de

DEHN Test Centre is a qualified third-party test facility for testing of products under UL's Third-Party Test Data Program.

Further certifications:

- DEKRA Certificate of approval for Customer's Test Facility.
- VDE Certificate of acceptance for the Test Data Acceptance Program (TDAP).

For further information about accreditation, see <https://www.dehn-international.com/en/centre-test-dehn> (QR-Code).

Test record

General information

Test date: 29th August 2024 to 11th September 2024

Tested by: Mr Julian Süß

Accompanied by: N/A

issued on: 11th September 2024 revision: 0

Test object

Provided by, manufacturer: Soltop Energie GmbH

No. of test objects: 3

Date of receipt of test objects: 29th Juli 2024

Condition of test objects: The received test objects were new and in a good condition

Description of the test objects: Photovoltaic base frame with clamp for connecting round wire.

- Figure 1 shows the simplified circuit diagram of the test set-up.
- Before the electric tests, the test samples had to be submitted to conditioning/ageing (→ see test regulations and Figure 3 to Figure 8).
- Figure 9 shows the test set-up integrated and connected to the 50 kA (10/350 µs) Impulse Current Generator.
- Figure 10 to Figure 15: show the test samples before and after the tests.
- Figure 16 to Figure 18 show the measurement of test sample temperature.
- Figure 19 to Figure 20 show the measurement of conductor length after connector.
- Figure 21 to Figure 23 show the measurement of the contact resistance.
- Figure 24 to Figure 27 show the measurement of the torque.
- The test samples were provided by Soltop Energie GmbH.

Test specification

Test following the principles of IEC 62561-1 Edition 3.0 (2023-03) "Lightning protection system components (LPSC) – Part 1: Requirements for connection components" chapter listed below

- Chapter 6.1 a)/c) – Tests for connection components, on 3 new test samples according to IEC 62561-1, Annex C, Figure C.1.
- Chapter 6.1 b) – The test objects shall be assembled to the manufacturer instructions (arrangement, tightening torques).
- Chapter 5.3 → Chapter 6.3 – The marking test was carried out during the DEHN product testing of the DEHN components.
- Chapter 5.3 → Chapter 6.3 – The marking test for the photovoltaic mounting system is not applied, due to absent markings.
- Chapter 6.4 a) – If not otherwise specified, the conductors and connections of the photovoltaic mounting system must be cleaned with a suitable degreasing agent followed by cleaning in demineralized water and dried.
Deviation: The cleaning of the connections was not applied.
- Chapter 6.4 b) – The used conductors comply with IEC 62561-2. The photovoltaic mounting system are classified as metal installation.
- Chapter 6.4 e) – The test arrangement described in the test report corresponds to the intended use. The tested conductors and connection components shall be used by the customer. The test with the smallest and largest conductor size is not applied.
- Chapter 4.2 → Chapter 6.5 – Conditioning/ageing of the test samples for general use:
Annex D.2 – Salt mist treatment in accordance with IEC 60068-2-52:2017, except clause 7, 10 and 11 which are not applicable → 3 cycles: 2 h spraying at 35° C with salt solution followed by 22 h recovery at 40 °C.
Annex D.3 – Treatment with humid sulphurous atmosphere in accordance with ISO 22479:2019 Method B with a sulphurous dioxide volume concentration of 667×10^{-6} → 7 cycles: 8 h heating time at 40 °C in humid saturated atmosphere followed by 16 h recovery.

- Chapter 4.1 → Chapter 6.6.1 – Test with three 10/350 μ s lightning impulse current with following parameters for class N – Normal duty:

$$I_{\text{imp}} = 50 \text{ kA} \pm 10 \%$$

$$W/R = 625 \text{ kJ}/\Omega -10 \% / +45 \%$$

The impulse current reaches the value $I_{\text{imp}} \leq 50 \mu\text{s} (T_{\text{imp}})$

$$t_d = < 5 \text{ ms}$$

- The impulse parameters are also defined in the following standard:
IEC 62305-1 Edition 2.0 (2010-12).
- Chapter 6.6.1 – The objects must cool down to approximately ambient temperature before each impulse current load.
- Chapter 6.6.2 a) – Measurement of the contact resistance with a source of at least 5 A, using voltmeter-ammeter method after the last load. The contact resistance after the last impulse current load must be equal or less than 3 m Ω .
- Chapter 6.6.2 b) – Evaluation of the mechanical strength of the test sample: Visual inspection of the test samples for damages, cracks, loose parts or deformation, which would be impairing its normal use.
- Chapter 4.4 b) → Chapter 6.6.2 f) – Measurement of conductor length after the connector. The 20 mm length of the conductor from the connector, prior to the test, is not less than 3 mm after the tests (for non-permanent connections).
- Chapter 4.4 b) → Chapter 6.6.2 d) – Determination of the loosening torque after the last 10/350 μ s impulse current. The loosening torque must be greater than 0,25 times and less than 1,5 times of the tightening torque.
- Chapter 4.3 a) → Chapter 6.6.2 g) – The photovoltaic mounting system are not intended to withstand a static-mechanical stress according to IEC 62561-1:2023-03.
- Chapter 4.4 b) → Chapter 6.6.2. g) – The static-mechanical test is not applied for screwing or bolting connection components.
- Chapter 4.4 b) → Chapter 6.6.2 g) – The static-mechanical test for the photovoltaic mounting system is not applicable to a system configuration with several connections (mechanical compound arrangement).

Test setup

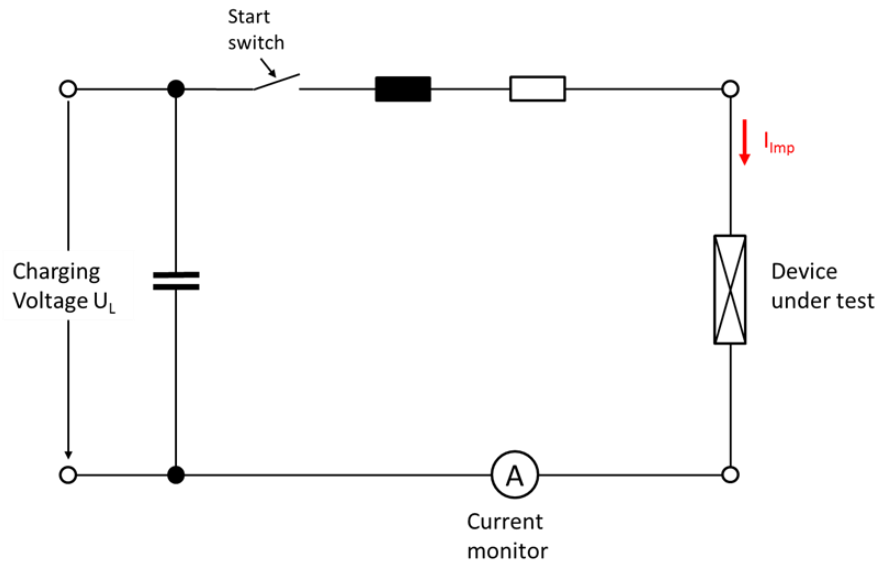


Figure 1: Simplified circuit diagram of the test set-up.

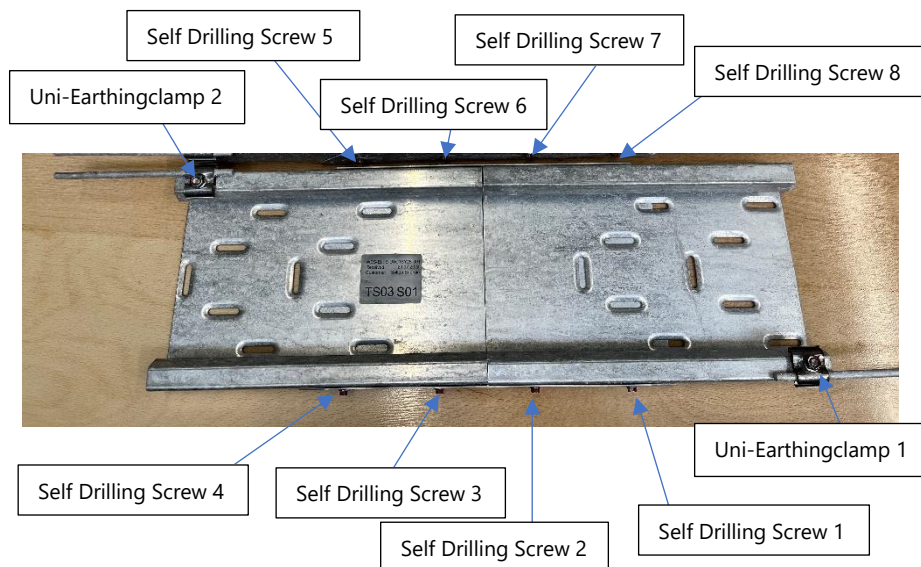


Figure 2: Bolt Positions for Testing.

Test-specific remarks

- The mechanical forces acting on the connecting leads may result in loosen terminals. Therefore, it is recommended to check all connections after a direct lightning strike.
- In the test, only the lightning-current capability of the arrangement was tested. All other specifications and wiring regulations are carried out according to the technical specification of the applicant.
- An assessment of the applicability as an air termination system according to IEC 62305-3:2010 „Protection against lightning – Part 3: Physical damage to structures and life hazard“ is not part of this test service.
- An assessment of the separation distance of the down conductor to any near parts according to IEC 62305-3:2010 „Protection against lightning – Part 3: Physical damage to structures and life hazard“ is not part of this test service.
- An assessment of the influence of the lightning current load on the safety function of the test objects is not part of this test service. This assessment will be carried out by applicant.

Measurement data

Tolerance ranges

		Class N – Normal duty		
		min.	target	max.
I	[kA]	45	50	55
W/R	[kJ/Ω]	406,25	625	906,25

Electrical test

Test sample	Impulse no.	I _{imp} [kA]	W/R [kJ/Ω]	T ₁ [μs]	T ₂ [μs]	I _{imp} ≤ 50 μs	W/R _{Td} < 5 ms
TS01 S01	1x 50 kA	50,7	664,2	13,9	358,2	OK	OK
	2x 50 kA	50,5	663,5	13,8	359,7	OK	OK
	3x 50 kA	50,4	661,9	13,8	360,6	OK	OK
TS02 S01	1x 50 kA	50,4	664,4	14,9	361,5	OK	OK
	2x 50 kA	50,4	664,3	14,9	361,1	OK	OK
	3x 50 kA	50,3	664,5	14,9	362,3	OK	OK
TS03 S01	1x 50 kA	50,4	664,4	14,6	360,9	OK	OK
	2x 50 kA	50,3	665,0	14,6	362,8	OK	OK
	3x 50 kA	50,3	663,5	14,7	362,4	OK	OK

Temperature

Measurement point		Test sample TS01 S01	Test sample TS02 S01	Test sample TS03 S01
		[°C]	[°C]	[°C]
UNI-Earthing Clamp 1 → see Figure 16	before imp. 1	23	23	23
	before imp. 2	23	24	24
	before imp. 3	24	24	24
UNI-Earthing Clamp 2 → see Figure 17	before imp. 1	23	23	23
	before imp. 2	23	24	23
	before imp. 3	24	24	23
UNI-Earthing Clamp 1 → see Figure 18	before imp. 1	23	23	23
	before imp. 2	23	24	24
	before imp. 3	24	24	24

Conductor length after connector

Measurement point		Test sample TS01 S01	Test sample TS02 S01	Test sample TS03 S01
		[mm]	[mm]	[mm]
UNI-Earthing Clamp 1 → see Figure 19	after assembly	20	20	20
	after imp. 3	20	20	20
UNI-Earthing Clamp 2 → see Figure 20	after assembly	20	20	20
	after imp. 3	20	20	20

Contact resistance

Measurement point		$R_{C \max}$	Test sample TS01 S01
			R [mΩ]
UNI-Earthing Clamp 1 → see Figure 21	after assembly	3 mΩ	0,400
	after imp. 3		2,503
Connection 1 → see Figure 22	after assembly	3 mΩ	0,040
	after imp. 3		0,441
UNI-Earthing Clamp 2 → see Figure 23	after assembly	3 mΩ	0,420
	after imp. 3		2,816
Measurement point		$R_{C \max}$	Test sample TS02 S01
			R [mΩ]
UNI-Earthing Clamp 1 → see Figure 21	after assembly	3 mΩ	0,380
	after imp. 3		2,399
Connection 1 → see Figure 22	after assembly	3 mΩ	0,038
	after imp. 3		0,078
UNI-Earthing Clamp 2 → see Figure 23	after assembly	3 mΩ	0,158
	after imp. 3		0,487
Measurement point		$R_{C \max}$	Test sample TS03 S01
			R [mΩ]
UNI-Earthing Clamp 1 → see Figure 21	after assembly	3 mΩ	0,723
	after imp. 3		1,142
Connection 1 → see Figure 22	after assembly	3 mΩ	0,036
	after imp. 3		0,056
UNI-Earthing Clamp 2 → see Figure 23	after assembly	3 mΩ	0,300
	after imp. 3		1,473

Torque

Test sample	Measurement point	Tightening torque [Nm]	Loosening torque [Nm]
TS01 S01	UNI – Earthing Clamp 1	10	11,4
	self-drilling screw 1	6	1,6
	self-drilling screw 2	6	1,6
	self-drilling screw 3	6	2,5
	self-drilling screw 4	6	2,2
	self-drilling screw 5	6	2,8
	self-drilling screw 6	6	3,1
	self-drilling screw 7	6	1,8
	self-drilling screw 8	6	1,9
	UNI – Earthing Clamp 2	10	13,8
TS02 S01	UNI – Earthing Clamp 1	10	9,8
	self-drilling screw 1	6	1,8
	self-drilling screw 2	6	2,0
	self-drilling screw 3	6	2,3
	self-drilling screw 4	6	1,7
	self-drilling screw 5	6	1,9
	self-drilling screw 6	6	1,8
	self-drilling screw 7	6	2,2
	self-drilling screw 8	6	3,5
	UNI – Earthing Clamp 2	10	6,3



Test sample	Measurement point	Tightening torque [Nm]	Loosening torque [Nm]
TS03 S01	UNI – Earthing Clamp 1	10	8,4
	self-drilling screw 1	6	2,5
	self-drilling screw 2	6	2,4
	self-drilling screw 3	6	2,5
	self-drilling screw 4	6	2,1
	self-drilling screw 5	6	2,3
	self-drilling screw 6	6	4,1
	self-drilling screw 7	6	1,9
	self-drilling screw 8	6	1,9
	UNI – Earthing Clamp 2	10	14,9

Test result

2x Duraklick aluminum floor rail with Duraklick external profile connector;
manufacturer Soltop Energie
Uni – Earthingclamp (Art.-Nr. 540251);
manufacturer DEHN SE

➤ **Test sample TS01 S01:**

- Figure 10 to Figure 11 shows the test sample before and after the test with 3x 50 kA (10/350 μ s).
- After the electrical test, no loose parts or deformation are visible, which would impairing its normal use.
- The contact resistances R_c after the last impulse current were $\leq 3 \text{ m}\Omega$.
- After the electrical test, the conductor length after the connectors is not less than 3 mm.
- The loosening torque of the screw-connections is greater than 0,25 times and less than 1,5 times of the tightening torque.

The test object **passed** the criteria based on IEC EN 62561-1 chapter 6.6, Class N with 3x 50 kA (10/350 μ s) and chapter 6.6.2 a)/b)/d)/f).

➤ **Remark:**

The measurement of contact resistance R_c was informative performed also before the conditioning/ageing process.

➤ **Test sample TS02 S01:**

- Figure 12 to Figure 13 shows the test sample before and after the test with 3x 50 kA (10/350 μ s).
- After the electrical test, no loose parts or deformation are visible, which would impairing its normal use.
- The contact resistances R_c after the last impulse current were $\leq 3 \text{ m}\Omega$.
- After the electrical test, the conductor length after the connectors is not less than 3 mm.
- The loosening torque of the screw-connections is greater than 0,25 times and less than 1,5 times of the tightening torque.

The test object **passed** the criteria based on IEC EN 62561-1 chapter 6.6, Class N with 3x 50 kA (10/350 μ s) and chapter 6.6.2 a)/b)/d)/f).

➤ **Remark:**

The measurement of contact resistance R_c was informative performed also before the conditioning/ageing process.

2x Duraklick aluminum floor rail with Duraklick external profile connector;
manufacturer Soltop Energie
Uni – Earthingclamp (Art.-Nr. 540251);
manufacturer DEHN SE

➤ **Test sample TS03 S01:**

- Figure 14 to Figure 15 shows the test sample before and after the test with 3x 50 kA (10/350 μ s).
- After the electrical test, no loose parts or deformation are visible, which would impairing its normal use.
- The contact resistances R_c after the last impulse current were $\leq 3 \text{ m}\Omega$.
- After the electrical test, the conductor length after the connectors is not less than 3 mm.
- The loosening torque of the screw-connections is greater than 0,25 times and less than 1,5 times of the tightening torque.

The test object **passed** the criteria based on IEC EN 62561-1 chapter 6.6, Class N with 3x 50 kA (10/350 μ s) and chapter 6.6.2 a)/b)/d)/f).

➤ **Remark:**

The measurement of contact resistance R_c was informative performed also before the conditioning/ageing process.

Figures



Figure 3: Test sample in the salt mist treatment device.

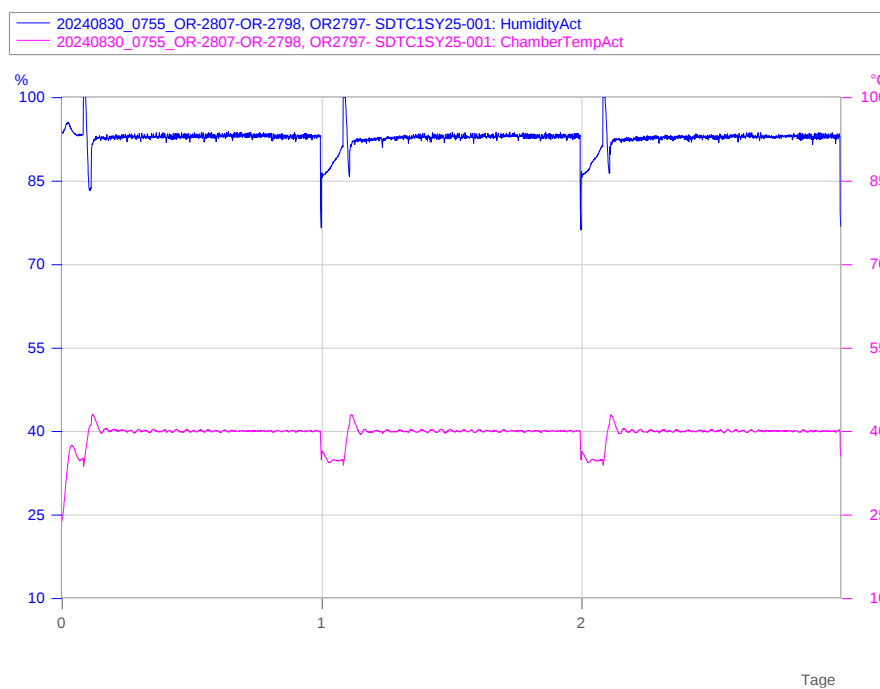


Figure 4: Profile of the salt mist treatment.

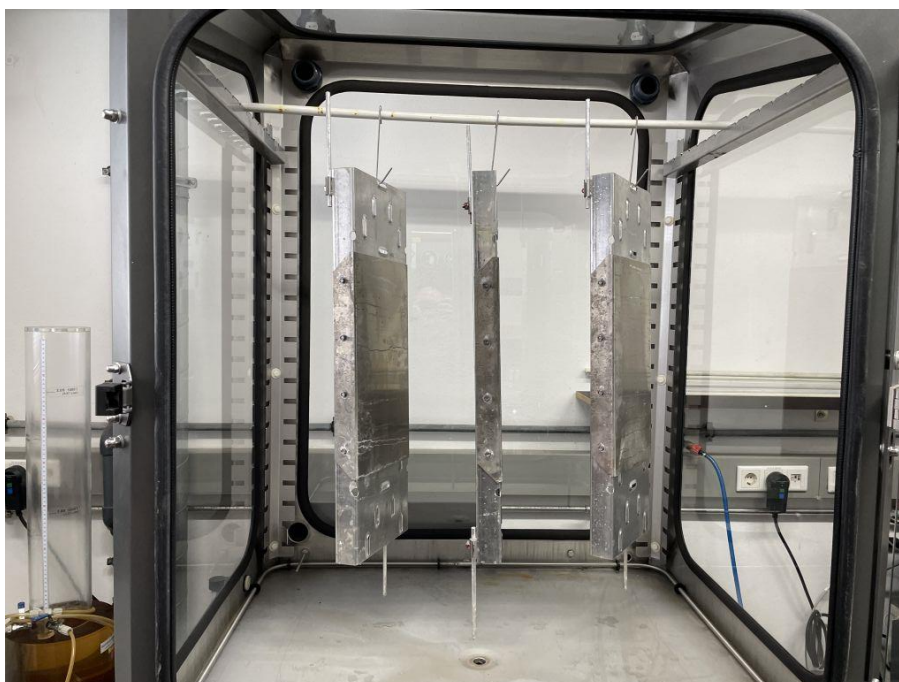


Figure 5: Test samples in the humid sulphurous atmosphere device.

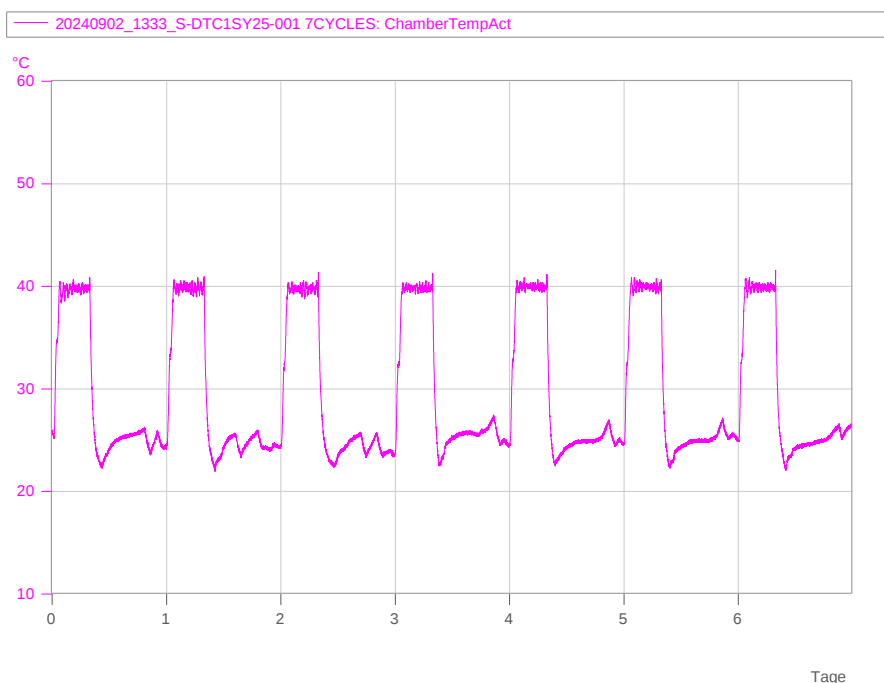


Figure 6: Temperature diagram of the humid sulphurous atmosphere treatment.



Figure 7: Test samples before the conditioning/ageing process.



Figure 8: Test samples after the conditioning/ageing process.



Figure 9: Electrical test – Overall view of the test set-up in the 50 kA (10/350 μ s) Impulse Current Generator.

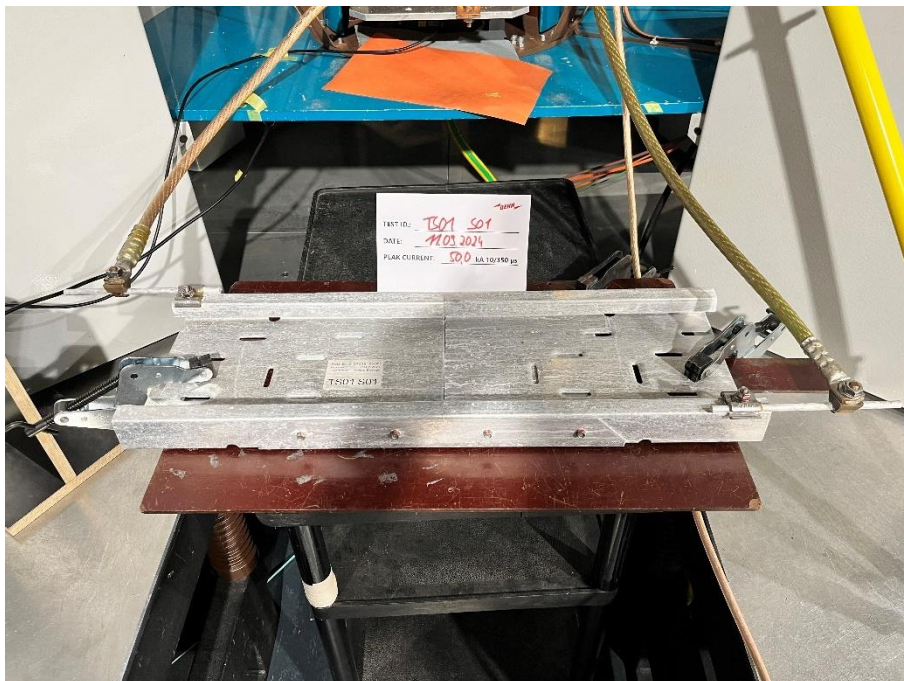


Figure 10: Test sample TS01 S01 before test with 3x 50 kA (10/350 μ s).

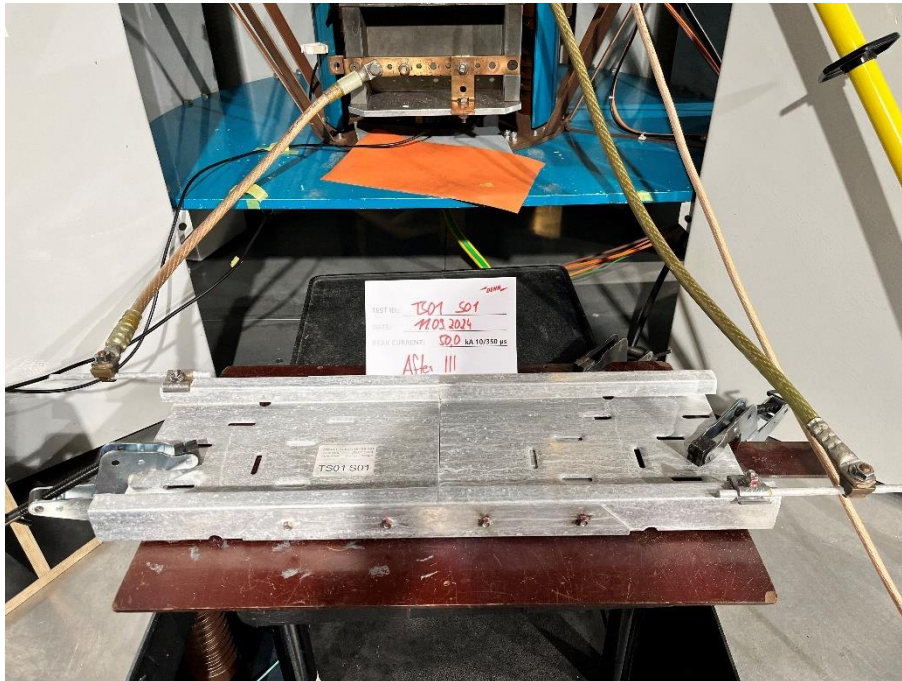


Figure 11: Test sample TS01 S01 after test with 3x 50 kA (10/350 µs).

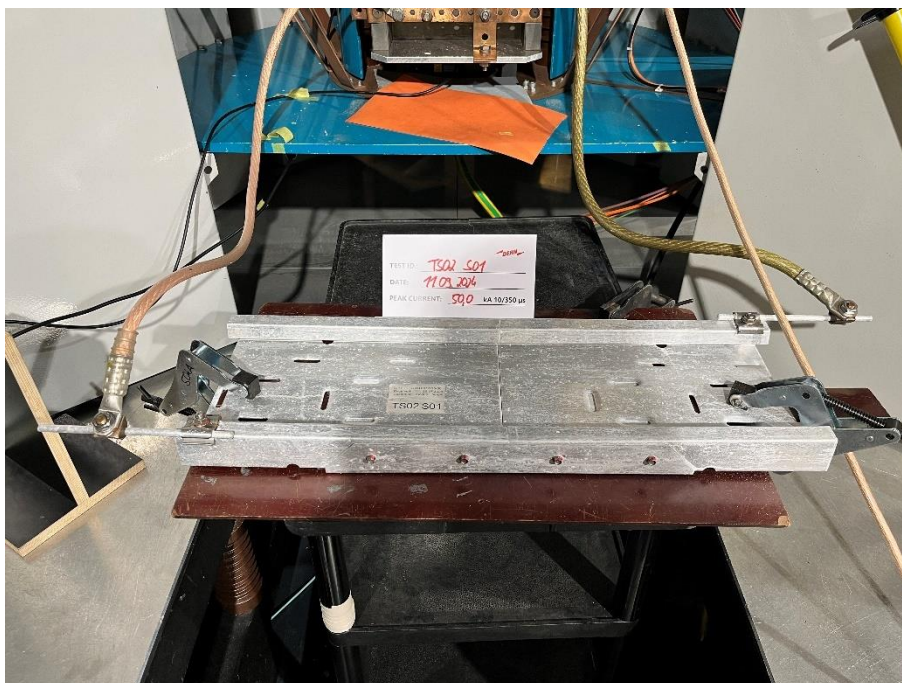


Figure 12: Test sample TS02 S01 before test with 3x 50 kA (10/350 µs).



Figure 13: Test sample TS02 S01 after test with 3x 50 kA (10/350 µs).

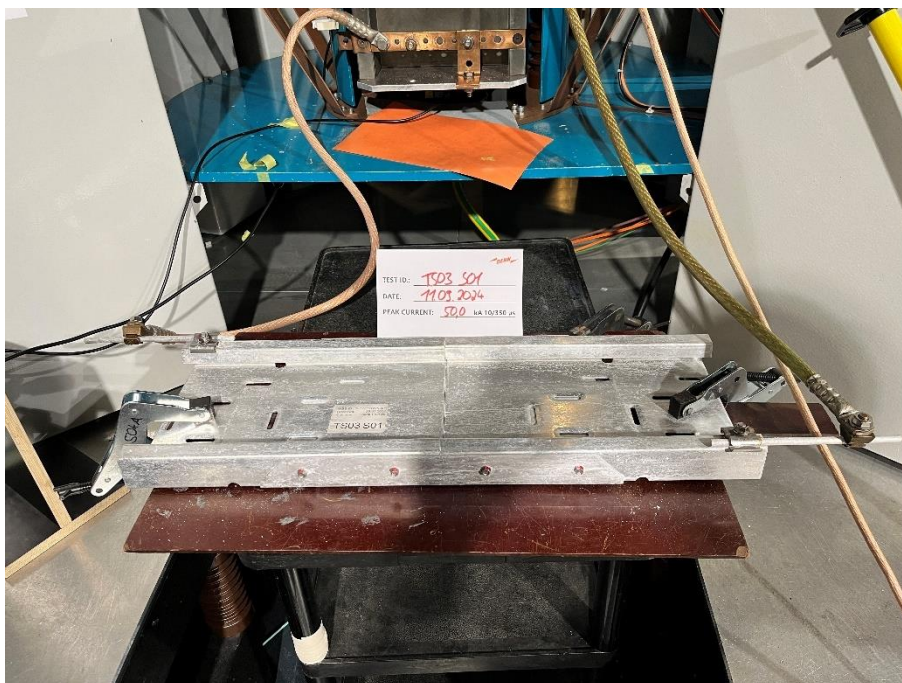


Figure 14: Test sample TS03 S01 before test with 3x 50 kA (10/350 µs).



Figure 15: Test sample TS03 S01 after test with 3x 50 kA (10/350 µs).

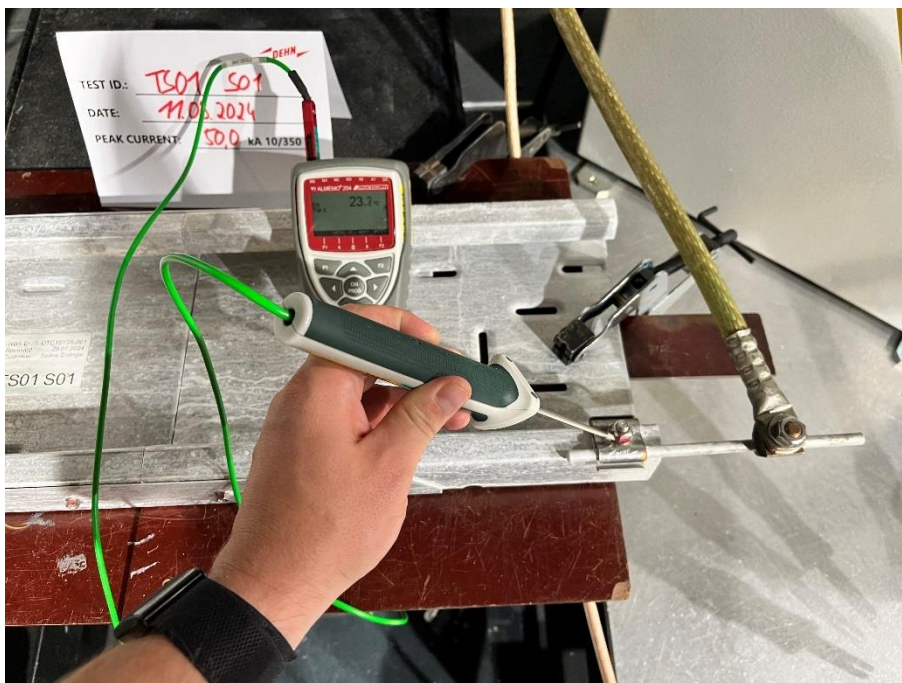


Figure 16: Measurement of test sample temperature – Uni-Earthing Clamp 1.



Figure 17: Measurement of test sample temperature – External connector.

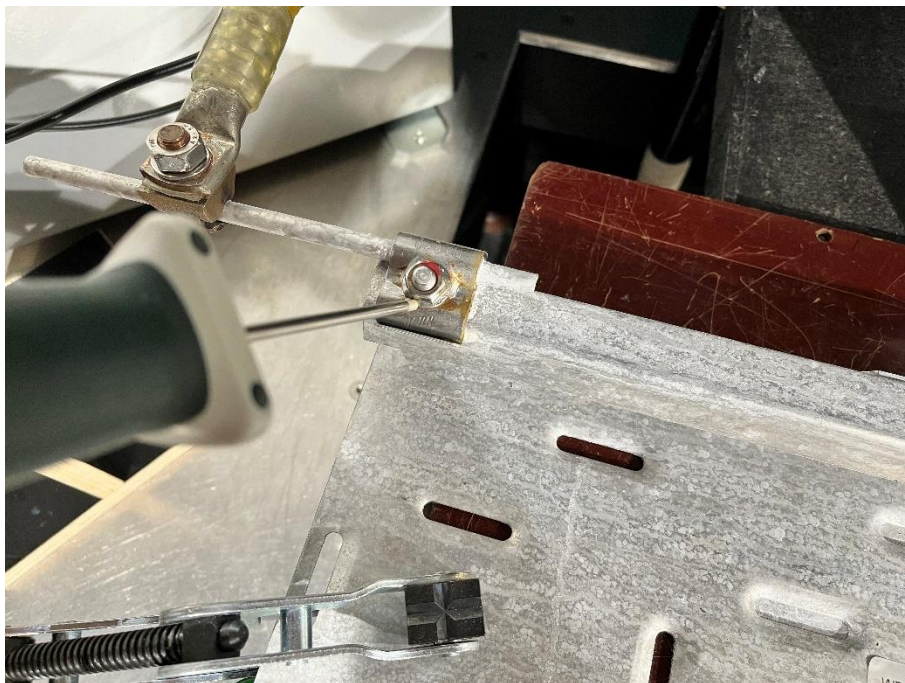


Figure 18: Measurement of test sample temperature – Uni-Earth Clamp 2.



Figure 19: Measurement of conductor length after connector – Uni-Earthing Clamp 1.

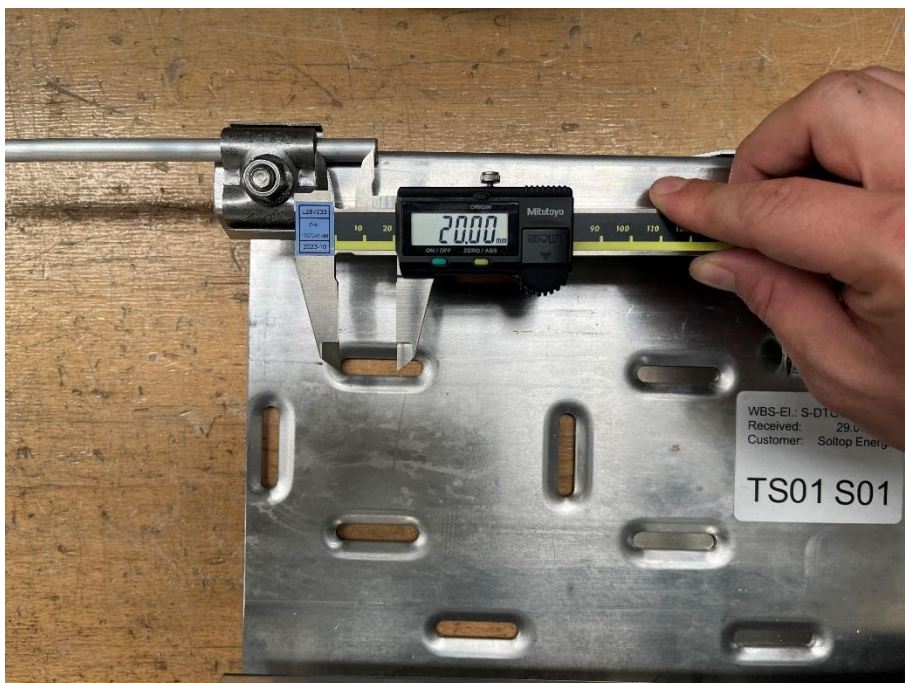


Figure 20: Measurement of conductor length after connector – Uni-Earthing Clamp 2.

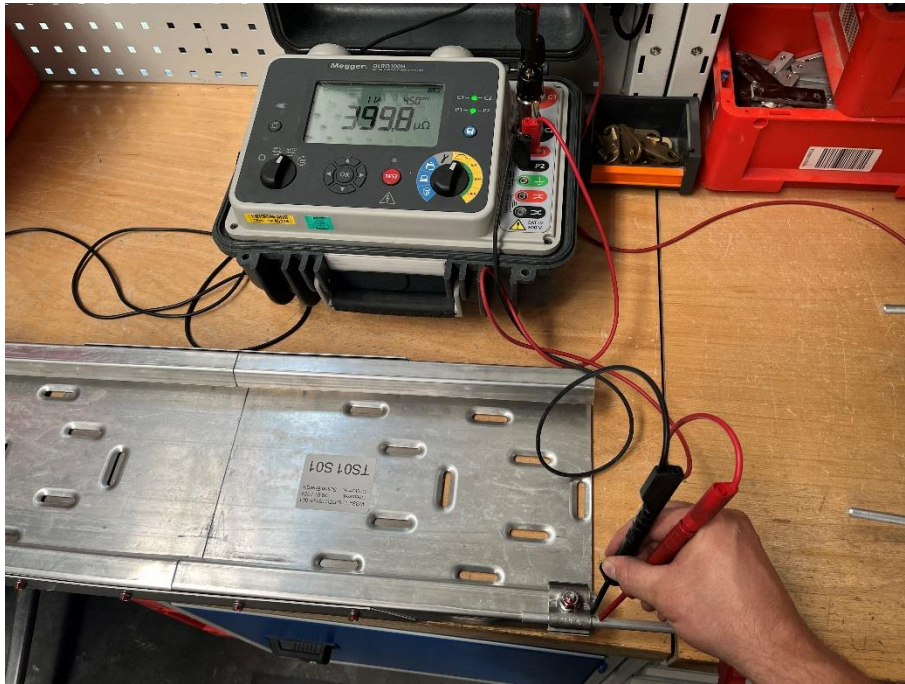


Figure 21: Measurement of contact resistance – Round wire Alu 8mm over Uni - Earthing Clamp 1 to Duraklick Floor Rail.

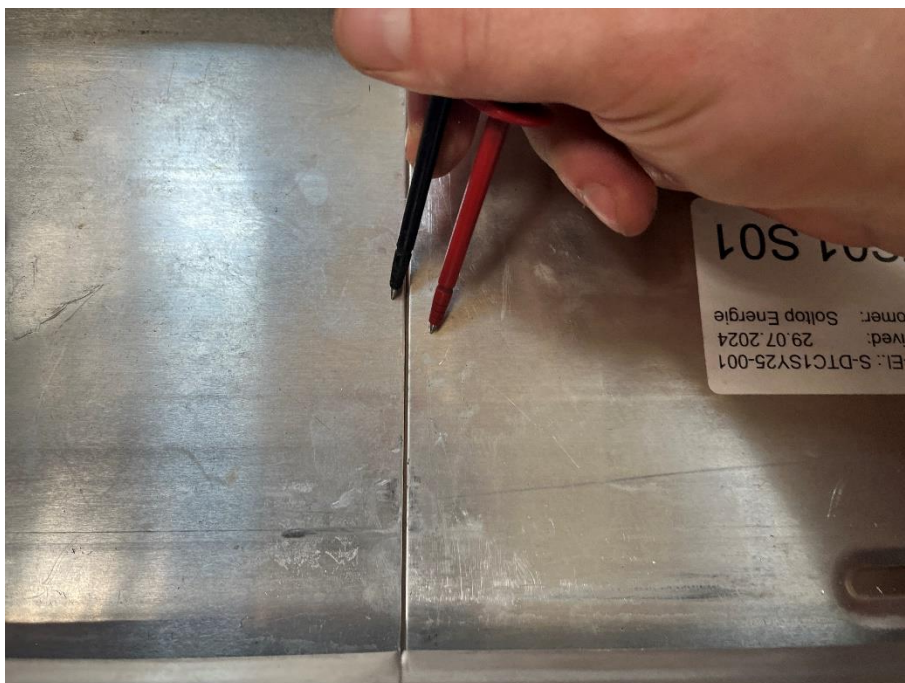


Figure 22: Measurement of contact resistance – Duraklick floor rail via Duraklick profile connector outside to Duraklick floor rail.



Figure 23: Measurement of contact resistance – Duraklick Floor Rail over Uni-Earthing Clamp 2 to Round Wire Alu 8mm.



Figure 24: Measurement of torque – Uni – Earthingclamp 1.

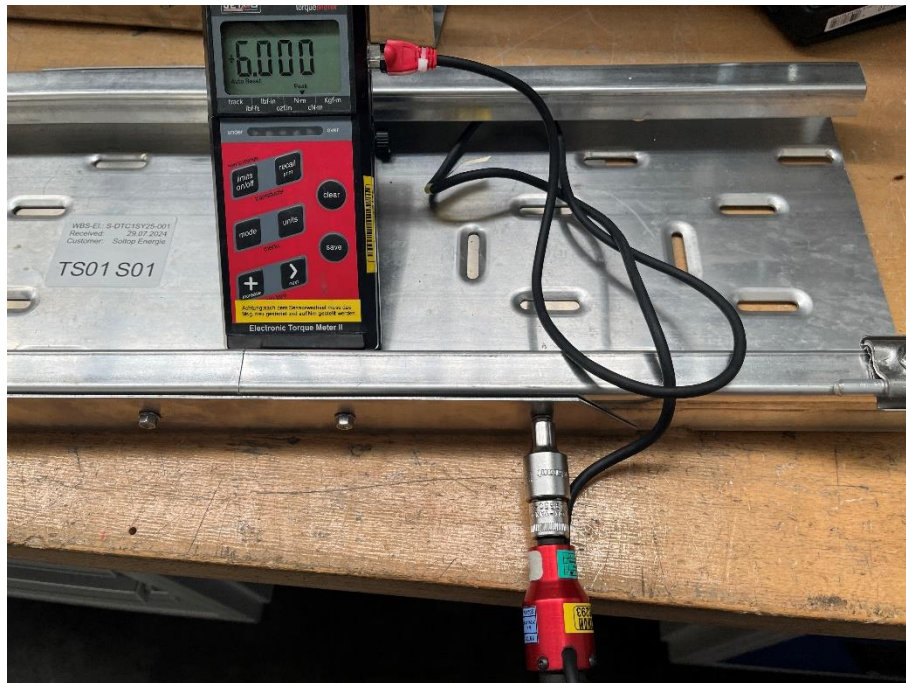


Figure 25: Measurement of torque – Self-drilling screw 1 – exemplary for self-drilling screws.

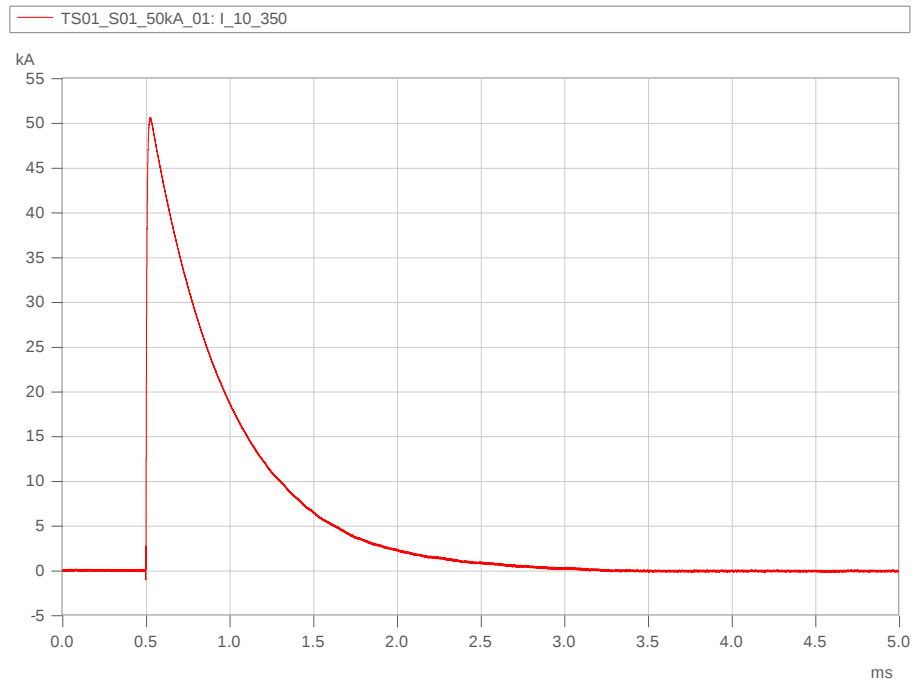


Figure 26: Measurement of torque – Self-drilling screw 2 – exemplary for self-drilling screws.

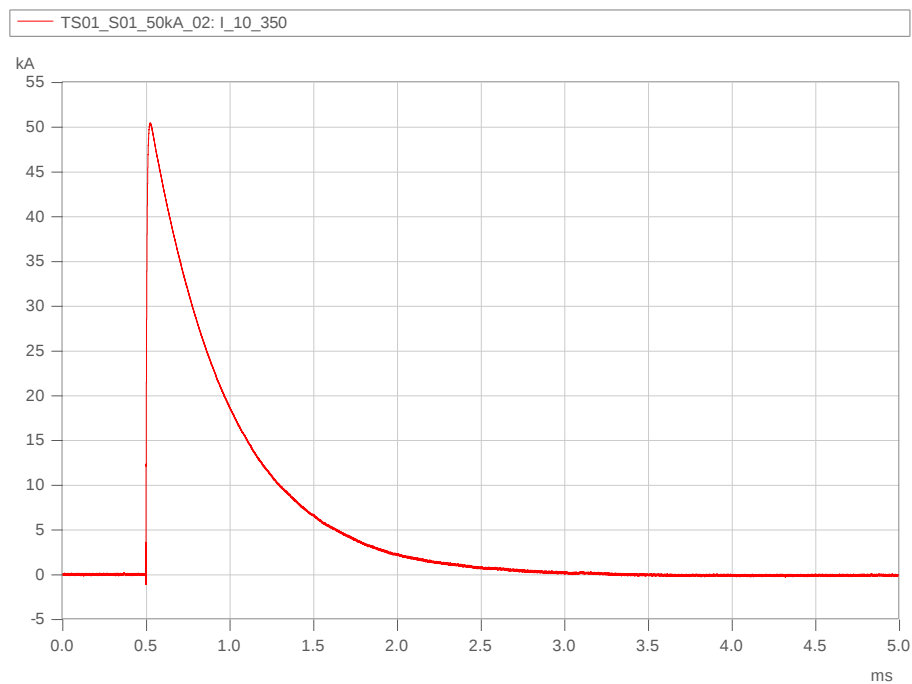


Figure 27: Measurement of torque – Uni – Earthingclamp 2.

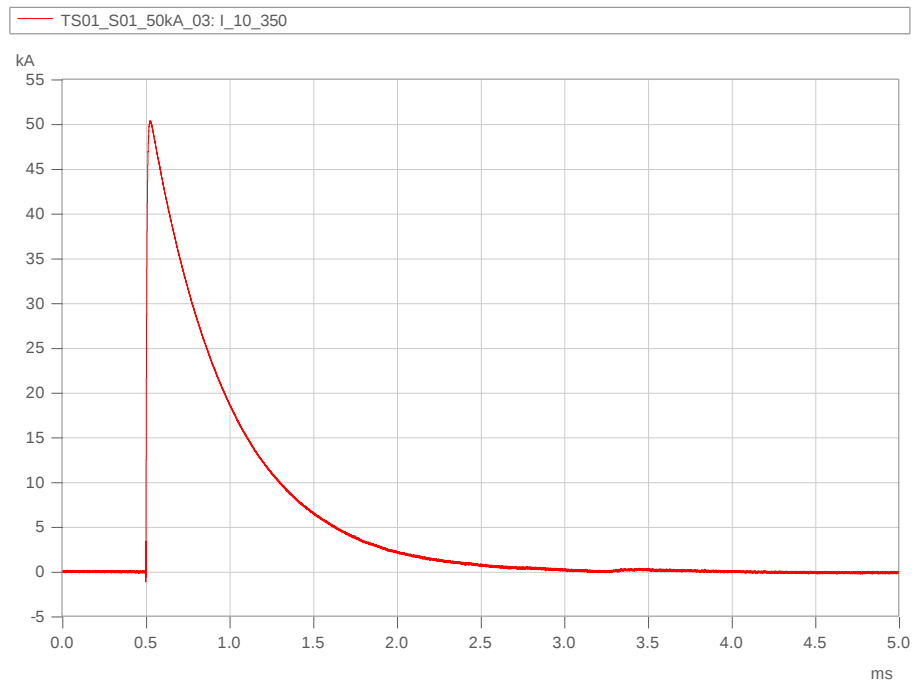
Oscillograms



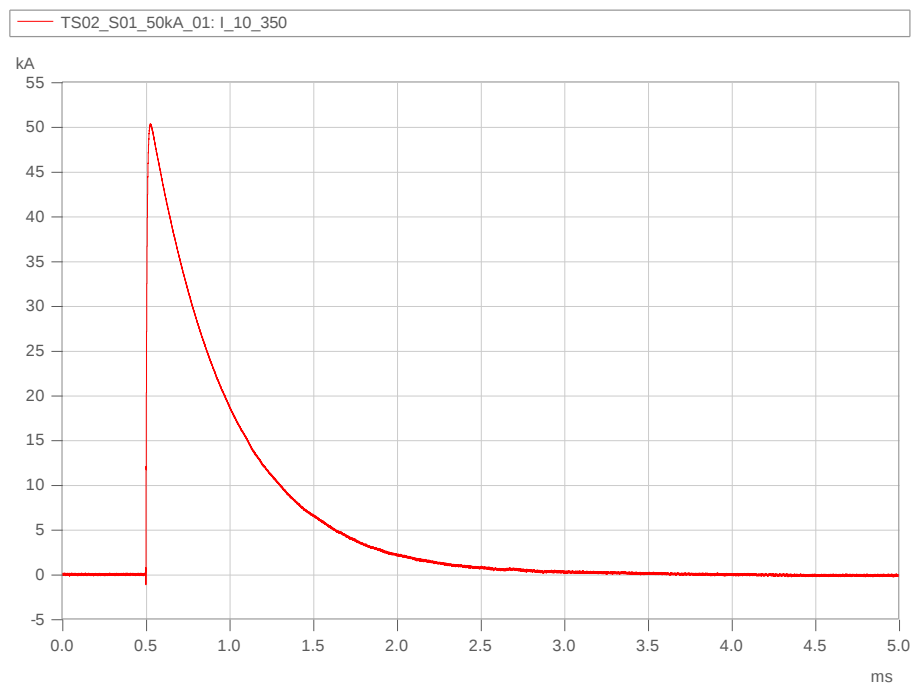
Oscillogram 1: Test sample TS01 S01: 1x 50 kA (10/350 μ s).



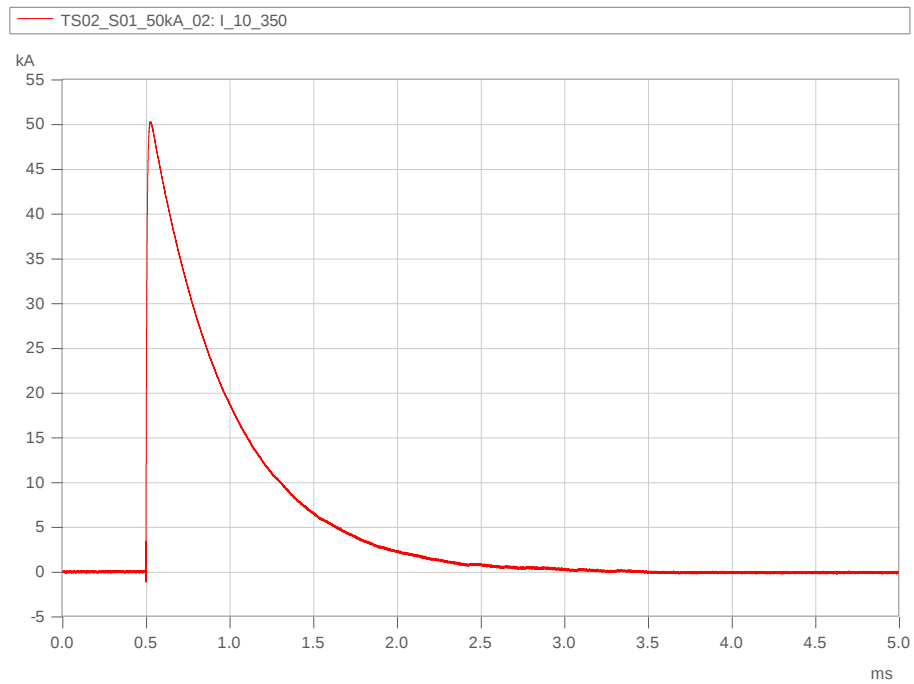
Oscillogram 2: Test sample TS01 S01: 2x 50 kA (10/350 μ s).



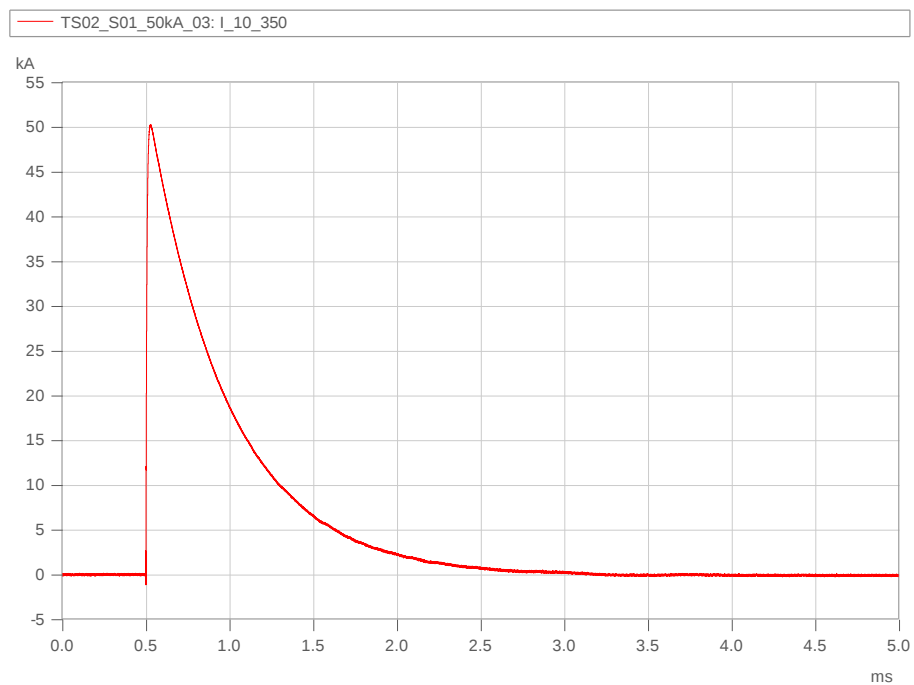
Oscillogram 3: Test sample TS01 S01: 3x 50 kA (10/350 μ s).



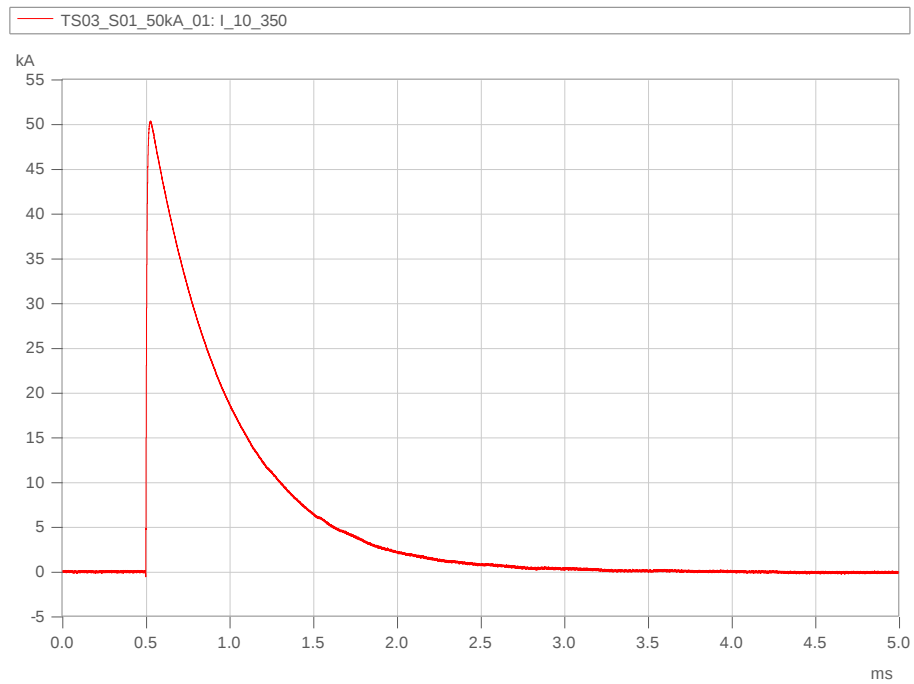
Oscillogram 4: Test sample TS02 S01: 1x 50 kA (10/350 μ s).



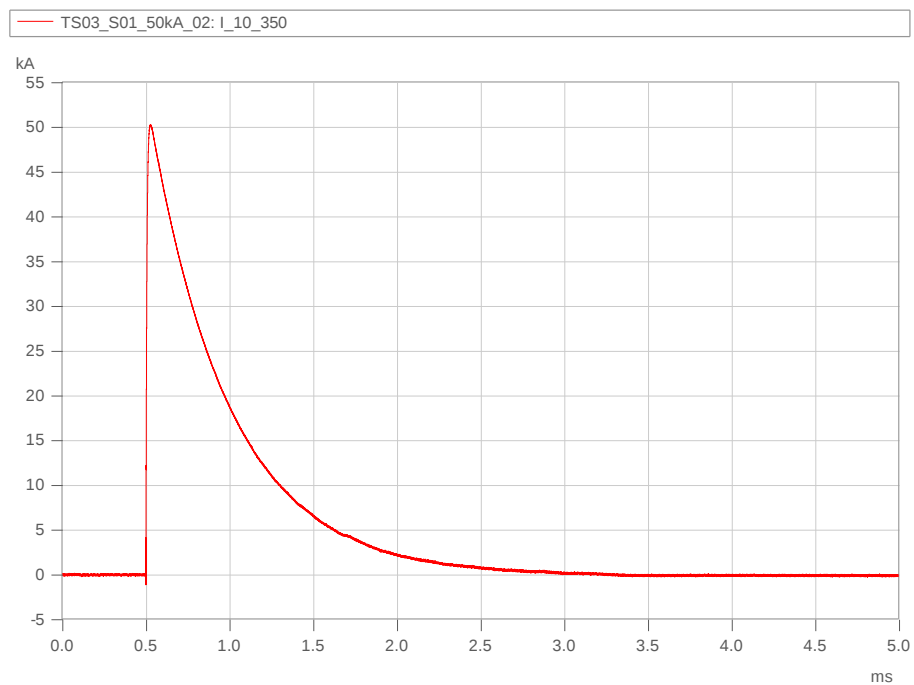
Oscillogram 5: Test sample TS02 S01: 2x 50 kA (10/350 µs).



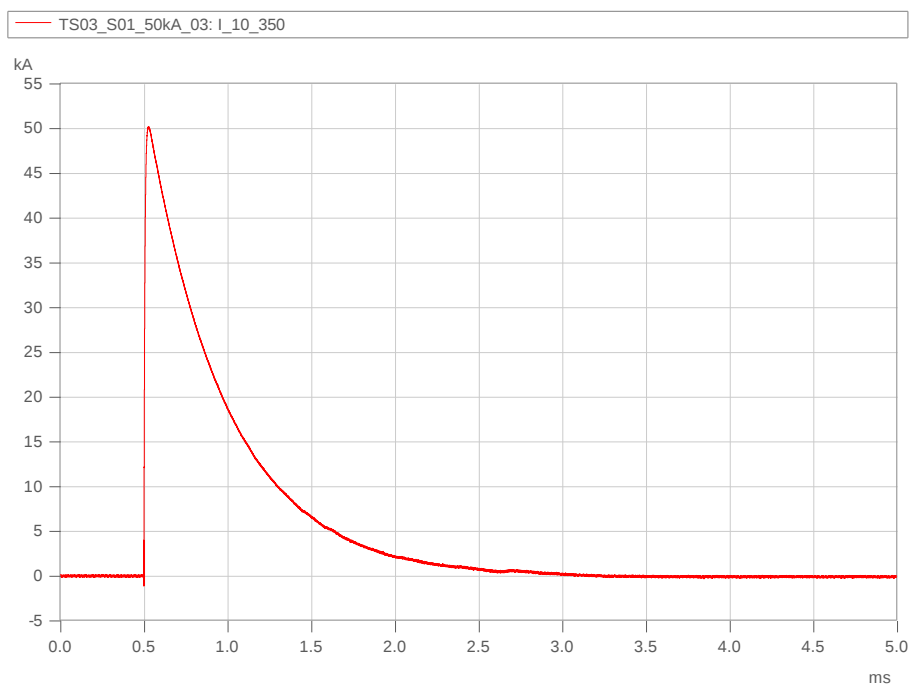
Oscillogram 6: Test sample TS02 S01: 3x 50 kA (10/350 µs).



Oscillogram 7: Test sample TS03 S01: 1x 50 kA (10/350 μ s).



Oscillogram 8: Test sample TS03 S01: 2x 50 kA (10/350 μ s).



Oscillogram 9: Test sample TS03 S01: 3x 50 kA (10/350 μ s).

Test conditions

Date:	Ambient temperature:	Air Humidity (rel.):	Atmospheric Pressure (abs.):
11/09/2024	23,7 °C	42,6 %	957,6 hPa

Measuring equipment

The tests were carried out at the test laboratories of DEHN, Neumarkt.

Type:	Manufacturer:	Model:	ID No.:	Last Cal. / Ver. Date:	Next Cal. / Ver. Date:
Impulse generator	HIGHVOLT Prüftechnik Dresden GmbH	IP 288/24 S	B4 27584	N/A	N/A
Current monitor	Pearson Electronics	1423	B4 11858	10.10.2023	10.10.2024
Oscilloscope	Tektronix GmbH	MSO54B	B4 44689	06.12.2023	06.12.2024
Environment gauge	G. Lufft Mess- und Regeltechnik GmbH	OPUS 20 THIP	B4 29472	08.02.2024	08.02.2025
Temperature gauge	Ahlborn Mess- und Regelungstechnik GmbH	FT01535L0100 / ZTD7 00-FS	B4 46256	13.11.2023	13.11.2024
Data logger	Ahlborn Mess- und Regelungstechnik GmbH	ALMEMO 204 KSU	B4 40845	N/A ¹⁾	N/A ¹⁾
Ohmmeter ²⁾	Megger Group Limited	DLRO100HB- LG1-P2	B4 46119	25.07.2024	25.07.2025
Torque measuring device	JETCO Torque Tools LLC	TTS-2000	B4 45115	N/A ¹⁾	N/A ¹⁾
Torque measuring device	JETCO Torque Tools LLC	IL-250I-G2/28 Nm	B4 46293	03.04.2024	03.04.2025
Slide gauge	Mitutoyo Deutschland GmbH	CD-15APX	B4 45129	06.10.2023	06.10.2024
Salt spray chamber	Köhler Automobiltechnik GmbH	HKT 1000	B4 33759	29.04.2024	29.04.2025
Kesternich chamber	RSI TestSysteme GmbH & Co.KG	Cab 1000	B4 41983	29.05.2024	29.05.2025

1) The device functions purely as a display, calibration is included in the connected sensor.

2) Deviation: Calibrated range from $\geq 0,2 \text{ m}\Omega$.

Annex A


Duraklick
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DEHN SE
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Hans-Dehn-Str. 1
92318 Neumarkt

Hergatz 12.09.2024

Bestätigung Querschnittsfläche Geprüfter Bauteile

Sehr geehrter Herr Süß,

Hiermit bestätigen wir, dass die Querschnittsfläche der geprüften Bauteile mehr als 50mm² beträgt.
(siehe angefügte Skizze)

Freundliche Grüße
SOLTOP Energie GmbH


Herbert Bernhard

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SOLTOP Energie GmbH · Lindauer Straße 15 · D-88145 Hergatz
Sitz der Gesellschaft: Hergatz · Registergericht: Kempten (Allgäu) · Geschäftsführer: Andreas Zimmerer
Handelsregister: HRB 14331 · MwSt.: 127/137/60/143 · UID: DE300491338 · EORI: DE3142919438322627
Warenanlieferung Deutschland: Max Müller Spedition GmbH · Hugo-Schrott-Straße 2-4 · 88279 Arntzell/Korb
Warenanlieferung Schweden: LGT Logistics AB · Nygårdsgatan 3 · 54351 Tibro
Warenanlieferung Finnland: LGT Logistics Oy · Saksalankatu 28 · 15100 Lahti

Annex A1: Confirmation of the minimum cross-section – Page 1 of 2.

Artikel 77.501.000
Profilverbinder
 $A = \text{ca. } 334 \text{ mm}^2$



Artikel 77.501.XXX
Bodenschiene
 $A = \text{ca. } 615 \text{ mm}^2$



Annex A2: Confirmation of the minimum cross-section – Page 2 of 2.