TÜV NORD
Umweltschutz

Essen, 19.12.2022
TNU-SST-E-Hrd

Test report

Measurement of airborne sound insulation and sound absorption of the noise barrier element of the type *Noistop ESSENTIAL* in a test stand

Test laboratory accredited by DAkkS according to DIN EN ISO/IEC 17025.

The accreditation applies for the test procedure described in the certificate.

The laboratory is also a notified measuring location in accordance with § 29b BImSchG

Client:	ROCKWOOL Danmark A/S – Rockfon Noistop Dept. Hovedgaden 501D DK - 2640 Hedehusene
TÜV-Order-No.:	822SST253 / 8000682774-1
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Standards:	EN ISO 10140-2:2021 EN ISO 354:2003 DIN EN 1793-1:2017 DIN EN 1793-2:2019

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Messstelle nach § 29b BImSchG
VMPA-Güteprüfstelle für Bauakustik

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1 Definition of tasks

ROCKWOOL Technical Insulation assigned the following task:

Measurement of airborne sound insulation and sound absorption of the noise barrier element of the type *Noistop ESSENTIAL*.

The test is carried out in the test stand with suppressed flank transmission at TÜV NORD Umweltschutz GmbH & Co. KG in Essen, Germany. The measurement results should also be shown and evaluated according to the specifications of DIN EN 1793-1 and DIN EN 1793-2.

2 Standards for measurement and evaluation

[1] **DIN EN ISO 10140-2**
Acoustics - Laboratory measurement of sound insulation of building elements - Part 2: Measurement of airborne sound insulation (ISO 10140-2:2021); German version EN ISO 10140-2:2021

[2] **DIN EN ISO 10140-4**
Acoustics - Laboratory measurement of sound insulation of building elements - Part 4: Measurement procedures and requirements (ISO 10140-4:2021); German version EN ISO 10140-4:2021

[3] **DIN EN ISO 10140-5**
Acoustics - Laboratory measurement of sound insulation of building elements - Part 5: Requirements for test facilities and equipment (ISO 10140-5:2021); German version EN ISO 10140-5:2021

[4] **DIN EN ISO 717-1**
Acoustics - Rating of sound insulation in buildings and of building elements - Part 1: Airborne sound insulation (ISO 717-1:2020); German version EN ISO 717-1:2020

[5] **DIN EN 1793-1**
Road traffic noise reducing devices - Test method for determining the acoustic performance - Part 1: Intrinsic characteristics of sound absorption under diffuse sound field conditions; German version EN 1793-1:2017

[6] **DIN EN 1793-2**
Road traffic noise reducing devices - Test method for determining the acoustic performance - Part 2: Intrinsic characteristics of airborne sound insulation under diffuse sound field conditions; German version EN 1793-2:2018

[7] **DIN EN 1793-3**
Road traffic noise reducing devices - Test method for determining the acoustic performance - Part 3: Normalised traffic noise spectrum; German version EN 1793-3:1997

[8] **DIN EN ISO 354**
Acoustics - Measurement of sound absorption in a reverberation room (ISO 354:2003); German version EN ISO 354:2003

[9] **DIN EN ISO 12999-1**
Acoustics - Determination and application of measurement uncertainties in building acoustics - Part 1: Sound insulation (ISO 12999-1:2020); German version EN ISO 12999-1:2020

[10] **DIN EN ISO 12999-2**
Acoustics - Determination and application of measurement uncertainties in building acoustics - Part 2: Sound absorption (ISO 12999-2:2020); German version EN ISO 12999-2:2020

3 Test object and test configuration

Noistop ESSENTIAL is a double-sided absorbing sound insulation element for the reduction of unwanted ambient noise, e.g. from traffic, neighbours, heat pumps, sports fields, etc. In addition, the modules can be clad on one side or on both sides with a cladding frame made of wooden beams.

The dimensions of the standard module are 2400 x 1000 mm (additional flanges of 35 mm on both sides for fastening). The modules are mounted on the centre support with a dimension of 70 x 70 x 3 mm on a base of masonry with a height of 250 mm serving as a levelling layer.

The sound-absorbing module core consists of highly compressed stone wool of the type Noistop Essential stone wool slabs from ROCKWOOL with standard dimensions of 2400 x 1000 x 48 mm and a density of 190 kg/m³. The stone wool is covered with a black PE fabric and embedded in a 60 mm thick steel construction consisting of a frame with a grid of steel bars, Ø 5mm (grid size 75 x 200 mm).

The following variant was measured as part of this investigation:

Noistop ESSENTIAL, absorbent on both sides

It was ensured that no system errors occurred due to the adaptation of the elements to the test stand. Therefore, a change in the acoustic properties is not to be expected.

Construction drawings of the client are shown in **Annex 3**.

3.1 Test setup for determining the airborne sound insulation

The noise barrier consists of a total of 6 noise barrier elements and a steel support described above (for test stand construction see annex 4). On each side of the support, two 1000 mm high elements with a length of 2470 mm and 1480 mm respectively are placed on top of each other and connected to the ceiling with a 700 mm high fitting piece each.

These were fixed and sealed to the side walls and to the ceiling of the test stand opening with steel sheet angle profiles (d = 3 mm).

The sound path transmission via the test stand side walls as well as via the floor and the ceiling of the test stand can be neglected due to the high flank insulation.

The effective test specimen area was S = 10.3 m².

The reverberation-regulating installations on the walls and ceilings of the test stand rooms to increase the measurement accuracy are not shown in **Appendix 4**.

3.2 Test setup for determining the airborne sound absorption

The sound absorption coefficient α_S of the sound-absorbing noise barrier element was determined according to DIN EN ISO 354. The reverberation chamber was equipped with reflectors (diffusors) for this purpose.

The element (test specimen) had a surface area of 10,3 m² and was placed antiparallel to the test stand walls on the floor and sealed to the floor.

4 Measurement

4.1 Measurement Equipment

In the measurement the following devices were used:

Measuring device	Manufacturer	Type	Serial-No.
building acoustics analyser[1)]	Norsonic	140	1403101/07
preamplifier	Norsonic	1209	12499
microphone 1	Norsonic	1225	91949
building acoustics analyser[2)]	Norsonic	140	14031021/07
preamplifier	Norsonic	1209	12292
microphone 2	Norsonic	1225	227033
calibrated class 1 calibrator[2)]	Norsonic	1251	29192
Loudspeaker (Dodecahedron)[3)]	Norsonic	229	35022

1) DAkkS calibrated 2023-09 2) DAkkS calibrated 2024-02 3) PTB-Tested in 2022

Additionally two rotating microphone setups of Norsonic have been used in the measurements.

4.2 Measurement of airborne sound insulation

The measurement was performed on September 28th, 2022.

For the acoustic irradiation of the source room speakers and pink noise have been used. The strong side insulation of the test bench ($R'_w \geq 67$ dB, referring to the surface of the unit under test) allows to quantify the airborne sound insulation of the unit under test, determined in accordance with [1] to [3], with the help of the sound insulation R:

$$R(f) = L_1(f) - L_2(f) + 10 \cdot \lg (S/A (f)) \text{ in dB}$$

with
- f mid-frequency of the respective 1/3-octave band
- $L_1(f)$ averaged 1/3-ovtave sound pressure level in the source room in dB
- $L_2(f)$ averaged 1/3-octave sound pressure level in the receiving room in dB
- S Testing surface of the unit under test in m^2
- A(f) Frequency dependant surface of sound absorption of the receiving room in m^2,

$$A(f) = 0.16 \times V_E / T (f)$$

V_E Volume of the receiving room in m^3

T(f) Average reverberation time of the receiving room for each 1/3-octave band in s

4.3 Measurement of sound absorption

The measurement of sound absorption was carried out according to DIN EN ISO 354:2003. The reverberation time which related to sound absorption was measured upon terminating a steady-state broadband pink noise signal:

- T_0 reverberation time of the empty reverberation room,
- T_1 reverberation time of the reverberation room after inserting the test object.

The sound absorption coefficient was determined as follows:

$$\alpha_S = \frac{A(f)}{S}$$

The equivalent sound absorption area A of the test object was calculated according to DIN EN ISO 354:2003:

$$A = 55{,}3 \cdot \frac{V}{c} \cdot \left(\frac{1}{T_1} - \frac{1}{T_0} \right) \quad \left[m^2 \right]$$

wherein:

αs	sound absorption coefficient,
V	Volume of the empty reverberation room [m³],
S	area covered by the test object [m²],
A	equivalent sound absorption area [m²]
c	speed of sound in the air (331 + 0,6 t) [m/s], with air temperature in °C,
T_0	reverberation time of the empty reverberation room [s],
T_1	reverberation time of the reverberation room after inserting the test object [s]

The sound absorption coefficient was measured on September 29th, 2022 under the following conditions:

Temperature: 17 °C,
Humidity: 54 %.

5 Measuring results

5.1 Airborne sound insulation

Annex 1 in the appendix shows the measurement protocol in accordance with the standard, the frequency-dependent sound reduction indexes R as well as the weighted sound reduction index in the test stand R_w for the measured noise protection element. The weighted sound reduction index is:

R_W = 22 dB

In DIN EN 1793-2, the single value DL_R is determined according to the product-specific characteristic of the sound insulation of noise barriers at roads as follows:

$$D_{L_R} = -10 \lg \left| 1 - \frac{\sum_{i=1}^{18} 10^{0,1\,Li}\, 10^{-0,1\,Ri}}{\sum_{i=1}^{18} 10^{0,1Li}} \right|$$

with

DL_R	Single-value specification of the airborne sound insulation property, given as the difference of the A-weighted sound pressure levels, in decibels
R_i	Sound reduction index in the i-th third octave band, as defined in DIN EN 10140-2
L_i	Standardised A-weighted sound pressure level, in decibels, of traffic noise in the i-th third octave band, as defined in EN 1793-3

With the frequency-dependent sound insulation values R_i from the measurement results in **Annex 1**, the following values for DL_R result according to DIN EN 1793-2:

Freq. Hz	Insulation value R_i dB	Traffic-noise spectra L_i dB	$10^{0,1*Li}*10^{-0,1*Ri}$	$10^{0,1*Li}$
100	8,0	-20	0,001585	0,010000
125	12,4	-20	0,000575	0,010000
160	11,3	-18	0,001175	0,015849
200	10,5	-16	0,002239	0,025119
250	12,7	-15	0,001698	0,031623
315	15,7	-14	0,001072	0,039811
400	16,1	-13	0,001230	0,050119
500	18,6	-12	0,000871	0,063096
630	19,5	-11	0,000891	0,079433
800	20,7	-9	0,001072	0,125893
1000	21,6	-8	0,001096	0,158489
1250	21,4	-9	0,000912	0,125893
1600	25,8	-10	0,000263	0,100000
2000	28,0	-11	0,000126	0,079433
2500	29,6	-13	0,000055	0,050119
3150	32,8	-15	0,000017	0,031623
4000	33,8	-16	0,000010	0,025119
5000	34,7	-18	0,000005	0,015849
			0,014893	1,037465
			DL_R	**18**

5.2 Sound absorption coefficient α_S

The frequency-dependent sound absorption coefficients α_S were calculated according to DIN EN ISO 354. The results are shown in **Appendix 2**.

In DIN EN 1793-1, the single value $DL_{\alpha,NRD}$ is determined to indicate the product-specific characteristic of the sound absorption of noise barriers at roads as follows:

$$D_{L\alpha,NRD} = -10 \lg \left| 1 - \frac{\sum_{i=1}^{18} \alpha_{NRDi}\, 10^{0,1\, Li}}{\sum_{i=1}^{18} 10^{0,1 Li}} \right|$$

with

$DL_{\alpha,NRD}$	Single-value specification of the sound absorption properties, as the difference of the A-weighted sound pressure levels in dB
L_i	Standardised A-weighted sound pressure level, in decibels, of traffic noise in the i-th third octave band, as defined in EN 1793-3
α_{NRDi}	Sound absorption coefficient in the i-th third octave band

With the frequency-dependent sound absorption coefficients α_S from the measurement result of **Annex 2** the following values result according to section 5 of DIN EN 1793-1:

Freq. Hz	Sound absorption coeff. α_{NRD}	Traffic-noise spectra L_i dB	$\alpha_{NRDi}*10^{0,1*Li}$	$10^{0,1*Li}$
100	0,15	-20	0,002	0.010
125	0,29	-20	0,003	0.010
160	0,50	-18	0,008	0.016
200	0,64	-16	0,016	0.025
250	0,68	-15	0,022	0.032
315	0,79	-14	0,031	0.040
400	0,88	-13	0,044	0.050
500	0,88	-12	0,056	0.063
630	0,89	-11	0,070	0.079
800	0,91	-9	0,114	0.126
1000	0,89	-8	0,142	0.158
1250	0,96	-9	0,121	0.126
1600	0,94	-10	0,094	0.100
2000	0,96	-11	0,076	0.079
2500	0,96	-13	0,048	0.050
3150	0,96	-15	0,030	0.032
4000	0,95	-16	0,024	0.025
5000	0,97	-18	0,015	0.016
			0.916	1.0374651
			$DL_{\alpha,NRD}$	**9**

5.3 Measurement uncertainty

According to [9], the measurement uncertainty for the weighted sound reduction index is ± 1.2 dB. This is the standard deviation of the measurement results obtained under comparative conditions (standard uncertainty σ_R for measurement situation A - characterisation of a component by test bench measurements according to EN ISO 12999-1:2020, Table 2).

According to [10] the reproducibility standard deviation of the single value $DL_{\alpha,NRD}$ is $\sigma_R = 0{,}10 \cdot DL_{\alpha,NRD} = 0{,}1 \cdot 9 = 0{,}9$ dB.

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Appendix 1:
Result of airborne sound insulation

Airborne sound insulation in accordance to ISO 10140-2

Laboratory measurement of airborne sound insulation of building elements

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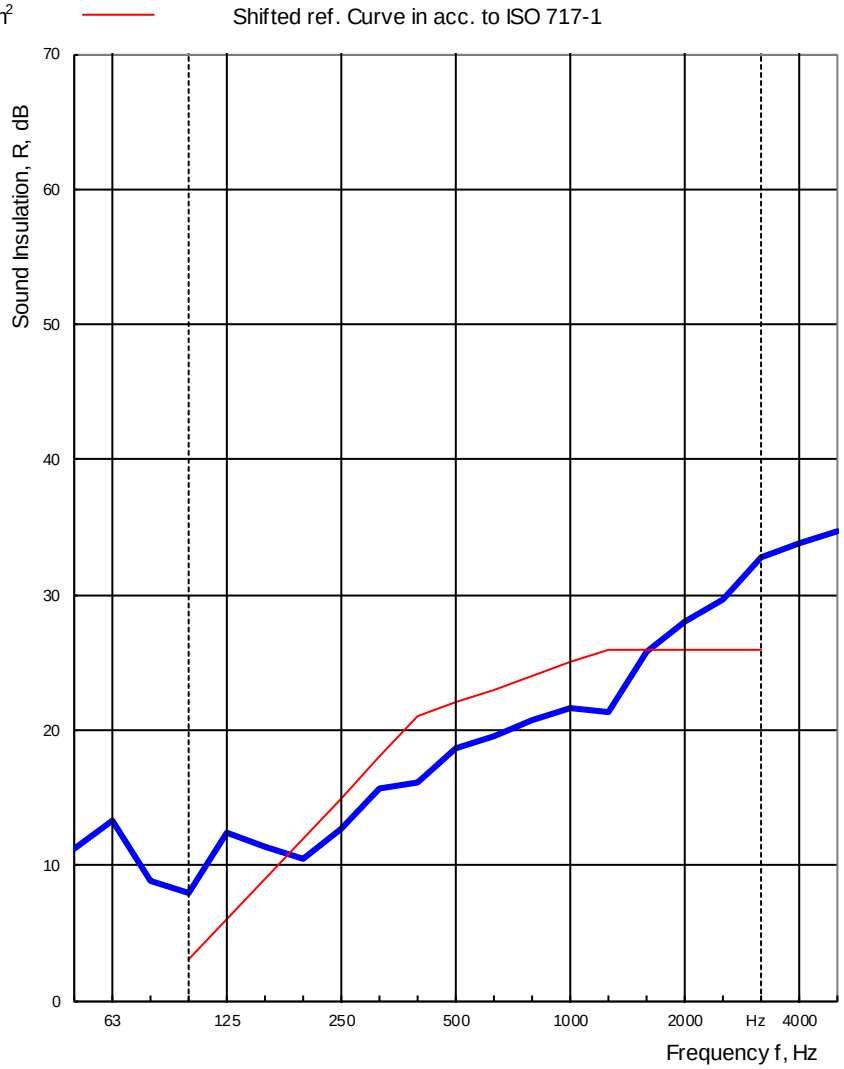
Client:	ROCKWOOL Danmark A/S, Hovedgaden 501D, DK-2640 Hedehusene Date of test: 28.09.2022
Manufacturer:	ROCKWOOL Danmark A/S -Rockfon, Noistop Dept., Hovedgaden 501D, DK-2640 Hedehusene
Product:	ROCKWOOL Noistop Essential
Specimen:	Noise barrier consisting of a total of 6 noise barrier elements. The 60 mm thick modules are mounted on the central support with a dimension of 70 x 70 x 3 mm on a base of masonry with a height of 250 mm. On each side of the support, two 1000 mm high elements with a length of 2470 mm and 1480 mm respectively were placed on top of each other and connected and sealed to the ceiling with a 700 mm high fitting piece. Module core made of "ROCKWOOL Noistop Essential stone wool", 190 kg/m³. Stone wool covered with PE fabric and set in a steel frame with a grid of steel bars, d=5mm. (For Details see measurement report)

Size of Specimen:	10,30 m^2
Mass per unit area:	20,40 kg/m^2
Temperature:	17,00 °C
Humidity:	55,6 %
Sending room volume:	63,9 m^3
Receiving room volume:	55,00 m^3

Frequency f [Hz]	R 1/3 Octave [dB]
50	11,2
63	13,3
80	8,8
100	8,0
125	12,4
160	11,3
200	10,5
250	12,7
315	15,7
400	16,1
500	18,6
630	19,5
800	20,7
1000	21,6
1250	21,4
1600	25,8
2000	28,0
2500	29,6
3150	32,8
4000	33,8
5000	34,7



Rating according to ISO 717-1

$R_w(C;C_{tr}) = 22\ (-1\ ;\ -4)$ dB

$C_{50\text{-}3150} = -1$ dB $C_{50\text{-}5000} = 0$ dB $C_{100\text{-}5000} = 0$ dB

$C_{tr,50\text{-}3150} = -4$ dB $C_{tr,50\text{-}5000} = -4$ dB $C_{tr,100\text{-}5000} = -4$ dB

Evaluation based on laboratory measurement

Testing Laboratory: TÜV NORD Umweltschutz GmbH & Co. KG, Am TÜV 1, 45307 Essen (Germany)

No. of test report: 8000682774-1

Date: 19.12.2022 Signature: Dipl.-Ing. Dirk Hausrad

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Appendix 2:
Result of sound absorption

Sound absorption coefficient according to DIN EN ISO 354:2003

Measurement of sound absorption in a reverberation room

TÜV NORD Umweltschutz

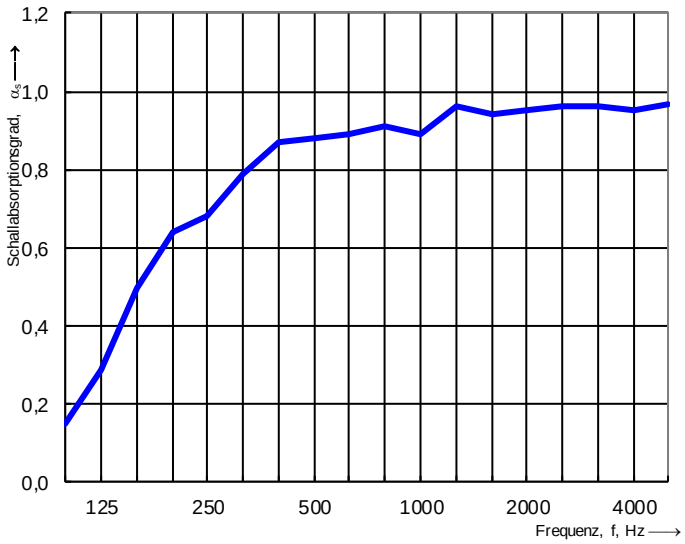
Client: ROCKWOOL Danmark A/S, Hovedgaden 501D, DK-2640 Hedehusene Date of test: 29.09.2022

Test setup: The tested noise barrier consists of a total of 6 noise barrier elements and a steel support (70 x 70 x 3mm). Two 1000 mm high elements with a length of 2470 mm and 1480 mm respectively were arranged on each side of the support and a 700 mm high fitting piece was mounted on each side. The 60 mm thick elements were placed on the hall floor antiparallel to the walls; end faces and floor joints were sealed.

Specimen: Sound barrier element consisting of a sound-absorbing modular core made of highly compressed ROCKWOOL stone wool of the type Noistop Essential stone wool slabs with standard dimensions 2400 x 1000 x 48 mm and a density of 190 kg/m³. The stone wool is covered with a layer of black PE fabric and set in a steel construction consisting of a 60 mm thick circumferential frame with a grid of steel bars, Ø 5mm (grid size 75 x 200 mm). (For Details see measurement report)

		Rev. Room without sample:		Rev. Room with sample:	
Test surface:	10,30 m²	Rel. Humidity:	54,7 %	Rel. Humidity:	54,6 %
Volume of rev. room:	200,0 m³	Air Temperature:	16,7 °C	Air Temperature:	16,7 °C
		Air pressure:	98,9 kPa	Air pressure:	99,1 kPa

Frequency f [Hz]	α_s
100	0,15
125	0,29
160	0,50
200	0,64
250	0,68
315	0,79
400	0,87
500	0,88
630	0,89
800	0,91
1000	0,89
1250	0,96
1600	0,94
2000	0,95
2500	0,96
3150	0,96
4000	0,95
5000	0,97



Testing Laboratory: TÜV NORD Umweltschutz GmbH & Co. KG, Am TÜV 1, 45307 Essen

No. of test report: 8000682774-1

Date: 19.12.2022 Signature: Dipl.-Ing. Dirk Hausrad

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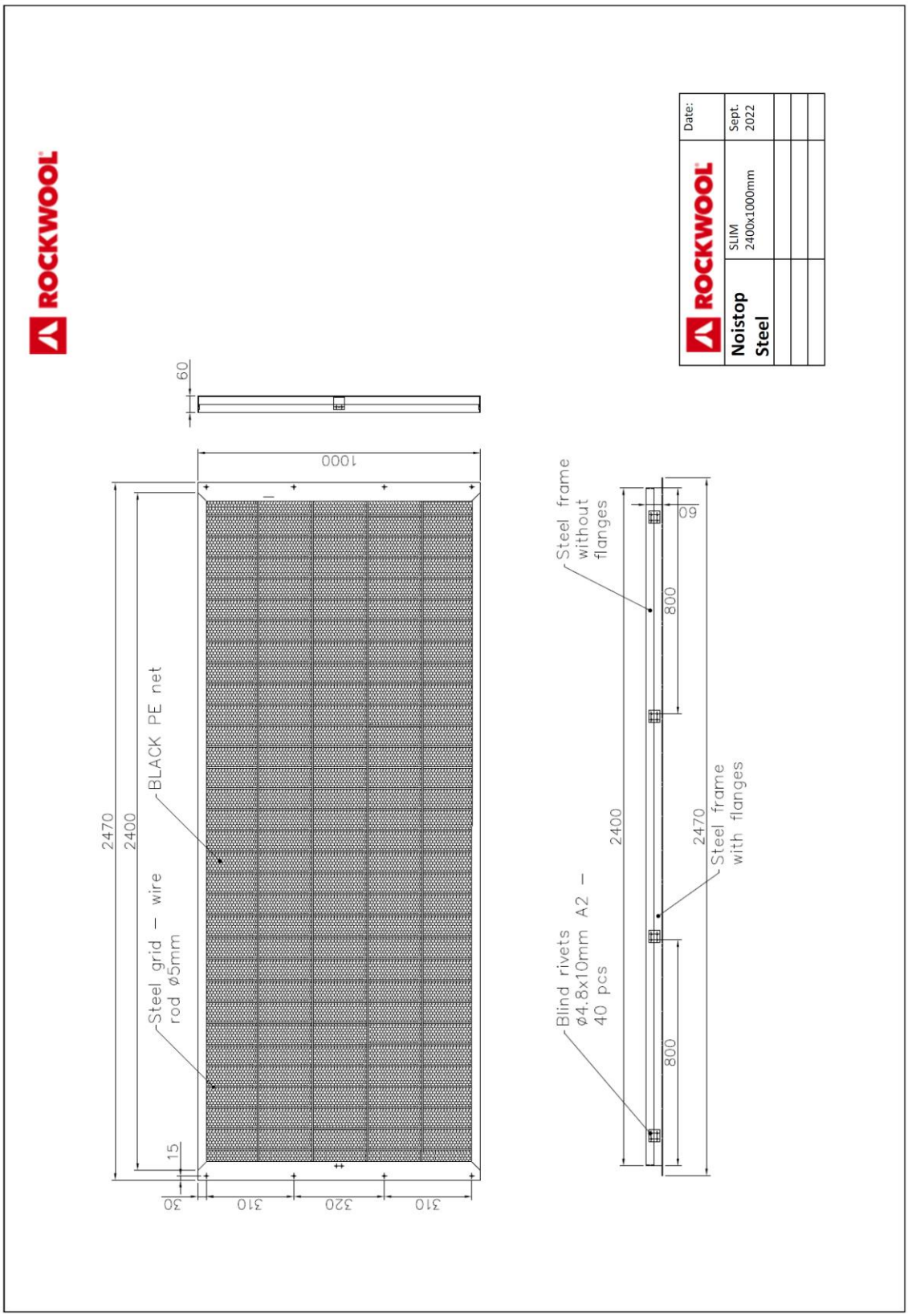
Appendix 3:

Construction plan of the manufacturer


ROCKWOOL
Noistop Steel
SLIM 2400x1000mm
Date:
Sept. 2022
60
1000
2470
2400
BLACK PE net
Steel grid – wire rod ø5mm
15
30
310
320
310
Steel frame without flanges
800
Steel frame with flanges
Blind rivets ø4.8x10mm A2 – 40 pcs

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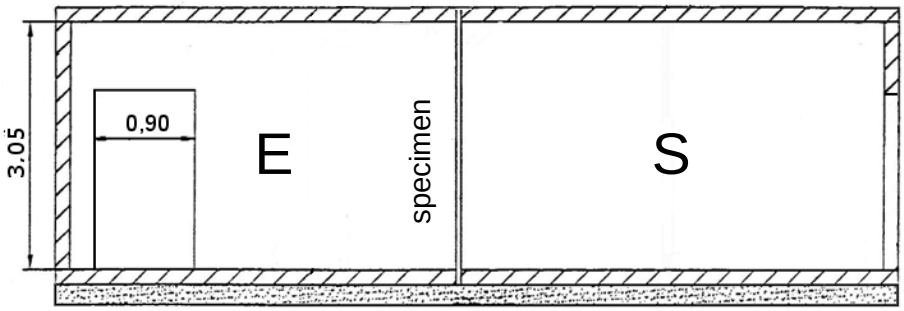
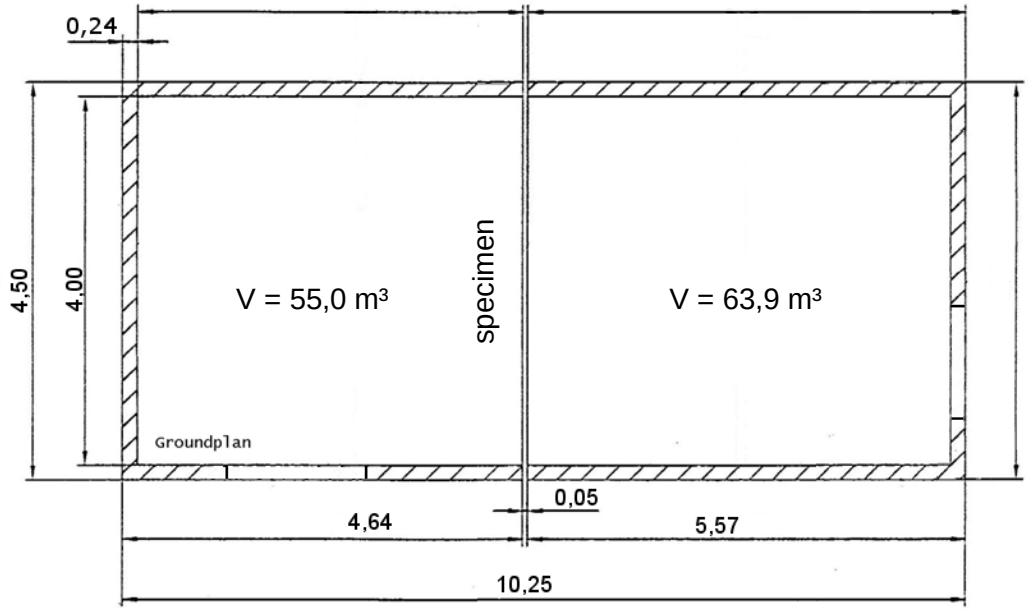
Appendix 4:

Construction of the wall test stand


3,05
0,90
E
specimen
S


0,24
4,50
4,00
V = 55,0 m³
specimen
V = 63,9 m³
Groundplan
0,05
4,64
5,57
10,25

Appendix 5:

Photo Documentation

Photo No.:	**1**	Test setup airborne sound insulation

Photo No.:	**2**	Test setup absorption measurement