

Report after 12,000 h

Revision 1

Artificial weathering climate S according to DIN EN 513/DIN EN 12608-1

to report number: 202120602-07

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Order number: 202120602

Incoming orders: 06.12.2021

Report date: 15.06.2023

Revision date: 19.07.2023

Reason for revision: Correction of the Charpy characteristic values in the initial state.

This report comprises 9 pages and an appendix.

The tests were carried out in the PSM test laboratory "Mechanical Testing of Plastics", which is accredited by DAkkS according to DIN EN ISO/IEC 17025.

No. of the accreditation certificate: **D-PL-20227-01-00**,

List of accredited standards see www.psm-merseburg.de

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Task and object of investigation

The client provided a total of one specimen for the weather fastness test. Table 1 lists the designations of the specimens.

Table 1: Designations of the samples

No.	Product type	Product no..	Designation	Batch no.
1	PVC-U Profile	2105-1102	Prima sliding sash	2011213

The weather fastness test was carried out according to DIN EN 513:2019-03 [1] / DIN EN 12608-1:2020-11 [2], climate zone S for a weathering period of 12,129 h.

To evaluate the aging behavior of the specimens, a color measurement is performed every 1,000 h by using DIN EN ISO/CIE 11664-4:2020-03 [3] and a comparison against a reference - non-weathered test specimen – in accordance with DIN ISO 4582:2019-03 [4] by determining the fastness number using the nine-step gray scale in accordance with DIN EN 20105-A02:1994-10 [5].

Furthermore, the notched impact strength was determined at the end of the weathering according to ISO 179-1:2010-06 [6].

Experimental Weathering parameters

Table 2: Conditions for weathering test according to DIN EN 513:2019-03/DIN EN 12608-1:2020-11, climate zone (S)

Type of weathering device	Q-Sun Xe-2-HS, rotating specimen rack, synchronous run
Service and calibration (manufacturer)	2021-10-20, 2023-01-18
Light source	Xenon arc lamp, silica glass
Filter	Daylight-Q, daylight filter
Broadband irradiance	300–400 nm
Irradiance (300–800 nm) E	$(550 \pm 55) \text{ W} \cdot \text{m}^{-2}$
Irradiance (300–400 nm) E	$(60 \pm 2) \text{ W} \cdot \text{m}^{-2}$
Radiometer	UC20/TUV calibration-radiometer
Calibration date UC20/TUV	2021-10-15, 2022-10-14
Surface temperature sensor	Black-standard thermometer BST
Specified value black-standard temperature	$(65 \pm 3) ^\circ\text{C}$
Reference Black-standard thermometer	UC202/IBP calibration-radiometer
Calibration date UC202/IBP	2021-10-22, 2022-10-13
Surface temperature sensor	White-standard thermometer WST
Specified value white-standard temperature	$45\text{--}50 ^\circ\text{C}$
Specified chamber temperature	$(30 \pm 3) ^\circ\text{C}$
Specified value relative-humidity U	$(65 \pm 10) \%$
Exposure time	114 min
Spray cycle	6 min
Spraying	Exposed surface
Mounting of the test specimens	Specimen holders
Start of the weathering	2021-12-12
Ende of the weathering (calculated)	2023-05-06
Interruption of the test ($\geq 72 \text{ h}$)	none
Lamp replacement	
	Number 7
	Dates 2022-02-07, 2022-04-11, 2022-06-14, 2022-08-25, 2022-11-05, 2023-01-10, 2023-03-21
Total exposure time	12,129 h
Total irradiance (300–800 nm) H	$24 \text{ GJ} \cdot \text{m}^{-2}$

Color measurement

The test conditions for evaluating color change according to the standard DIN EN ISO/CIE 11664-4:2020-03 [3] are listed in Table 3.

Table 3: Test conditions for determining the color/color change according to DIN EN ISO/CIE 11664-4:2020-03

Equipment	Konica Minolta CM-36dG Spectrophotometer
Calibration by manufacture	2021-09-23, 2022-11-10
Colour space	CIELAB $L^*a^*b^*$
Observer	10°
CIE Illuminant	D65 (6504 K)
Geometry	di:8° – specular component included
Spectral Range	360 to 740 nm
Wavelength Interval	10 nm
Apertures	LAV – 25.4 mm
Material	2105-1102
Preconditioning of material	– Initial state: 16 h at 23 °C and 50 % relative humidity – Weathering, every 1,000 h
Specimen geometry	– Plate, 45 mm x 89 mm (Width x Length)
Tester	Dr. Schoßig

For the determination of the color distance a comparison of the reference sample (standard) and the samples for testing will be done. Within the scope of this test report, the color distances ΔE_{ab}^* according to CIELAB 1976 and additionally according to ISO/CIE 11664-6:2014-02 CIEDE2000 (ΔE_{00}) [7] are used to evaluate the change in color. The nomenclature can be found in Table 4.

Table 4: Nomenclature according to DIN EN ISO/CIE 11664-4:2020-03

Symbols	Designation
L^*	CIELAB-Lightness
a^*	CIELAB-Coordinate
$+a^*$	Red
$-a^*$	Green
b^*	CIELAB-Coordinate
$+b^*$	Yellow
$-b^*$	Blue
$\Delta E = \Delta E_{ab}^*$	a, b Color difference CIE 1976
ΔE_{00}	Color difference according to [7]

The CM-36DG spectrophotometer (FA. KONICA MINOLTA, INC) with CM-S100W SPECTRA MAGIC NX PRO software was used for the color measurements from a weathering duration of 1,000 h. The spectrophotometer was used to measure the color of the test specimens. The color measurements on the test specimens were performed with the largest aperture with a diameter of 25.4 mm ($A = 506.7 \text{ mm}^2$) at three different locations with three measurements each, and the evaluation software gives the averaged values as the result.

Evaluation of the color fastness with the gray scale

The evaluation of the change of color according to DIN EN 20105-A02:1994-10 was carried out in the light chamber LED Color Viewing Light M 2.0 Hybrid of the company JUST NORMLICHT GMBH (Weilheim/ Teck, Germany). The irradiation is performed by the LED lamps located in the ceiling of the light chamber. The specimens to be evaluated are placed in the center of the chamber on a 45 ° specimen stand. In the following Table 5 are the test parameters.

Table 5: Test conditions for determining the color change according to DIN EN 20105-A02:1994-10

Equipment	LED Color Viewing Light M 2.0 Hybrid
Illuminated Area	65 mm x 38 mm x 36 mm (Width x Height x Length)
CIE Illuminant	D65
Light source	LED
Color temperature Set / Current	D65 – 6500 K / 6569 K
Gray scale	DIN EN 20105-A02:1994-10, including half steps
Date of first use	2021-02-11 (VI / 2182) 2022-02-25 (VQ / 2182) 2023-04-24 (WA / 2712)
Batch / Certificate of Conformity	VI / 2182 (2018) VQ / 2182 (2022) WA / 2712 (2022)
Material	2105-1102
Preconditioning of material	– Initial state: 16 h at 23 °C und 50 % relative humidity – Weathering: every 1,000 h

Determination of Charpy-impact strength

The test parameters as well as the nomenclature for the determination of the notches Charpy impact strength according to ISO-1:2010-06 are listed in Table 6 as well as in Table 7.

Table 6: Test conditions according to ISO 179-1:2010-06

Used pendulum impact tester	Zwick HIT 25P
Method	ISO 179-1/1fA

Specimen	50 mm x 6 mm x profile wall thickness
Impact direction	flatwise – <i>f</i>
Notch type	A
Notch radius	0.25 mm ± 0.05 mm
Notch depth	Double V-notch, 1.5 mm on each side
Material description	see Table 1
Impact velocity	2.9 m s ⁻¹
Nominal impact energy of the pendulum hammer	2 J
Number of test specimen	10 per measurement series
Climate at pretreatment, 16 h	23 °C and 50 % relative humidity
Test climate	23 °C and 50 % relative humidity
Test date	2023-06-02

Table 7: Nomenclature for the non-instrumented impact test according to ISO 179-1:2010-06

Description	Symbol and/or calculation	Unit
Charpy impact strength of notched specimen	$a_{cN} = \frac{E_c}{h \cdot b_N}$	(kJ/m ²)
Corrected impact energy	E_c	(J)
Specimen width	b	(mm)
Remaining width at the notch base	b_N	(mm)
Specimen thickness	h	(mm)
Notch radius	r_N	(mm)
Support span	L	(mm)
Specimen length	l	(mm)
Mean value	$\bar{x}$	
Standard deviation	s	
Variance	v	
Mode of failure		
– Complete break	C	
– Hinge break	H	
– Partial break	P	
– Non-break	N	

Results

Colorimetric evaluation and color fastness

The results of the color measurement of the initial state are shown in Table 8 and the color changes due to artificial weathering are listed in Table 9.

Table 8: Color coordinates of the initial state

Designation	Color coordinates		
	L^*	a^*	b^*
2105-1102	95.15	-0.79	-0.41

Table 9: Color change and indication of fastness number

Time of exposure (h)	Dose of irradiation (GJ m ⁻²)	Color coordinates			Total color distance ΔE_{ab}^*	Fastness number
		ΔL^*	Δa^*	Δb^*		
1,000	2.10	0.49	-0.08	1.03	1.14	4–5
2,000	4.01	0.75	0.04	0.47	0.88	4–5
3,000	6.05	0.64	0.03	0.38	0.74	4–5
4,000	8.04	0.62	0.00	0.41	0.74	5
5,000	9.94	0.65	-0.01	0.47	0.80	4–5
6,061	12,01	0.73	-0.03	0.55	0.91	4–5
7,000	14.04	0.79	-0.04	0.58	0.98	5
8,000	15.94	0.84	-0.05	0.68	1.07	4–5 W
9,000	18.56	0.91	-0.03	0.68	1.14	4–5 W
10,101	20.35	1.00	-0.04	0.77	1.26	4 Str, Br
11,000		no measurement carried out				
12,129	24.02	1.03	-0.09	1.09	1.50	4–5 Str, Br

Abbreviations of qualitative terms (Table 2, ISO 105-A02:1993-09)

Bl	Bluer	W	Weaker
G	Greener	Str	Stronger
R	Redder	D	Duller
Y	Yellower	Br	Brighter

The colorimetric result after weathering is shown in appendix 1.

The results of the Charpy V-notch impact strength for the initial state as well as after weathering of 12,129 h are shown in Table 10.

Table 10: Charpy V-notch impact strength

Time of exposure (h)	b_N	h	E_c	a_{cN}
Initial state	3.08 ± 0.04	2.27 ± 0.04	0.482 ± 0.013	$68,9 \pm 1,57$
12,129	3.01 ± 0.05	2.28 ± 0.05	0.390 ± 0.015	56.8 ± 2.32

The protocol for determining the impact strength is shown in appendix 2.

Reference

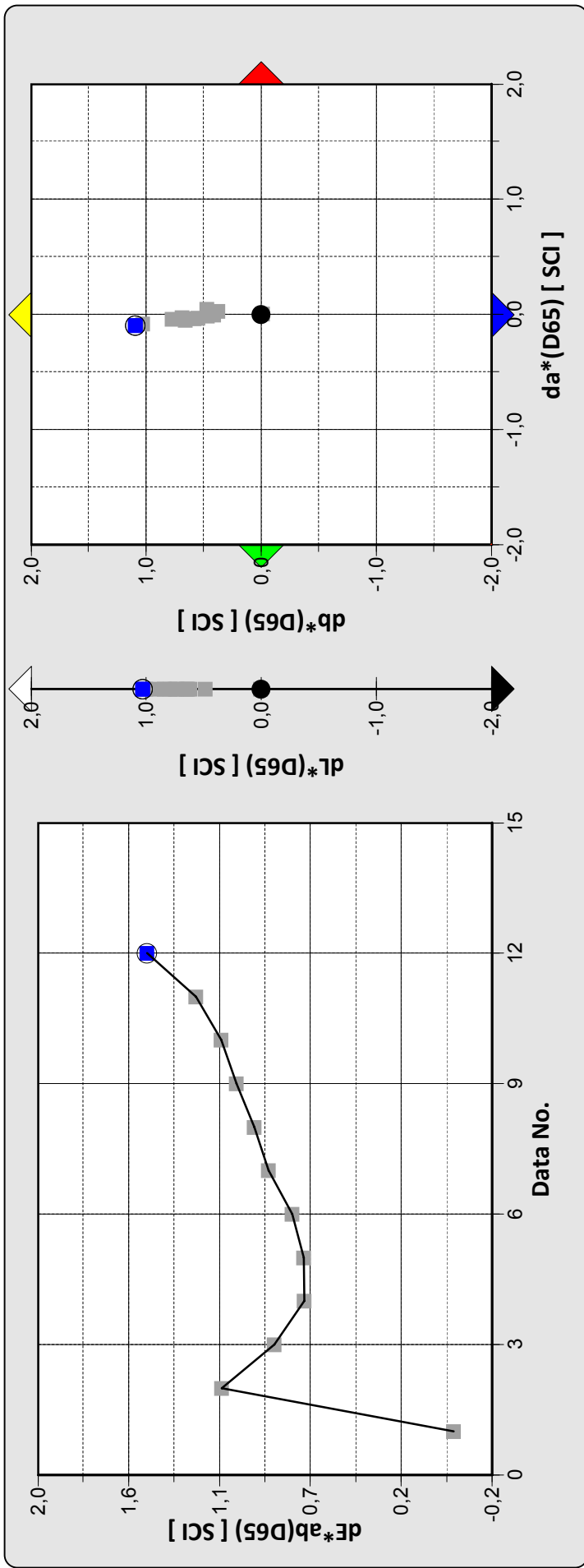
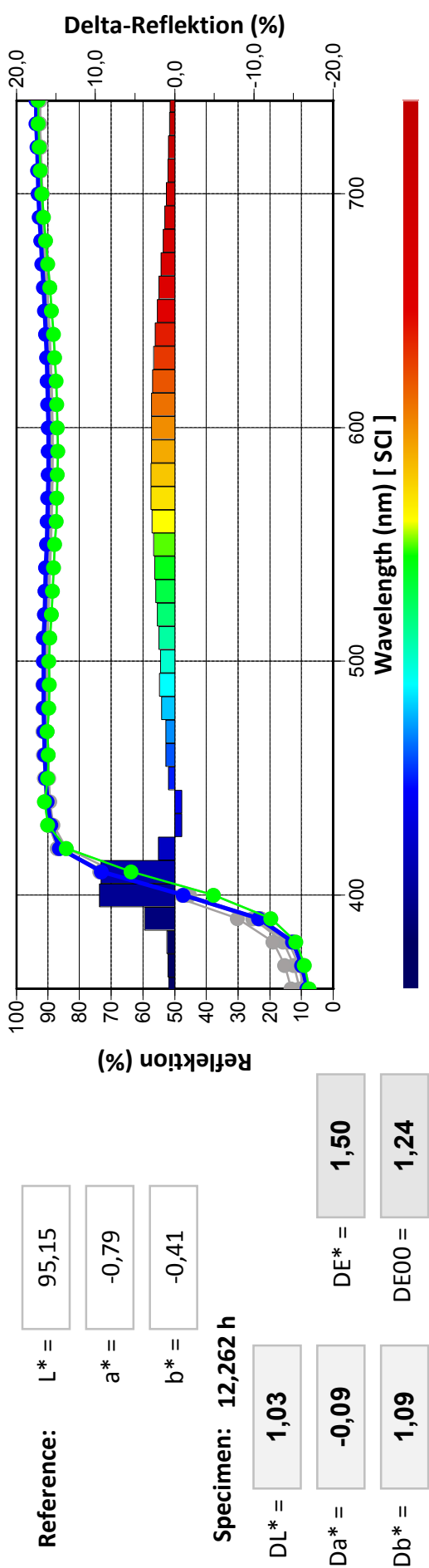
- [1] DIN EN 513 (2019-03): Plastics – Poly(vinyl chloride) (PVC) based profiles – Determination of the resistance to artificial weathering.
- [2] DIN EN 12608-1 (2020-11): Unplasticized poly(vinyl chloride) (PVC-U) profiles for the fabrication of windows and doors - Classification, requirements and test methods - Part 1: Non-coated PVC-U profiles with light coloured surfaces.
- [3] DIN EN ISO/CIE 11664-4 (2020-03): Farbmeterik – Teil 4: CIE 1976 L* a* b* Farbraum.
- [4] DIN ISO 4582 (2019-03): Kunststoffe – Bestimmung der Änderung der Farbe und anderer Eigenschaften nach Bestrahlung hinter Glas, nach natürlicher oder nach künstlicher Bewitterung.
- [5] DIN EN 20105-A02 (1994-10): Textilien – Farbechtheitsprüfungen – Teil A02: Graumaßstab zur Bewertung der Änderung der Farbe.
- [6] ISO 179-1 (2010-06): Plastics – Determination of charpy properties – Part 1: Non-instrumented impact test.
- [7] ISO/CIE 11664-6 (2014-02): Colorimetry – Part 6: CIEDE2000 Colour-difference formula.

Appendix

Appendix 1: Colorimetric result

Appendix 2: Protocol of the determination of the impact strength

12.12.2021





Determination of the Charpy impact properties acc. DIN EN ISO 179-1

Parameter table:

Order no.	: 202320116 UK07
Customer	: GEALAN Pvt Ltd
Standard	: acc.to DIN EN ISO 179-1
Method	: ISO 179-1/1fA
Pendulum impact tester	: Zwick/Roell HIT25P
Impact velocity	: 2,9 m/s
Nominal working capacity of the pendulum	: 2,0 Joule
Material	: PVC Profil Reference
Material composition and form	: 50 mm x 6 mm x Profile wall thickness
Test specimen production	: Double- V - Notch A
Number of test specimens	: 10
Climate	: Conditioning: 16 h standard climate (23 °C, 50 % rel. Humidity) Test: standard climate (23 °C, 50 % rel. Humidity)
Comments	: Impact occurs on the inner surface
Tester	: Ageev
Test date	: 14.12.2021
Test result	: $68,9 \pm 1,57 \text{ kJ/m}^2 \text{ P}^*$

Results table:

Nr	b mm	h mm	E_c J	a_{cN} kJ/m ²	Failure mode
1	3,10	2,34	0,498	68,7	P
2	3,10	2,25	0,498	71,4	P
3	3,14	2,27	0,479	67,2	P
4	3,06	2,31	0,479	67,7	P
5	3,06	2,29	0,476	68,0	P
6	3,08	2,29	0,496	70,3	P
7	3,07	2,22	0,457	67,1	P
8	3,14	2,23	0,479	68,4	P
9	3,00	2,30	0,491	71,2	P
10	3,09	2,22	0,472	68,7	P

Statistics table:

Series n = 10	b_N mm	h mm	E_c J	a_{cN} kJ/m ²
$\bar{x}$	3,08	2,27	0,482	68,9
s	0,04	0,04	0,0133	1,57
v	1,33	1,81	2,75	2,28



Determination of the Charpy impact properties acc. DIN EN ISO 179-1

Parameter table:

Order no.	: 202320116 UK07
Customer	: GEALAN Pvt Ltd
Standard	: acc.to DIN EN ISO 179-1
Method	: ISO 179-1/1fA
Pendulum impact tester	: Zwick/Roell HIT25P
Impact velocity	: 2,9 m/s
Nominal working capacity of the pendulum	: 2,0 Joule
Material	: PVC Profil Reference
Material composition and form	: 50 mm x 6 mm x Profile wall thickness
Test specimen production	: Double- V - Notch A
Number of test specimens	: 10
Climate	: Conditioning: 16 h standard climate (23 °C, 50 % rel. Humidity) Test: standard climate (23 °C, 50 % rel. Humidity)
Comments	: Impact occurs on the inner surface
Tester	: Ageev
Test date	: 02.06.2023
Test result	: 56,8 ± 2,32 kJ/m² C*

Results table:

Nr	b _N mm	h mm	E _c J	a _{cN} kJ/m²	Failure mode
1	3,00	2,32	0,377	54,2	H
2	3,01	2,33	0,401	57,2	H
3	3,04	2,20	0,394	58,9	H
4	3,08	2,24	0,404	58,5	H
5	3,01	2,24	0,406	60,2	H
6	3,07	2,26	0,409	58,9	H
7	2,98	2,28	0,363	53,4	H
8	2,93	2,34	0,384	56,1	H
9	2,96	2,35	0,380	54,6	H
10	3,05	2,23	0,382	56,2	H

Statistics table:

Series n = 10	b _N mm	h mm	E _c J	a _{cN} kJ/m²
$\bar{x}$	3,01	2,28	0,390	56,8
s	0,05	0,05	0,0151	2,32
v	1,60	2,32	3,87	4,08