Sikafloor® Marine
SOUND TEST REPORT

Sikafloor® Marine FLF Type 8.1
Litosilo Steel (ClassNK), SeaRox SL 436

PERFORMED BY Delta Acoustics

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DELTA Test Report

TEST Reg. no. 100

Sound insulation properties of Sikafloor® Marine flooring constructions

Sikafloor® Marine FLF Type 8.1

Performed for Sika Services AG

DANAK 100/2171
Project no.: I101015
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Sikafloor® Marine FLF Type 8.1

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Summary

The airborne sound insulation and the impact sound insulation are measured according to the ISO and ASTM standards.

Furthermore, the structure-borne sound properties are measured according to ASTM standards and measuring procedure applied by DELTA Acoustics.

Remark

The test results apply only to the objects tested.

DELTA, 30 May 2016

Leif Ødegaard
Acoustics

Contents

1. Introduction

This test report describes the results and procedures for measurements of acoustical and structural vibration properties for marine flooring systems.

2. Test facilities and methods

2.1 Standards

The airborne sound insulation, the impact sound insulation and the structure-borne sound insulation are measured according to the following standards and methods:

1) ISO 10140:2010: “Acoustics – Laboratory measurement of sound insulation of building elements” -- Part 1, 2, 3, 4 and 5.
2) ISO 717:2013: “Acoustics – Rating of sound insulation in buildings and of building elements” -- Part 1 and 2.
3) “Procedure for measurement of acoustical and structural properties of marine flooring systems”, DELTA Technical Note, TC-100853.
4) ASTM E2963-15: “Standard Test Method for Laboratory Measurement of Acoustical Effectiveness of Ship Noise Treatments – Laboratory Measurement of Acoustical Effectiveness for Marine Bulkhead and Deck Treatments”.
5) ASTM E756-5(2010): “Standard Test Method for Measuring Vibration-Damping Properties of Materials”.

2.2 Test facilities

The measurements are carried out in two reverberant rooms at the Technical University of Denmark, 2800 Kgs. Lyngby. The test facilities are shown in Figure 1.

The rooms are built on two separate foundations made of concrete with a wall thickness of 30 cm. Between the source room and the receiving room there is an opening of 2.99 m x 3.37 m, i.e. in the ceiling of the source room and in the floor of the receiving room, see Figure 1.

The volume of the source room and receiving room is 243 m^3 and 230 m^3, respectively.

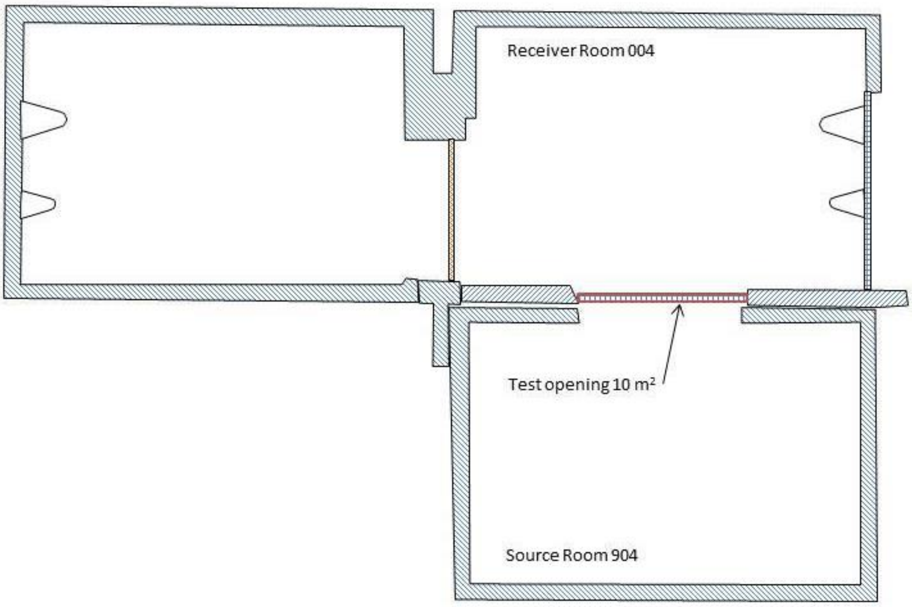


Figure 1
A sketch of the measurement rooms at the Technical University of Denmark.

Excitation of the deck with air-borne noise and impact noise is carried out with loudspeakers and a tapping machine as stated in ISO 10140:2010.

Excitation of the deck with structure-borne noise is performed by means of a vibration exciter coupled to a steel plate, which is mounted perpendicularly and below the steel deck positioned in the opening. By means of this arrangement a reverberant vibrational field is established both in the steel plate coupled to the exciter and the steel deck simulating the real conditions occurring in a ship structure. A sketch of the arrangement is shown in Figure 2.

The steel deck is stiffened by 4 flat bars spaced 740 mm in the longitudinal direction. The steel deck is elastically mounted in the test opening. The gap between the opening and steel deck is sealed by mineral wool and tape.

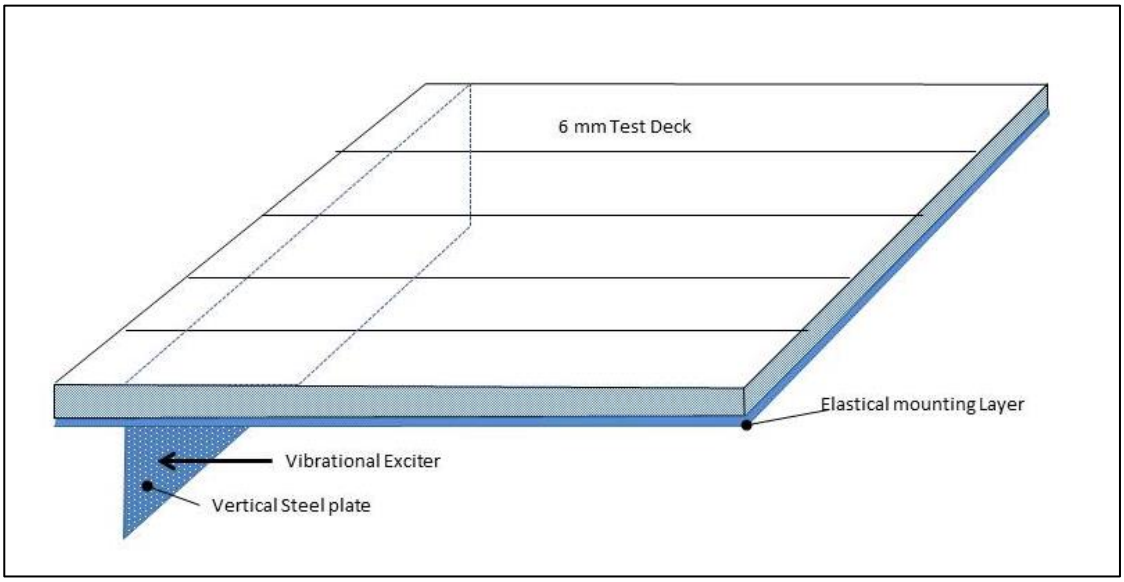


Figure 2
A sketch of the arrangement consisting of the 6 mm test deck, the elastic mounting of the deck and the 6 mm steel plate coupled to the test deck. The arrow indicates the position of the electro-dynamic exciter.

2.3 Measurement methods

2.3.1 ISO 10140:2010

During the airborne and structure-borne sound measurements the excitation is performed by means of broadband pink noise in the frequency range 20-10000 Hz.

The response, i.e. the sound pressure level in the receiving room for the airborne and impact sound insulation measurements or the velocity level on the floor for the structure-borne sound measurements, will be measured in one-third octave filter bands with centre frequencies from 50 Hz to 5000 Hz.

Measurements in the one-third octave filter bands of 50 Hz, 63 Hz and 80 Hz are not required according to ISO 10140:2010. However, based on experience from previous measurements on ships, it seems reasonable to include these frequency ranges.

Due to the volume of the test rooms, some additionally uncertainty occurs for the measurements in the one-third octave filter bands of 50 Hz, 63 Hz and 80 Hz. In Section 2 the measurement results from these frequency bands are therefore presented for information only.

All relevant instruments in the test setup are calibrated before and during the testing period for every construction.

2.3.1.1 Airborne sound insulation

The airborne sound insulation is normally specified by the sound reduction index, R, as defined according to the ISO 10140 series:

$$R = L_1 - L_2 + 10\log(S/A)\,dB$$

where

L_1 = average sound pressure level in the source room

L_2 = average sound pressure level in the receiving room

S = area of the test floor, which was 10 m^2

A = equivalent absorption area in m^2 in the receiving room

From the measured values of R, the weighted sound reduction index, R_w (formerly: air-borne sound insulation index I_a) is calculated. The calculations follow the procedure as stated in ISO 717-1:2013.

2.3.1.2 Impact sound insulation

The normalized impact sound pressure level, L_n, is defined as the impact sound pressure level, L_i, increased by a correction term given in decibels and being ten times the common logarithm of the ratio between the measured equivalent absorption area A of the receiving room and the reference equivalent absorption area A_0, i.e.

$$L_n = L_i + 10\log(A/A_0)\text{ dB} \qquad (1)$$

where

$$A_0 = 10\text{ m}^2$$

For each measurement series the weighted normalised impact sound pressure level $L_{n,w}$ (formerly: impact sound index I_i) is calculated as stated in ISO 717-2:2013.

2.4 Measurement of structure-borne sound properties

No international ISO standard exists for measurement of structure-borne sound insulation properties for marine floors and bulkheads. Consequently, this test will be carried out by means of a method previously performed by DELTA and used for similar constructions.

Vibrational power is supplied to the steel deck by means of the arrangement described in Figure 2. The supply of constant vibrational power is monitored during the measurement period by means of a force transducer mounted between the vertical steel plate and the vibration exciter. Further, the acceleration level at the input position on the vertical steel plate is measured for monitoring purpose.

The response is measured as the velocity level, L_V in dB re 10^{-9} m/s in minimum 16 different positions on the test surface, on the steel deck below the test construction and on the floor.

Measurement positions are selected pseudo-randomly on the test structure.

2.4.1 Effect of treatment

From the average value of the velocity level measured on the test surface the transmission loss TL_v and insertion loss Il_v and Il_p will be calculated. Further, the radiation efficiency will be calculated.

The measured transmission loss TL_v in dB for the constructions describes the difference between the velocity level on the steel deck after installation of the floor construction and the velocity level measured on top of the floor covering. Thus the transmission loss expresses the reduction in the velocity level from the steel deck to the floor covering

The transmission loss TL_v for a structure during test is calculated using the following formula:

$$TL_v = L_{v,above} - L_{v,below}$$

where

$L_{v,above}$ = time and space average vibration velocity on top of the test construction in the receiver room, dB re: 1 nm/s

$L_{v,below}$ = time and space average vibration velocity below of the test construction in the source room, dB re: 1 nm/s.

The measured insertion loss IL_V in dB describes the difference between the velocity level measured on the bare steel deck before installation of the floor construction and the velocity level measured on top of the applied floor construction. The insertion loss IL_V describes the improvement of the vibration level on the floor achieved by using the floor covering.

The insertion loss IL_v for a structure during test is calculated using the following formula:

$$IL_v = L_{v,above} - L_{v,ref}$$

where

$L_{v,above}$ = time and space average vibration velocity on top of the test construction in the receiver room, dB re: 1 nm/s

$L_{v,ref}$ = time and space average vibration velocity of the bare steel deck before application of the test construction room, dB re: 1 nm/s.

The measured insertion loss IL_p in dB regarding radiated structure-borne sound to the room describes the difference between the measured radiated sound pressure level in the receiving room before installation of the floor covering and the measured radiated sound pressure level after applying the floor covering. The insertion loss IL_p thus expresses the improvement of the sound level in the room above the deck achieved by using the floor covering.

The insertion loss IL_p for a structure-borne radiated noise is calculated using the following formula:

$$IL_p = L_{p,test\ construction} - L_{p,ref}$$

where

$L_{P,test\ construction}$ = averaged sound pressure level in dB re 20µPa in the receiving room with the test construction mounted on the steel reference deck.

$L_{P,ref}$ = averaged sound pressure level in dB re 20µPa in the receiving room with the bare steel deck without the test construction mounted.

2.4.2 Radiation efficiency

The radiation index describes the ability of a vibrating floor to radiate sound. A high radiation index combined with a high velocity level on the floor covering causes high noise levels in the rooms above the deck covering.

The radiation efficiency is normally expressed as a logarithmic quantity named the radiation index, $10\log\sigma$. If the radiation index is determined from sound power measurements in a reverberant room this can be calculated using the following formula:

$$10\log\sigma = L_W - L_v - 10\log(S/1m^2) + 34 \text{ dB}$$

or based on the averaged sound pressure level in the receiving room:

$$10\log\sigma = L_P - L_v + 10\log V - 10\log T - 10\log(S/1m^2) + 10\log(1+ F\lambda/8V) + 20 \text{ dB}$$

where

L_W = averaged sound power in dB re 1pW

L_P = averaged sound pressure level in dB re. 20µPa in the receiving room

L_v = averaged velocity level in dB re 1nm/s measured on the surface of the covering floor

S = area of the test floor, which is 10 m^2

V = volume in m^3 of the receiving room, which is 230 m^3

T = reverberation time in seconds

F =total area in m^2 of the surface in the receiving room, which is 300 m^2

λ = wavelength in m of the centre frequency of the one-third octave filter band in question.

$10\log(1+ F\lambda/8V)$ is normally called the Waterhouse correction

Due to a very high damping in some of the tested constructions, the radiated structure-borne noise from the floor coverings can be influenced by flanking noise contribution from the test rooms. This phenome take place in the high frequency range above 2 kHz.

Consequently, the radiated sound pressure level in the receiving room can optionally be determined using intensity measuring technique. The radiation index might in these situations be calculated based on the measured sound power level and not on basis of the measured sound pressure level.

2.5 ASTM E2963-15

The full scale test of marine flooring constructions is expensive and are normally done for a number of different flooring constructions mounted successive upon the reference steel deck. This allows comparing the different flooring constructions directly. However, this means that the reference deck must not be removed from the test opening during the measuring series. This is necessary in order not to introduce differences due to the mounting in the test facilities.

Measurements of transmission loss and acceptance will be performed simultaneously with airborne noise excitation in the source room. Measurements of sound absorption are done in connection with the transmission loss measurements. Measurements of transmission loss are performed in accordance with ASTM E90-09.

Primarily the damping properties for the constrained damped test constructions will be determination of the loss factor will be determined using the test beam method e.g. as described in ASTM E756-5(2010).

The loss factor cannot be evaluated for floating floors, as the loss factor does not describe the vibration damping properties for such floor systems.

All calculations are performed for each one-third octave band frequencies.

2.5.1 Transmission loss

According to ASTM E90-09 the transmission loss for a structure during test is calculated using following formula:

$$TL = L_1 - L_2 + 10 Log[S/A_2]$$

where

TL = transmission loss of the structure, dB

L_1 = time and space average sound pressure level in the source room, dB re 20 μPa

L_2 = time and space average sound pressure level in the receiver room, dB re 20 μPa

S = surface area of the test structure, m^2

A_2 = equivalent absorption area in m^2 in the receiving room

2.5.2 Acceptance

Measurements of acceptance are performed by generating an acoustic signal in the source room and measuring the generated sound pressure level in the source room as well as the surface vibration of the test structure.

The acceptance of a structure during test is defined here as assuming a reverberant receiver room:

$$L_{\Lambda} = L_1 - L_v$$

where

L_{Λ} = acceptance of the structure, dB re 20 µPa/10nm/s

L_1= time and space average sound pressure level in the source room, dB re 20 µPa, and

L_v = time and space average surface vibration velocity level on the test structure, dB re 10 nm/s.

For each measurement of vibration, the measured acceleration level will be converted to velocity using the equation:

$$L_v = L_a - 20*Log(2*\pi*f) + 60$$

where

L_v = vibration velocity level in dB re 10 nm/s

L_a = vibration acceleration level in dB re 10 µm/s^2

f = one-third-octave band centre frequency.

The space and time averaged vibration velocity level will be calculated in each one-third-octave band.

2.5.3 Radiation efficiency

Measurements of radiation efficiency will be performed separately with structure-borne noise excitation with the exciter system as described in Section 2.2.

Measurements of radiation efficiency are performed by energizing the vibration exciter and measuring the responding vibration of the test structure as well as the sound pressure level in the receiving room.

The calculation of radiation efficiency for a structure under test uses the equation:

$$L_\sigma = L_2 - L_v - 10*Log[4*S/A_2] + 13.7 \text{ *)}$$

where

L_σ = radiation efficiency of the structure, dB re 20 µPa/10 nm/s

L_2 = time and space average sound pressure level in the receiver room, dB re 20 µPa

L_v = time and space average vibration velocity level in the receiver room, dB re 10 nm/s

S = surface area of the test structure, m^2

A_2 = equivalent absorption area in m^2 in the receiving room.

**) The formula used is corrected compared to ASTM E2963-15[4, formula 8] due to error in the standard. The error is to be notified to ASTM. By using the corrected formula, the same values as stated in Section 2.4.2 will be obtained except for the Waterhouse correction used in Section 2.4.2.*

2.5.4 Absorption

The change in absorption will be evaluated based on the measurement of the reverberation time in the receiving room (treated side of construction) and the calculated absorption area. An absorption coefficient α will be calculated based on the reverberation time with the bare steel deck installed and the reverberation time with the floor construction applicated.

The calculation of treatment absorption is performed using the following equation:

$$\alpha = (A_{Treat} - A_{No\ treat})/S_{Treat}$$

where

A_{Treat} = equivalent sound absorption area after the treatment has been applied (m^2)

$A_{NoTreat}$ = equivalent sound absorption area in the same room prior to application of the treatment (m^2)

S_{Treat} = surface area of the test structure (m^2).

2.5.5 Damping for constrained damped constructions

Primarily the damping properties for the constrained damped test constructions will be determined as the loss factor will be using the test beam method e.g. as described in ASTM E756-5(2010). Based on the measured values a regression analysis is performed in order to get estimated 1/3-octave values for the loss factor.

Alternative the damping properties of the constrained damped test constructions will also be evaluated by measuring the total loss factor using the guide lines described in ISO 10848-1:2006: "Acoustics -- Laboratory measurement of the flanking transmission of airborne and impact sound between adjoining rooms -- Part 1: Frame document- Section 7.3 Measurement of structural reverberation time".

The excitation method is vibrator excitation with the exciter mounted as described in Section 2. The impulse response is measured e.g. with the MLS (Maximum Length Sequence) or vibration sweep techniques. The integrated impulse response method is used with backward integration of the squared impulse response as defined in ISO 3382: "Measurement of the reverberation time of rooms with reference to other acoustical parameters".

The relation between the total loss factor and the structural reverberation time is as follows:

$$\eta_{total} = 2.2/ (f*T_s)$$

where

f = frequency in Hz

T_s = structural reverberation time in seconds.

This method allows a practical approach for applying damping properties for the test construction without removing the construction from the test opening.

Based on the measured values a regression analysis is performed in order to get estimated 1/3-octave values for the loss factor.

2.5.6 Damping for floating floor constructions

The loss factor for floating floor constructions cannot be evaluated, as the loss factor does not describe the vibration damping properties for such systems.

An estimate for the structure born noise reduction for floating floor constructions might be estimated based on the insertion loss IL_v determined as described in section 2.4.1. This is not a part of ASTM E2963-15.

2.5.7 Effect of treatment

Transmission Loss

To calculate the effect of the treatment on transmission loss uses the equation:

$$\Delta TL = TL_{Treat} - TL_{Non2Treat}$$

where

ΔTL = change in transmission loss due to the application of the treatment, dB

TL_{Treat} = transmission loss calculated for the test structure with the treatment, dB

$TL_{Non\text{-}Treat}$ = transmission loss calculated for the test structure without the treatment, dB.

Acceptance

To calculate the effect of the treatment on acceptance, use the equation:

$$\Delta L_{\Lambda} = L_{\Lambda,\ Treat} - L_{\Lambda,\ Non\text{-}Treat}$$

where

ΔL_{Λ} = change in acceptance due to the application of the treatment, dB

$L_{\Lambda,Treat}$ = acceptance calculated for the test structure with the treatment, dB

$L_{\Lambda,Non\text{-}Treat}$ = acceptance calculated for the test structure without the treatment, dB.

Radiation efficiency

To calculate the effect of the treatment on radiation efficiency, use the equation:

$$\Delta L_\sigma = L_{\sigma,\ Non\text{-}Treat} - L_{\sigma,\ Treat}$$

where

ΔL_σ = change in radiation efficiency due to the application of the treatment, dB

$L_{\sigma,Treat}$ = radiation efficiency calculated for the test structure with the treatment, dB

$L_{\sigma,Non\text{-}Treat}$ = radiation efficiency calculated for the test structure without the treatment, dB.

Loss factor

The change in damping loss for constrained damped constructions will be computed using the equation

$$\Delta\eta = \eta_{treated} - \eta_{non\text{-}treated}$$

where

η = damping loss factor. This will be a function of frequency.

3. Measurement uncertainty

According to EN ISO 12999-1:2014 precision of laboratory measurements expressed as the reproducibility standard deviations are as follows (two-sided 95 % confidence level and k = 1.96)

Value	σ_{R95} (k =1.96, two-sided)
R_w	± 2.4 dB
$L_{n,w}$	± 3.0 dB

The standard deviations of the structural and acceptance vibrations measurements are in the range to 2.5 dB to 4.5 dB depending of frequency and position on the test deck.

The standard deviations of the structural sound measurements are in the range to 0.1 dB to 2.5 dB depending of frequency.

4. General measurement results

4.1 Measurements according to ISO standards and structure-borne sound measuring method

Results of the measurements of the air-borne sound insulation, the impact sound insulation and the structure-borne sound insulation for the investigated floor constructions are for each tested construction.

The results are expressed as one-third octave values in the frequency ranges 50 Hz to 5000 Hz and, when appropriate, as a single-number quantity calculated according to the ISO standards.

The results of the sound pressure measurement in the frequency range below 100 Hz are given for the information only, as the dimensions of the two reverberant rooms are too small for measuring precisely in this frequency range.

Furthermore, the results of the measurements on the bare steel deck are indicated with black on each diagram for the air-borne sound and the impact sound measurements. The difference between the curves for the test deck and the curves for the reference steel deck thus indicates the improvement in the sound reduction and the impact sound insulation caused by the applied floor construction.

4.2 Measurements according to ASTM E2963-15

The results of the measurements of the air-borne sound insulation, acceptance and the radiation efficiency for the investigated floor constructions are for each tested construction.

The results are expressed as one-third octave values in the frequency ranges 50 Hz to 5000 Hz and, when appropriate, as a single-number quantity calculated according to the ISO standards.

The results of the sound pressure measurement in the frequency range below 100 Hz are given for the information only, as the dimensions of the two reverberant rooms are too small for measuring precisely in this frequency range.

The acoustical effectiveness regarding transmission loss, acceptance, radiation efficiency, and absorption and loss factor (where relevant) is calculated based on reference measurements on a bare steel deck for each deck construction.

5. Results for Sikafloor® Marine FLF Type 8.1

The floating floor consists of 30 mm mineral wool Type SeaRox SL 436, with a density of 140 kg/m^3. The top layer consists of 2 steel plates, thickness 3 mm and 1.5 mm respectively, which are glued with 1 mm layer of PU RED.

The total surface mass is approx. 40.8 kg/m^2 for the test construction. The total building height is 35.5 mm.

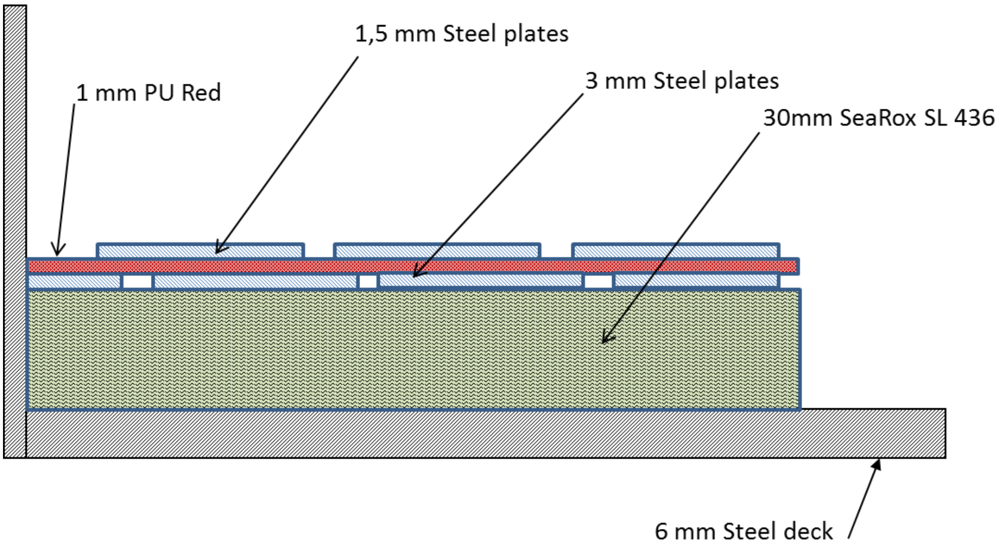


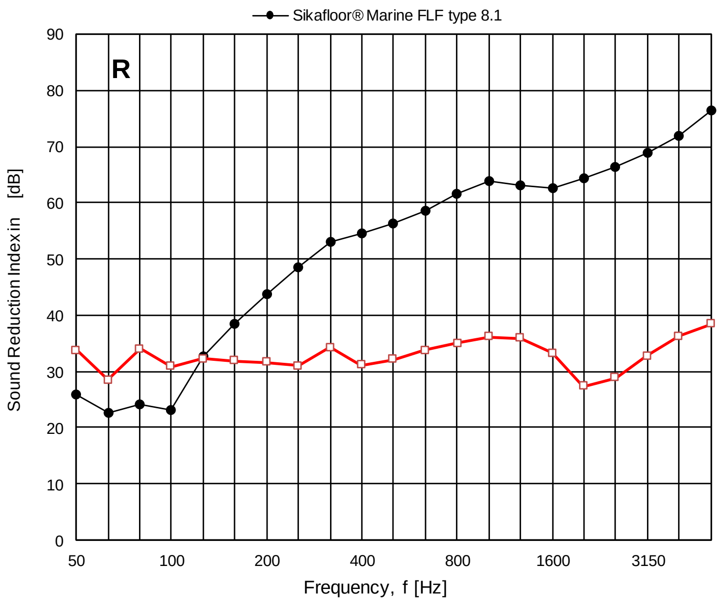
Figure 3
Principle sketch of the test construction.

Layer	Density kg/m^3	Thickness mm
Mineral wool SeaRox SL 436	140	30
Toplayer 3 and 1.5 mm steel plates glued with 1 mm PU RED	6659	5.5

Table 1
Product data for the tested construction.

The main results are given in the Graph sheets.

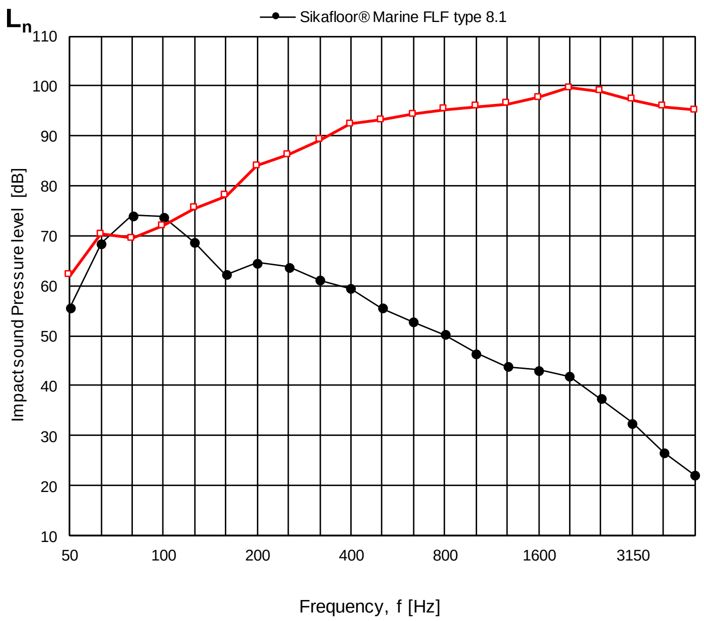
5.1 Results according to ISO standards



Frequency f [Hz]	R 1/3-octave [dB]
50	25.9
63	22.6
80	24.2
100	23.1
125	32.8
160	38.5
200	43.7
250	48.6
315	53.1
400	54.5
500	56.3
630	58.6
800	61.7
1000	63.8
1250	63.1
1600	62.7
2000	64.5
2500	66.5
3150	68.8
4000	71.8
5000	76.4

R,w	56

Figure 4
Measured sound reduction index R for the Sikafloor® Marine FLF Type 8.1 expressed in dB per one-third octave frequency bands. For comparison the results of the measurements on the bare steel deck are also shown.

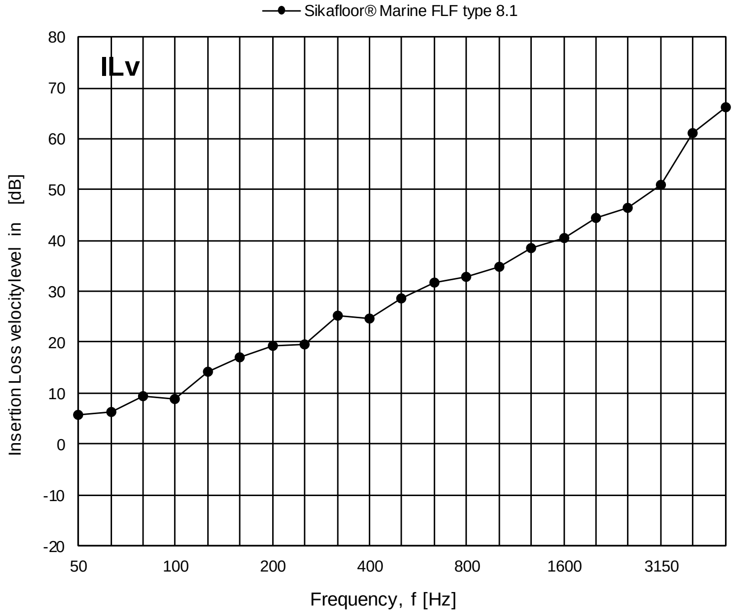


Frequency f [Hz]	L 1/3-octave [dB]
50	55.5
63	68.5
80	74.0
100	73.9
125	68.7
160	62.2
200	64.6
250	63.7
315	61.2
400	59.5
500	55.6
630	52.8
800	50.2
1000	46.5
1250	43.9
1600	43.2
2000	41.9
2500	37.3
3150	32.5
4000	26.7
5000	22.1

Ln,w	59

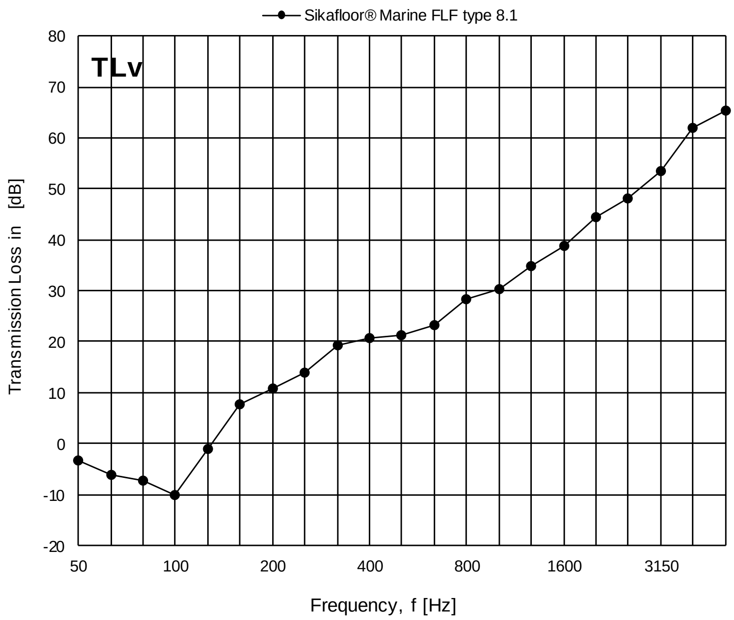
Figure 5
Measured normalized impact sound pressure level L_n for Sikafloor® Marine FLF Type 8.1 expressed in dB re 20 μPa per one-third octave frequency band. For comparison the results of the measurements on the bare steel deck are also shown.

5.2 Structure-borne noise properties



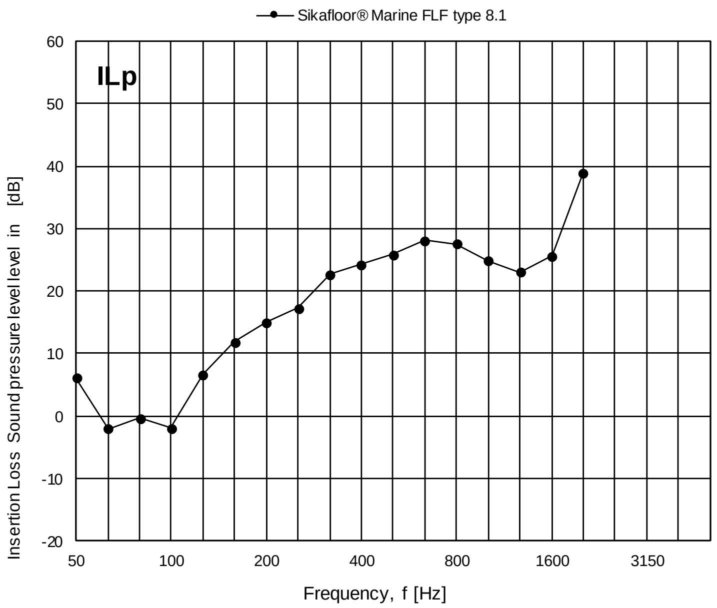
Frequency f [Hz]	ILv 1/3-octave [dB]
50	5.8
63	6.3
80	9.4
100	8.8
125	14.2
160	17.0
200	19.4
250	19.5
315	25.1
400	24.7
500	28.7
630	31.8
800	32.9
1000	34.8
1250	38.4
1600	40.3
2000	44.4
2500	46.5
3150	51.1
4000	61.0
5000	66.2

Figure 6
Measured Insertion Loss IL_v for Sikafloor® Marine FLF Type 8.1 expressed in dB per one-third octave frequency band. The insertion loss IL_v refers to the mean velocity level in dB re 10-9 m/s on top of the floor covering.



Frequency f [Hz]	TLv 1/3-octave [dB]
50	-3.4
63	-6.3
80	-7.3
100	-10.2
125	-1.0
160	7.8
200	10.8
250	13.8
315	19.4
400	20.7
500	21.2
630	23.2
800	28.2
1000	30.2
1250	34.8
1600	38.7
2000	44.3
2500	48.2
3150	53.6
4000	61.9
5000	65.4

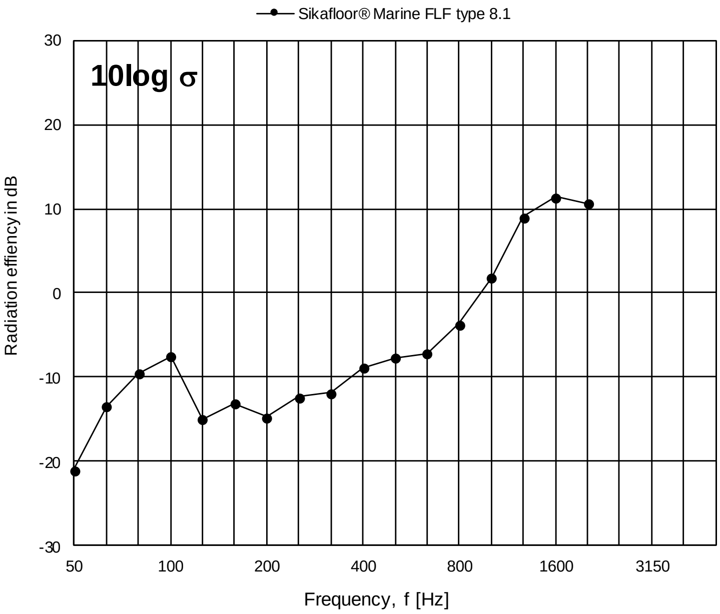
Figure 7
Measured Transmission Loss TL_v for Sikafloor® Marine FLF Type 8.1 expressed in dB per one-third octave frequency band. The insertion loss IL_v refers to the mean velocity level in dB re 10-9 m/s on top of the floor covering.



Frequency f [Hz]	ILp 1/3-octave [dB]
50	6.0
63	-2.1
80	-0.4
100	-2.0
125	6.7
160	11.9
200	15.0
250	17.2
315	22.7
400	24.2
500	25.9
630	28.1
800	27.5
1000	24.8
1250	23.0
1600	25.6
2000	39.0
2500	
3150	
4000	
5000	

Figure 8

Measured insertion loss IL_p for Sikafloor® Marine FLF Type 8.1 expressed in dB per one-third octave frequency band. The insertion loss IL_p refers to the radiated mean sound pressure level in dB re 20 μPa in the receiving room above the floor.

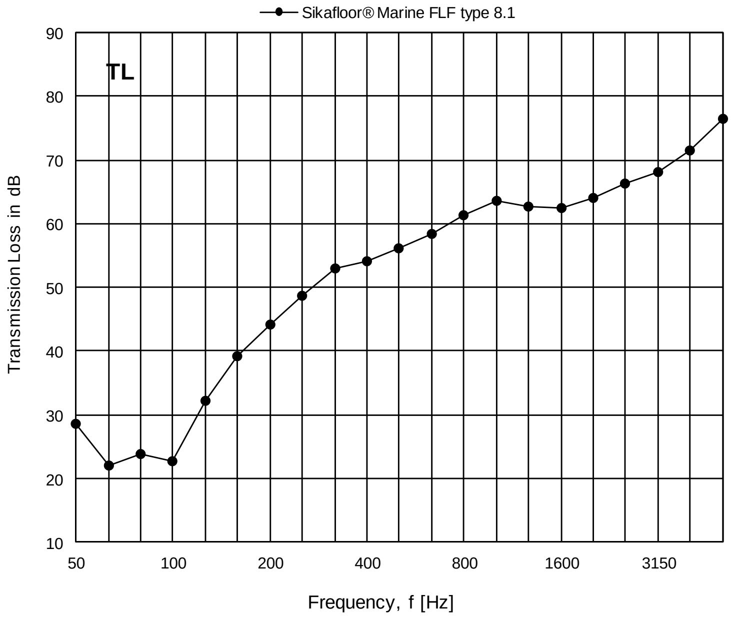


Frequency f [Hz]	10logσ 1/3-octave [dB]
50	-21.0
63	-13.5
80	-9.5
100	-7.5
125	-15.0
160	-13.1
200	-14.7
250	-12.3
315	-11.9
400	-8.9
500	-7.7
630	-7.2
800	-3.7
1000	1.8
1250	9.0
1600	11.4
2000	10.7
2500	
3150	
4000	
5000	

Figure 9

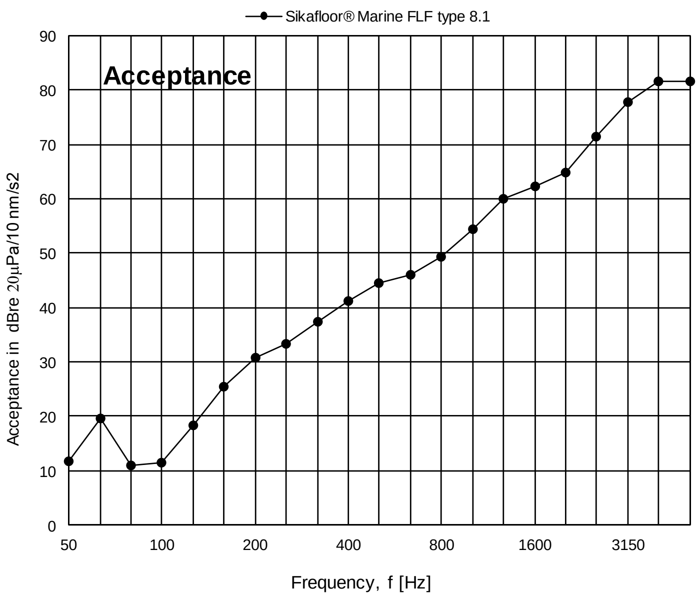
Measured radiation index 10 logσ for Sikafloor® Marine FLF Type 8.1 expressed in dB per one-third octave frequency band.

5.3 Results according to ASTM E2963-15



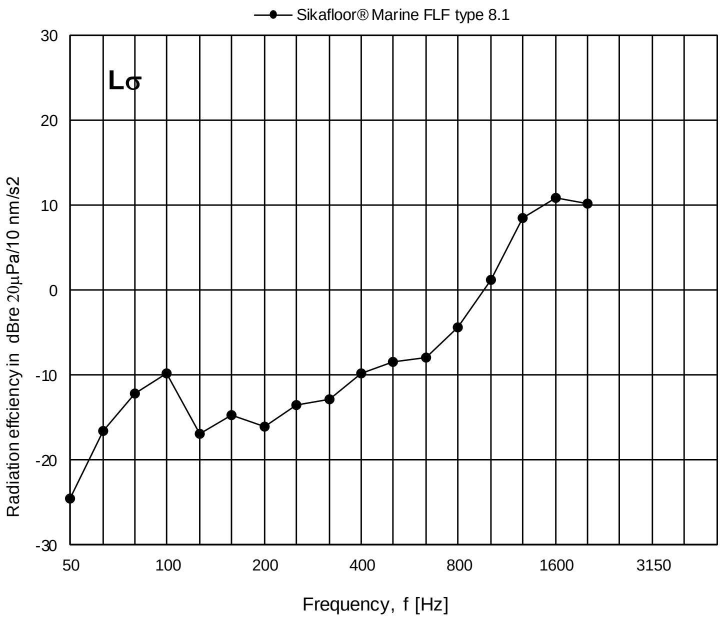
Frequency f [Hz]	TL 1/3-octave [dB]
50	28.6
63	21.9
80	23.8
100	22.8
125	32.1
160	39.1
200	44.2
250	48.6
315	53.0
400	54.0
500	56.1
630	58.4
800	61.4
1000	63.5
1250	62.7
1600	62.4
2000	64.0
2500	66.3
3150	68.2
4000	71.6
5000	76.5
STC	58

Figure 10
Measured transmission loss TL for Sikafloor® Marine FLF Type 8.1 expressed in dB per one-third octave frequency band.



Frequency f [Hz]	Acceptance 1/3-octave [dB]
50	11.8
63	19.6
80	11.0
100	11.3
125	18.2
160	25.4
200	30.9
250	33.3
315	37.4
400	41.2
500	44.4
630	46.1
800	49.3
1000	54.3
1250	59.9
1600	62.4
2000	64.9
2500	71.4
3150	77.8
4000	81.8
5000	81.6

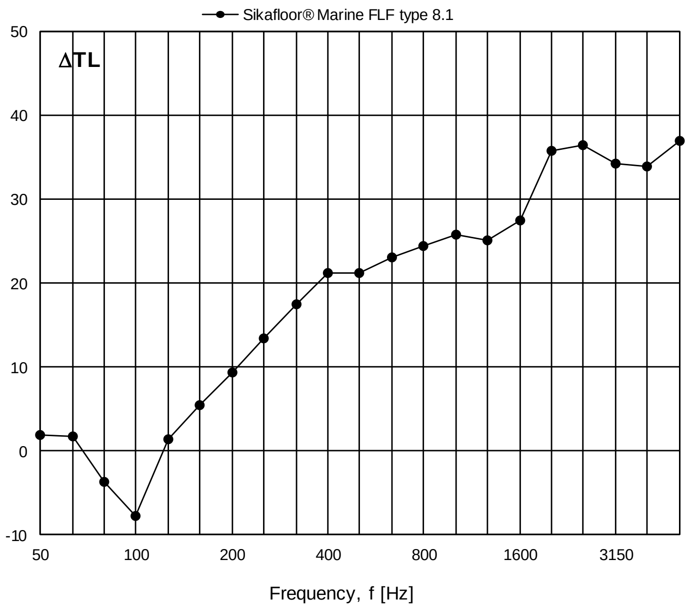
Figure 11
Measured acceptance L_A for Sikafloor® Marine FLF Type 8.1 expressed in dB per one-third octave frequency band.



Frequency f [Hz]	Lσ 1/3-octave [dB]
50	-24.6
63	-16.6
80	-12.2
100	-9.8
125	-16.9
160	-14.7
200	-16.1
250	-13.6
315	-12.9
400	-9.8
500	-8.5
630	-7.9
800	-4.4
1000	1.2
1250	8.5
1600	10.9
2000	10.2
2500	
3150	
4000	
5000	

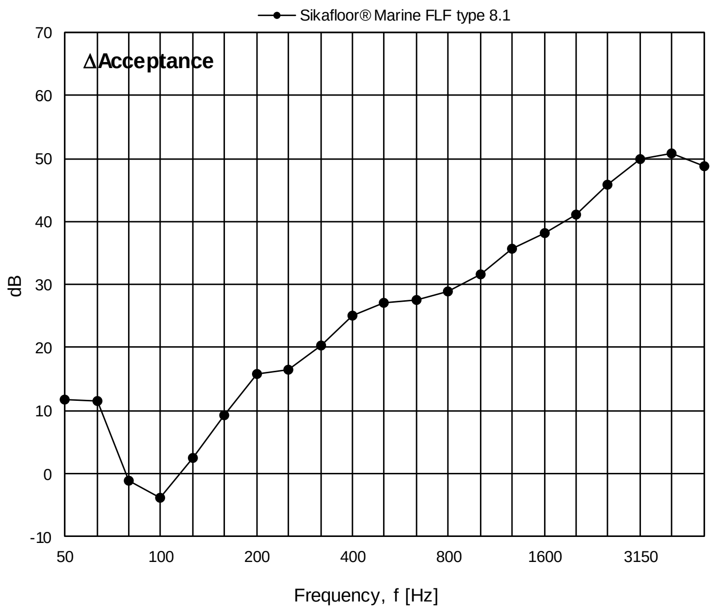
Figure 12
Measured radiation index L_σ for Sikafloor® Marine FLF Type 8.1 expressed in dB per one-third octave frequency band.

5.3.1 Effectiveness



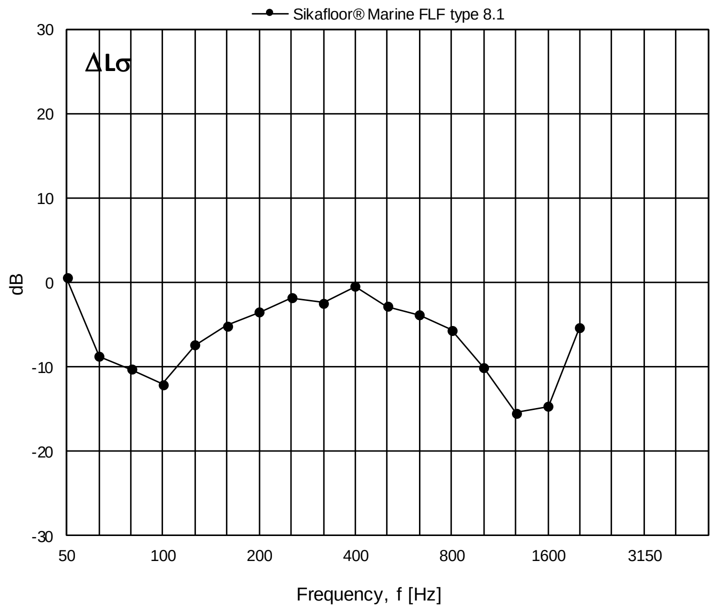
Frequency f [Hz]	ΔTL dB
50	1.9
63	1.8
80	-3.7
100	-7.8
125	1.3
160	5.5
200	9.4
250	13.4
315	17.4
400	21.2
500	21.3
630	23.1
800	24.4
1000	25.9
1250	25.2
1600	27.5
2000	35.8
2500	36.5
3150	34.2
4000	33.9
5000	36.9

Figure 13
Measured changes in transmission loss TL for Sikafloor® Marine FLF Type 8.1 expressed in dB per one-third octave frequency band.



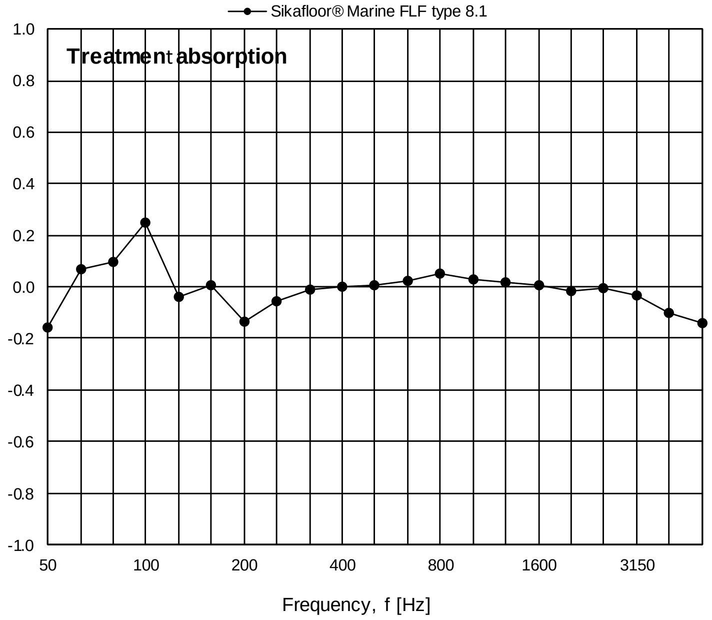
Frequency f [Hz]	dB
50	11.8
63	11.4
80	-1.2
100	-3.8
125	2.4
160	9.1
200	15.7
250	16.4
315	20.4
400	25.0
500	27.0
630	27.6
800	28.8
1000	31.7
1250	35.6
1600	38.2
2000	41.1
2500	45.9
3150	50.0
4000	50.9
5000	48.8

Figure 14
Measured change in acceptance for Sikafloor® Marine FLF Type 8.1 expressed in dB per one-third octave frequency band.



Frequency f [Hz]	dB
50	0.6
63	-8.7
80	-10.3
100	-12.1
125	-7.4
160	-5.1
200	-3.5
250	-1.8
315	-2.4
400	-0.4
500	-2.8
630	-3.9
800	-5.6
1000	-10.1
1250	-15.5
1600	-14.7
2000	-5.3
2500	
3150	
4000	
5000	

Figure 15
Measured change in radiation efficiency for Sikafloor® Marine FLF Type 8.1 expressed in dB per one-third octave frequency band.



Frequency f [Hz]	α
50	-0.16
63	0.07
80	0.10
100	0.25
125	-0.04
160	0.00
200	-0.13
250	-0.06
315	-0.01
400	0.00
500	0.00
630	0.02
800	0.05
1000	0.03
1250	0.02
1600	0.00
2000	-0.02
2500	-0.01
3150	-0.04
4000	-0.10
5000	-0.14

Figure 16
Measured treatment absorption for Sikafloor® Marine FLF Type 8.1 per one-third octave frequency band.

6. Comments

The measured airborne sound insulation will in practices be better than measured in the laboratory due to flanking noise contribution from the test room. This applies for measured values above approximately $R'_W > 58$ dB.

The radiated structure-borne noise from the floor is influenced by flanking noise from the test room for values above 2 kHz. Consequently, the values for the radiation efficiency and the insertion loss IL_p for the sound pressure level are not stated.

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7. References

[1] ISO 10140:2010: "Acoustics – Laboratory measurement of sound insulation of building elements" -- Part 1, 2, 3, 4, and 5.

[2] ISO 717:2013: "Acoustics – Rating of sound insulation in buildings and of building elements" -- Part 1 and 2.

[3] "Procedure for measurement of acoustical and structural properties of marine flooring systems", DELTA Technical Note, TC-100853.

[4] ASTM E2963-15: "Standard Test Method for Laboratory Measurement of Acoustical Effectiveness of Ship Noise Treatments – Laboratory Measurement of Acoustical Effectiveness for Marine Bulkhead and Deck Treatments".

[5] ASTM E756-5(2010): "Standard Test Method for Measuring Vibration-Damping Properties of Materials".

[6] ASTM E90-09: "Standard Test Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions and Elements".

[7] ASTM E413-10: "Classification for Rating Sound Insulation".

[8] ISO 10848-1:2006: "Acoustics -- Laboratory measurement of the flanking transmission of airborne and impact sound between adjoining rooms" -- Part 1: Frame document.

[9] ISO 3382: "Measurement of the reverberation time of rooms with reference to other acoustical parameters".

8. Instrumentation

Instrument	Type	A&V No	Calibration		
			Latest	Inter-mediate	Next
Real-Time Frequency Analyser	B&K 2270	1496L	Feb. 2015	-	Feb. 2017
Measuring Microphone	B&K 4165	0893L	Oct. 2014	-	Oct. 2016
Measuring Microphone	B&K 4165	006S	May 2014	-	May 2016
Microphone Preamplifier	B&K 2619	703	July 2014	-	July 2016
Microphone Preamplifier	B&K 2619	1395L	Jan. 2014	-	Jan. 2016
Microphone Power Supply	B&K 5935	1040L	April 2014	-	April 2016
Microphone Power Supply	B&K 5935	1585L	May 2015	-	-
Sound Level Calibrator	B&K 4231	1158L	August 2015	-	-
Sensor for Temperature and Humidity	Elpro Ecolog TH1	1216L	May 2014	-	-
Exiter system	Ling 406	-	-	-	-
Force transducer (monitoring only)	B&K 8200	-	-	-	-
Accelerometer	IMI 608/A11	1501L	Aug. 2011	-	March 2017
Accelerometer	IMI 608/A11	1502L	March 2011	-	March 2017-
Accelerometer	IMI 608/A11	1503L	March 2011	-	March 2017-
Charge Amplifier	B&K 2635	0496T	Jan. 2014	Jan 2016	Jan. 2018
Charge Amplifier	B&K 2635	0495T	Jan. 2014	Jan 2016	Jan. 2018
Charge Amplifier	B&K 2635	0660L	Jan. 2014	Jan 2016	Jan. 2018
Charge Amplifier	B&K 2635	0498TL	Dec. 2014	-	Dec..2016
Accelerometer	B&K 4381	1587L	March 2015	-	March 2017
Accelerometer	B&K 4381	1588L	March 2015	-	March 2017
Sound Calibrator	B&K 4231	1158L	Aug. 2015	-	Aug. 2017
Vibration Calibrator	B&K 4294	1414L	Oct. 2013	Oct. 2015	Oct. 2016
Data acquisition	NI USB 9162	14L005	Jan. 2015	-	Jan. 2017
Data acquisition	PCI-4472	1333L	April 2016	-	April 2018
Measuring Microphone	B&K 4144	1256L	Nov. 2014		Nov. 2014
Measuring Microphone	B&K 4144	0859L	Oct. 2014	Nov. 2015	Nov. 2017
Tapping Machine	B&K 3207	1250 L	-	-	-
Data acquisition and data analysis software Noise Lab Capture 4.0	DELTA	-	-	-	-
Acoustical software Dirac	B&K	-	-	-	-
Data acquisition and data analysis software Pulse &Pulse Reflex	B&K	-	-	-	-

Table 2
Instruments used for the tests.

Graph Sheets 1-8

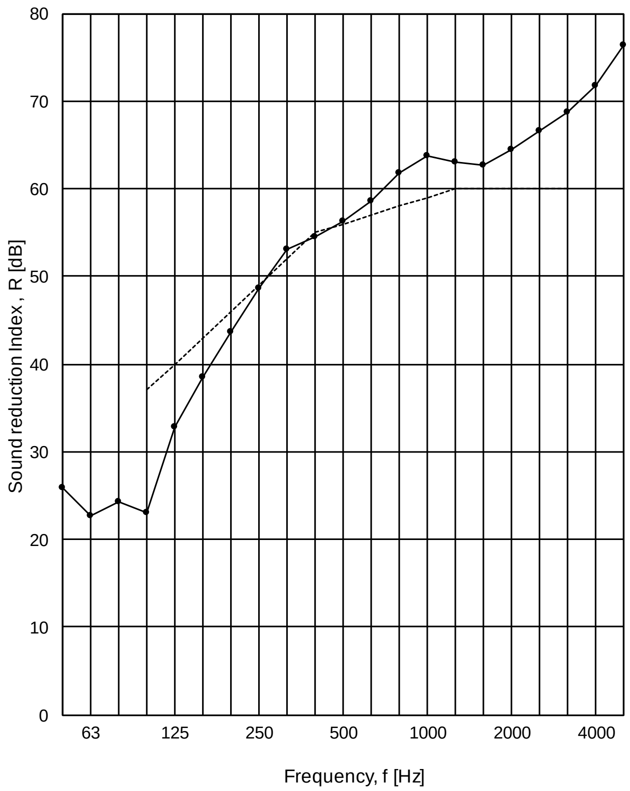
Graph Sheet 1

Laboratory measurement of sound reduction Index according to EN ISO 10140:2010

Customer:	Sika Services AG
Date of test:	10 May 2016
Description of Test Specimen:	Sikafloor® Marine FLF type 8.1
Test specimen mounted by:	The Client
Place of mesurement:	Danish Technical University, Lyngby, Denmark

Test Areas, S:	10.0	m^2
Mass pr unit area:	13.7	kg/m^2
Temperature of air 004:	19.1	°C
Humidity of Air 004	51	% RH
Temperature of air 904:	16.7	°C
Humidity of Air 904	46	% RH
Source Room Volumen	243	m^3
Receiving Room Volumen	230	m^3

Frequency f [Hz]	R' 1/3-octave [dB]
50	25.9
63	22.6
80	24.2
100	23.1
125	32.8
160	38.5
200	43.7
250	48.6
315	53.1
400	54.5
500	56.3
630	58.6
800	61.7
1000	63.8
1250	63.1
1600	62.7
2000	64.5
2500	66.5
3150	68.8
4000	71.8
5000	76.4



Reference Curve stated

Weighted sound reduction index according to EN ISO 717-1:2013:

R'w = 56 dB

Evaluation based on laboratory measurement results obtained by an engineering method EN ISO 10140:2010 part 1, 2, 3 and 5

DELTA, 30 May 2016

Leif Ødegaard, DELTA Acoustics

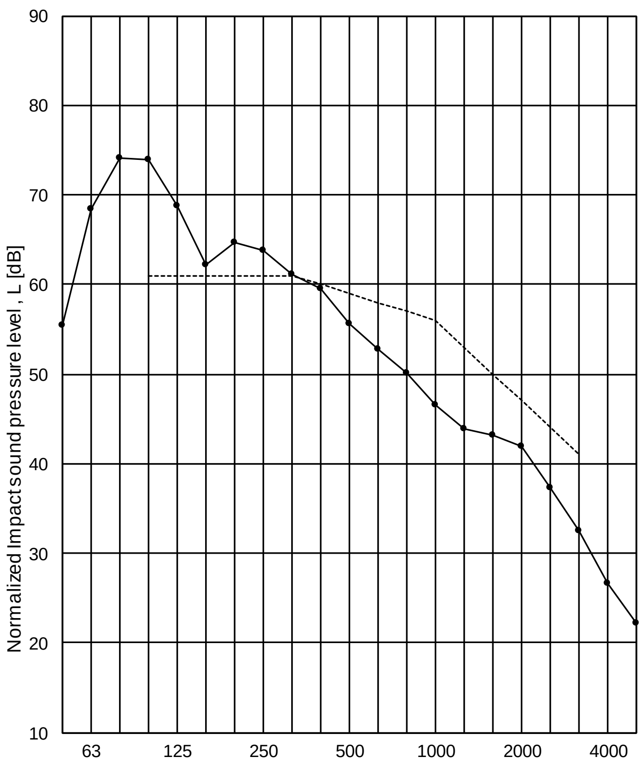
Graph Sheet 2

Laboratory measurement of normalized impact sound pressure level according to EN ISO 10140:2010

Customer:	Sika Services AG
Date of test:	9 May 2016
Description of Test Specimen:	Sikafloor® Marine FLF type 8.1
Test specimen mounted by:	The Client
Place of mesurement:	Danish Technical University, Lyngby, Denmark

Test Areas, S:	10.0	m^2
Mass pr unit area:	13.7	kg/m^2
Temperature of air 004:	18.8	° C
Humidity of Air 004	53	% RH
Temperature of air 904:	15.7	° C
Humidity of Air 904	57	% RH
Source Room Volumen	243	m^3
Receiving Room Volumen	230	m^3

Frequency f [Hz]	L 1/3-octave [dB]
50	55.5
63	68.5
80	74.0
100	73.9
125	68.7
160	62.2
200	64.6
250	63.7
315	61.2
400	59.5
500	55.6
630	52.8
800	50.2
1000	46.5
1250	43.9
1600	43.2
2000	41.9
2500	37.3
3150	32.5
4000	26.7
5000	22.1



Frequency, f [Hz]
Reference Curve stated

Weighted normalized impact sound pressure level according to EN ISO 717-2:2013:

$L_{n,w}$ = 59 dB Calculated Impact Insulation Class IIC according to E989 ASTM : 46 dB

Evaluation based on laboratory measurement results obtained by an engineering method EN ISO 10140:2010 part 1, 3, 4 and 5

DELTA, 30 May 2016

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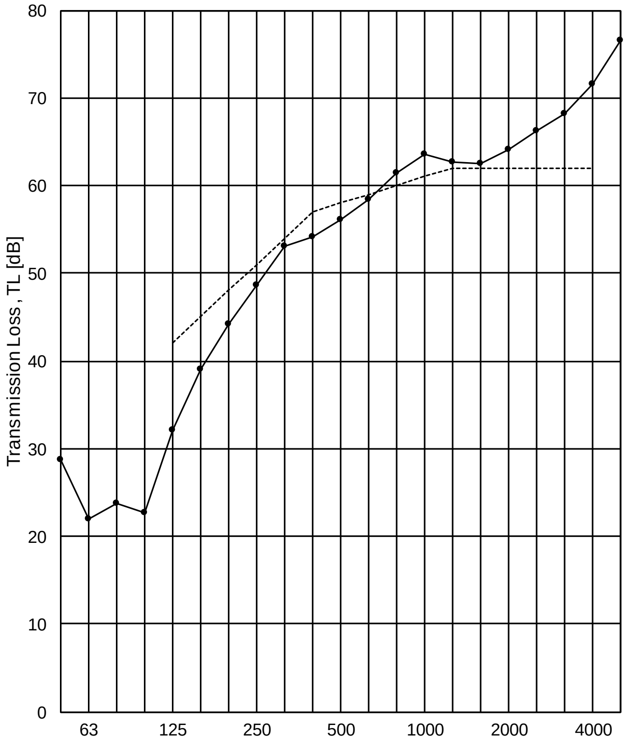
Graph Sheet 3

Laboratory measurement of airborne sound transmission loss according to ASTM E2963-15

Customer:	Sika Services AG
Date of test:	9 May 2016
Description of Test Specimen:	Sikafloor® Marine FLF type 8.1
Test specimen mounted by:	The Client
Place of mesurement:	Danish Technical University, Lyngby, Denmark

Test Areas, S:	10.0	m^2
Mass pr unit area:	13.7	kg/m^2
Temperature of air 004:	18.8	°C
Humidity of Air 004	53	% RH
Temperature of air 904:	15.7	°C
Humidity of Air 904	57	% RH
Source Room Volumen	243	m^3
Receiving Room Volumen	230	m^3

Frequency f [Hz]	TL 1/3-octave [dB]
50	28.6
63	21.9
80	23.8
100	22.8
125	32.1
160	39.1
200	44.2
250	48.6
315	53.0
400	54.0
500	56.1
630	58.4
800	61.4
1000	63.5
1250	62.7
1600	62.4
2000	64.0
2500	66.3
3150	68.2
4000	71.6
5000	76.5



Frequency, f [Hz]
Reference Curve stated

Weighted Sound Transmission Class according to ASTM E413 - 10 Classification for Rating Sound Insulation

STC = 58 dB

Evaluation based on laboratory measurement results obtained by an engineering method

DELTA, 30 May 2016

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Graph Sheet 4

Laboratory measurement of radiation efficiency according to ASTM E2963-15

Customer:	Sika Services AG
Date of test:	9 May 2016
Description of Test Specimen:	Sikafloor® Marine FLF type 8.1
Test specimen mounted by:	Client
Place of mesurement:	Danish Technical University, Lyngby, Denmark

Test Areas, S:	10.0 m^2
Mass pr unit area:	13.7 kg/m^2
Temperature of air 004:	18.8 ° C
Humidity of Air 004	53 % RH
Temperature of air 904:	15.7 ° C
Humidity of Air 904	57 % RH
Source Room Volumen	243 m^3
Receiving Room Volumen	230 m^3

Frequency f [Hz]	Lσ 1/3-octave [dB]
50	11.8
63	19.6
80	11.0
100	11.3
125	18.2
160	25.4
200	30.9
250	33.3
315	37.4
400	41.2
500	44.4
630	46.1
800	49.3
1000	54.3
1250	59.9
1600	62.4
2000	64.9
2500	71.4
3150	77.8
4000	81.8
5000	81.6

Evaluation based on laboratory measurement results obtained by an engineering method

DELTA, 30 May 2016

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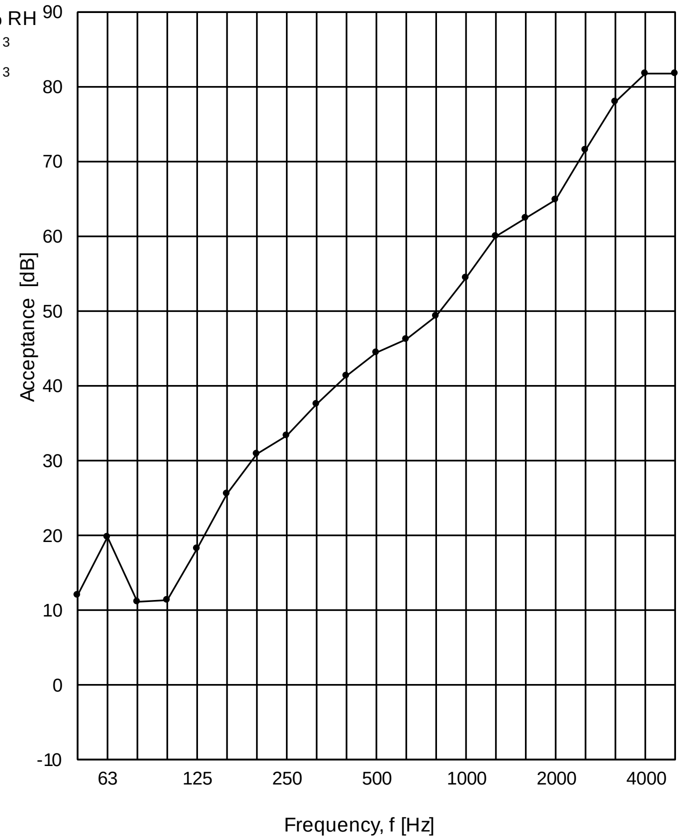
Graph Sheet 5

Laboratory measurement of acceptance according to ASTM E2963-15

Customer: Sika Services AG
Date of test: 9 May 2016
Description of Test Specimen: Sikafloor® Marine FLF type 8.1
Test specimen mounted by: The Client
Place of mesurement: Danish Technical University , Lyngby, Denmark

Test Areas, S: 10.0 m^2
Mass pr unit area: 13.7 kg/m^2
Temperature of air 004: 18.8 ° C
Humidity of Air 004 53 % RH
Temperature of air 904: 15.7 ° C
Humidity of Air 904 57 % RH
Source Room Volumen 243 m^3
Receiving Room Volumen 230 m^3

Frequency f [Hz]	Lσ 1/3-octave [dB]
50	11.8
63	19.6
80	11.0
100	11.3
125	18.2
160	25.4
200	30.9
250	33.3
315	37.4
400	41.2
500	44.4
630	46.1
800	49.3
1000	54.3
1250	59.9
1600	62.4
2000	64.9
2500	71.4
3150	77.8
4000	81.8
5000	81.6



Evaluation based on laboratory measurement results obtained by an engineering method

DELTA, 30 May 2016

Leif Ødegaard, DELTA Acoustics

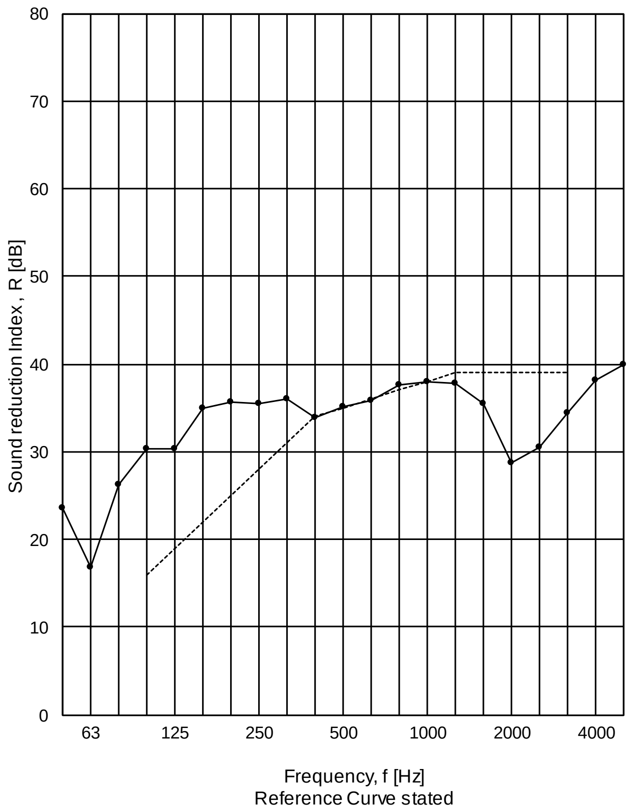
Graph Sheet 6

Laboratory measurement of sound reduction Index according to EN ISO 10140:2010

Customer:	Sika Services AG
Date of test:	3 May 2016
Description of Test Specimen:	6 mm Reference Deck
Test specimen mounted by:	The Client
Place of mesurement:	Danish Technical University, Lyngby, Denmark

Test Areas, S:	10.0	m^2
Mass pr unit area:	45.0	kg/m^2
Temperature of air 004:	24.0	° C
Humidity of Air 004	40	% RH
Temperature of air 904:	22.0	° C
Humidity of Air 904	42	% RH
Source Room Volumen	243	m^3
Receiving Room Volumen	230	m^3

Frequency f [Hz]	R' 1/3-octave [dB]
50	23.5
63	16.8
80	26.3
100	30.3
125	30.3
160	35.0
200	35.6
250	35.5
315	36.0
400	33.8
500	35.2
630	35.8
800	37.6
1000	38.0
1250	37.8
1600	35.5
2000	28.7
2500	30.4
3150	34.4
4000	38.1
5000	39.9



Weighted sound reduction index according to EN ISO 717-1:2013:

R'w = 35 dB

Evaluation based on laboratory measurement results obtained by an engineering method EN ISO 10140:2010 part 1, 2, 3 and 5

DELTA, 3 May 2016

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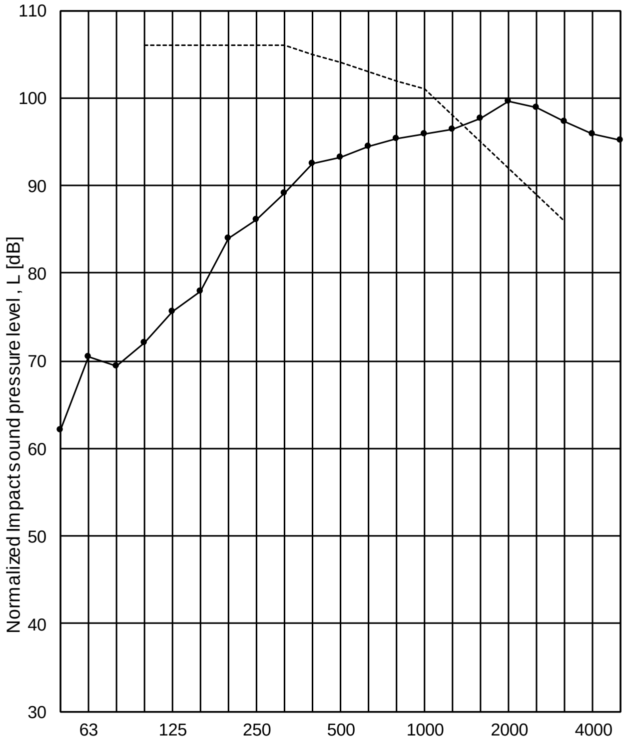
Graph Sheet 7

Laboratory measurement of normalized impact sound pressure level according to EN ISO 10140:2010

Customer:	Sika Services AG
Date of test:	3 May 2016
Description of Test Specimen:	6 mm Reference Deck
Test specimen mounted by:	The Client
Place of mesurement:	Danish Technical University , Lyngby, Denmark

Test Areas, S:	10.0	m^2
Mass pr unit area:	45	kg/m^2
Temperature of air 004:	24	° C
Humidity of Air 004	40	% RH
Temperature of air 904:	22	° C
Humidity of Air 904	42	% RH
Source Room Volumen	243	m^3
Receiving Room Volumen	230	m^3

Frequency f [Hz]	L 1/3-octave [dB]
50	62.0
63	70.4
80	69.5
100	72.0
125	75.5
160	77.9
200	84.0
250	86.2
315	89.2
400	92.4
500	93.2
630	94.4
800	95.3
1000	95.9
1250	96.3
1600	97.7
2000	99.6
2500	98.9
3150	97.3
4000	95.9
5000	95.2



Frequency, f [Hz]
Reference Curve stated

Weighted normalized impact sound pressure level according to EN ISO 717-2:2013:

$L_{n,w}$ = 104 dB Calculated Impact Insulation Class IIC according to E989 ASTM : 3 dB

Evaluation based on laboratory measurement results obtained by an engineering method EN ISO 10140:2010 part 1, 3, 4 and 5

DELTA, 3 May 2016

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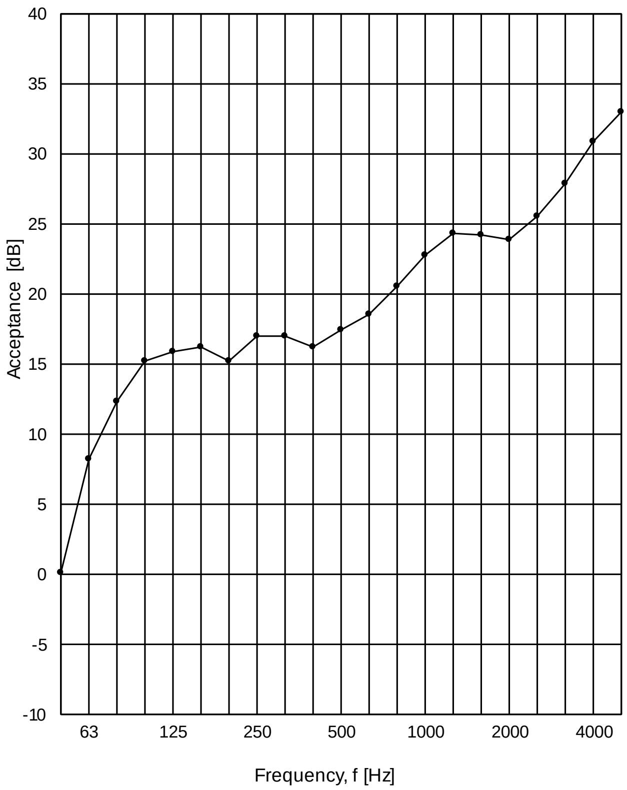
Graph Sheet 8

Laboratory measurement of acceptance according to ASTM E2963-15

Customer:	Sika Services AG
Date of test:	3 May 2016
Description of Test Specimen:	6 mm Reference Deck
Test specimen mounted by:	The Client
Place of mesurement:	Danish Technical University, Lyngby, Denmark

Test Areas, S:	10.0	m^2
Mass pr unit area:	45.0	kg/m^2
Temperature of air 004:	24.0	°C
Humidity of Air 004	40	% RH
Temperature of air 904:	22.0	°C
Humidity of Air 904	42	% RH
Source Room Volumen	243	m^3
Receiving Room Volumen	230	m^3

Frequency f [Hz]	Lσ 1/3-octave [dB]
50	0.0
63	8.2
80	12.3
100	15.1
125	15.8
160	16.2
200	15.2
250	16.9
315	17.0
400	16.2
500	17.4
630	18.6
800	20.5
1000	22.7
1250	24.3
1600	24.2
2000	23.8
2500	25.5
3150	27.8
4000	30.8
5000	32.9



Evaluation based on laboratory measurement results obtained by an engineering method

DELTA, 3 May 2016

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SIKA WORLDWIDE

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WHO WE ARE

Sika is a specialty chemicals company with a leading position in the development and production of systems and products for bonding, sealing, damping, reinforcing and protecting in the building sector and the motor vehicle industry. Sika has subsidiaries in 90 countries around the world and manufactures in over 160 factories. Its more than 17,000 employees generated annual sales of CHF 5,6 billion in 2014.

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