



Test report



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Order:

Investigation of the long-term behaviour of **Whisper® NBO-40-A3** noise barrier wall types using time lapse test based on EN 14389-1:2015, EN 14389-2:2015 and EN 60721-3-4:1995 for 50 simulated years.

Customer:

Sealed Air Verpackungen GmbH

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Time period of the test:

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This report contains 17 pages, 1 supplement of 6 pages and 1 attachment of 21 pages.



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1. Task information

The BTI was commissioned by the client to carry out investigations on various Whisper® NBO-40-A3 noise barrier wall types with regard to long-term behaviour based on

- Austrian standard ÖNORM EN 14389-1: 2015 Road traffic noise reducing devices - Procedures for assessing long-term performance - Part 1: Acoustical characteristics
- ÖNORM EN 14389-2: 2015 Road traffic noise reducing devices - Procedures for assessing long-term performance - Part 2: Non-acoustical characteristics.

Various impacts resulting from the influence factor "External environmental conditions" are defined in

- ÖVE EN 60721-3-4/A1: 1997, Classification of environmental conditions - Part 3: Classification of groups of environmental parameters and their severities; section 4: Stationary use at non-weather-protected locations (IEC 721-3-4:1995/A1:1996)

Under certain circumstances, these may lead to cracks, chipping, loss of material, loss of strength, rotting, discolouration, etc. and thus to a reduced service life of the component. Dimensioning of exterior stresses was performed in accordance with EN 14389-1 and -2. However, the duration and setup of the impacts are not standardised and there is still a considerable need for research with regard to the performance of time-lapse tests of long-term behaviour of materials and components.

2. General principles for estimating service life

The technical service life refers to the time between the erection and the mean expected failure of a material, component or structure. It defines the service life during which such an object - under consideration of the necessary and standard maintenance measures as well as wear and tear - can fully satisfy its functions and intended use.

In this document, the general "reference service life of components" is considered to correspond with the technical service life.

The service life in situ and in practice is usually influenced by other local factors, which also must be taken into account.

In science, various methods have been established for ESLC, the estimated service life of components. In addition to engineering approaches, probabilistic methods and mixed approaches, ISO 15686 with its factor method can be used as a general model for predicting the service life of components.

$$ESCL = RSLC * A * B * C * D * E * F * G$$

In this equation, the individual factors refer to classes of object conditions: Quality characteristics (A, B, C) environmental conditions (D, E) and conditions of use (F, G). The factors assess the object-specific situation of a reference component service life and are suggested to range between 0.8 and 1.2 - preferably between 0.9 and 1.1.

Category	Factor	Class-factor	Sub-factors
Part quality	A	Component quality	Product quality, experience, complexity, sustainability
	B	Design quality	Constructive protection, planning quality, complexity
	C	Manufacturing quality	Project management, installation conditions, complexity
Environment	D	Interior environmental conditions	Indoor air conditions, temperature, chemical attack, biological attack
	E	Exterior environmental conditions	Location, sun, humidity, temperature, biological attack, mechanical shocks, wind
Conditions of use	F	Intensity of use	Mechanical influences, type of use, intensity of soiling and cleaning, visual requirements, updated building documentation
	G	Level of maintenance	Maintenance cycle, maintenance quality, building documentation, accessibility

Fig. 1: Influencing material factors according to ISO 15686-4

For the noise barrier types considered below, the following (simplified approach) applies:

$$ESCL = RSLC * A * B * C * E * F * G$$

- A Component quality
types, place of production, LE, type testing, quality assurance, in-house production control, storage
- B Planning documents, technical documentation, assembly guidelines, quality assurance
- C Manufacturing quality: Transport, storage, assembly, quality assurance at the building site
- E Exterior environmental conditions: Location, temperature, solar radiation, humidity, biological attack, mechanical shocks, wind
- F Intensity of use:
Mechanical influences, contamination/cleaning, optical requirements
- G Level of maintenance:
Maintenance cycle, maintenance quality

As an alternative to a numerical determination of the factors, which as a rule is associated with a considerable uncertainty, it is possible to carry out a qualitative determination of the factors (e.g. by dividing the factor values into groups such as "worse", "corresponds to the reference value" or "better").

Basically, the estimation of RSLC requires long-term experiments with a statistically relevant number of specimens. The analysis of specimens aged in a real environment remains an important reference for laboratory experiments, too.

In practice, short-term tests (time-lapse tests) have been and are being carried out, which have some selected effects on the specimens and observe their effects. Rapid ageing tests are one approach to confirming newer products with approximate long-term history of use. Usually, the components in these tests are subjected to simulation cycles in climatic chambers where temperature and humidity, for example, change regularly in the course of the test. This allows conclusions to be drawn about the ageing behaviour in practice.

In this context, the fundamental problems of the transferability of short-term tests to longer periods of observation and the transferability of special test conditions to real applications on site are pointed out. This can only be mitigated by at least conducting parallel inspections of aged real objects. ISO 15686-7 provides the basis for performance evaluation for feedback of service life data of existing objects and buildings from practice. Also included is a definition of the necessary terms and instructions on how to describe and document the technical performance to ensure the required consistency. The feedback of service life data from practice is an important element for data validation.

According to ISO 15686-6 (2004), the following data sources can be used with regard to reference service life:

1. Information from construction product manufacturers
2. Summarized empirical values
3. Expert survey by means of the Delphi method
4. Materials science research results (e.g. corrosion rate of steel with defined environmental impacts)
5. Failure Mode Effects Analysis (FMEA) studies

3. Test program:

The test program conforms to the framework specified in ÖNORM EN 14389-2:2015. (See Tab. 1, Tab. 3 and Tab. 2.)

Tab. 1: Framework program of the influences as excerpt from ÖNORM EN 14389-2:2015

	Classifications	Identified Exposures List 1.	Location variation (Distance from carriageway)			Additional possible Climatic variations	
			< 5 m	5 m to 10 m	> 10 m	HOT	COLD
Table 1 (K)	Climatic conditions	IV. Dew V. Freeze/thaw VI. Cold VII. Heat VIII UV Radiation XII. Water	4K2	4K2	4K2		4K3 ^c
Table 2 (Z)	Special Climatic Conditions	XIII. Water spray	4Z7	4Z7	4Z6		
Table 3 (B)	Biological conditions		4B1	4B1	4B1	4B2 ^d	
Table 4 (C)	Chemically Active substances	I. Chemical agents II. De-icing salts ^a XI Ozone ^b	4C2 4C3 ^a 4C4 ^b	4C2 4C3 ^a 4C4 ^b	4C2 4C2 4C4 ^b		
Table 5 (S)	Mechanically Active Substances	III. Dirty water/ Dust	4S2	4S2	4S2		
Table 6 (M)	Mechanical Conditions	IX. Traffic Vibration	4M4	4M4	4M3		

Selection of more severe categories:

^a Applicable only if de-icing salts used.
^b Applicable only if in marine/coastal environment.
^c Extreme cold climate.
^d Hot humid conditions.
^{*} Detailed classification may be selected according to the local conditions.

Tab. 2: Framework program of the influences as excerpt from ÖVE EN 60721-3-4:1995 Table 2

Environmental parameter	Class	Unit	Special condition Z
<i>j) Low air pressure³⁾</i>	4Z10	kPa	84
<i>l) Heat radiation¹⁾</i>	4Z1	None	Negligible
	4Z2	None	Heat radiation due, for instance, to process conditions
<i>m) Movement of surrounding air</i>	4Z3	m/s	20
	4Z4	m/s	30
	4Z5	m/s	50
<i>q) Water from sources other than rain²⁾</i>	4Z6	None	Negligible
	4Z7	None	Splashing water
	4Z8	None	Water jets
	4Z9	None	Water waves

1) Heat radiation may occur in special cases and should be considered where applicable.
2) Underwater conditions are not considered.
3) Class 4Z10 corresponds to an altitude of approximately 1 400 m.

Tab. 3: Framework program of the influences as excerpt from ÖVE EN 60721-3-4:1995

Environmental parameter	Unit	Class					
		4K1	4K2	4K3	4K4	4K4H	4K4L
a) Low air temperature	°C	-20	-33	-50	-65	-20	-65
b) High air temperature	°C	+35	+40	+40	+55	+55	+35
c) Low relative humidity ¹⁾	%	20	15	15	4	4	20
d) High relative humidity ¹⁾	%	100	100	100	100	100	100
e) Low absolute humidity ¹⁾	g/m ³	0,9	0,26	0,03	0,003	0,9	0,003
f) High absolute humidity ¹⁾	g/m ³	22	25	36	36	36	22
g) Rain intensity	mm/min	6	6	15	15	15	15
h) Rate of change of temperature ²⁾	°C/min	0,5	0,5	0,5	0,5	0,5	0,5
i) Low air pressure ³⁾	kPa	70	70	70	70	70	70
j) High air pressure	kPa	106	106	106	106	106	106
k) Solar radiation	W/m ²	1120	1120	1120	1120	1120	1120
l) Heat radiation	None	5)	5)	5)	5)	5)	5)
m) Movement of surrounding air	m/s	5)	5)	5)	5)	5)	5)
n) Condensation	None	Yes	Yes	Yes	Yes	Yes	Yes
o) Precipitation (rain, snow, hail, etc.)	None	Yes	Yes	Yes	Yes	Yes	Yes
p) Low rain temperature ⁴⁾	°C	+5	+5	+5	+5	+5	+5
q) Water from sources other than rain	None	5)	5)	5)	5)	5)	5)
r) Ice and frost formation	None	Yes	Yes	Yes	Yes	Yes	Yes

1) The low and high relative humidities are limited by the low and high absolute humidities, so that, for instance, for environmental parameters a) and c) or b) and d), the severities given in table 1 do not occur simultaneously. See annex B for the relationship between air temperature and humidity.

2) Averaged over a period of 5 min.

3) The value 70 kPa represents a limit value for open-air use, normally at about 3 000 m altitude. In some geographical areas, open-air use may take place at higher altitudes. For some restricted applications at lower altitudes, a value may be selected from table 2.

4) This rain temperature should be considered together with high air temperature b) and solar radiation k). The cooling effect of the rain should be considered in connection with the surface temperature of the product.

5) Conditions occurring at the location concerned should be selected from table 2.

The conditions selected in agreement with the client were chosen as follows (see Fig. 2):

- Climate class 4K2 (-33 to +40 °C)
- An older internal control test with material from a noise barrier wall built 30 years ago resulted in good agreement with the assumption of approx. 100 days of ageing in the climate chamber equivalent to 50 years for wood-chip concrete.
- To achieve a more homogeneous temperature distribution in the test material, the cycle was defined as one frost/defrost cycle per 24 h. A holding time of 9.5 h at -33 °C and at +40 °C per cycle, or twice that per theoretical year, results from the temperature change rate of 0.5 K/min.
- The lighting is switched on for a total of 3 hours during the warm-up phase (corresponds to approx. 2000 hours of sunlight per year). The duration was distributed over the first 10 simulated years such that 6 equal blocks resulted, each separated from each other by 0.5 h (3-6 1h blocks) in order to avoid a concentrated temperature input and related surface temperature increases.
- Sprinkling with salt water (1%) to simulate an increased salt concentration along streets and realized over a time period of 10 minutes (spreading over the surface) using spray bars (~34 L/m²).
- The sprinkling is done during the cooling-off phase. This represents one of the worst-case scenarios, since, due to the amount of liquid in combination with the time of application (no time for evaporation) and the falling temperature, increased frost stress is to be expected.

- Measurement of the acoustical characteristics every 10 theoretical years by Kubisch Data GmbH, Technologieparkstraße 3, 4820 Bad Ischl
The acoustic measurements are documented in attachment 1.

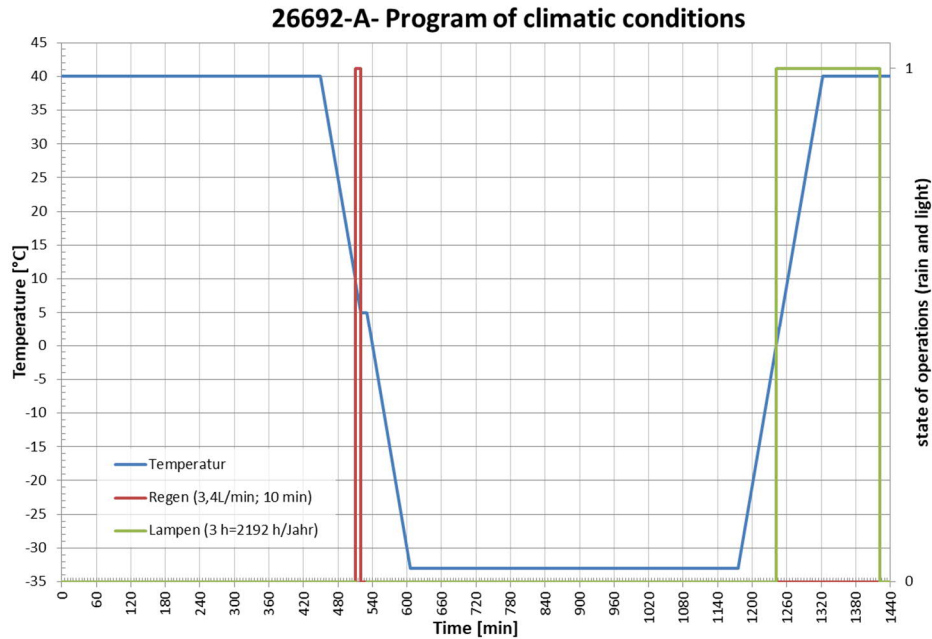


Fig. 2: Program of the climatic conditions in the climate chamber

4. Material

The Whisper® NBO-40-A3 element is a product of the company Sealed Air from Kettering, England. It consists of foamed polyethylene (LDPE) with closed cells. These cells were later partially opened by drilling (perforated Whisper element) and milling (milled Whisper element) in order to improve the sound reflectivity.

5. Test chamber setup

The test chamber consists of a light panel, as shown in Fig. 3 and Fig. 4, made of daylight lamps (Osram Ultra Vitalux300), a UV bar in the middle, and infrared lamps (Philipps IR lamps, 175W) at the top and bottom. This panel was positioned with a clearance of ~60 cm relative to the surface of the test body. Two spray bars for sprinkling were installed above the light panel, and set such that nearly the entire surface of the test body is moistened. To protect the lamps, a plate is mounted under the spray bar, which should prevent drops from reaching the lamps and destroying them.

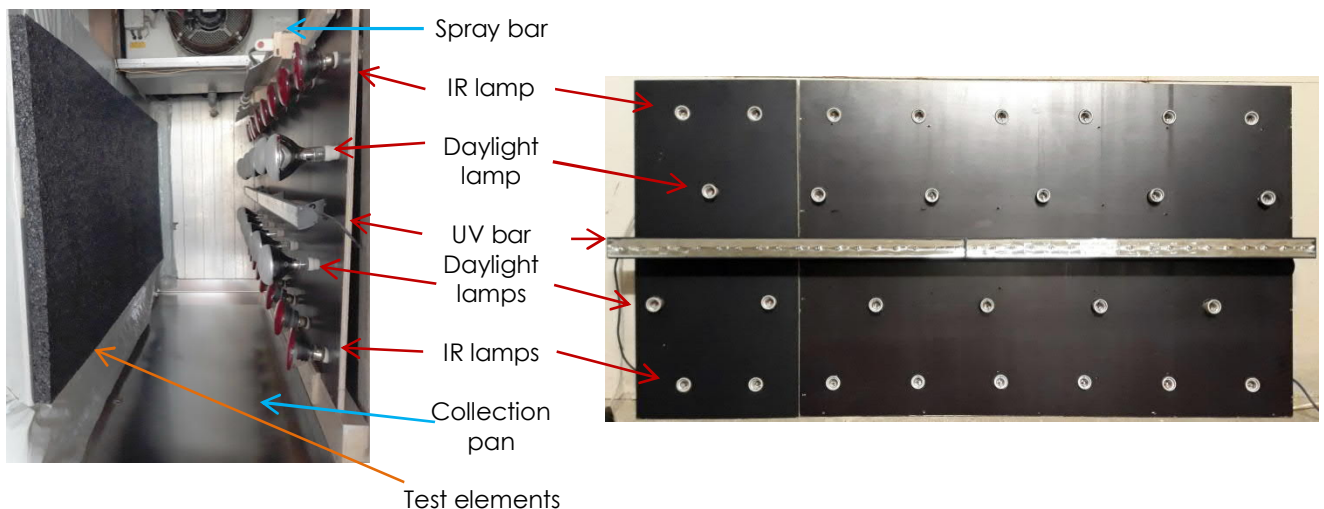


Fig. 3: Setup of the light panels and test chamber



Fig. 4: View into the test chamber (left image) and onto the light panel in the switched-on condition (without collection pans and test elements; right image).

6. Results

Initial state

The milled Whisper noise barrier element weighs 1.22 kg. The milling trajectories are spaced 1 cm apart and have a web approx. 1.5 cm wide along the edge. See Fig. 5.

As a result of the surface treatment (addition of milling trajectories), small plastic fibres have remained in the opened hollow spaces, some of which have been washed out during the course of the test. Due to the light irradiation not being completely homogeneous, as well as the irradiation all at once (1 x 3 h), the element surface overheated and was therefore replaced with a new element weighing 1.23 kg after a small change to the airflow and the switch-on times of the lamps (6 x 0.5 h). See Tab. 4 and Tab. 5.

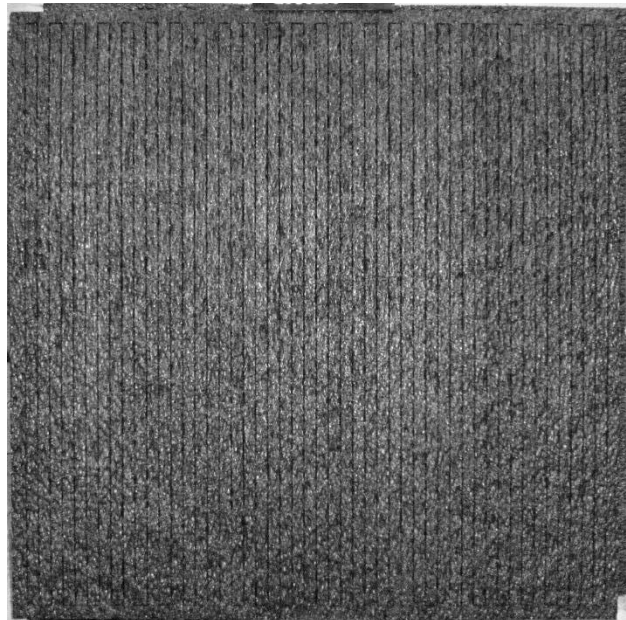


Fig. 5: Initial state of the milled Whisper® NBO-40-A3 absorber element

The perforated Whisper noise barrier element weighs 1.25 kg. It has 4 mm boreholes in a 10 x 10 mm grid pattern. See Fig. 6.

Due to the light irradiation not being completely homogeneous, as well as the irradiation all at once (1 x 3 h), the element surface overheated and was therefore replaced with a new element weighing 1.22 kg after a small change to the airflow and the switch-on times of the lamps (6 x 0.5 h). See Tab. 4 and Tab. 5.

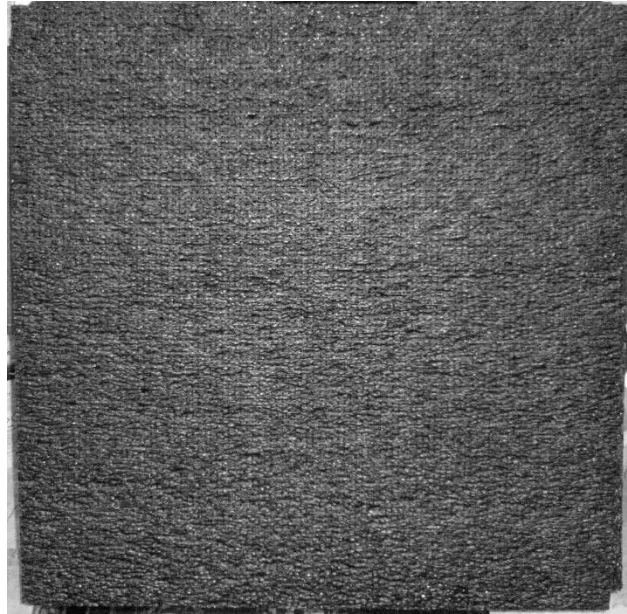


Fig. 6: Initial state of the perforated Whisper® NBO-40-A3 absorber element

After cycle 1 (10 theoretical years)

The milled Whisper element shows signs of overheating (upper third) due to the light conditions and air circulation not being completely homogeneous, and was therefore replaced with a new element after consulting with the client. The element has gained 0.8 kg in moisture/salt. 0.6 kg of the absorber in the form of wood-chip concrete chips/fragments fell into the collection pan. See also Fig. 7, as well as Tab. 4 and Tab. 5. The temperature profile for the original element for the simulated years 0-10 is shown in Fig. 20 in the attachment. According to the thermocouple, positioned near the surface of the Whisper element, temperatures of up to 79.2 °C occurred (see Fig. 20 in the attachment).

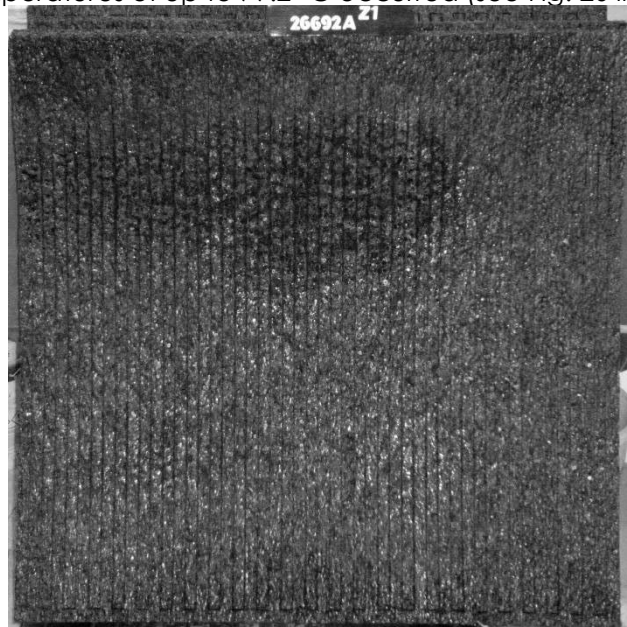


Fig. 7: Condition of the old, milled Whisper® NBO-40-A3 absorber element after 10 theoretical years with clear signs of overheating in the top third

The newly inserted element was deformed due to the variation in thermal stress after 10 theoretical years. Especially in the lower area, there are signs of salt residue left behind during evaporation. The element has gained 0.8 kg in moisture/salt. See also Fig. 8, as well as Tab. 4 and Tab. 5. The temperature profile for the new element for the simulated years 0-10 is shown in Fig. 21 in the attachment. According to the thermocouple (positioned in the hot spot; near the surface, approx.

1/3 of the way from the top and approx. 1/3 from the left edge), temperatures of up to 84.8 °C occurred in the Whisper element (see Fig. 21 in the attachment).

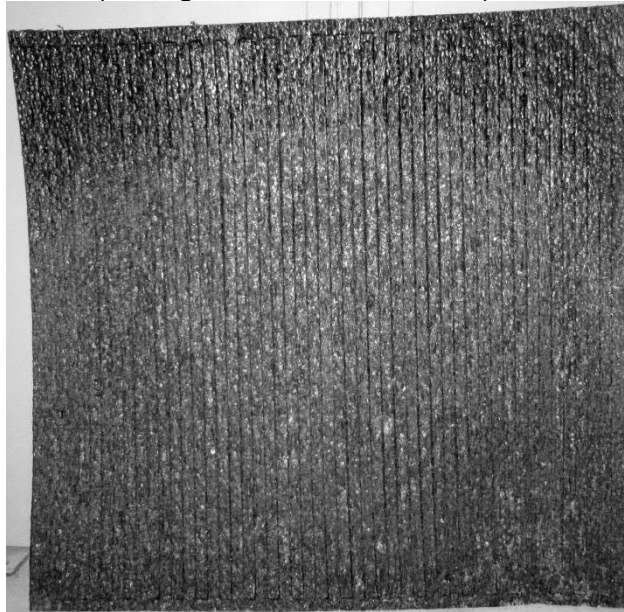


Fig. 8: Condition of the new, milled Whisper® NBO-40-A3 absorber element after 10 theoretical years with the airflow slightly modified compared to the upper element (Fig. 7).

The perforated Whisper element shows signs of overheating (lower third) due to the light conditions and air circulation not being completely homogeneous and was therefore replaced with a new element after consulting with the client. The element has gained 0.5 kg in moisture/salt. See also Fig. 9, as well as Tab. 4 and Tab. 5. The temperature profile for the original element for the simulated years 0-10 is shown in Fig. 20 in the attachment. According to the thermocouple, positioned near the surface of the Whisper element, temperatures of up to 79.2 °C occurred (see Fig. 20 in the attachment).

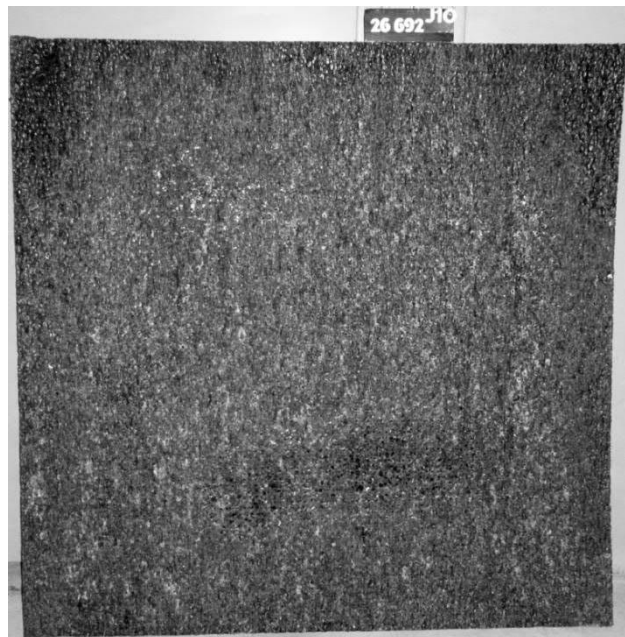


Fig. 9: Condition of the old, perforated Whisper® NBO-40-A3 absorber element after 10 theoretical years

The newly inserted element was deformed due to the variation in thermal stress after 10 theoretical years. Especially in the lower area, there are signs of salt residue left behind during evaporation. The element has gained 0.2 kg in moisture/salt. See also Fig. 10, as well as Tab. 4 and Tab. 5. The temperature profile for the new element for the simulated years 0-10 is shown in Fig. 21 in the

attachment. According to the thermocouple, temperatures of up to 84.8 °C occurred near the surface of the Whisper element (see Fig. 21 in the attachment).

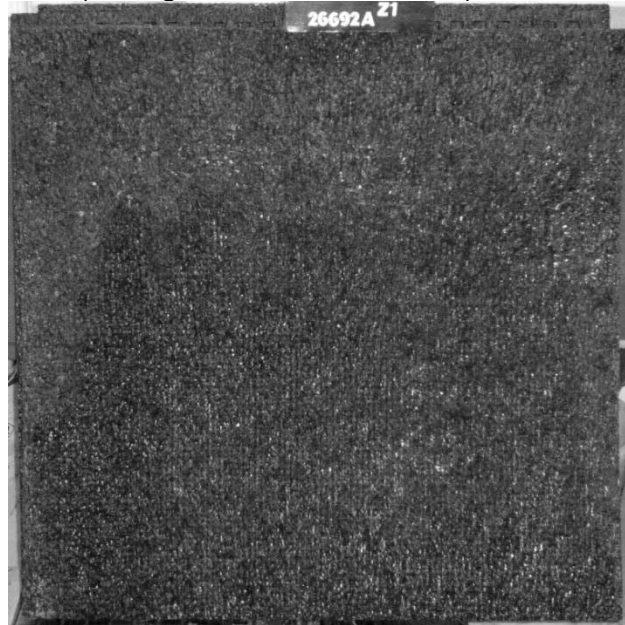


Fig. 10: Condition of the new, perforated Whisper® NBO-40-A3 absorber element after 10 theoretical years

After cycle 3 (30 theoretical years)

The thermally caused deformation of the element was partially corrected using more fastening points. There are signs of salt residue left behind during evaporation on nearly the entire surface, but especially concentrated in the lower area. The element gained 0.1 kg in moisture/salt. See also Fig. 11, as well as Tab. 4 and Tab. 5. The temperature profile for the simulated years 20-30 is shown in Fig. 23 in the attachment. According to the thermocouple, Whisper element surface temperatures of up to 80.1 °C occurred (see Fig. 23 in the attachment).

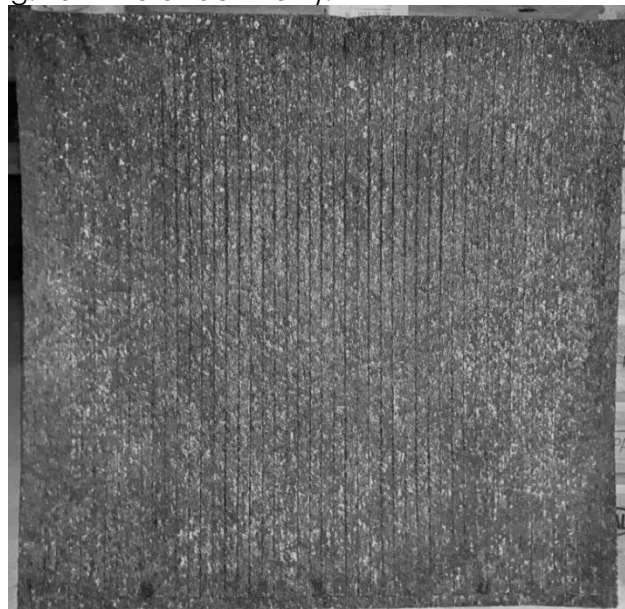


Fig. 11: Condition of the milled Whisper® NBO-40-A3 absorber element after 30 theoretical years

Due to the not completely homogeneous light irradiation and despite the changed switch-on times, there are slight signs of overheating in the lower third. After consulting with the client, it was decided to continue to age this element despite the signs of overheating. There are signs of salt residue left behind during evaporation on nearly the entire surface of the element, but especially concentrated in the lower area. The element gained 0.1 kg in moisture/salt. See also Fig. 12 and Fig. 13 as well as

Tab. 4 and Tab. 5. The temperature profile for the simulated years 20-30 is shown in Fig. 23 in the attachment. According to the thermocouple (positioned in the hot spot; near the surface, approx. 1/3 of the way from the bottom and approx. 1/3 from the right edge), temperatures of up to 80.1 °C occurred in the Whisper element (see Fig. 23 in the attachment).



Fig. 12: Condition of the perforated Whisper® NBO-40-A3 absorber element after 30 theoretical years;



Fig. 13: Condition of the perforated Whisper® NBO-40-A3 absorber element after 30 theoretical years; details of the scorched surface

After cycle 4 (40 theoretical years)

Compared to the previous cycle, the milling trajectories have widened. The element does not show any other obvious changes, however. The element has gained 0.6 kg in moisture/salt. See also Fig. 14, as well as Tab. 4 and Tab. 5. The temperature profile for the simulated years 30-40 is shown in Fig. 24 in the attachment. According to the thermocouple, Whisper element surface temperatures of up to 88.4 °C occurred (see Fig. 24 in the attachment).

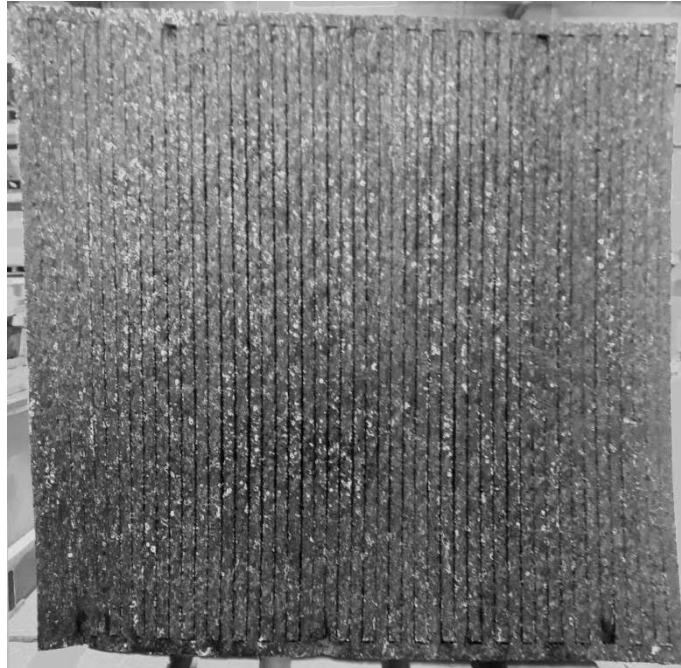


Fig. 14: Condition of the milled Whisper® NBO-40-A3 absorber element after 40 theoretical years

Except for a thicker crust of salt residue, no obvious changes compared to the previous cycle are noticeable. The element gained 0.1 kg in moisture/salt. See also Fig. 15, as well as Tab. 4 and Tab. 5. The temperature profile for the simulated years 30-40 is shown in Fig. 24 in the attachment. According to the thermocouple (positioned in the hot spot; Near the surface, approx. 1/3 of the way from the bottom and approx. 1/3 from the right edge), temperatures of up to 88.4 °C occurred in the Whisper element (see Fig. 24 in the attachment).

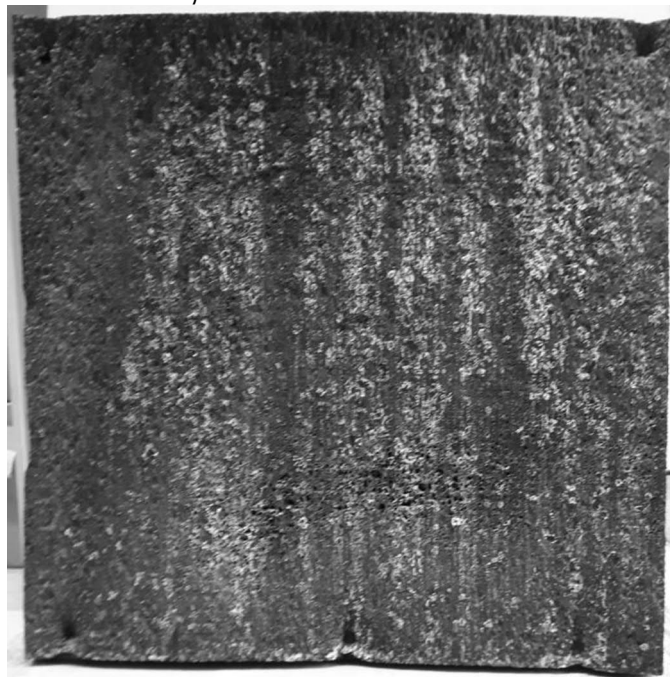


Fig. 15: Condition of the perforated Whisper® NBO-40-A3 absorber element after 40 theoretical years

After cycle 5 (50 theoretical years)

Compared to the previous cycle, the milling trajectories have widened and the thermally caused deformations have worsened. In addition, there was more salt residue on the surface. The element gained 0.3 kg in moisture/salt. See also Fig. 16, as well as Tab. 4 and Tab. 5. The temperature profile

for the simulated years 40-50 is shown in Fig. 25 in the attachment. According to the thermocouple, Whisper element surface temperatures of up to 82.3 °C occurred (see Fig. 25 in the attachment).

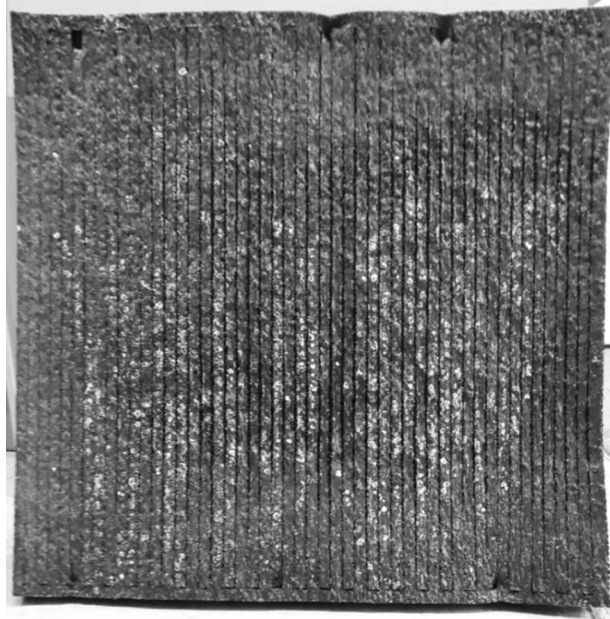


Fig. 16: Condition of the milled Whisper® NBO-40-A3 absorber element after 50 theoretical years

Stronger signs of surface overheating are noticeable than after the previous cycle, and the amount of salt residue has increased. The element has gained 0.2 kg in moisture/salt. See also Fig. 17, as well as Tab. 4 and Tab. 5. The temperature profile for the simulated years 40-50 is shown in Fig. 25 in the attachment. According to the thermocouple (positioned in the hot spot; near the surface, approx. 1/3 of the way from the bottom and approx. 1/3 from the right edge), temperatures of up to 82.3 °C occurred in the Whisper element (see Fig. 25 in the attachment).

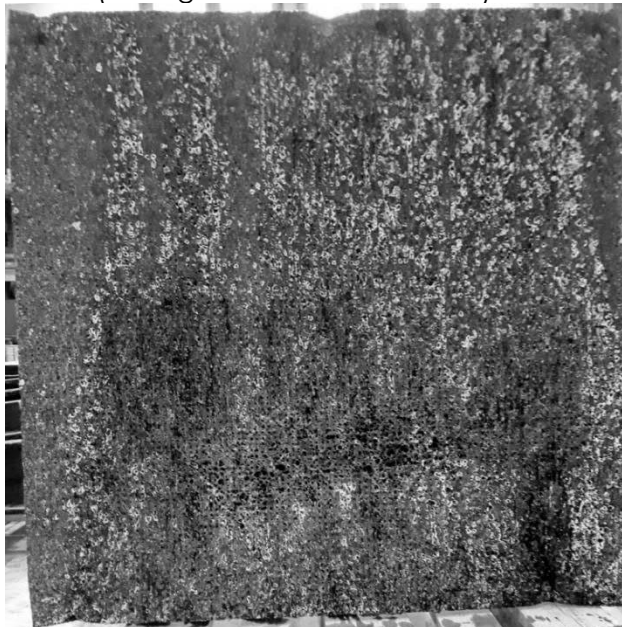


Fig. 17: Condition of the perforated Whisper® NBO-40-A3 absorber element after 50 theoretical years

7. Weighing results

The test element was weighed at the beginning and at times near the times of the acoustical measurements. The weights can be seen in Tab. 4 and Tab. 5. The times of the acoustical measurements were after the first cycle (10 theoretical years) on the following day, 5 days after the 2nd cycle (new panel, 10 theoretical years), 5 days after the end of the 4th cycle (new panel, 30

theoretical years) and, for the 5th (new panel, 40 theoretical years) and 6th cycles (new panel, 50 theoretical years), 6 days after the end of each cycle. The reason for the longer time periods between the acoustical measurements and the end of the ageing cycle has to do with the influence of the moisture of the test elements. Drier elements deliver better acoustical values than wetter ones. Values for these can be found in the acoustical measurement report.

Tab. 4: Weighing results of the Whisper® NBO-40-A3 elements up to the time they were exchanged for new ones due to strong signs of melting on the surface after the first ageing cycle

theoretical years	Whisper milled	Whisper perforated
	weight [kg]	weight [kg]
0	1,22	1,25
10	2,02	1,76

Tab. 5: Weighing results of the new Whisper® NBO-40-A3 elements after each ageing cycle

theoretical years	Whisper milled	Whisper perforated
	weight [kg]	weight [kg]
0	1,23	1,22
10	2,01	1,39
20	-	-
30	1,31	1,27
40	1,82	1,29
50	1,53	1,36

8. Acoustical tests for Whisper® NBO-40-A3 plates

10.1 In-situ measurements (excerpt from attachment 1: Test report 1793-5 from Kubisch Data GmbH, Technologieparkstraße 3, 4820 Bad Ischl)

To determine the effects of ageing on the sound reflection of the Whisper® NBO-40-A3 absorber plates from DELTA BLOC (manufactured by Sealed Air), in-situ sound reflection measurements are to be performed on a test setup specifically constructed for this, with wall dimensions of at least 4 m x 4 m, on the premises of the Bautechnischen Institut (BTI) in Puchenau. Ageing is performed in a climate chamber by BTI. Over the course of 20 days, approx. 10 years of ageing is simulated. Due to the limited size of the climate chamber, only 1 m² of the absorber surface can be subjected to artificial ageing. For standardized measurements of in-situ sound reflection according to ÖNORM EN 1793-5, 4 m x 4 m are required in order to be able to take the sound reflection into account over the entire frequency range from 200 Hz to 5000 Hz. In addition, no other reflecting surfaces may be present in the immediate vicinity. In the present case, an inference is to be derived from the sound reflection measurement results for the absorber area of 1 m² to a full surface (of at least 16 m², according to the standard). The results shown in Tab. 6 or Fig. 18 for the perforated Whisper plates, and in Tab. 7 or Fig. 19 for the milled Whisper plates show the single numbers with regard to sound reflection (DL_{Ri}) in acc. with ÖNORM EN 1793-5 on a fully covered wall element with the dimensions 4 m x 4 m, measured with a method adapted to the 1 m² absorber surface (DL_{Ri}) and values converted to 16 m² (DL_{Ri}). In addition to the ageing stage, the weight of the absorber is also given as an indirect reference to the water content in the absorber and the time specified as the drying time between the end of the ageing cycle and measurement.

Tab. 6: Results of the noise reflection measurements of the perforated Whisper® NBO-40-A3 absorber with specification of the drying time before the acoustical measurement and the Whisper plate weight in kg (in column headings) over the 50 simulated years

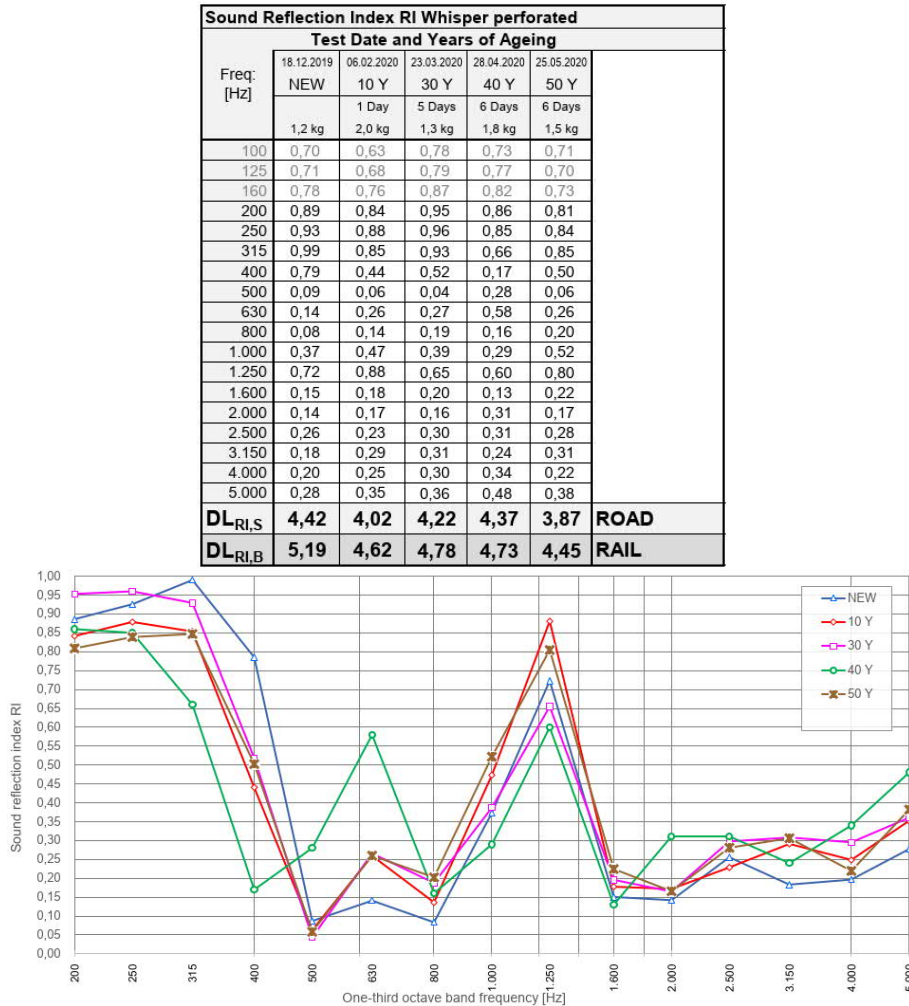


Fig. 18: Results of the noise reflection measurements of the perforated Whisper® NBO-40-A3 absorber

Tab. 7: Results of the noise reflection measurements of the milled Whisper® NBO-40-A3 absorber with specification of the drying time before the acoustical measurement and the Whisper plate weight in kg (in column headings) over the 50 simulated years

Sound Reflection Index RI Whisper milled						
Freq: [Hz]	Test Date and Years of Ageing					
	18.12.2019	06.02.2020	23.03.2020	28.04.2020	25.05.2020	
	NEW	10 Y	30 Y	40 Y	50 Y	
	1,3 kg	1,4 kg	1,3 kg	1,3 kg	1,4 kg	
100	0,71	0,62	0,73	0,66	0,80	
125	0,72	0,68	0,76	0,72	0,78	
160	0,78	0,76	0,82	0,79	0,80	
200	0,89	0,86	0,90	0,83	0,89	
250	0,93	0,90	0,94	0,87	0,91	
315	0,97	0,86	0,92	0,86	0,87	
400	0,67	0,50	0,58	0,52	0,56	
500	0,07	0,37	0,20	0,09	0,31	
630	0,08	0,54	0,26	0,23	0,45	
800	0,04	0,30	0,16	0,17	0,24	
1.000	0,37	0,29	0,28	0,38	0,25	
1.250	0,65	0,48	0,60	0,75	0,66	
1.600	0,19	0,07	0,14	0,23	0,31	
2.000	0,13	0,09	0,13	0,20	0,13	
2.500	0,26	0,23	0,23	0,25	0,16	
3.150	0,18	0,19	0,26	0,25	0,22	
4.000	0,11	0,20	0,14	0,16	0,15	
5.000	0,19	0,12	0,35	0,38	0,12	
DL_{RI,S}	4,78	4,45	4,66	4,24	4,17	ROAD
DL_{RI,B}	5,56	5,42	5,39	4,82	4,95	RAIL

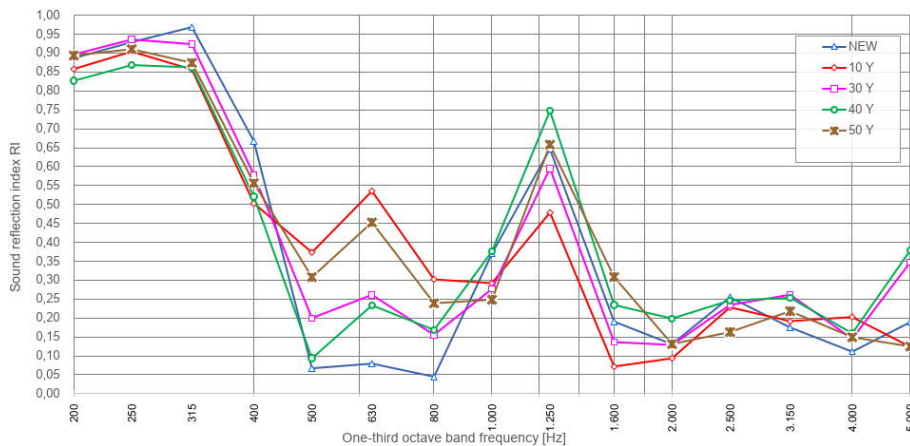


Fig. 19: Results of the noise reflection measurements of the milled Whisper® NBO-40-A3 absorber

The comparison of the measurement results of the different ageing stages is relevant to the overall assessment of the effect of ageing on sound reflection. As the results in Table 2 and Table 3 show, the measured values DL_{RI} for the ageing stages from 0 years to 50 years range between 3.9 dB and 4.8 dB for the street traffic noise spectrum and 4.5 dB to 5.6 dB for the rail traffic noise spectrum.

The measurement results overall show no clear trend which would allow a conclusion to be made about the dependency of absorption on the ageing stage.

Comparing the DL_{RI} values with the weight, and indirectly with the water content / degree of contamination of the absorber surface, as given in Tab. 6 and Tab. 7, a clear trend is apparent, which indicates that the DL_{RI} values decrease with increasing water content, i.e., the sound reflection increases.

Here, it is to be noted that, according to ÖNORM EN 1793-5, the expanded measurement uncertainty lies at approx. 1.33 dB_(A).

9. Result:

The investigation of the long-term behaviour was primarily with respect to the ageing of Whisper® NBO-40-A3 absorbers without a supporting structure. Biological attack, mechanical effects, such as vibrations, as well as massive UV irradiation should be investigated separately, if relevant. The performed ageing test with more than 2400 hours of ageing over 5 months in acc. with EN 14389-1:2015, EN 14389-2:2015 and EN 60721-3-4:1995 led to the following results:

Whisper® NBO-40-A3 elements in general:

The tests have shown that, due to the one-sided temperature application, intensified by the thermal insulation capacity, the elements deform to a greater degree on the thermally impinged side than on the protected side. These different deformations cause the plates to warp.

Whisper® NBO-40-A3 elements, milled:

The tests have shown that the surface optically changes from matte to glossy as a result of superficial overheating. If overheating continues, the milling trajectories widen and, as a further consequence, signs of melting appear on the surface. This occurs at temperatures of 111 °C (see also BTI report 26692-B1/2020).

Surface temperatures higher than 100 °C are to be avoided.

The acoustical characteristics did not get significantly worse over the 50 simulated years and beyond, but a clear trend was apparent indicating that the surface contaminants (e.g., salt, etc.) reduced the DL_{RI} values.

Whisper® NBO-40-A3 elements, perforated:

The perforated Whisper plates showed a very similar behaviour to the milled ones, with one difference being that the signs of melting were not as apparent. Surface temperatures higher than 100 °C are to be avoided.

The acoustical characteristics did not get significantly worse over the 50 simulated years and beyond, but a clear trend was apparent indicating that the surface contaminants (e.g., salt, etc.) reduced the DL_{RI} values.

Tab. 8: Results of the acoustical measurement of the sound reflection on Whisper® NBO-40-A3 absorber plates

	Model	Austrian Standard EN 1793-5 (16m²) Weight: Drying Time: 1,22 kg -	Ageing of a 1m² test surface					Note:
			NEW	10 J 2,07 kg 1 Day	30 J 1,31 kg 5 Days	40 J 1,82 kg 6 Days	50 J 1,53 kg 6 Days	
ROAD	WHISPER PERFORATED	5,25 [3,92 - 6,58]	4,42	4,02	4,22	4,37 ¹⁾	3,87 ¹⁾	1) Salt/Limescale deposits on the absorbant material
RAIL	WHISPER PERFORATED	6,14 [4,81 - 7,47]	5,19	4,62	4,78	4,73 ¹⁾	4,45 ¹⁾	1) Salt/Limescale deposits on the absorbant material
ROAD	WHISPER VERTICALLY-MILLED	5,37 [4,04 - 6,70]	4,78	4,45	4,66	4,24 ¹⁾	4,17 ¹⁾	1) Salt/Limescale deposits on the absorbant material
RAIL	WHISPER VERTICALLY-MILLED	5,91 [4,58 - 7,24]	5,56	5,42	5,39	4,82 ¹⁾	4,95 ¹⁾	1) Salt/Limescale deposits on the absorbant material

BTI Bautechnisches Institut GmbH

Director:



DI(FH) Dr. René Eckmann

Tester:

DI Edgar Klammer

Attachment 1:

Sound reflection measurements on site by Kubisch Data GmbH, Technologieparkstraße 3, 4820 Bad Ischl; Test report 1793-5

21 pages

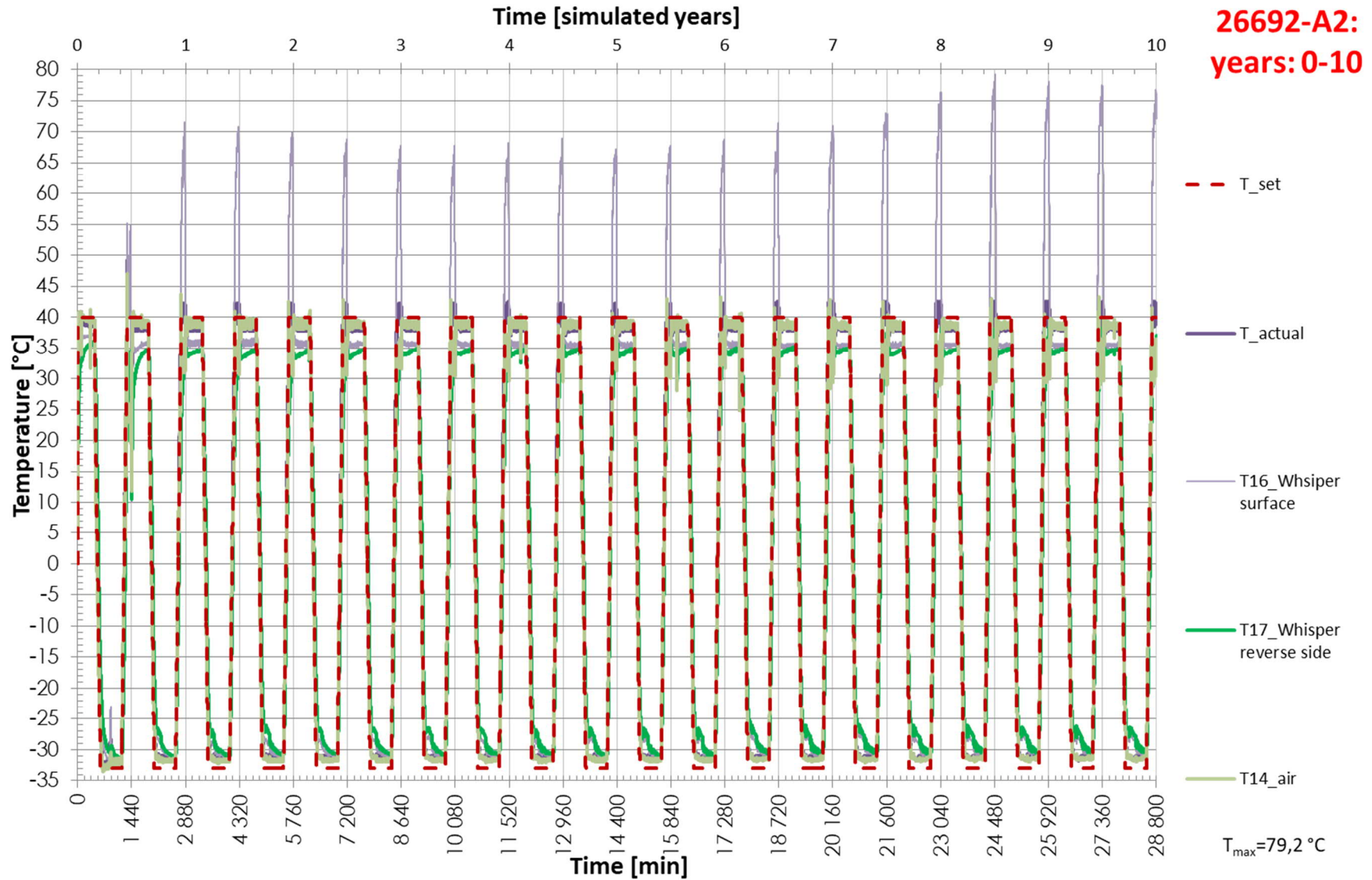


Fig. 20: Temperature profile, recorded using Pt1000 thermocouples which were positioned in the chamber over the first 10 simulated years (old element)

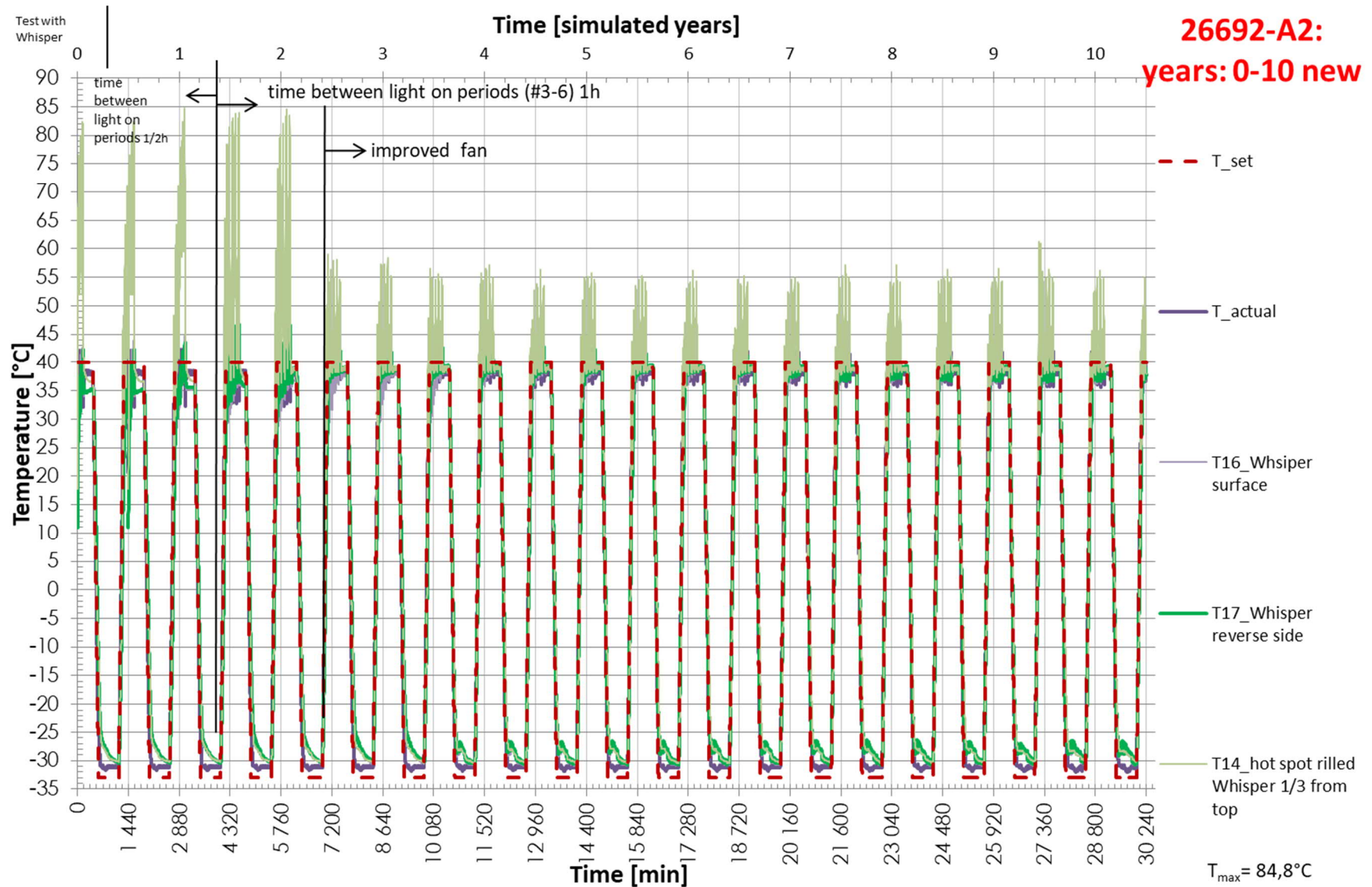


Fig. 21: Temperature profile, recorded using Pt1000 thermocouples which were positioned in the chamber over the first 10 simulated years (new element)

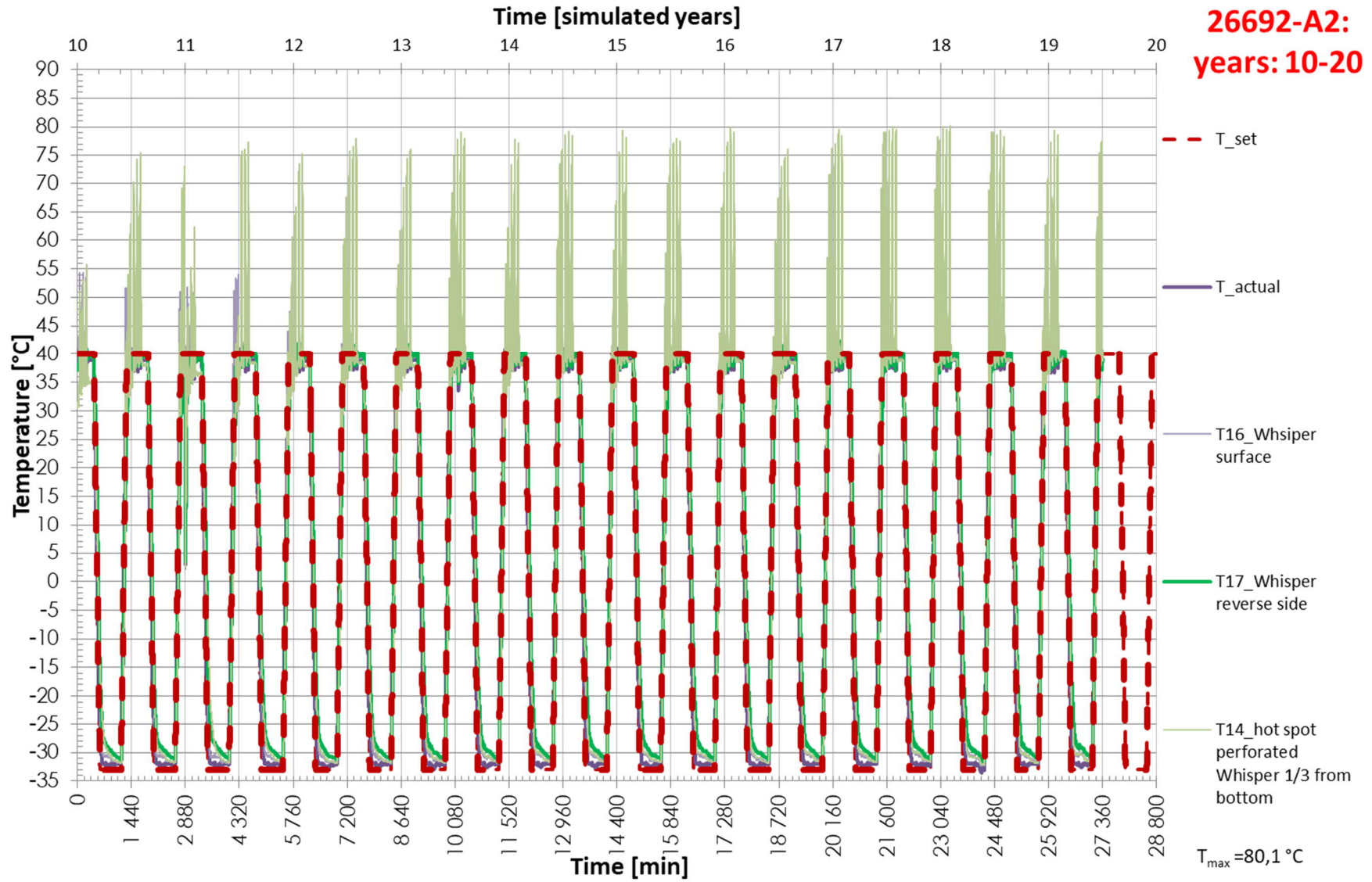


Fig. 22: Temperature profile, recorded using Pt1000 thermocouples which were positioned in the chamber over 10-20 simulated years (new element)

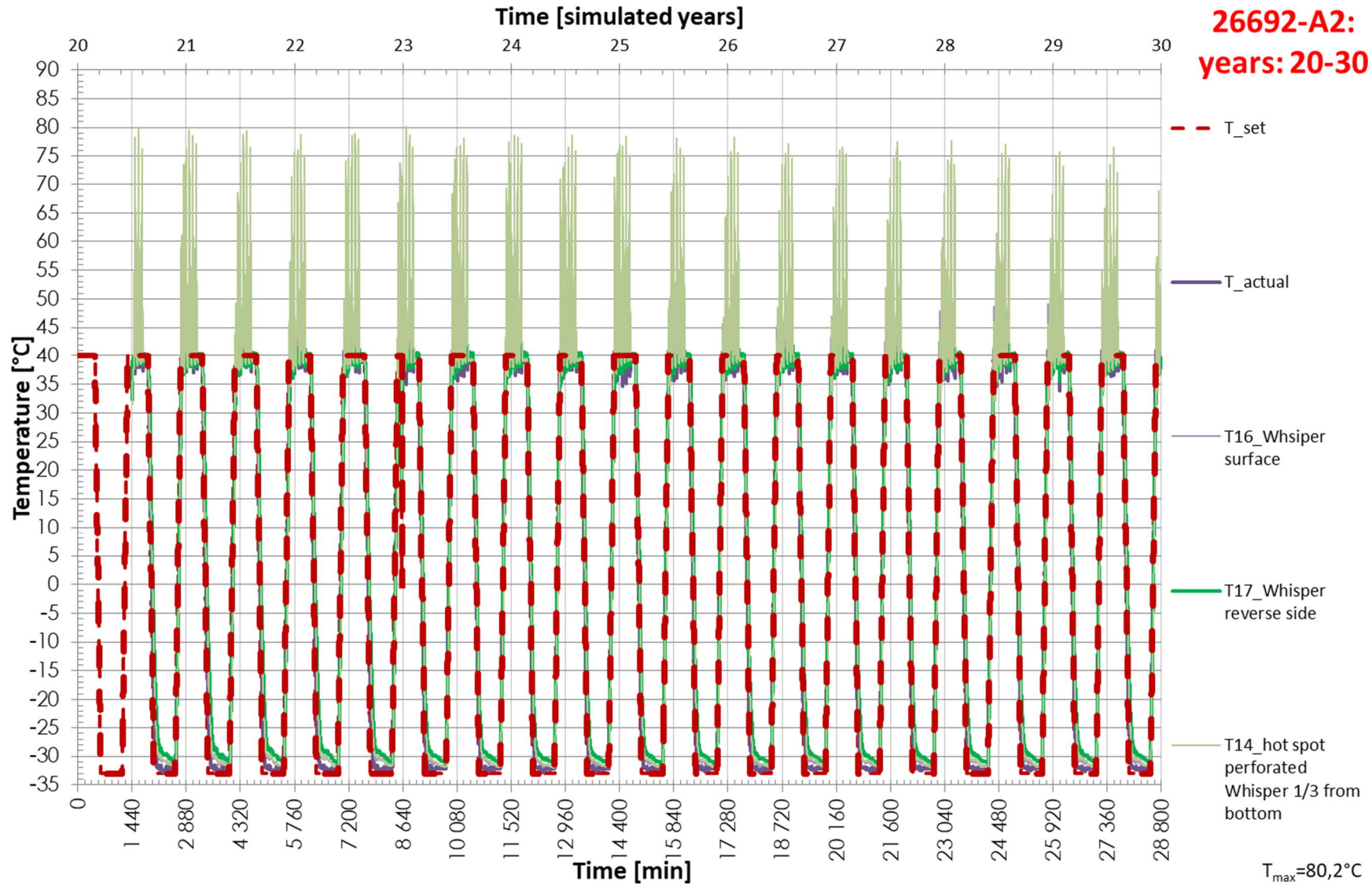


Fig. 23: Temperature profile, recorded using Pt1000 thermocouples which were positioned in the chamber over 20-30 simulated years (new element)

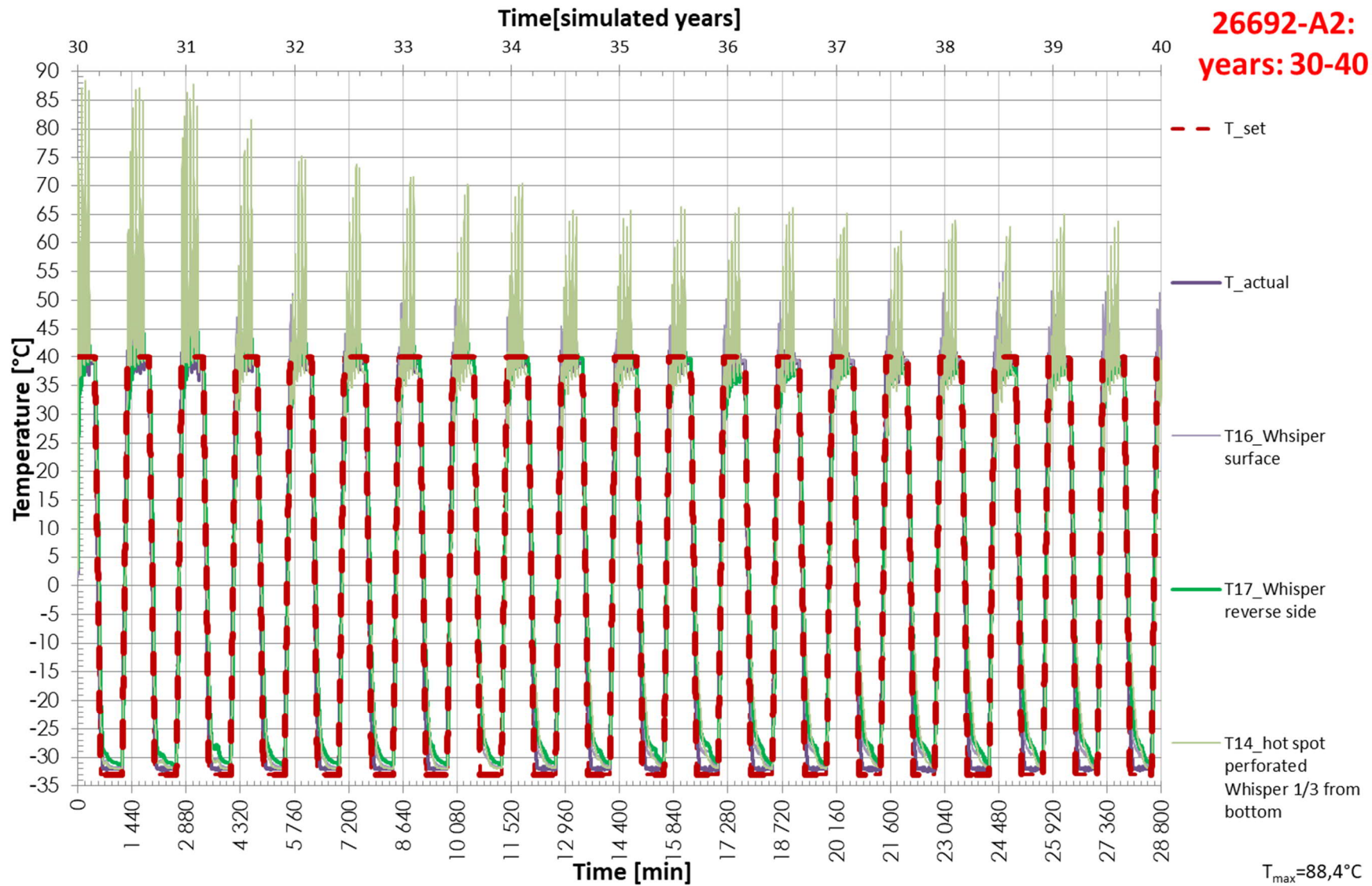


Fig. 24: Temperature profile, recorded using Pt1000 thermocouples which were positioned in the chamber over 30-40 simulated years (new element)

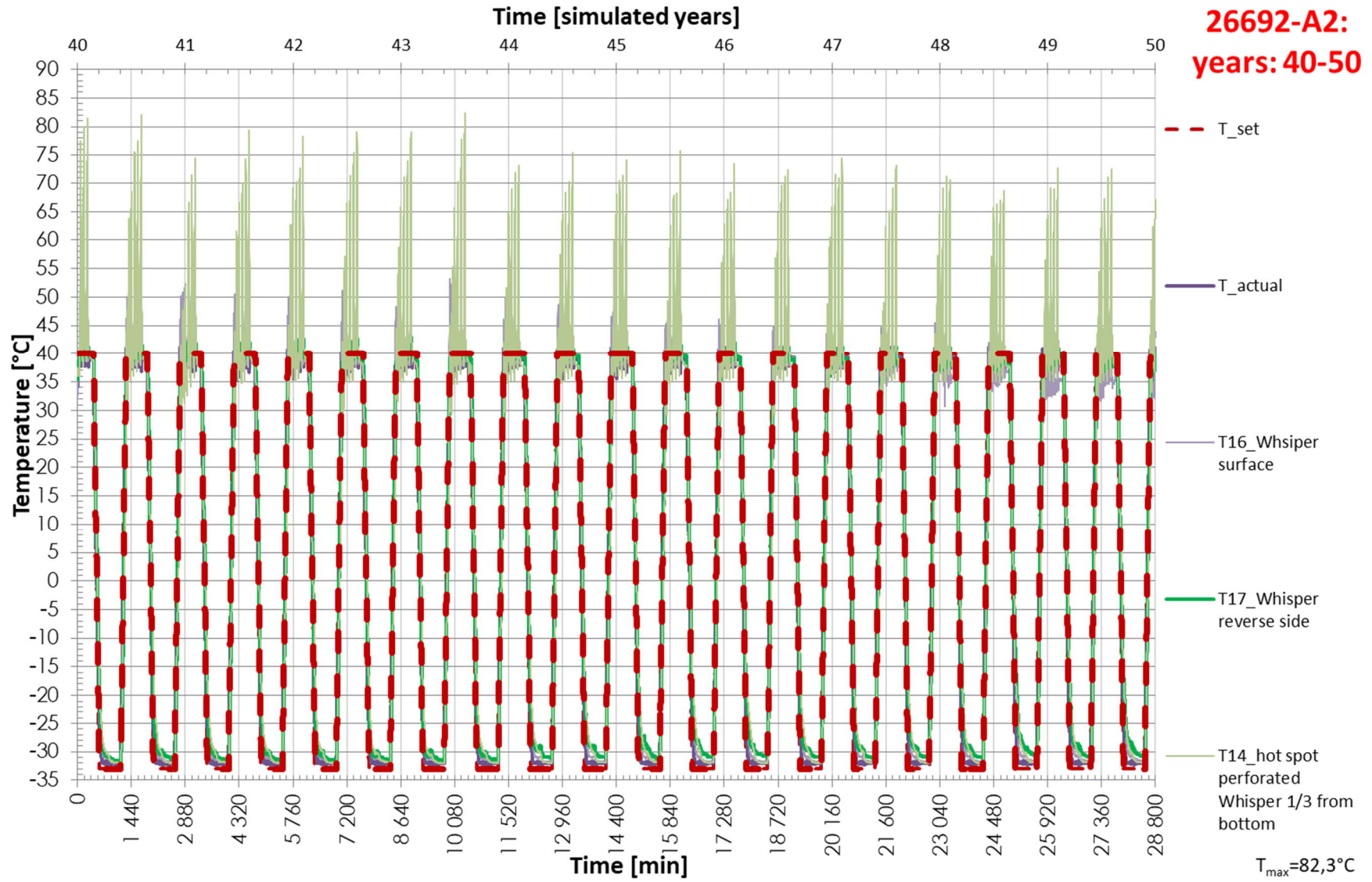


Fig. 25: Temperature profile, recorded using Pt1000 thermocouples which were positioned in the chamber over 40-50 simulated years (new element)