

Polymer Service GmbH Merseburg

An-Institut an der Hochschule Merseburg

**Interim Report after 10,101 h**

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

to report number: 202120602-01

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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.

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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	41201-03300	I-60 sliding sash	2011213

The weather fastness test is carried out according to DIN EN 513:2019-03 [1] / DIN EN 12608-1:2020-11 [2], climate zone 5 for a weathering period of 10,101 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].



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)	2023-02-06
Interruption of the test ($\geq 72 \text{ h}$)	none
Lamp replacement	
	Number 6
	Dates 2022-02-07, 2022-04-11, 2022-06-14, 2022-08-25, 2022-11-05, 2023-01-14
Total exposure time	10,101 h
Total irradiance (300–800 nm) H	$20 \text{ GJ} \cdot \text{m}^{-2}$



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 included
Spectral Range	360 to 740 nm
Wavelength Interval	10 nm
Apertures	LAV – 25.4 mm
Material	41201-03300
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}) [6] 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 [6]

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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 mm²) 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)
Batch / Certificate of Conformity	VI / 2182 VQ / 2182
Material	41201-03300
Preconditioning of material	– Initial state: 16 h at 23 °C und 50 % relative humidity – Weathering: every 1,000 h

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Results

Colorimetric evaluation and color fastness

The results of the color measurement of the initial state are shown in Table 6 and the color changes due to artificial weathering are listed in Table 7.

Table 6: Color coordinates of the initial state

Designation	Color coordinates		
	L^*	a^*	b^*
41201-03300	95.15	-0.79	-0.41

Table 7: 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	0.66	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

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



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): Profile aus weichmacherfreiem Polyvinylchlorid (PVC-U) zur Herstellung von Fenstern und Türen – Klassifizierung, Anforderungen und Prüfverfahren – Teil 1: Nicht beschichtete PVC-U Profile mit hellen Oberflächen.
- [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/CIE 11664-6 (2014-02): Colorimetry – Part 6: CIEDE2000 Colour-difference formula.