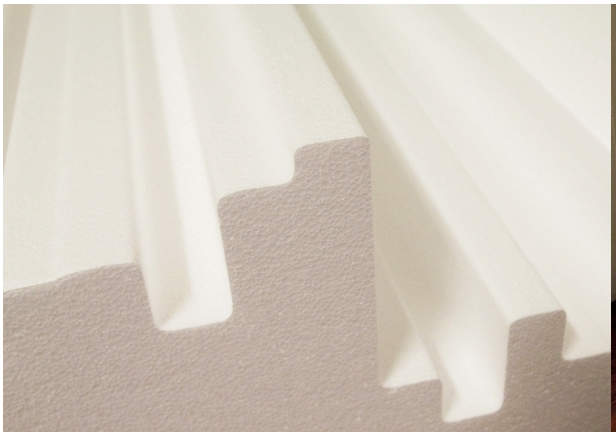
Optiffuser

High-performance, high bandwidth lightweight 1D diffuser.



General product information

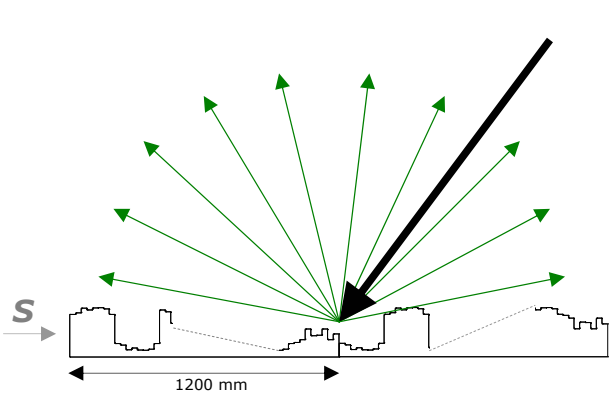
The Optiffuser comes in packs of four panels. Two positives and two negatives (see page 5) per package.

Diffusion performance:	Page 8 – 11.
Absorption coefficients:	Page 12.
Dimensions per pack:	1205 x 605 x 500 mm (four panels per pack).
Dimensions per panel:	1200 x 600 x 220 mm.
Total coverage:	2,88 m² per package.
Material:	Expanded Polystyrene (EPS), 42 kg/m³, see pages 13 - 16 for full material specification.
Weight per panel:	3 / 4 kg, positive / negative panel, unpainted.
Placement:	Page 3 – 5.
Mounting:	Attach directly against wall/ceiling or as described on page 6.
Recommended glue:	Polyurethane based.
Recommended paint:	Any water based paint compatible with spray gun.
Contact:	jens@resonatorstockholm.com tel. +46(0)760-159999

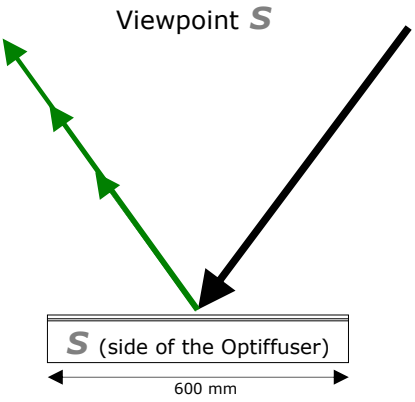
The Optiffuser is an optimized, cost effective, high performance 1D stepped diffuser, made of EPS (Expanded Polystyrene) in order to keep cost and weight down. Unlike wood, EPS can easily be processed into complex shapes, thus maximizing diffusion performance by shape optimization using the latest BEM-modelling (Boundary Element Method) techniques, in this case done with AFMG "Reflex". The panels can be used unpainted, although coating is highly recommended in order to increase the durability of the material, and acoustic performance (see absorption data on page 12). If there is a need to protect the diffusers from impact, a perforated steel plate with a high perforation percentage (> ≈ 65 %) can be used to cover the panels whilst not degrading scattering performance noticeably.

The Optiffuser is designed to scatter in one dimension (1D, see below) and this is often beneficial compared to 2D diffusers that scatter energy in two planes, especially in control room design. 2D diffusers generally exhibit a high attenuation for incident energy and higher absorption coefficients and thus are less suited for the back wall in a typical control room. The optimum diffused sound field in a LEDE (Live End - Dead End) room should arrive from the rear and rear sides, and with enough energy to properly terminate the ISD-gap (Initial Signal Delay) in order to enhance localization and add "space". If the dimension of the control room is too short to provide a sufficient ISD-gap using the rear wall, or if the rear wall cannot be utilized, adding 1D diffusers to the rear sidewalls and/or ceiling might be an option if rotated 90 degrees so that the energy is directed towards the rear and not partially scattered back to the receiver within the ISD-gap. Naturally, the rear wall needs to be reflective (in the considered frequency range at least; above approx. 300-400 Hz, but with the possible exception for the area directly behind the sweet spot, treated for early reflections if the room length is short) for this approach to be successful.

Scattering properties of a 1D diffuser:



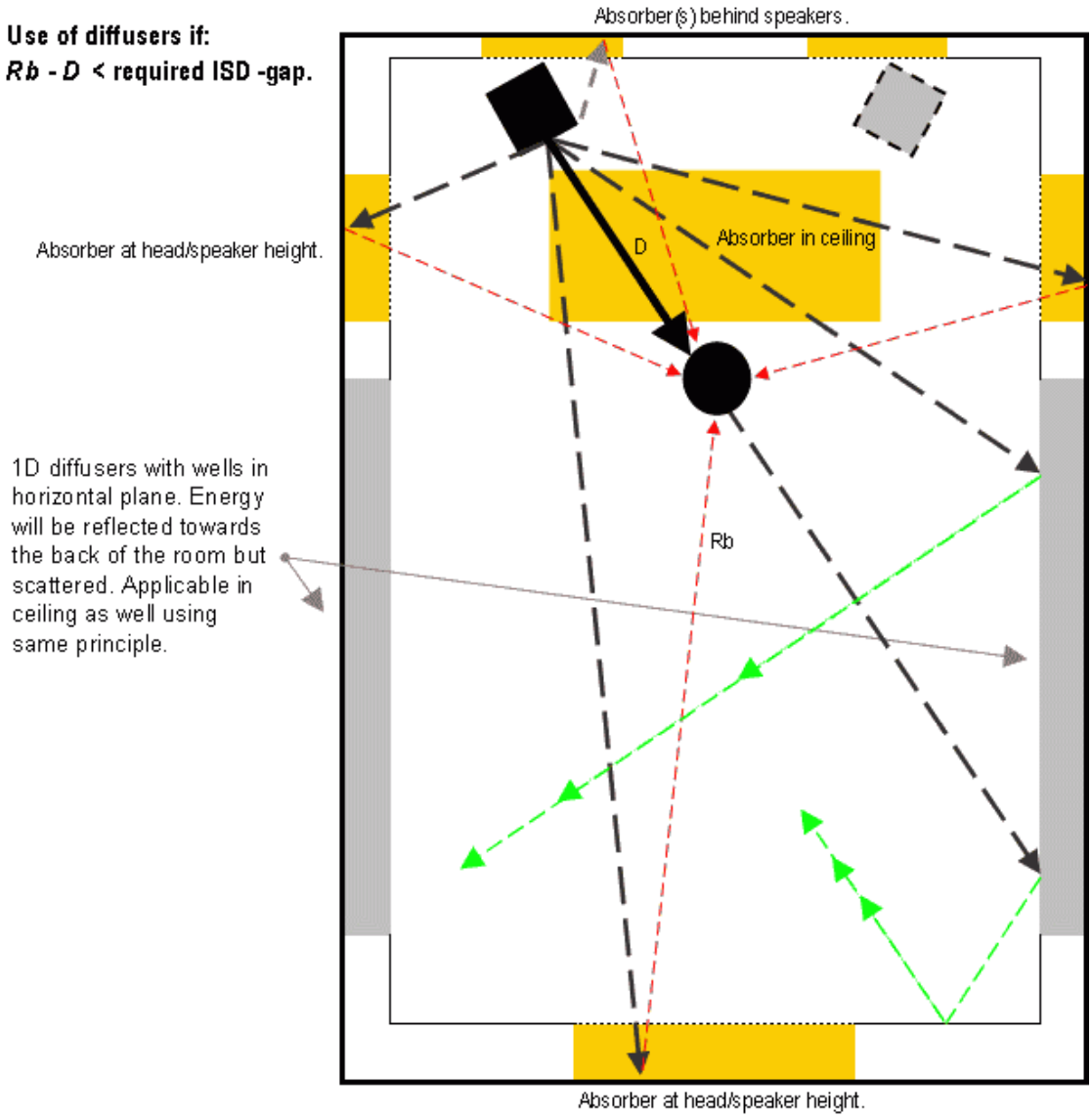
Energy scattered uniformly in this plane.



Energy will not be scattered in this plane[1].

[1] Any object will scatter sound to some degree due to edge diffraction effects.

The ISD-gap should be at least approximately 12 ms (if not dictated by a recording room) but preferably closer to 20 ms. An estimate of achievable ISD-gap length using the rear wall can be made by calculating the difference in time between the reflection path using the back wall (*Rb*) and direct sound (*D*):

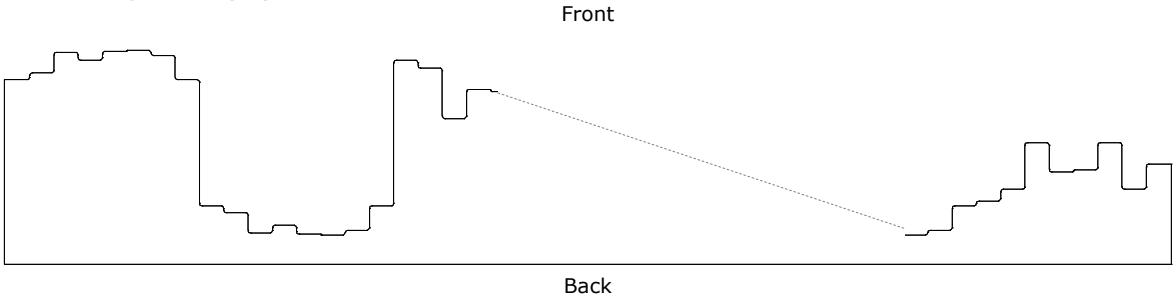


In a recording space, we generally want to reduce early, strong reflections whilst keeping and scattering the later, constructive reflections that build up the decay of the space. Use absorption at early reflection points and diffusers if the distance to source/receiver is longer than approximately 2-3 meters. If 2D scattering is preferred, see page 5. Use broadband absorption sparsely and steer clear of thin absorbers in order to avoid short, uneven decay times. Pressure based absorbers are recommended for all absorption needs except early reflection points.

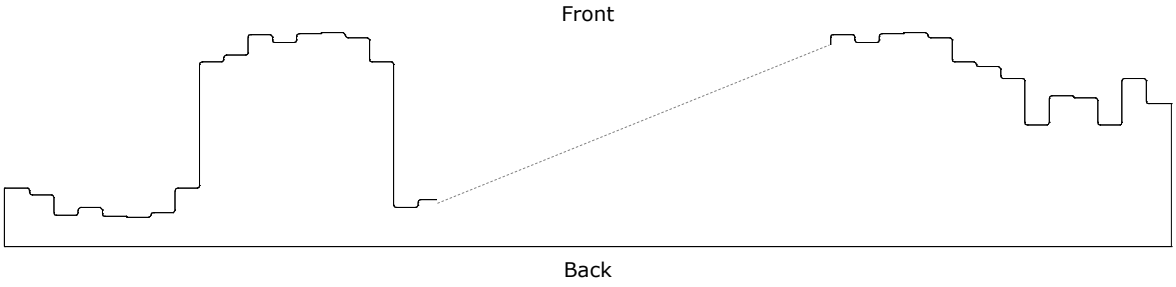
In order to maximize performance, use the following sequence:

2 periods (2400mm total): **P (A-B)** + **N (A-B)**
3 periods (3600mm total): **P (A-B)** + **N (A-B)** + **P (B-A)**
4 periods (4800mm total): **P (A-B)** + **N (A-B)** + **P (B-A)** + **N (B-A)**

Positive panel (**P**):



Negative panel (**N**):



Relative orientation within parentheses. The total orientation can be flipped without affecting performance. If longer than four periods (4,8 meters) is needed; simply repeat the pattern. If two-dimensional scattering is required, simply use positive and negative panels (A-B orientation for both) forming 1,2 x 1,2 meter squares, and rotate every other square 90 (or -90) degrees relative to the previous one. 2D scattering can be useful in recording rooms when the distance between the source and diffuser is longer than approximately 2-3 meters. If shorter, use 1D setup and angle the panels so that the energy is reflected away from the receiver and use broadband absorption at reflection points.

The diffuser panels should be mounted (glued[1]) firmly, either directly against the wall or, if low frequency absorption is needed, against panels that are mounted with an air gap and mineral wool behind (but not touching) the panel. The construction needs to be sealed (airtight) and the resonant frequency of the panel absorber can be estimated using:

$f = 500/(\sqrt{(m*d)})$

m = kg/m² of the panel (total; diffusers and panel combined).
d = air gap in cm (including the wool).

An unpainted diffuser is about 4,4 kg/m² for the positive panel and 5,6 kg/m² for the negative, and if painted[2] twice (front only), the average mass (one positive and one negative panel) is about 5,7 kg/m². If for example, added to a normal 22mm MDF board (approx. 16 kg/m² but varies with brand), with a 9,5 cm build depth, the panel absorber would exhibit a theoretical resonant frequency (maximum absorption) of about 35 Hz. Please note that this is a theoretical value and will vary depending on different mounting conditions, bending stiffness of the combined materials etc. It is nearly impossible to exactly predict the resonant frequency of a membrane absorber unless using extremely complicated models (BEM) and inputting lots of data and even if done right, the prediction is still likely to be unreliable.

Use tables on page 7 as a quick overview of possible (theoretical) centre frequencies of absorption using different combinations of panel mass and build depth. Panel mass refers to the panel without diffusers. The estimated resonant frequency calculated is the result of the total mass per m², including diffusers.

Glue[1] the panels to the wall/panels and sides of adjacent diffuser panels before spray-painting if possible in order to minimize labour and the risk of gaps in the coating.

[1] Use polyurethane glue. Also glue the sides of the panels to one another since the material otherwise might expand/contract with temperature a few millimetres and create gaps that will also increase absorption that should be avoided.

[2] The diffusers can be painted (manually or spray-painted) with water based paint. Currently, I recommend latex paint but there might be better options. Please let me know if you found any other good alternatives that produces a hard surface not requiring too many coatings. A not yet tested idea is adding some cement based filler powder to the paint. The use of a primer on the EPS before painting might also improve the coating.

Average mass of diffusers ≈ 5.0 kg/m² (positive and negative panel, untreated).

Panel (kg/m³):	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Depth (mm)	Theoretical center frequency																				
35	89	85	81	77	74	71	69	67	65	63	61	60	58	57	56	55	53	52	51	51	50
37	86	82	78	75	72	69	67	65	63	61	59	58	56	55	54	53	52	51	50	49	48
40	83	79	76	72	69	67	65	63	61	59	57	56	55	53	52	51	50	49	48	47	47
42	81	77	73	70	67	65	63	61	59	57	56	54	53	52	51	50	49	48	47	46	45
45	79	75	71	68	66	63	61	59	57	56	54	53	52	50	49	48	47	46	46	45	44
47	77	73	69	66	64	62	59	58	56	54	53	51	50	49	48	47	46	45	44	44	43
50	75	71	68	65	62	60	58	56	54	53	52	50	49	48	47	46	45	44	43	42	42
52	73	69	66	63	61	59	57	55	53	52	50	49	48	47	46	45	44	43	42	41	41
54	71	68	65	62	59	57	55	54	52	51	49	48	47	46	45	44	43	42	41	41	40
57	70	66	63	61	58	56	54	52	51	49	48	47	46	45	44	43	42	41	40	40	39
59	68	65	62	59	57	55	53	51	50	48	47	46	45	44	43	42	41	40	40	39	38
62	67	64	61	58	56	54	52	50	49	47	46	45	44	43	42	41	40	39	39	38	37
64	66	62	60	57	55	53	51	49	48	47	45	44	43	42	41	40	39	39	38	37	37
67	65	61	58	56	54	52	50	48	47	46	44	43	42	41	40	40	39	38	37	37	36
69	63	60	57	55	53	51	49	48	46	45	44	43	42	41	40	39	38	37	37	36	35
71	62	59	56	54	52	50	48	47	45	44	43	42	41	40	39	38	37	37	36	35	35
74	61	58	55	53	51	49	48	46	45	43	42	41	40	39	38	38	37	36	35	35	34
76	60	57	55	52	50	48	47	45	44	43	42	40	40	39	38	37	36	36	35	34	34
79	59	56	54	51	49	48	46	45	43	42	41	40	39	38	37	36	36	35	34	34	33
81	59	56	53	51	49	47	45	44	43	41	40	39	38	37	37	36	35	34	34	33	33
84	58	55	52	50	48	46	45	43	42	41	40	39	38	37	36	35	35	34	33	33	32
86	57	54	51	49	47	46	44	43	41	40	39	38	37	36	36	35	34	33	33	32	32
88	56	53	51	49	47	45	43	42	41	40	39	38	37	36	35	34	34	33	32	32	31
91	55	52	50	48	46	44	43	41	40	39	38	37	36	35	35	34	33	33	32	31	31
93	55	52	49	47	45	44	42	41	40	39	38	37	36	35	34	33	33	32	32	31	30
96	54	51	49	47	45	43	42	40	39	38	37	36	35	34	34	33	32	32	31	31	30
98	53	50	48	46	44	43	41	40	39	38	37	36	35	34	33	33	32	31	31	30	30
101	53	50	48	46	44	42	41	39	38	37	36	35	34	34	33	32	32	31	30	30	29
103	52	49	47	45	43	42	40	39	38	37	36	35	34	33	32	32	31	31	30	29	29
105	51	49	46	44	43	41	40	38	37	36	35	34	34	33	32	31	31	30	30	29	29
108	51	48	46	44	42	41	39	38	37	36	35	34	33	32	32	31	30	30	29	29	28
110	50	48	45	43	42	40	39	38	37	35	35	34	33	32	31	31	30	30	29	28	28
113	50	47	45	43	41	40	38	37	36	35	34	33	32	32	31	30	30	29	29	28	28
115	49	47	44	43	41	39	38	37	36	35	34	33	32	31	31	30	29	29	28	28	27
118	49	46	44	42	40	39	38	36	35	34	33	33	32	31	30	30	29	29	28	28	27
120	48	46	44	42	40	39	37	36	35	34	33	32	31	31	30	29	29	28	28	27	27

Average mass of diffusers ≈ 5,7 kg/m² (positive and negative panel, painted).

Panel (kg/m³):	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
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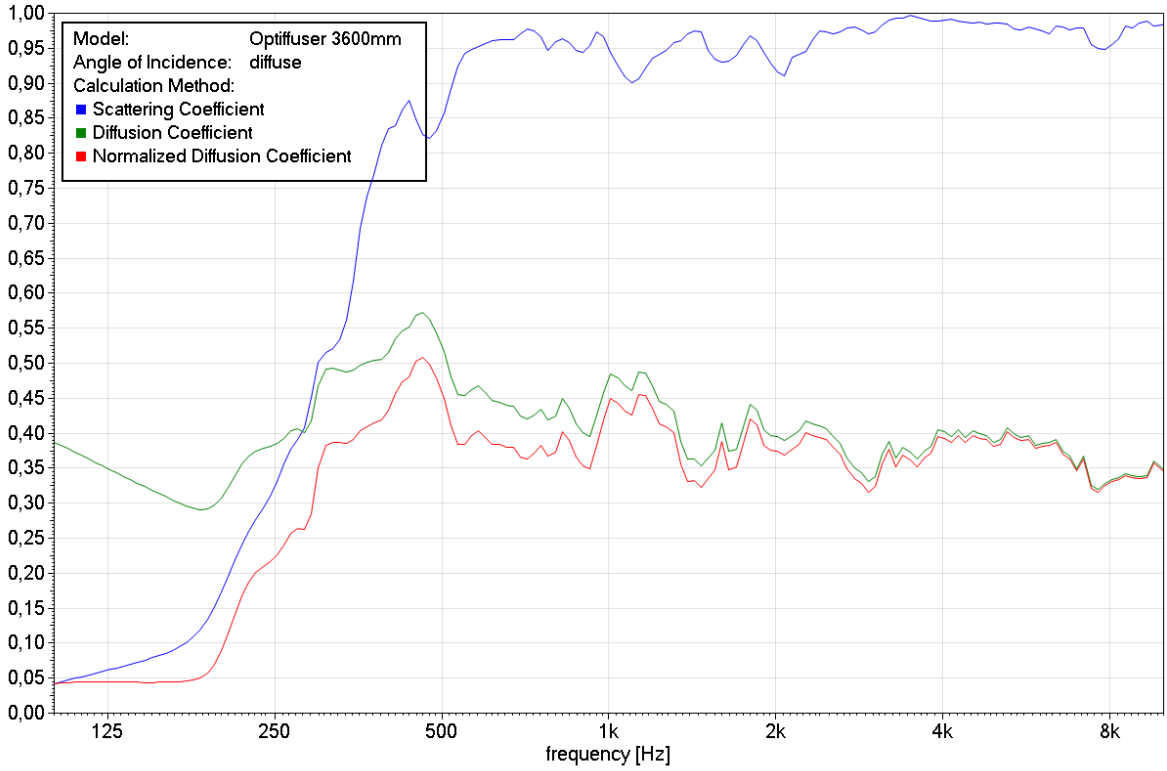
37	83	79	76	73	70	67	65	63	61	60	58	57	55	54	53	52	51	50	49	48	47
40	80	77	73	70	68	65	63	61	60	58	56	55	54	53	51	50	49	48	48	47	46
42	78	74	71	68	66	63	61	60	58	56	55	53	52	51	50	49	48	47	46	45	45
45	76	72	69	66	64	62	60	58	56	55	53	52	51	50	49	48	47	46	45	44	43
47	74	70	67	65	62	60	58	56	55	53	52	51	49	48	47	46	45	45	44	43	42
50	72	69	66	63	61	59	57	55	53	52	51	49	48	47	46	45	44	43	43	42	41
52	70	67	64	62	59	57	55	54	52	51	49	48	47	46	45	44	43	42	42	41	40
54	69	66	63	60	58	56	54	52	51	50	48	47	46	45	44	43	42	41	41	40	39
57	67	64	61	59	57	55	53	51	50	48	47	46	45	44	43	42	41	41	40	39	38
59	66	63	60	58	55	54	52	50	49	47	46	45	44	43	42	41	41	40	39	38	38
62	65	62	59	56	54	53	51	49	48	47	45	44	43	42	41	41	40	39	38	38	37
64	63	60	58	55	53	52	50	48	47	46	44	43	42	41	41	40	39	38	38	37	36
67	62	59	57	54	52	51	49	47	46	45	44	43	42	41	40	39	38	38	37	36	36
69	61	58	56	53	51	50	48	47	45	44	43	42	41	40	39	38	38	37	36	36	35
71	60	57	55	53	51	49	47	46	44	43	42	41	40	39	38	38	37	36	36	35	34
74	59	56	54	52	50	48	46	45	44	43	41	40	40	39	38	37	36	36	35	34	34
76	58	55	53	51	49	47	46	44	43	42	41	40	39	38	37	36	36	35	34	34	33
79	57	54	52	50	48	46	45	44	42	41	40	39	38	37	37	36	35	34	34	33	33
81	56	54	51	49	47	46	44	43	42	41	40	39	38	37	36	35	35	34	33	33	32
84	56	53	51	49	47	45	44	42	41	40	39	38	37	36	36	35	34	33	33	32	32
86	55	52	50	48	46	44	43	42	41	39	38	37	37	36	35	34	34	33	32	32	31
88	54	51	49	47	45	44	42	41	40	39	38	37	36	35	35	34	33	33	32	31	31
91	53	51	49	47	45	43	42	41	39	38	37	36	36	35	34	33	33	32	32	31	30
93	53	50	48	46	44	43	41	40	39	38	37	36	35	34	34	33	32	32	31	31	30
96	52	49	47	45	44	42	41	40	38	37	36	36	35	34	33	33	32	31	31	30	30
98	51	49	47	45	43	42	40	39	38	37	36	35	34	34	33	32	31	31	30	30	29
101	51	48	46	44	43	41	40	39	37	36	36	35	34	33	32	32	31	31	30	29	29
103	50	48	46	44	42	41	39	38	37	36	35	34	33	33	32	31	31	30	30	29	29
105	49	47	45	43	42	40	39	38	37	36	35	34	33	32	32	31	30	30	29	29	28
108	49	47	45	43	41	40	38	37	36	35	34	33	33	32	31	31	30	29	29	28	28
110	48	46	44	42	41	39	38	37	36	35	34	33	32	32	31	30	30	29	29	28	28
113	48	46	44	42	40	39	38	36	35	34	34	33	32	31	31	30	29	29	28	28	27
115	47	45	43	41	40	38	37	36	35	34	33	32	32	31	30	30	29	29	28	28	27
118	47	45	43	41	39	38	37	36	35	34	33	32	31	31	30	29	29	28	28	27	27
120	46	44	42	41	39	38	36	35	34	33	33	32	31	30	30	29	28	28	27	27	26

The performance of diffusers is not easily measured. If done correctly, it needs to be done in full scale and preferably using the standard 3,6 meter total width of sample and this results in the need of a very large room. Although boundary plane measurements have been conducted to verify function, the sample was only 2,4 meters (two periods). Fortunately, the boundary element method has been proven accurate in predicting spatial scattering performance of diffusers so the data extracted by "Reflex" is the best indicator of performance. Total panel width for data below is 3,6 meter (three periods, P - N - P). Coefficients for lower periods (shorter total panel width) are higher but not very useful.

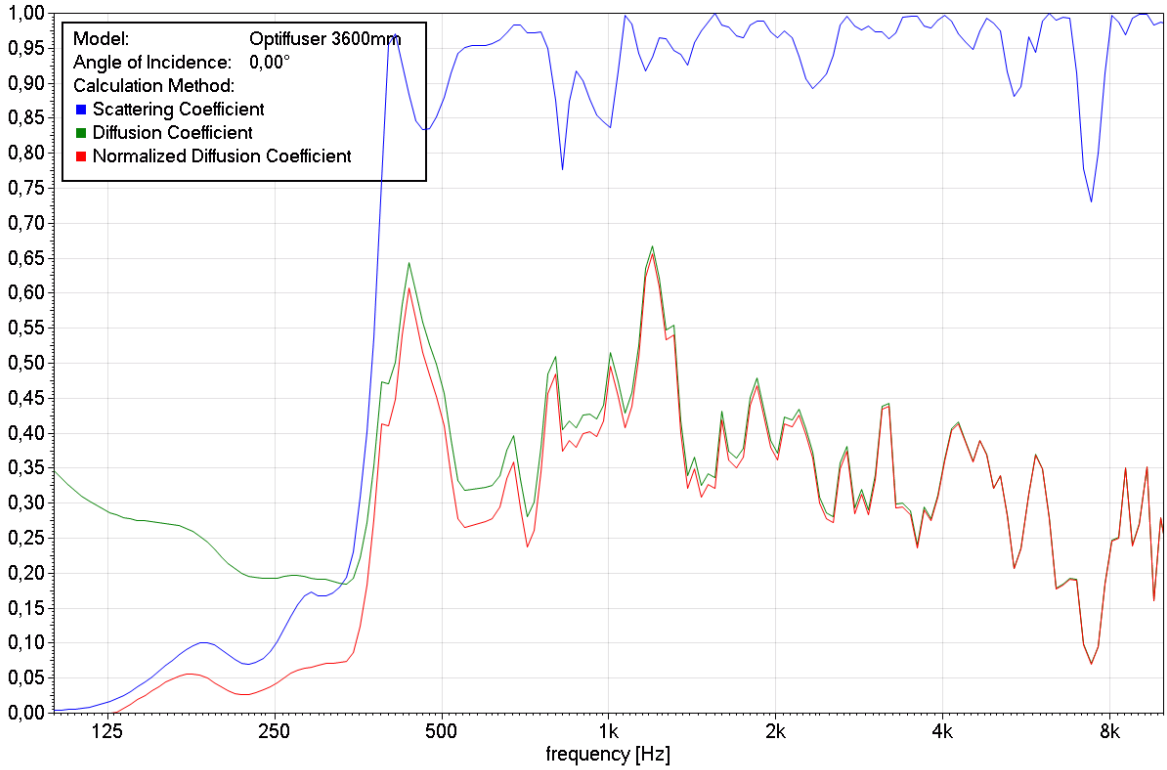
Scattering and diffusion coefficients, random incidence, 3,6 meter panel:



1/24 octave resolution, no averaging. Data from BEM-model.

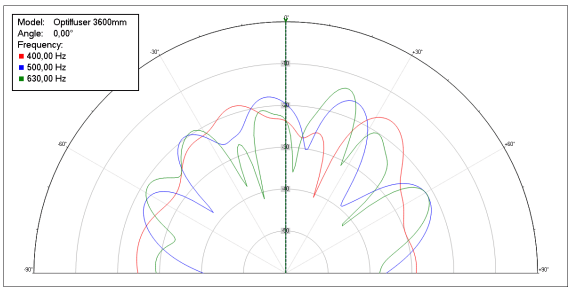
Normalized diffusion coefficients at random incidence above about 0,6 is theoretically impossible to achieve unless very narrow bandwidth. Values above approximately 0,3 are generally considered good and bandwidths in the order of 300 Hz to 10 kHz are rare. Comparing diffuser performance is difficult unless the same total width of the panels are compared. Shorter panels give higher values. At the end of this document, you will find graphs of the popular QRD N7 diffuser using the same total and effective depth (and same total width) for easy comparisons.

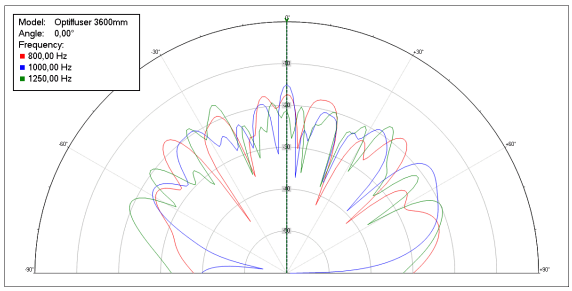
Scattering and diffusion coefficients, normal incidence, 3,6 meter panel:

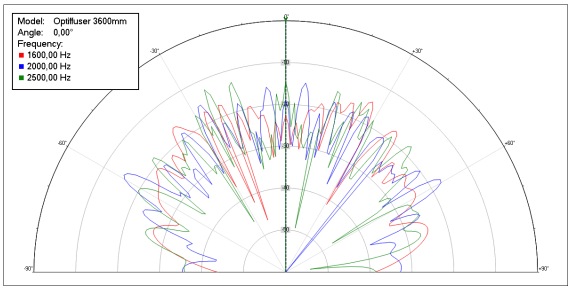


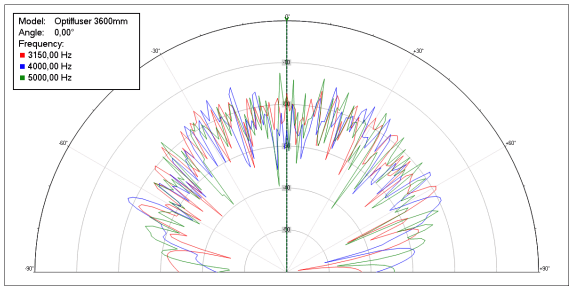
1/24 octave resolution, no averaging. Data from BEM-model.

Polar plots, normal incidence, 3,6 meter panel:

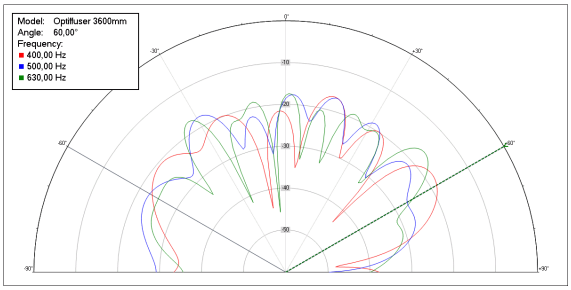


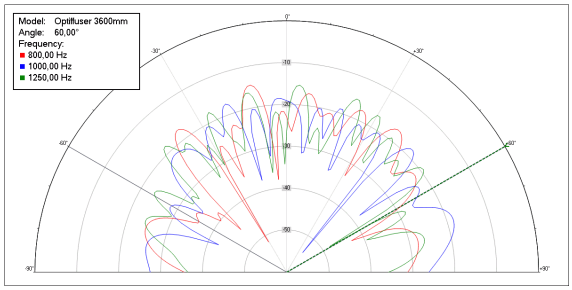


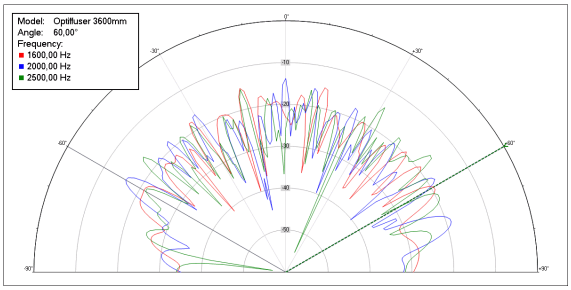


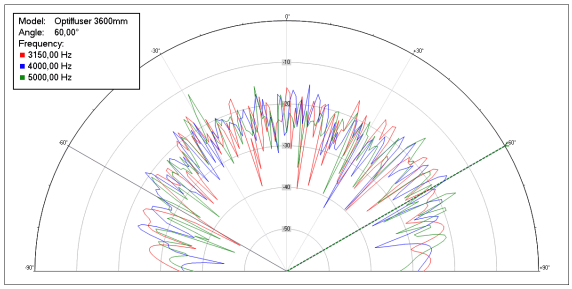


Polar plots, 60 degrees incidence, 3,6 meter panel:

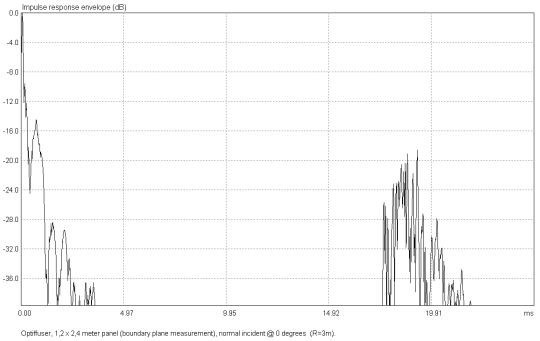


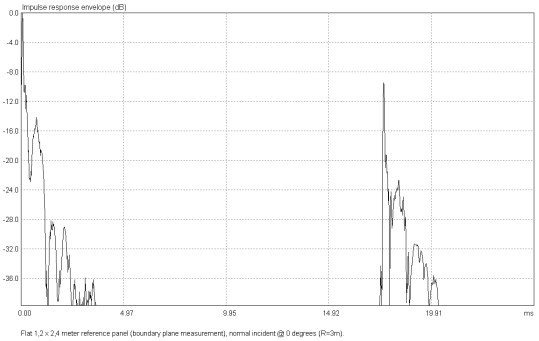




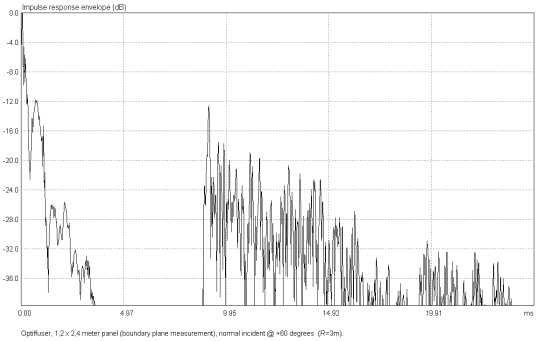


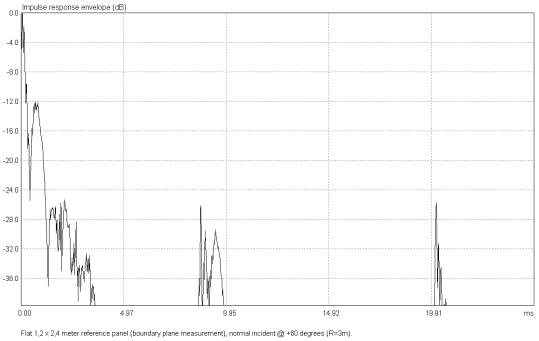
Although BEM-modelling is a powerful tool to predict spatial performance, the technique does not provide any data for temporal scattering performance, also important for a good diffuser. Full scale boundary plane measurements of a 2,4 meter panel have been performed in order to verify temporal scattering. Below shows 0, +60 and -60 degrees:



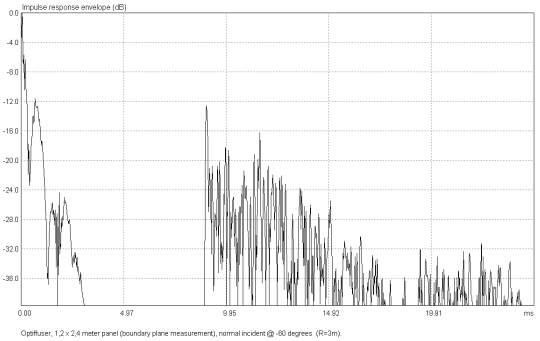


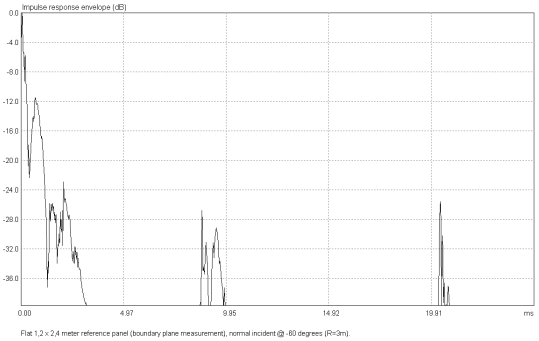
Left: Optiffuser, 2,4 x 1,2 meter panel, normal incidence @ 0 degrees.
Right: Reference reflector, 2,4 x 1,2 meter, normal incidence @ 0 degrees.



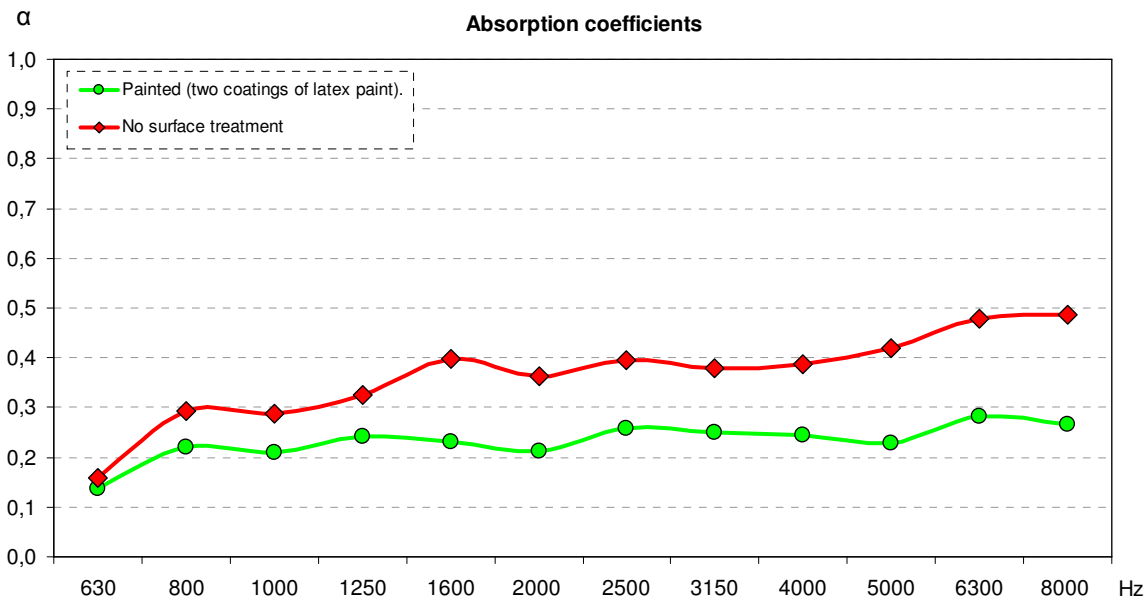


Left: Optiffuser, 2,4 x 1,2 meter panel, normal incidence @ +60 degrees.
Right: Reference reflector, 2,4 x 1,2 meter, normal incidence @ +60 degrees.





Left: Optiffuser, 2,4 x 1,2 meter panel, normal incidence @ -60 degrees.
Right: Reference reflector, 2,4 x 1,2 meter, normal incidence @ -60 degrees.



Absorption properties extracted from multiple measurements done in a small (50 m^3) reverberant room with four panels (2,88 m^2) on the floor in a corner (two sides also exposed) and calculated using Sabine's equation. Values below the 630 Hz band are not displayed since this method is simply too unreliable for lower frequencies and different mounting conditions will drastically affect the result. The reduced absorption due to coating is significant and coating is therefore highly recommended not only due to grater durability of the panels but also because of reduced absorption.

Ideally, a diffuser should not absorb anything (in the operational bandwidth at least) but all diffusers absorb due to diffraction effects. Absorption coefficients between 0,2 and 0,4 are common.

MATERIAL SAFETY DATA, JACKOPOR

1. IDENTIFICATION OF PRODUCT AND COMPANY

TRADE NAME:	Jackopor, Jackodren and EPS
CHEMICAL NAME:	Expanded polystyrene (EPS)
FORMULA:	$(C_6H_5CH=CH_2)_n$
TYPE OF PRODUCT:	Insulation, Road Fill and Packing Material
SUPPLIER:	Jackon AB
ADDRESS:	Box 38, 428 21 Kållered
VISITING ADDRESS:	Sagsjövägen 3
TELEPHONE:	+46 (0)31-700 88 10
TELEFAX:	+46 (0)31-15 62 50
ISSUED BY:	Daniel Tholén

2. COMPOSITION AND INFORMATION ON INGREDIENTS

Material:	CAS-nr	Conc. (weight)	Classification[1]:
Polystyrene	9003-53-6	>98%	Not classified
Pentane (different isomers)	109-66-0/78-78-4	<2%	F+,Xn,N;R12-65-66-67-61/53

ANNOTATION: The content of pentane is highest immediately after production thereafter it decreases continuously. Almost all pentane is gone after about one month.

1) Definition, see section 16.

3. HAZARDS IDENTIFICATION

The product is not classified as health-endangering, ecologically dangerous and it's not easily set on fire. No special risks at normal usage.

4. FIRST AID MEASURES

No symptoms are known.

INHALATION:	Fresh air.
SKIN CONTACT:	No measures to be taken.
EYE CONTACT:	No measures to be taken.
INGESTION:	No measures to be taken.
MEDICAL INFORMATION:	Suitable treatment if symptoms shown.

5. FIRE-FIGHTING MEASURES

EXTINGUISHING MEDIAS: Foam or sprayed water. Powder, carbon dioxide sand or soil can be used for small fires. Do not use water jets (stick jets).

FIRE-FIGHTING: Use protective equipment and oxygen mask. Material close to the fire shall be removed.

FIRE AND EXPLOSION HAZARDS: Not classified as fire hazardous – still it's combustible. Combustion gases contain carbon dioxide (CO_2) and small amounts carbon monoxide (CO). Oxygen deficiency causes larger amounts of carbon monoxide.

6. ACCIDENTAL RELEASE MEASURES

PROTECTIVE MEASURE: Remove everything that can cause ignition.

TIDYING OF WASTE: Put the material in a container for recycling or rubbish incineration. Section 13 gives information concerning recycling and waste management.

7. HANDLING AND STORAGE

HANDLING: Avoid inhalation of smoke and fume from heated product. Remove ignition sources.

STORAGE: Store dry and cool. Keep away from sunlight and ignition sources. EPS is a very light material and it can be spread by the wind during storage, take action.

8. EXPOSURE CONTROLS AND PERSONAL PROTECTION

HYGIENIC THRESHOLD VALUE:	Pentane 2000 mg/m^3 (short-time value)
PREVENTIVE MEASURES:	Handle recent made EPS in ventilated spaces
BREATHING PROTECTION:	No measures to be taken
EYE PROTECTION:	No measures to be taken
HAND PROTECTION:	No measures to be taken
SKIN PROTECTION:	Normal work clothes

9. PHYSICAL AND CHEMICAL PROPERTIES

APPEARANCE:	Boards, blocks or refined
COLOUR:	White or inked
SMELL:	Almost non-existent
SOLUBILITY:	Soluble in organic solvents
SOLUBILITY IN WATER:	Not soluble
DENSITY:	15-40 kg/m^3
EXPLOSIVE LIMITS:	1,3 - 7,8 % by volume (pentane)
IGNITION TEMPERATURE:	285°C (DIN 51794)
SAGGING POINT:	>70°C

10. STABILITY AND REACTIVITY

STABILITY: Normally stable. Dissolves at temperatures above 200°C.

CONDITIONS TO AVOID: Heat, fire and sparks. Avoid sun exposure during long time of periods. Avoid contact with organic solvents.

11. TOXICOLOGICAL INFORMATION

DATA FOR APPRAISAL: The information is based on the knowledge concerning the elements and the toxicity for similar products.

ACUTE TOXICITY - ORAL: LD_{50}>2000 mg/kg (estimated).
ACUTE TOXICITY - DERMAL: LD_{50}>2000 mg/kg (estimated).
ACUTE TOXICITY - INHALATION: LC_{50} expected larger than 5 mg/l.

INHALATION: High concentration of pentane fumes irritates the bronchi

SKIN CONTACT: Not irritating

EYE CONTACT: Dust can cause mechanical irritation

MUTAGENICITY: Not mutagenic

CARCINOGENICITY: Not carcinogenic

12. ECOLOGICAL INFORMATION

DATA FOR APPRAISAL: The information is based on the knowledge concerning similar products.

MOBILITY: The product is not soluble in water, it floats

PERSISTENCE AND DEGRADABILITY: Persistent in the environment

BIO ACCUMULATIVE POTENTIAL: No bioaccumulation

AQUATIC TOXICITY: The product is not toxic for aquatic life

13. DISPOSAL CONSIDERATIONS

The material is appropriate to recycle or energy recovers.
Recommendation:
Clean products: recycling

Contaminated products: energy recovery
Products contaminated with health-endangering or ecologically dangerous material: According to waste regulation.

Dumping of the material causes no dangers or discharges.

14. TRANSPORT INFORMATION

Not classified as dangerous goods according to UN, IMO, ADR/RID or IATA/ICAO.

15. REGULATORY INFORMATION

Not classified as health-endangering or ecologically dangerous according to applying legislation regarding chemical products.

16. OTHER INFORMATION

Issued January 2005.

The information in this document is based on our present knowledge and it is only to be used in purpose of health, security and environment. The information is not to be considered as a specification or guarantee for the products specific characteristics.

Emission measures are performed according to SP method 1598 report 94:k2 084:2

Explanation of classifications from section 2:

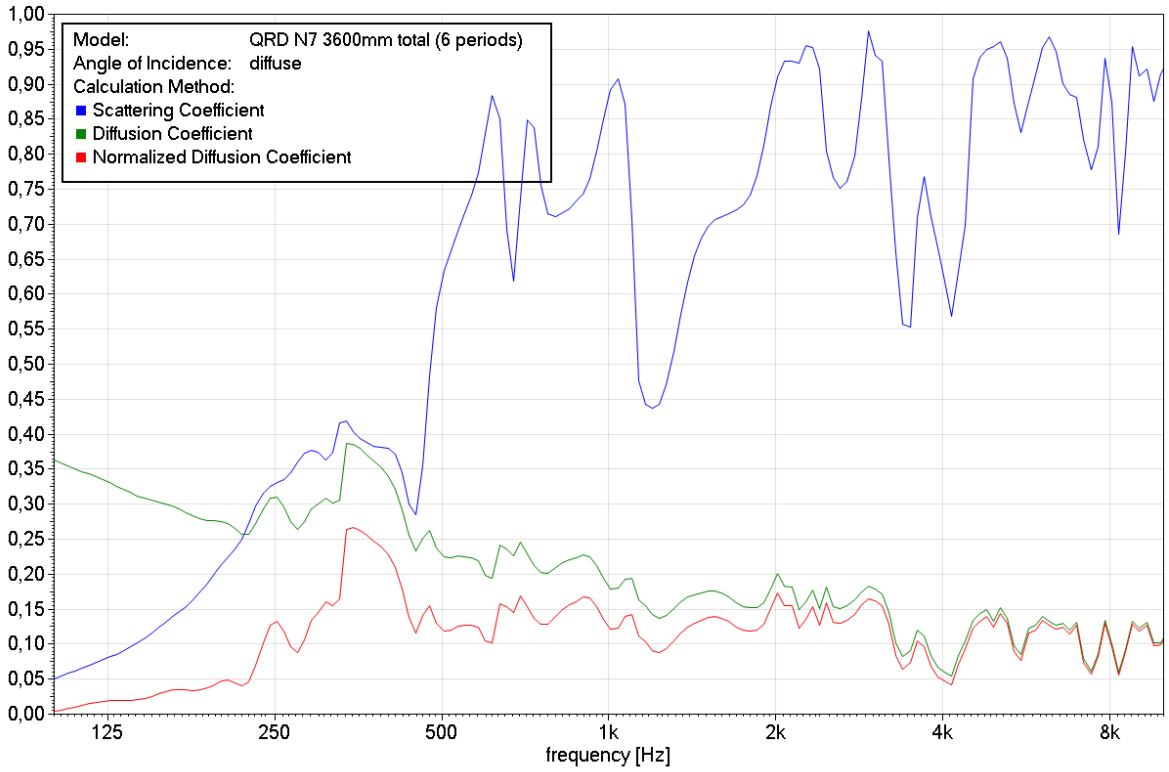
F+	Extremely easy to set on fire
N	Ecologically harmful
Xn	Health-endangering

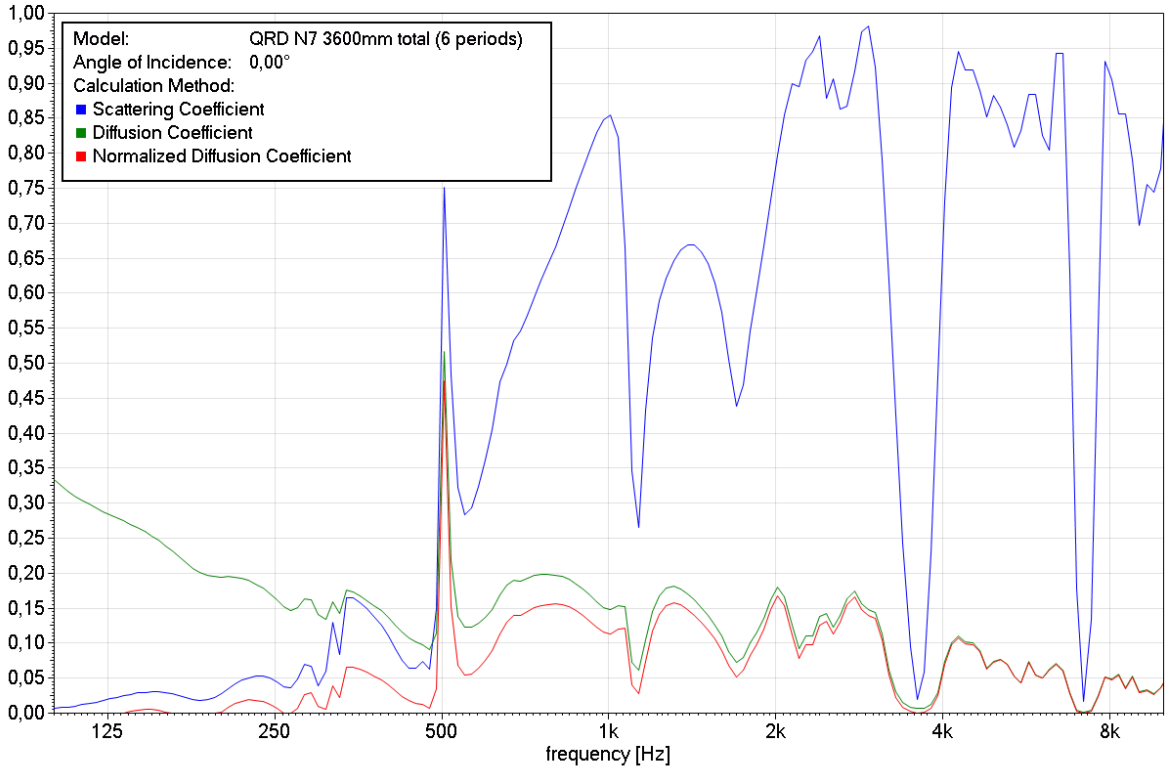
R12	Extremely easy to set on fire
R65	Dangerous: can cause lung injuries if ingested
R66	Repeatedly contact can cause dry skin
R67	Fumes can make you drowsy and dazed
R51/53	Poisonous to aquatic life

Below are some BEM-model predictions of the popular QRD N7 diffuser using the same effective dimensions and resolution as used previously in this document for easy comparison against the Optiffuser performance:

QRD N7:

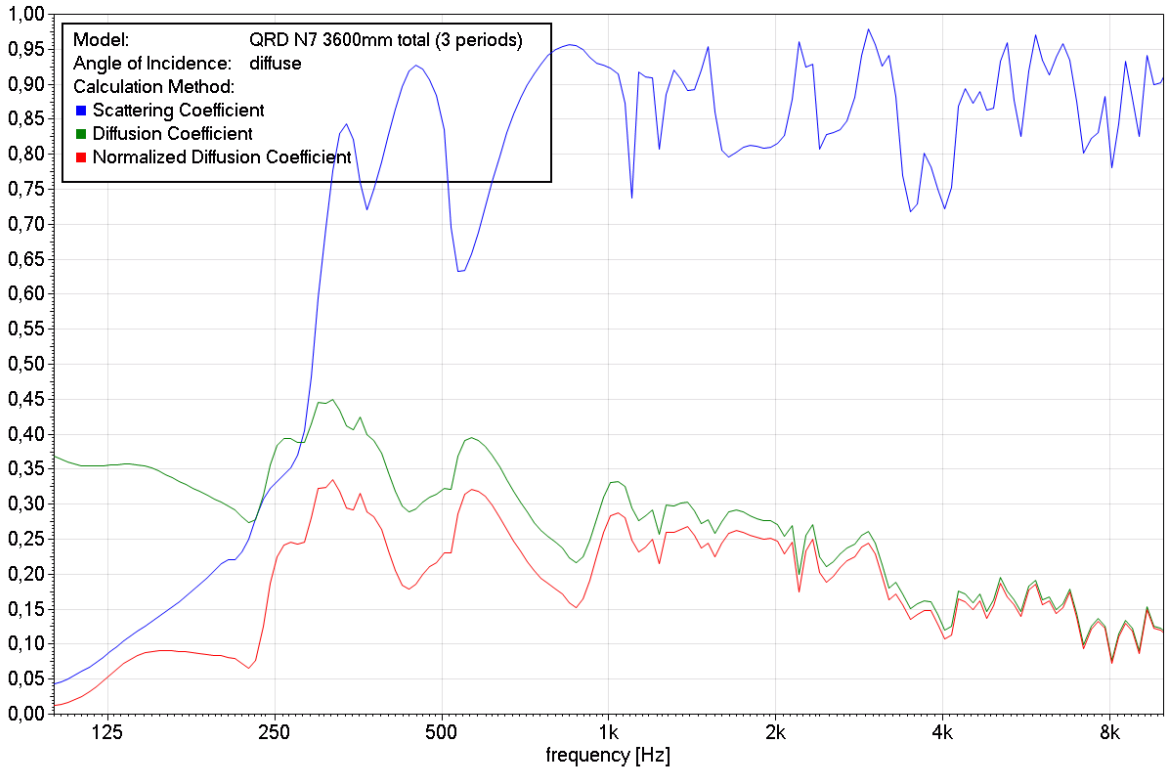
Random & normal incidence, 3,6 meter (six 0,6 m periods) panel:

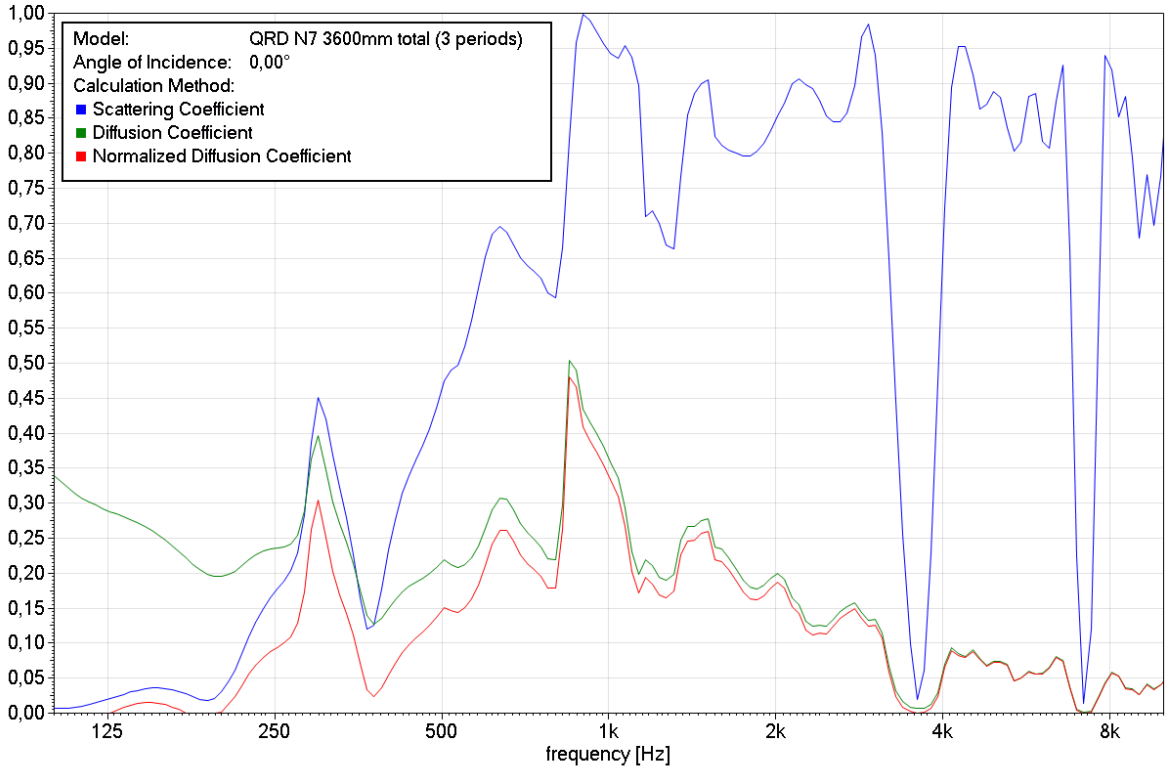




QRD N7:

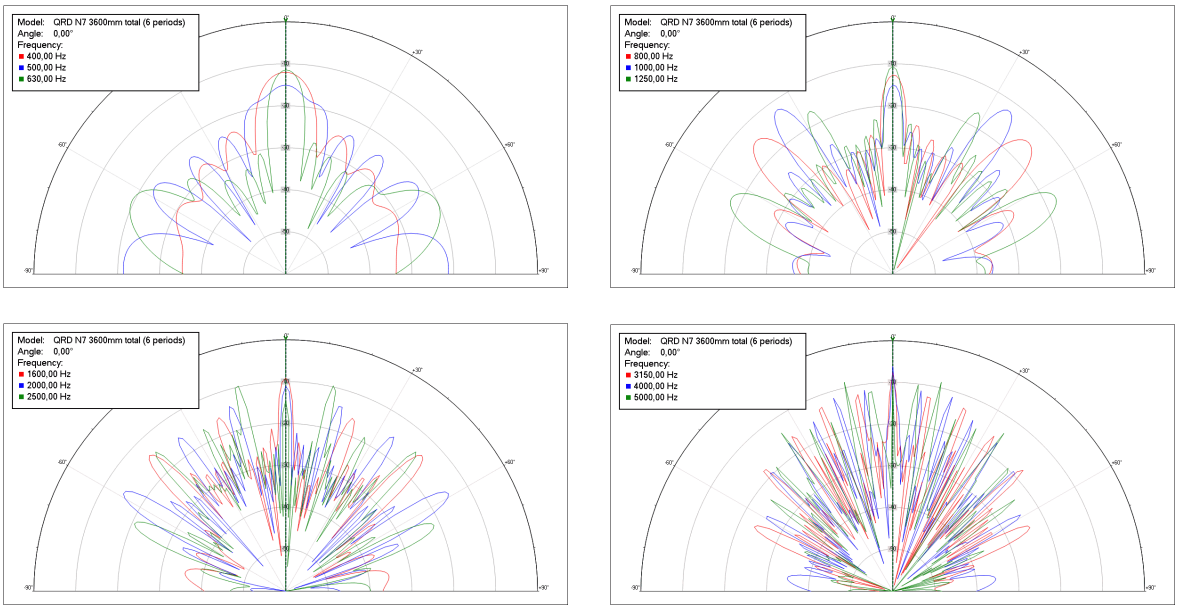
Random & normal incidence, 3,6 meter (three 1,2 m periods) panel:



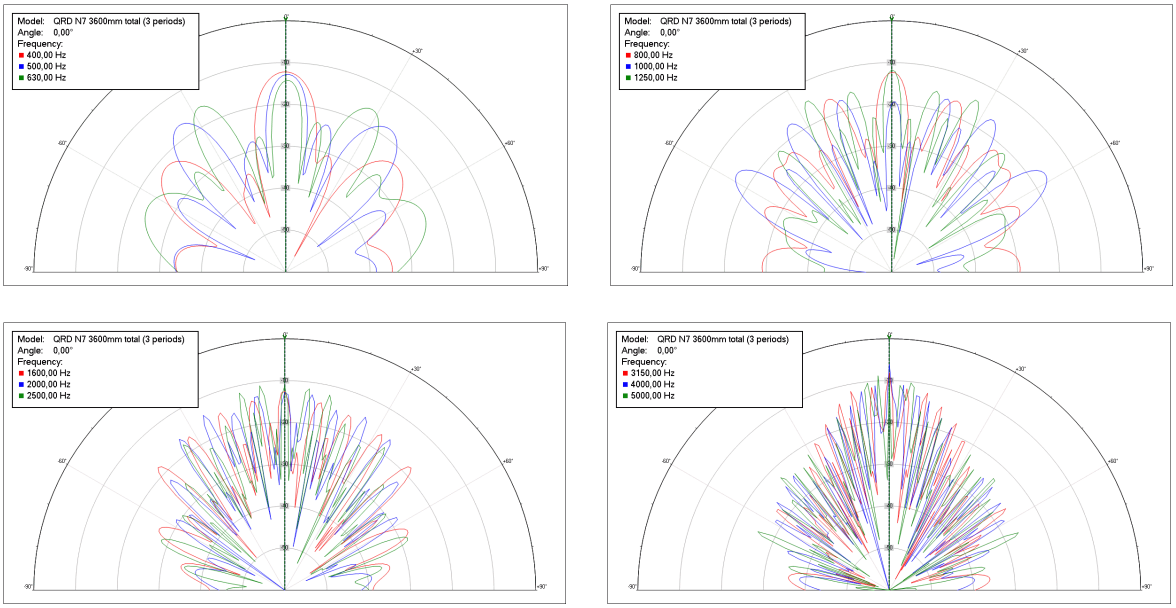


QRD N7:

Polar plots, normal incidence, 3,6 meter (six 0,6 m periods) panel:

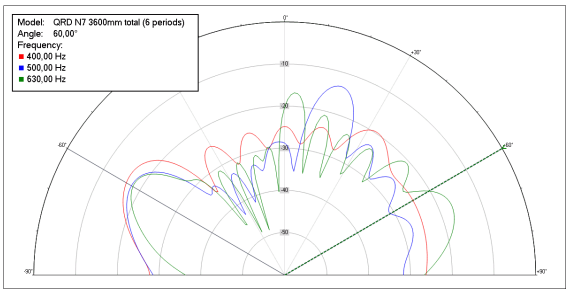


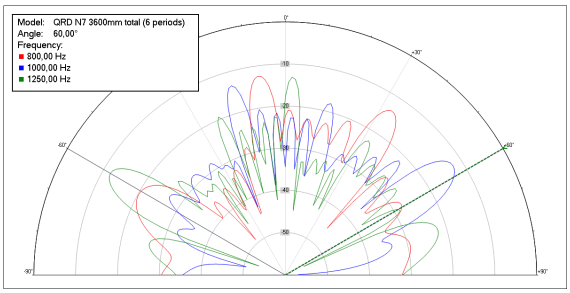
Polar plots, normal incidence, 3,6 meter (three 1,2 m periods) panel:

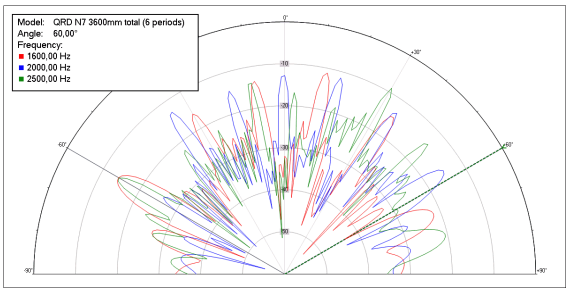


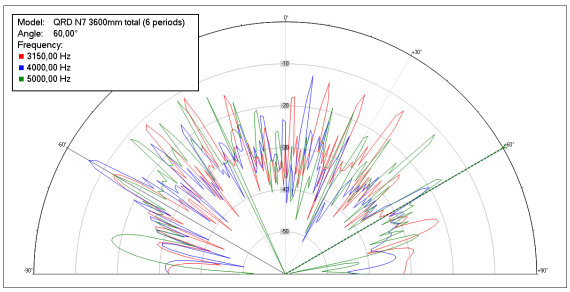
QRD N7:

Polar plots, 60 degrees incidence, 3,6 meter (six 0,6 m periods) panel:

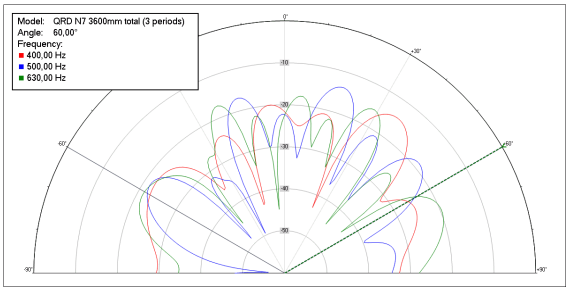


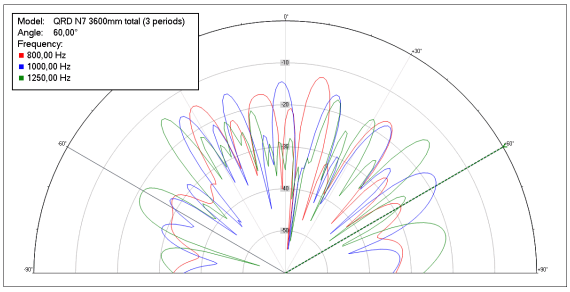


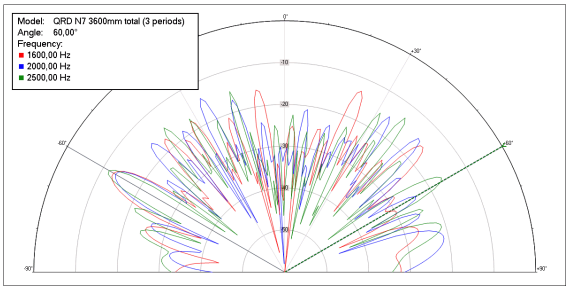


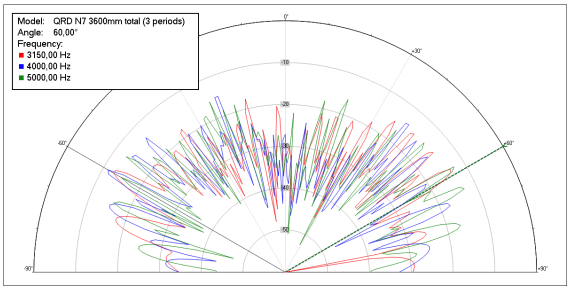


Polar plots, 60 degrees incidence, 3,6 meter (three 1,2 m periods) panel:

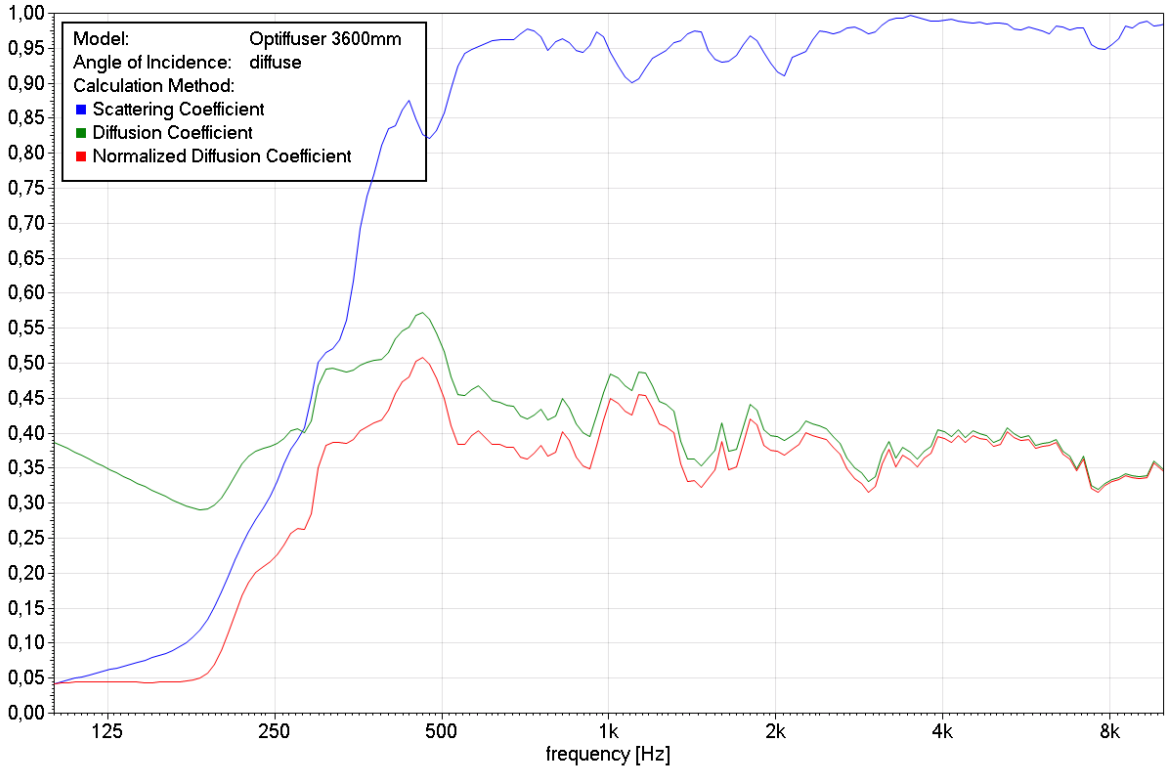


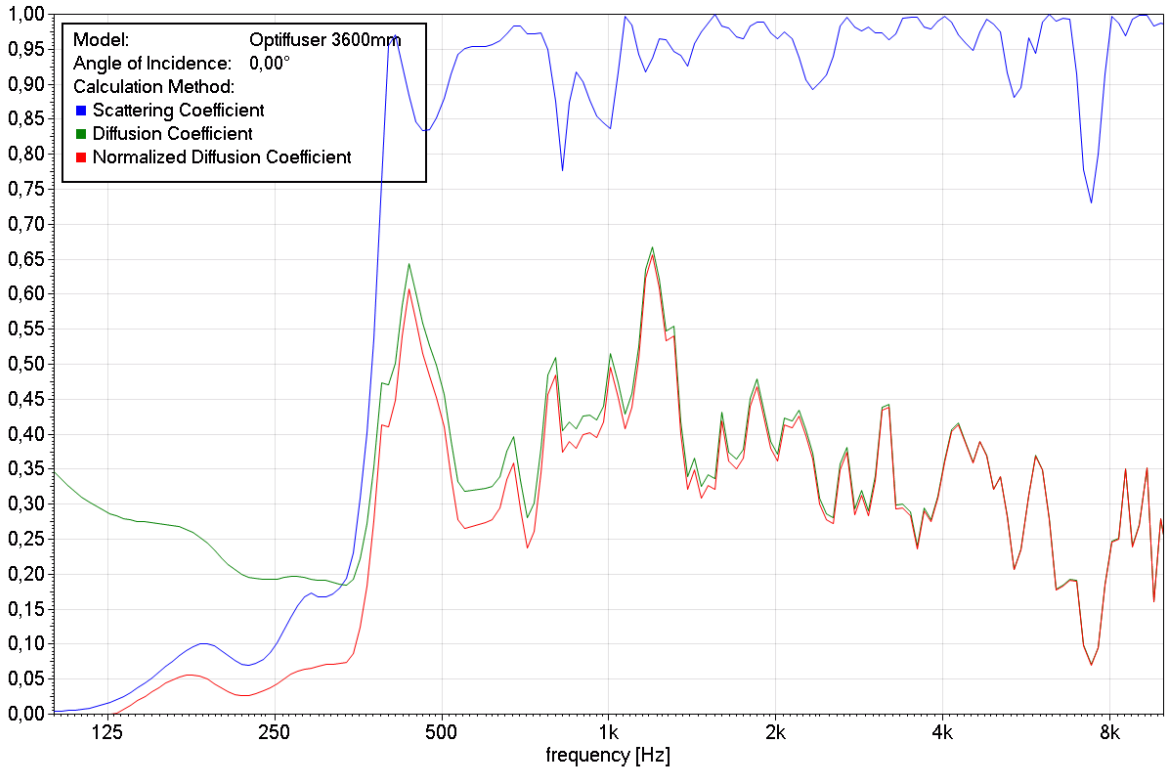






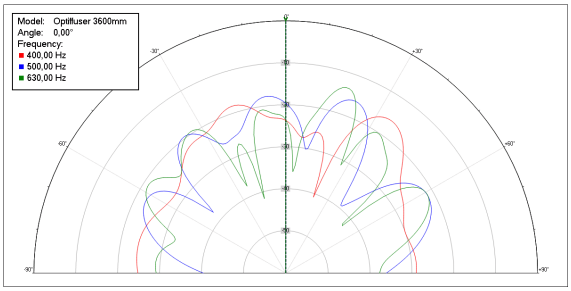
Optiffuser (again for convenience):
Random & normal incidence, 3,6 meter (three 1,2 m periods) panel:

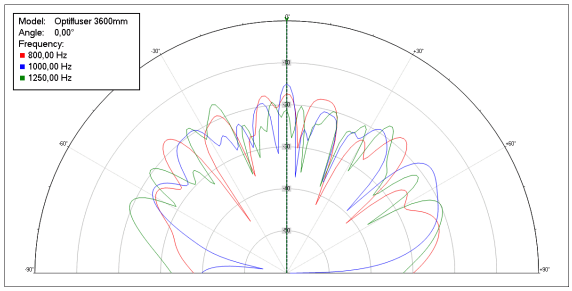


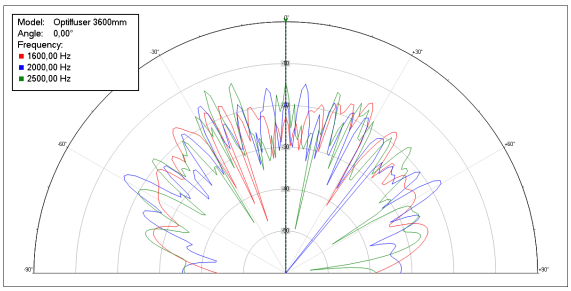


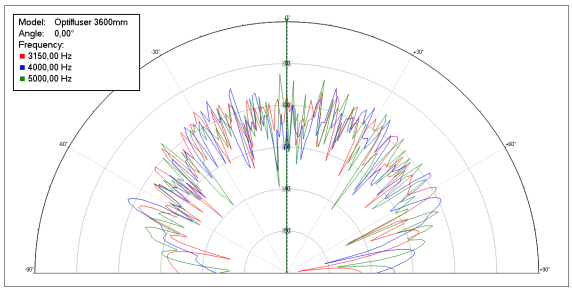
Optiffuser:

Polar plots, normal incidence, 3,6 meter (three 1,2 m periods) panel:









Polar plots, 60 degrees incidence, 3,6 meter (three 1,2 m periods) panel: