Acoustic Emission Sensors

Specification

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Revision Record

Date	Changes
12-2015	Codes for sensor cables renamed.

Purpose of this Document

This document:

- Gives hints on how to select an appropriate AE-sensor for a specific application and AE-sensor handling
- Describes physical dimensions, frequency range and environmental conditions of Vallen AE-sensors
- Provides reference frequency response diagrams for certain AE-sensor types.

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1 Introduction

The sensor constitutes the first part in an AE measurement chain and as of this is of particular importance. A subsequent measurement system can only process signals which the AE-sensor picked up. Anything an AE-sensor does not pick up is lost for analysis.

An AE-sensor converts the surface movement caused by an elastic wave into an electrical signal which can be processed by the measurement equipment. The piezoelectric element of the AE-sensor should pick up faintest surface movements (i.e. have high sensitivity) and convert this movement most efficiently to an electrical voltage.

AE-sensors can be designed highly sensitive at a certain frequency (also termed resonant) or with a broad frequency response (broad band). Special AE-sensor models for high temperatures are also available as well as ATEX certified sensors for installation in hazardous area. Our ATEX certified sensors are not part of this specification but described in an own specification (see Note below).

The following sections of this document give an overview about the right AE-sensor selection for an application and detailed specifications of the Vallen Systeme sensor product range.

2 Guide for Acoustic Emission Sensor Selection

Vallen Systeme GmbH provides various sensors for all kinds of AE-applications. Selecting an appropriate sensor for a specific AE-application is crucial for the success of the measurement. In most cases the main criterion for the AE-sensor selection should be the frequency response which must suit the application. In some special applications environmental and legal requirements (e.g. high temperature, water/oil tightness, hazardous area installation) may pose more severe restrictions on AE-sensor selection than the frequency response. This chapter gives useful hints on how to select a suitable AE-sensor for every application. For more information about our AE-sensors, AE-sensor selection or specific applications please contact us directly at info@vallen.de.

2.1 Environmental conditions

The majority of AE-sensors are specified for normal environmental conditions as one would face during field testing or in the lab. However some applications on hot machinery surfaces require special AE-sensors. Using the AE-sensors outside of the specified temperature range could cause permanent damage to the sensor or corrupt the sensor signal. For high temperature environments only a few AE-sensors may be suitable and the temperature range should be the first criterion to constrict the AE-sensor variety.

Some applications have a demand for AE-sensors suitable for installation in hazardous areas or for water-/oil resistant AE-sensors. Special solutions are available for this demand and need to be first priority for the AE-sensor selection.

Note: AE-sensors for hazardous areas
Vallen Systeme offers an intrinsically safe product family (ISAFE3). This product family is ATEX certified and consists not only of a family of AE-sensors but also of special signal isolator to fulfil all safety requirements for hazardous areas of zone 0, zone 1 or zone 2. For more details please see the ‘Vallen ISAFE3 Operation Manual’ or contact us at info@vallen.de.

2.2 Frequency range

Vallen Systeme follows a coarse and arbitrary classification into 3 frequency regimes, which is justified by the fact that most applications can be classified into one of these frequency regimes: low (20 kHz - 100 kHz), standard (100 kHz - 400 kHz) and high (>400 kHz). Attenuation per unit distance increases with frequency. For most applications, frequencies above 400 kHz are meaningless and are cut-off in order to minimize electronic noise. Some standard preamplifiers and signal processors are able to process frequencies up to 2.2 MHz (e.g. AMSY-6). The classification in low-, standard- and high frequency regime is arbitrary and there are applications which use different frequency classes dependent on the presence of background noise (move to higher frequencies) or wide sensor spacing (move to lower frequencies). However, for the majority of applications this classification is useful for getting a fast overview.

AE-sensors that respond uniformly to a very broad band of exciting frequencies are referred to as broadband or wideband sensors. Wideband AE-sensors with a flat response curve are usually desired if the frequency of interest is still unknown (e.g. research or feasibility study) or if different frequencies in one signal should be analyzed (e.g. modal analysis).

Most AE-sensors are of resonant type which means they are most sensitive at their resonance frequency. These AE-sensors may have other frequency bands where their sensitivity is low. The resonance frequency is the decisive factor for which application these AE-sensors can be used.

Resonant AE-sensors are usually used if the frequency content itself is not of interest but only AE features such as amplitude, arrival time or energy. To clarify: These features are - to some extend - affected by the peak frequency and frequency range of the AE-sensor. Therefore AE-features can only be compared if recorded with the same AE-sensor type.

Finding the right frequency range for a specific application has to consider factors such as material, specimen size and background noise. Attenuation is frequency dependent: the higher the frequency, the higher is the attenuation per unit distance. Usually the AE-sensor spacing can be extended when moving to lower frequencies. On the other hand background noise, such as from production machinery, is usually more prominent in lower frequency range (<100 kHz). Therefore false triggering can be avoided when moving to higher frequencies.

Note:

Most EN- or ASTM standards recommend a frequency range for an application and an operator or inspector should stick to this recommendation.

2.2.1 Overview of frequency regimes and applications

Certain frequency ranges have been proven to be best suitable for specific applications.

Application	20-100 kHz	100-400 kHz	>400 kHz
Corrosion screening of flat bottom storage tanks	x		
Leakage detection in water/oil pipelines	x		
Hot reheat pipe crack detection		x	
Integrity testing of pressure vessels		x	
Partial discharge detection	x (when noise is low)	x	
Integrity testing of metallic structures		x	
Integrity testing of composite materials		x	
Integrity testing of concrete structures	x		
Drying process monitoring of plants/wood		x	
AE-testing of small specimen			x

2.2.2 Determining the correct frequency range of AE-sensors for an integrity testing application

The elastic wave is usually heavily affected by the propagation mechanisms before it reaches the AE-sensor. The frequency content of the wave is particularly affected by the source mechanism as well as the material through which the wave propagates.

The material in which an elastic wave propagates has a very inhomogeneous effect on the frequency distribution; attenuating certain frequencies stronger than others. Also wave propagation could be affected by macroscopic features of the test object, e.g. dispersion (different wave velocities at different frequencies) in plate like structures.

The correct frequency range for a certain application can be determined experimentally where possible. A very flat-response broadband AE-sensor and AE-measurement equipment is needed. The broadband AE-sensor shall be mounted to the object. Pencil lead breaks (Hsu-Nielsen source) are used to excite elastic waves which the AE-sensor picks up. The waveforms of the measured signals can be characterized for their primary frequency content by performing Fast Fourier Transforms (FFT) on the signals. The FFTs should be done on the time periods of the signal that have the highest amplitudes. AE-sensor selection is guided by the primary frequency content identified by the FFTs. An AE-sensor (wideband or resonant) should have significant response over the range of frequencies excited with the highest amplitudes.

Note for AE-source mechanisms not related to crack initiation or - propagation:

The above mentioned method is applicable in cases were a pencil lead break is a good equivalent for an AE-source. This may not be the case for all AE source mechanisms (e.g. leakage). A similar approach would be possible if a different artificial AE-source is applied which is similar to the expected source.

Note for plate like structures:

If the object under test is a plate like structure, pencil lead breaks should be performed in a sufficient distance from the AE-sensor in order that only plate waves excite the AE-sensor. Usually distances larger than 20x plate thickness are sufficient. Additionally pencil lead breaks should be made on the top (or bottom side) of the plate, to generate asymmetric wave modes, and, if possible, at the center of the plate's edge to generate symmetrical wave modes.

2.3 AE-sensor size and frequency response

The size of the piezoelectric element affects the resonance frequency of the AE-sensor. In general the resonance frequency is higher for smaller piezo-elements. Therefore the desired resonance frequency has a major influence on the sensor size; i.e. the lower the frequency range of an AE-sensor the larger its size.

2.4 Integrated preamplifier vs. external preamplifier

Vallen Systeme GmbH provides AE-sensors with and without integrated preamplifier. AE-sensors with integrated preamplifier are referred to as active sensors, whereas those without integrated preamplifiers are referred to as passive sensors. In general AE-sensors with integrated preamplifier are larger and heavier than similar AE-sensors without integrated preamplifier. However, AE-sensors with integrated preamplifier are better suited for usage in the field, because measurement setup can be realized faster and the number of connectors which can be mixed-up is reduced. Especially thin cables such as the sensor-to-preamplifier cable may be troublesome in the field since they must be handled with extra care.

Passive AE-sensors require an external preamplifier. The cable length between AE-sensor and external preamplifier is usually 1.2 meters and should not be further extended unless the setup cannot be realized with this cable length. The shorter the cable from sensor to preamplifier, the higher is the sensitivity of the sensor. The lower the AE-sensor's capacity, the worse the influence of cable length on the sensitivity. The cable transmitting the signal from the preamplifier to the measuring system can be several hundred meters long.

In general AE-sensors with integrated preamplifier are more cost effective than a similar passive AE-sensor together with an external preamplifier. The additional costs of the second solution can be justified by a more flexible setup when for instance the gain of the external preamplifier or the frequency response of AE-sensor needs to be adapted for different applications.

2.5 Sensor coupling verification pulse

The piezoelectric element of an AE-sensor transforms mechanical vibrations into an electrical signal. In turn, an electrical pulse applied to the piezoelectric element results in a mechanical excitation which could be used to emit a mechanical wave into the test object. This wave can be used for instance to verify the sensor coupling quality.

A voltage pulse is transmitted from the AE system (i.e. AMSY series) through the preamplifier to the AE-sensor and generates a wave in the structure under test. The wave from the pulsing AE-sensor propagates through or along the test object and can be picked up by neighboring AE-sensors. The amplitude of the received AE-signal gives an indication whether an AE-sensor is coupled appropriately to the structure.

The preamplifier must support the so-called "pulse through" functionality. That means, the preamplifier, when not supplied by 28 V_{DC}, internally disconnects the preamplifier output from the cable that delivers the high voltage pulse, in order to prevent damage from the preamplifier,

and connects the high voltage pulse to the piezo electric sensor element. Preamplifiers that do not support the pulse through functionality must not be used for pulsing, because they might get damaged permanently. The user of an AMSY-6 (or its predecessors) can define in a software menu which kind of preamplifier is connected to a signal processor. All Vallen Systeme external preamplifiers (i.e. AEP series, see “Acoustic Emission Preamplifier” document) support the pulse through capability. Most Vallen Systeme AE-sensors with integrated preamplifiers also support the pulse through functionality. This is indicated by a “C” (calibration bypass) at the end of the AE-sensor name, e.g. VS150-RI**C** (see Chapter 3 AE-sensor nomenclature). All passive AE-sensors (without integrated preamplifier) can be used for pulsing anyway.

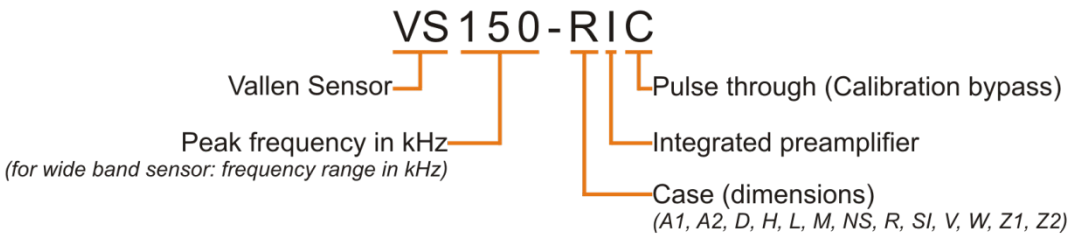
Vallen Systeme supports another pulsing mode for its intrinsically safe AE-sensors. Hereby only a low energy control signal is transmitted from the signal processor to the sensor and sensor-internal electronics is used to supply a high energetic pulse to the piezoelectric element, because high energetic pulses are prohibited on intrinsically safe circuit cables.

By investigating the post-pulse oscillation of the piezoelectric element, which is influenced by coupling, the coupling quality of the pulsing AE-sensor can be verified. This coupling verification method is referred to as ‘auto sensor test - self test mode' in ASTM E2374-04.

Investigating the pulse received by neighboring sensors is called 'auto sensor test - near neighbor mode’.

3 AE-sensor nomenclature

Most Vallen Sensors are named systematically by its peak frequency and information about the case type and preamplifier information:



Third party sensors are labeled differently, these sensors are AE*xxxx*, M31 and M58.

4 Overview of AE sensors

The following tables give a short overview of the main parameters of sensors. The column “Details on page” refers to the page where you find a more detailed description and the frequency response curve of the respective sensor.
For specification of sensor cables and magnetic holders please see our specification of “Accessories for Acoustic Emission Systems”. For information about preamplifiers (external preamplifiers as well as preamplifiers integrated in sensor) please see our specification of “Acoustic Emission Preamplifiers”.

4.1 Standard environment models

AE-sensor Model	Freq. Range [kHz]	f_{Peak} [kHz]	Details on page	Size DxH [mm]	Weight [g]	Case Material	Wear Plate	Temp. Range [°C]	Connector	Capa-city [pF]	Comment	Magnetic holder
VS30-V	25-80		15	20.3 x 37	69	Stainless steel	Ceramics	-5 to +85	Microdot	140		MAG4V
VS30-SIC-46dB	25-80		16	28.6 x 51.8	170	Stainless steel	Ceramics	-5 to +85	BNC		Integrated preamplifier: 46dB gain	MAG4SI
VS45-H	20-450	280	17	20.3 x 22	36	Aluminum	Ceramics	-20 to +100	Microdot	270		MAG4H
VS75-V	30-120	75	18	20.3 x 37	63	Stainless steel	Ceramics	-5 to +85	Microdot	140		MAG4V
VS75-SIC-34dB VS75-SIC-40dB	30-120	75	19 20	28.6 x 51.8	162	Stainless steel	Ceramics	-5 to +85	BNC		Integrated preamp.: 34dB gain Integrated preamp.: 40dB gain	MAG4SI
VS75-SI-40dB	30-120	75	21	28.6 x 51.8	161	Stainless steel	Ceramics	-5 to +85	BNC		Integrated preamp.: 40dB gain No pulse through	MAG4SI
VS150-M	100-450	150	22	20.3 x 14.3	24	Stainless steel	Ceramics	-50 to +100	Microdot	350		MAG4M
VS150-MS	100-450	150	23	20.3 x 14.3	24	Stainless steel	Ceramics	-50 to +100	SMC	350		MAG4M
VS150-L	100-450	150	24	20.3 x 14.3	26	Stainless steel	Stainless steel	-50 to +100	SMC	350		MAG4M

AE-sensor Model	Freq. Range [kHz]	f_{Peak} [kHz]	Details on page	Size DxH [mm]	Weight [g]	Case Material	Wear Plate	Temp. Range [°C]	Connector	Capa-city [pF]	Comment	Magnetic holder
VS150-R	100-450	150	25	28.6 x 31.5	81	Stainless steel	Ceramics	-40 to +85	BNC	350		MAG4R
VS150-K	100-450	150	26	20.3 x 22	45	Stainless steel	Stainless steel	-50 to +100	SMC	350	Enhanced ingress protection rating IP54 with connected cable.	MAG4H
VS150-RI	100-450	150	none	28.6 x 31.5	81	Stainless steel	Ceramics	-40 to +85	BNC		Integrated preamp.: 40dB gain No pulse through	MAG4R
VS150-RIC	100-450	150	27	28.6 x 31.5	81	Stainless steel	Ceramics	-40 to +85	BNC		Integrated preamp.: 34dB gain	MAG4R
VS370-A1	170-590	370	28	M7x0.75 x 13.5	3	Stainless steel	Stainless steel	-40 to 125	SMC (top)	47		MAG4A1
VS370-A2	170-590	370	29	8.5 x 13 M7x0.75 x 8.5	3.5	Stainless steel	Stainless steel	-40 to 125	SMC (top)	47	optimized for magnetic holder MAG4A1	MAG4A1
VS375-M	250-700	375	30	20.3 x 14.3	21	Stainless steel	Ceramics	-50 to +100	Microdot	390		MAG4M
VS375-RIC	250-700	375	31	28.6 x 31.5	80	Stainless steel	Ceramics	-40 to +85	BNC		Integrated preamp.: 34dB gain	MAG4R
VS600-A1	390-850	600	32	M7x0.75 x 13.5	2.5	Stainless steel	Stainless steel	-40 to 125	SMC (top)	109		MAG4A1
VS600-A2	390-850	600	33	8.5 x 13 M7x0.75 x 8.5	3	Stainless steel	Stainless steel	-40 to 125	SMC (top)	109	optimized for magnetic holder MAG4A1	MAG4A1

AE-sensor Model	Freq. Range [kHz]	f_{Peak} [kHz]	Details on page	Size DxH [mm]	Weight [g]	Case Material	Wear Plate	Temp. Range [°C]	Connector	Capa-city [pF]	Comment	Magnetic holder
VS600-Z1	550-730	600	34	4.75 x 5.8	0.8[1] 20[2]	Stainless steel	Ceramics	-10 to +110	SMA/BNC[3]	200[4]	100 cm integral cable	-
VS600-Z2	400-800	600	35	4.75 x 5.3	0.8[1] 20[2]	Stainless steel	Stainless steel	-40 to +110	SMA/BNC[3]	200[4]	100 cm integral cable	-
VS700-D	150-800	600 - 800	36	6.3 x 10	1.5[1] 20[2]	E-copper, tinned	Neodyne	-20 to +70	SMA/BNC[3]	163[4]	35 cm integral cable	Integral
VS900-M	100-900	350	37	20.3 x 14.3	22	Stainless steel	Ceramics	-50 to +100	Microdot	540		MAG4M
VS900-RIC	100-900	350	38	28.6 x 31.5	80	Stainless steel	Ceramics	-40 to +85	BNC		Integrated preamp.: 34 dB gain	MAG4R

4.2 Watertight AE-sensors

AE-sensor Model	Freq. Range [kHz]	f_{Peak} [kHz]	Details on page	Size DxH [mm]	Weight [g]	Case Material	Wear Plate	Temp. Range [°C]	Connector	Capa-city [pF]	Comment	Magnetic holder
VS150-K2	100-450	150	39	20.3 x 22	56	Stainless steel	Stainless steel	-40 to +100	SMC on 1 m integrated cable	350	IP code IP68	MAG4H

[1] Weight without integral cable
[2] Weight with integral cable
[3] SMA to BNC adapter included
[4] Capacity with integral cable

AE-sensor Model	Freq. Range [kHz]	f_{Peak} [kHz]	Details on page	Size DxH [mm]	Weight [g]	Case Material	Wear Plate	Temp. Range [°C]	Connector	Capa-city [pF]	Comment	Magnetic holder
VS150-WIC-V01	100-450	150	40	32.0 x 48.0	184	Stainless steel	Ceramics	-40 to +85	LEMO		Integrated preamp.: 34dB gain IP code IP68 with con. cable	MAG4W -V1
VS375-WIC-V01	250-700	375	41	32.0 x 48.0	181	Stainless steel	Ceramics	-40 to +85	LEMO		Integrated preamp.: 34dB gain IP code IP68 with con. cable	MAG4W -V1
VS900-WIC-V01	100-900	350	42	32.0 x 48.0	184	Stainless steel	Ceramics	-40 to +85	LEMO		Integrated preamp.: 34dB gain IP code IP68 with con. cable	MAG4W -V1

4.3 High temperature AE-sensor

AE-sensor Model	Freq. Range [kHz]	f_{Peak} [kHz]	Details on page	Size DxH [mm]	Weight [g]	Case Material	Wear Plate	Temp. Range [°C]	Connector	Capa-city [pF]	Comment	Magnetic holder
VS160-NS	100-450	150	43	20.3 x 14.3	22	Stainless steel	Ceramics	-50 to +180	SMC	350		MAG4NS

4.4 AE-sensors for hazardous areas

Vallen Systeme offers an intrinsically safe product family (ISAFE3). This product family is ATEX certified and consists not only of a family of AE-sensors but also of special signal isolator to fulfil all safety requirements for hazardous areas of zone 0, zone 1 or zone 2. For more details please see the ‘Vallen ISAFE3 Operation Manual’ or contact us at info@vallen.de.

4.5 Third party AE-sensors with longer delivery time

AE-sensor Model	Freq. Range [kHz]	f_{Peak} [kHz]	Details on page	Size DxH [mm]	Weight [g]	Case Material	Wear Plate	Temp. Range [°C]	Connector	Capa-city [pF]	Comment	Magnetic holder
AE1045S	100-1500	Flat	44	20 x 20	31	Stainless steel	Ceramics	-20 to +80	Microdot	89		MAG4S

AE-sensor Model	Freq. Range [kHz]	f_{Peak} [kHz]	Details on page	Size DxH [mm]	Weight [g]	Case Material	Wear Plate	Temp. Range [°C]	Connector	Capa-city [pF]	Comment	Magnetic holder
AE2045S	200-2500	Flat	44	20 x 20	31	Stainless steel	Ceramics	-20 to +80	Microdot	140		MAG4S
AE104A	100-400	Flat	45	8 x 18	5	Stainless steel	Ceramics	-20 to +80	Microdot	40		MAG4A
AE105A	450-1150	800	45	8 x 18	5	Stainless steel	Ceramics	-20 to +80	Microdot	60		MAG4A
AE144A	100-500	200	45	8 x 18	5	Stainless steel	Ceramics	-20 to +80	Microdot	30		MAG4A
AE204A	180-700	375	46	8 x 18	5	Stainless steel	Ceramics	-20 to +80	Microdot	46		MAG4A
M31	300-800	750	46	3 x 3	0.2[5]	Stainless steel	Ceramics	-20 to +80	Microdot / BNC[6]	89[7]	50 cm integral cable	-
M58	700-900	750 and 800	46	5 x 3	0.4[5]	Stainless steel	Ceramics	-20 to +80	Microdot / BNC[6]	260[7]	100 cm integral cable	-

Note:
The lower the AE-sensor's capacity the worse the influence of cable length

[5] Weight without integral cable
[6] Microdot to BNC adapter included
[7] Capacity with integral cable

5 AE-Sensor Data Sheets

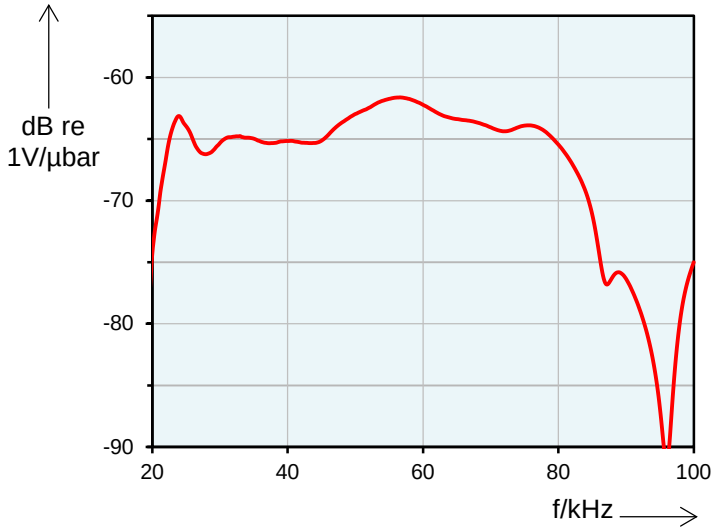
For specification of sensor cables and magnetic mounting holders please see our specification of “Accessories for Acoustic Emission Systems”. For information about preamplifiers (external preamplifiers as well as preamplifiers integrated in sensor) please see our specification of “Acoustic Emission Preamplifiers”.

5.1 Standard environment AE-sensors

5.1.1 VS30-V

VS30-V

The VS30-V is a passive piezoelectric AE-sensor. The low frequency response makes it especially suited for monitoring large objects or objects made of highly attenuating material. The VS30-V can be used for tank floor corrosion and leak detection, leak detection in pipelines, partial discharge detection and integrity testing of concrete structures.
Remark to frequency response curve below: cable used: RG 178/ 0.3m. VS30-V has 6 dB less sensitivity if used with 1.2 m long cable.



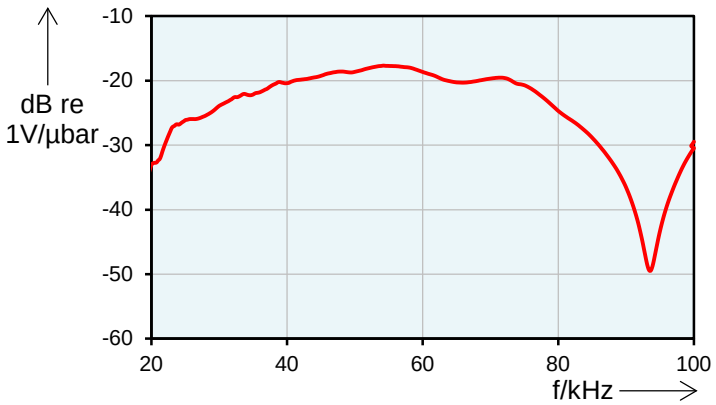
Technical Specification			
Frequency Range (f_{Peak}) [kHz]	25 to 80	**Size (D x H) [mm]**	20.3 x 37.0
Capacity [pF]	140	**Weight [g]**	69
Integrated Preamplifier	No	**Case Material**	Stainless Steel (1.4571/ 1.4404)
Operating Temperature [°C]	-5 to +85	**Wear Plate**	Ceramics
Vibration – Sinus Sweep	2 Oct/Min, 5 to 180 Hz, 40 g	**Connector**	Microdot
Ingress Protection Rating	IP40	**Shield Cross-Talk [dB]**	< -80

Accessories			
Preamplifier	AEP5, AEP3N, AEP4H-ISTB	**Sensor Cable**	CBL-1-1M2-V5
Mounting Holder	MAG4V, AEP4H-ISTB		

5.1.2 VS30-SIC-46dB

VS30-SIC-46dB

The VS30-SIC-46dB is a piezoelectric AE-sensor with integrated preamplifier. The low frequency response makes it especially suited for monitoring large objects or objects made of highly attenuating material. The VS30-SIC-46dB can be used for tank floor corrosion and leak detection, leak detection in pipelines, partial discharge detection and integrity testing of concrete structures.
The integrated preamplifier has 46 dB gain and supports pulse through for automatic sensor testing.



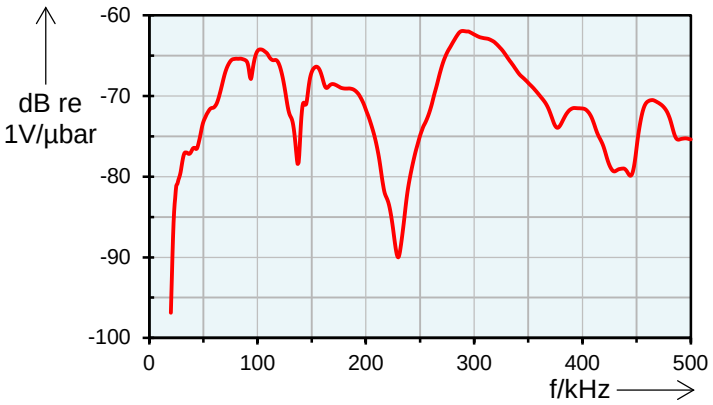
Technical Specification			
Frequency Range (f_{Peak}) [kHz]	25 to 80	**Size (D x H) [mm]**	28.6 x 51.8
Power Supply [V_{DC}]	28 ± 2	**Weight [g]**	170
Typ. Power [W]	0.56 / 2.5 @ Signal 0% / 100%	**Case Material**	Stainless Steel (1.4571/ 1.4404)
Integrated Preamplifier	Yes	**Wear Plate**	Ceramics
Preamplifier Gain [dB]	46	**Connector**	BNC
Pulse Through	Yes	**Shield Cross-Talk [dB]**	< -80
Operating Temperature [°C]	-5 to +85	**Typ. Noise (max. 1/s) [$dB_{AE\ Peak}$]**	18.5 @ 25 - 45 kHz
Vibration – Sinus Sweep	2 Oct/Min, 5 to 50 Hz, 20 g	**Typ. Noise [μV_{RMS}]**	2.6 @ 25 - 45 kHz
Ingress Protection Rating	IP40		

Accessories			
Mounting Holder	MAG4SI	**Sensor Cable**	CBL-1-xM-V1

5.1.3 VS45-H

VS45-H

The VS45-H is a passive piezoelectric AE-sensor with a wide frequency response. Its frequency response is characterized by a peak at 280 kHz and can be used in the frequency range from 40 kHz to 450 kHz. It is a broad band response AE-sensor covering the low frequency and standard frequency range.



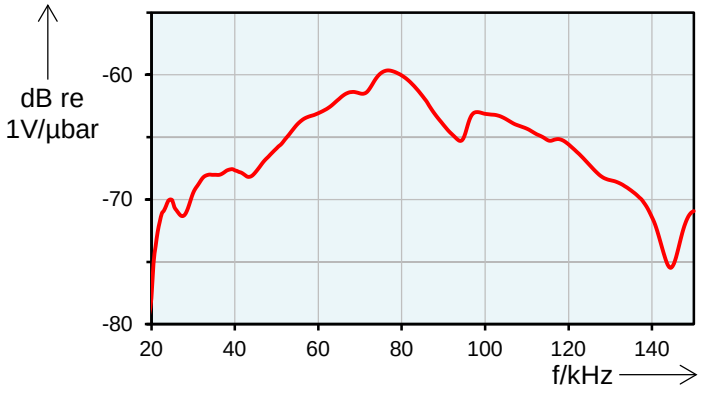
Technical Specification			
Frequency Range (f_{Peak}) [kHz]	20 to 450 (280)	**Size (D x H) [mm]**	20.3 x 22.0
Capacity [pF]	270	**Weight [g]**	36
Integrated Preamplifier	No	**Case Material**	Stainless Steel (1.4571/ 1.4404)
Operating Temperature [°C]	-20 to +100	**Wear Plate**	Ceramics
Vibration – Sinus Sweep	2 Oct/Min, 5 to 180 Hz, 40 g	**Connector**	Microdot
Ingress Protection Rating	IP40	**Shield Cross-Talk [dB]**	< -80

Accessories			
Preamplifier	AEP5, AEP3N	**Sensor Cable**	CBL-1-1M2-V5
Mounting Holder	MAG4H		

5.1.4 VS75-V

VS75-V

The VS75-V is a passive piezoelectric AE-sensor. Its frequency response is characterized by a peak at 75 kHz where it exhibits a resonance. The low frequency response makes it suited for monitoring large objects or objects made of highly attenuating material. The VS75-V can be used for integrity testing of bitumen coated pressure vessels and for detecting partial discharge.
Remark to frequency response curve below: cable used: RG 178/ 0.3m. VS75-V has 6 dB less sensitivity if used with 1.2 m long cable.



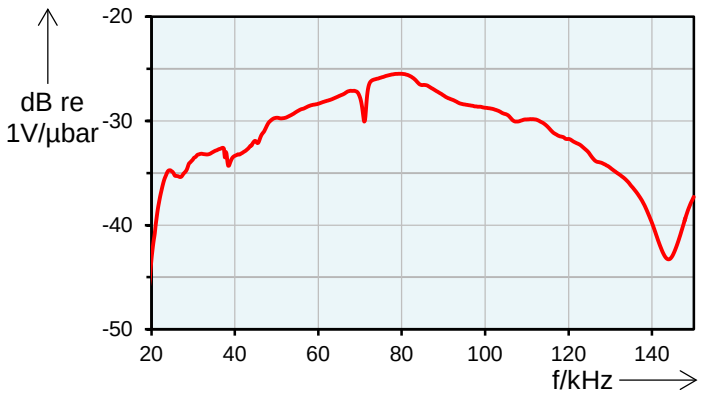
Technical Specification			
Frequency Range (f_{Peak}) [kHz]	30 to 120 (75)	**Size (D x H) [mm]**	20.3 x 37.0
Capacity [pF]	140	**Weight [g]**	63
Integrated Preamplifier	No	**Case Material**	Stainless Steel (1.4571/ 1.4404)
Operating Temperature [°C]	-5 to +85	**Wear Plate**	Ceramics
Vibration – Sinus Sweep	2 Oct/Min, 5 to 180 Hz, 40 g	**Connector**	Microdot
Ingress Protection Rating	IP40	**Shield Cross-Talk [dB]**	< -80

Accessories			
Preamplifier	AEP5, AEP3N	**Sensor Cable**	CBL-1-1M2-V5
Mounting Holder	MAG4V		

5.1.5 VS75-SIC-34dB

VS75-SIC-34dB

The VS75-SIC-34dB is an AE-sensor with integrated preamplifier. Its frequency response is characterized by a peak at 75 kHz where it exhibits a resonance. The low frequency response makes it suited for monitoring large objects or objects made of highly attenuating material. The VS75-SIC-34dB can be used for integrity testing of bitumen coated pressure vessels and for detecting partial discharge.
The integrated preamplifier has 34 dB gain and supports pulse through for automatic sensor testing.



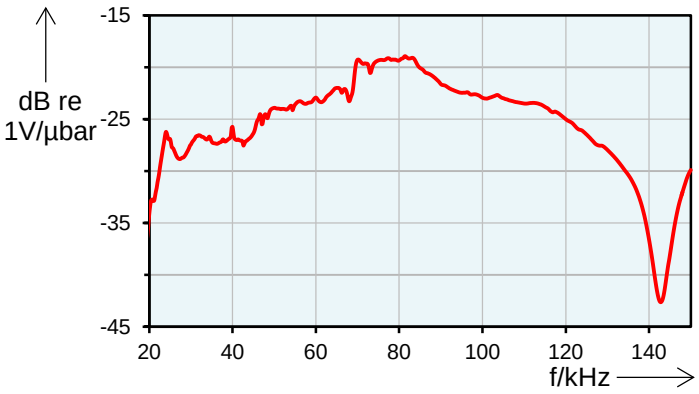
Technical Specification			
Frequency Range (f_{Peak}) [kHz]	30 to 120 (75)	**Size (D x H) [mm]**	28.6 x 51.8
Power Supply [V_{DC}]	28 ± 2	**Weight [g]**	162
Typ. Power [W]	0.56 / 2.5 @ Signal 0% / 100%	**Case Material**	Stainless Steel (1.4571/ 1.4404)
Integrated Preamplifier	Yes	**Wear Plate**	Ceramics
Preamplifier Gain [dB]	34	**Connector**	BNC
Pulse Through	Yes	**Shield Cross-Talk [dB]**	< -80
Operating Temperature [°C]	-5 to +85	**Typ. Noise (max. 1/s) [$dB_{AE\ Peak}$]**	29.2 @ 25 - 300 kHz
Vibration – Sinus Sweep	2 Oct/Min, 5 to 50 Hz, 20 g	**Typ. Noise [μV_{RMS}]**	6.8 @ 25 - 300 kHz
Ingress Protection Rating	IP40		

Accessories			
Mounting Holder	MAG4SI	**Sensor Cable**	CBL-1-xM-V1

5.1.6 VS75-SIC-40dB

VS75-SIC-40dB

The VS75-SIC-40dB is a piezoelectric AE-sensor with integrated preamplifier. Its frequency response is characterized by a peak at 75 kHz where it exhibits a resonance. The low frequency response makes it suited for monitoring large objects or objects made of highly attenuating material. The VS75-SIC-40dB can be used for integrity testing of bitumen coated pressure vessels and for detecting partial discharge.
The integrated preamplifier has 40 dB gain and supports pulse through for automatic sensor testing.



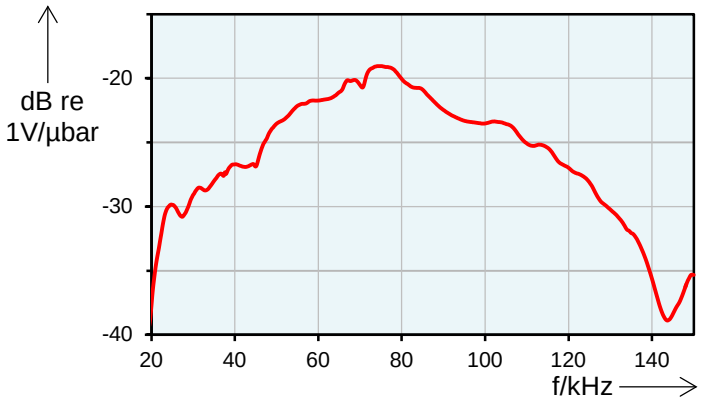
Technical Specification			
Frequency Range (f_{Peak}) [kHz]	30 to 120 (75)	**Size (D x H) [mm]**	28.6 x 51.8
Power Supply [V_{DC}]	28 ± 2	**Weight [g]**	162
Typ. Power [W]	0.56 / 2.5 @ Signal 0% / 100%	**Case Material**	Stainless Steel (1.4571/ 1.4404)
Integrated Preamplifier	Yes	**Wear Plate**	Ceramics
Preamplifier Gain [dB]	40	**Connector**	BNC
Pulse Through	Yes	**Shield Cross-Talk [dB]**	< -80
Operating Temperature [°C]	-5 to +85	**Typ. Noise (max. 1/s) [$dB_{AE\ Peak}$]**	29.5 @ 25 - 300 kHz
Vibration – Sinus Sweep	2 Oct/Min, 5 to 50 Hz, 20 g	**Typ. Noise [μV_{RMS}]**	7.3 @ 25 - 300 kHz
Ingress Protection Rating	IP40		

Accessories			
Mounting Holder	MAG4SI	**Sensor Cable**	CBL-1-xM-V1

5.1.7 VS75-SI-40dB

VS75-SI-40dB

The VS75-SIC-40dB is a piezoelectric AE-sensor with integrated preamplifier. Its frequency response is characterized by a peak at 75 kHz where it exhibits a resonance. The low frequency response makes it suited for monitoring large objects or objects made of highly attenuating material. The VS75-SIC-40dB can be used for integrity testing of bitumen coated pressure vessels and for detecting partial discharge.
The integrated preamplifier has 40 dB gain.



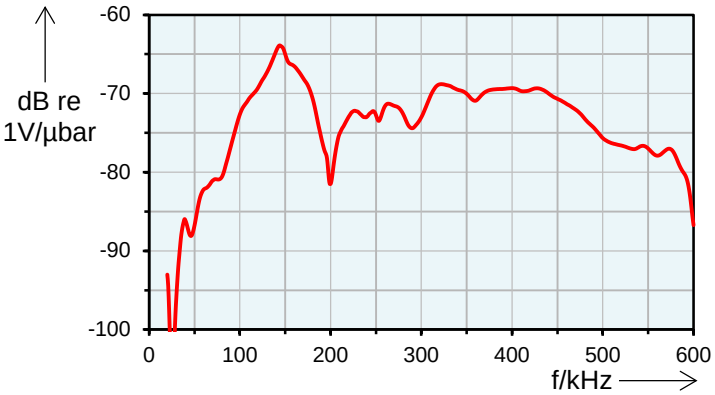
Technical Specification			
Frequency Range (f_{Peak}) [kHz]	30 to 120 (75)	**Size (D x H) [mm]**	28.6 x 51.8
Power Supply [V_{DC}]	28 ± 2	**Weight [g]**	161
Typ. Power [W]	0.56 / 2.5 @ Signal 0% / 100%	**Case Material**	Stainless Steel (1.4571/ 1.4404)
Integrated Preamplifier	Yes	**Wear Plate**	Ceramics
Preamplifier Gain [dB]	40	**Connector**	BNC
Pulse Through	No	**Shield Cross-Talk [dB]**	< -80
Operating Temperature [°C]	-5 to +85	**Typ. Noise (max. 1/s) [$dB_{AE\ Peak}$]**	29.5 @ 25 - 300 kHz
Vibration – Sinus Sweep	2 Oct/Min, 5 to 50Hz, 20 g	**Typ. Noise [μV_{RMS}]**	7.3 @ 25 - 300 kHz
Ingress Protection Rating	IP40		

Accessories			
Mounting Holder	MAG4SI	**Sensor Cable**	CBL-1-xM-V1

5.1.8 VS150-M

VS150-M

The VS150-M is a passive piezoelectric AE-sensor. Its frequency response is characterized by a peak at 150 kHz where it exhibits a resonance. It is suitable for almost all AE application and especially suited for integrity inspection of metallic pressure vessels.



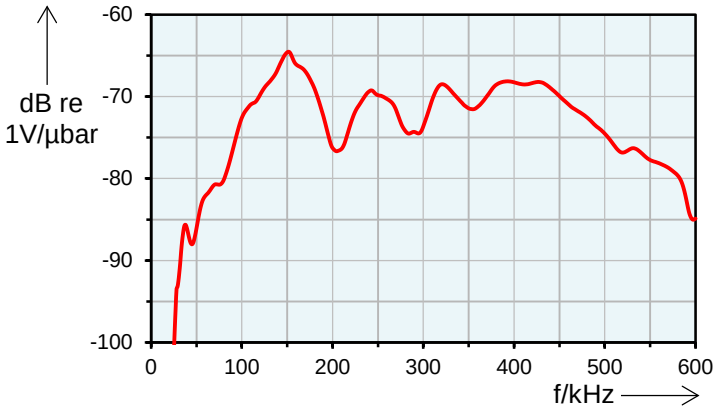
Technical Specification			
Frequency Range (f_{Peak}) [kHz]	100 to 450 (150)	**Size (D x H) [mm]**	20.3 x 14.3
Capacity [pF]	350	**Weight [g]**	24
Integrated Preamplifier	No	**Case Material**	Stainless Steel (1.4571/ 1.4404)
Operating Temperature [°C]	-50 to +100	**Wear Plate**	Ceramics
Vibration – Sinus Sweep	2 Oct/Min, 5 to 180 Hz, 40 g	**Connector**	Microdot
Ingress Protection Rating	IP40	**Shield Cross-Talk [dB]**	< -80

Accessories			
Preamplifier	AEP5, AEP3N	**Sensor Cable**	CBL-1-1M2-V5
Mounting Holder	MAG4M		

5.1.9 VS150-MS

VS150-MS

The VS150-MS is a passive piezoelectric AE-sensor. Its frequency response is characterized by a peak at 150 kHz where it exhibits a resonance. It is suitable for almost all AE application and especially suited for integrity inspection of metallic pressure vessels.



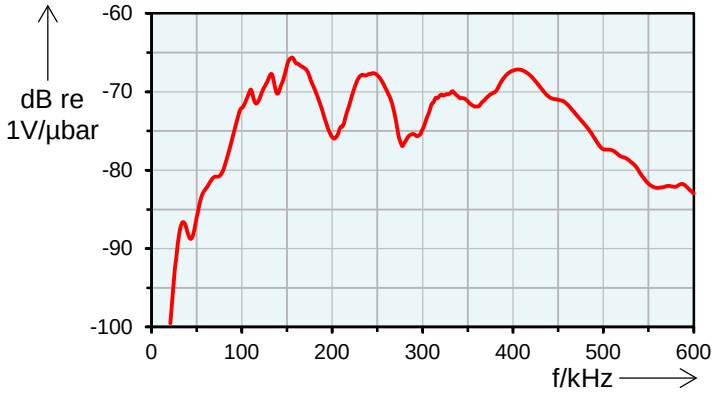
Technical Specification			
Frequency Range (f_{Peak}) [kHz]	100 to 450 (150)	**Size (D x H) [mm]**	20.3 x 14.3
Capacity [pF]	350	**Weight [g]**	24
Integrated Preamplifier	No	**Case Material**	Stainless Steel (1.4571/ 1.4404)
Operating Temperature [°C]	-50 to +100	**Wear Plate**	Ceramics
Vibration – Sinus Sweep	2 Oct/Min, 5 to 180 Hz, 40 g	**Connector**	SMC
Ingress Protection Rating	IP40	**Shield Cross-Talk [dB]**	< -80

Accessories			
Preamplifier	AEP5, AEP3N	**Sensor Cable**	CBL-1-1M2-V15
Mounting Holder	MAG4M		

5.1.10 VS150-L

VS150-L

The VS150-L is a passive piezoelectric AE-sensor. Its frequency response is characterized by a peak at 150 kHz where it exhibits a resonance. It is suitable for almost all AE application. The VS150-L has a full metal housing that makes it especially suited for adhesively mounting it to a test object. In this respect it is suited for inspecting objects that have no ferro-magnetic surface such as composites and Al alloys.



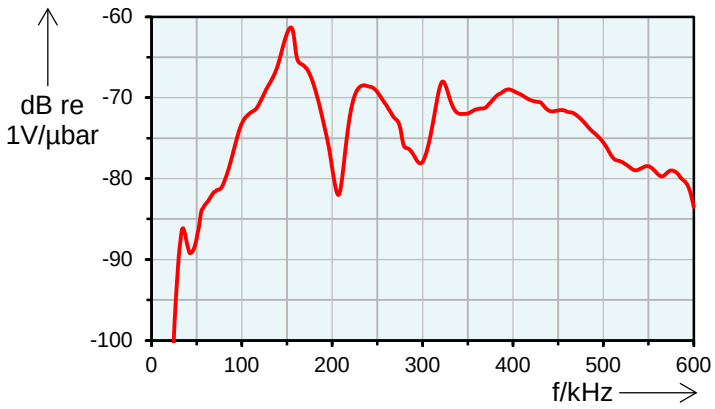
Technical Specification			
Frequency Range (f_{Peak}) [kHz]	100 to 450 (150)	**Size (D x H) [mm]**	20.3 x 14.3
Capacity [pF]	350	**Weight [g]**	26
Integrated Preamplifier	No	**Case Material**	Stainless Steel (1.4571/ 1.4404)
Operating Temperature [°C]	-50 to +100	**Wear Plate**	Stainless Steel (1.4571/ 1.4404)
Vibration – Sinus Sweep	2 Oct/Min, 5 to 180 Hz, 40 g	**Connector**	SMC
Ingress Protection Rating	IP40	**Shield Cross-Talk [dB]**	< -80

Accessories			
Preamplifier	AEP5, AEP3N	**Sensor Cable**	CBL-1-1M2-V15
Mounting Holder	MAG4M		

5.1.11 VS150-R

VS150-R

The VS150-R is a passive piezoelectric AE-sensor. Its frequency response is characterized by a peak at 150 kHz where it exhibits a resonance. It is suitable for almost all AE application and especially suited for integrity inspection of metallic pressure vessels.



Technical Specification			
Frequency Range (f_{Peak}) [kHz]	100 to 450 (150)	**Size (D x H) [mm]**	28.6 x 31.5
Capacity [pF]	350	**Weight [g]**	81
Integrated Preamplifier	No	**Case Material**	Stainless Steel (1.4571/ 1.4404)
Operating Temperature [°C]	-40 to +85	**Wear Plate**	Ceramics
Vibration – Sinus Sweep	2 Oct/Min, 5 to 180 Hz, 40 g	**Connector**	BNC
Ingress Protection Rating	IP40	**Shield Cross-Talk [dB]**	< -80

Accessories			
Preamplifier	AEP5, AEP3N	**Sensor Cable**	CBL-1-xM-V1
Mounting Holder	MAG4R		

5.1.12 VS150-K

VS150-K

The VS150-K is a passive piezoelectric AE-sensor. Its frequency response is characterized by a peak at 150 kHz where it exhibits a resonance. It is suitable for almost all AE application. The VS150-K has a full metal housing and a watertight cap and it is rated IP54. The mechanical design makes it especially suited for adhesively mounting it to a test object.

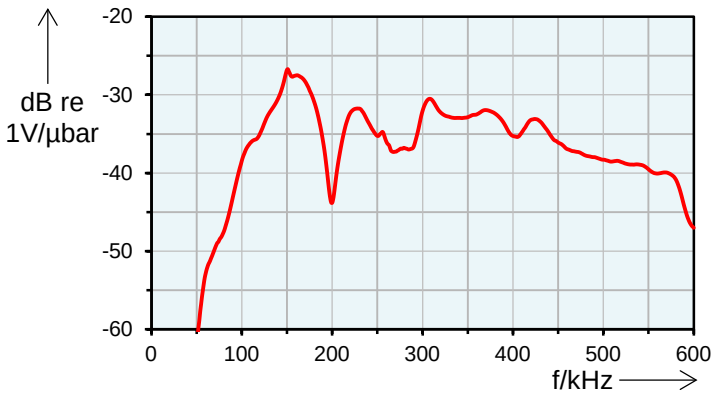
Technical Specification			
Frequency Range (f_{Peak}) [kHz]	100 to 450 (150)	**Size (D x H) [mm]**	20.3 x 22
Capacity [pF]	350	**Weight [g]**	45
Integrated Preamplifier	No	**Case Material**	Stainless Steel (1.4571/ 1.4404)
Operating Temperature [°C]	-50 to +100	**Wear Plate**	Stainless Steel (1.4571/ 1.4404)
Vibration – Sinus Sweep	2 Oct/Min, 5 to 180 Hz, 40 g	**Connector**	SMC
Ingress Protection Rating	IP54 (with connected cable)	**Shield Cross-Talk [dB]**	< -80

Accessories			
Preamplifier	AEP5, AEP3N	**Sensor Cable**	CBL-1-1M2-V15
Mounting Holder	MAG4H		

5.1.13 VS150-RIC

VS150-RIC

The VS150-RIC is a piezoelectric AE-sensor with integrated preamplifier. Its frequency response is characterized by a peak at 150 kHz where it exhibits a resonance. It is suitable for almost all AE application and especially suited for integrity inspection of metallic pressure vessels.
The integrated preamplifier has 34 dB gain and supports pulse through for automatic sensor testing.



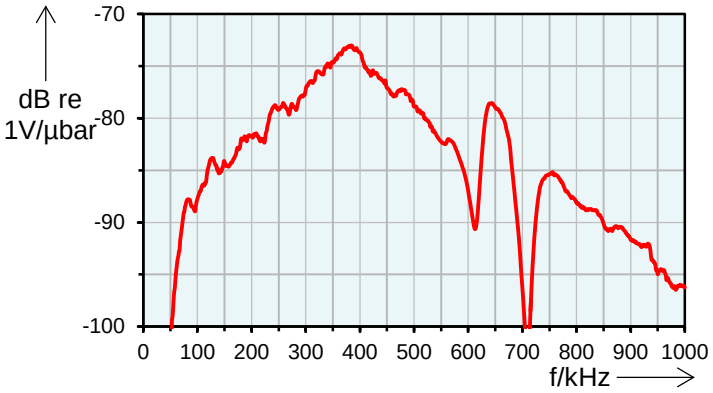
Technical Specification			
Frequency Range (f_{Peak}) [kHz]	100 to 450 (150)	**Size (D x H) [mm]**	28.6 x 31.5
Power Supply [V_{DC}]	28 ± 2	**Weight [g]**	81
Typ. Power [W]	0.56 / 2.5 @ Signal 0% / 100%	**Case Material**	Stainless Steel (1.4571/ 1.4404)
Integrated Preamplifier	Yes	**Wear Plate**	Ceramics
Preamplifier Gain [dB]	34	**Connector**	BNC
Pulse Through	Yes	**Shield Cross-Talk [dB]**	< -80
Operating Temperature [°C]	-40 to +85	**Typ. Noise (max. 1/s) [$dB_{AE\ Peak}$]**	25.2 @ 95 - 300 kHz
Vibration – Sinus Sweep	2 Oct/Min, 5 to 50 Hz, 20 g	**Typ. Noise [μV_{RMS}]**	5.0 @ 95 - 300 kHz
Ingress Protection Rating	IP40		

Accessories			
Mounting Holder	MAG4R	**Sensor Cable**	CBL-1-xM-V1

5.1.14 VS370-A1

VS370-A1

The VS370-A1 or -A2 is a passive piezoelectric AE-sensor. Its frequency response is characterized by a peak at 370 kHz where it exhibits a resonance. It is a small foot-print AE-sensor with a threaded housing and a top connector. The VS370-A* is intended for screwing it into a holding mechanism.



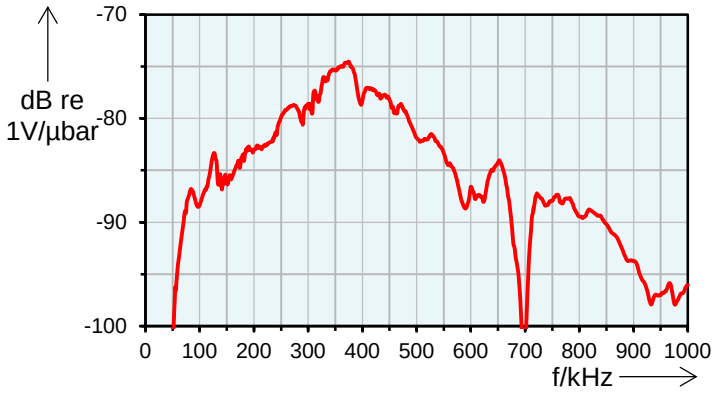
Technical Specification			
Frequency Range (f_{Peak}) [kHz]	170 to 590 (370)	**Size (D x H) [mm]**	7.0 x 13.5 (M7 x 0.75)
Capacity [pF]	47	**Weight [g]**	3
Integrated Preamplifier	No	**Case Material**	Stainless Steel (1.4571/ 1.4404)
Operating Temperature [°C]	-40 to +125	**Wear Plate**	Stainless Steel (1.4571/ 1.4404)
Vibration – Sinus Sweep	2 Oct/Min, 5 to 180 Hz, 40 g	**Connector**	SMC (top)
Ingress Protection Rating	IP40	**Shield Cross-Talk [dB]**	< -80

Accessories			
Preamplifier	AEP5, AEP3N	**Sensor Cable**	CBL-1-1M2-V15
Mounting Holder	MAG4A1		

5.1.15 VS370-A2

VS370-A2

The VS370-A1 or -A2 is a passive piezoelectric AE-sensor. Its frequency response is characterized by a peak at 370 kHz where it exhibits a resonance. It is a small foot-print AE-sensor with a threaded housing and a top connector. The VS370-A* is intended for screwing it into a holding mechanism.



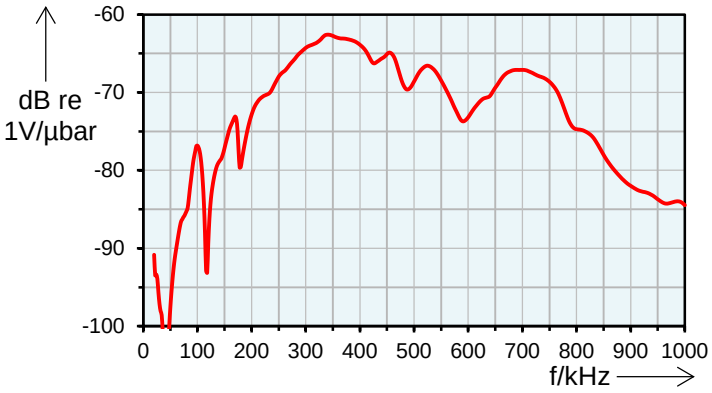
Technical Specification			
Frequency Range (f_{Peak}) [kHz]	170 to 590 (370)	**Size (D x H) [mm]**	8.5 x 13.0 (M7 x 0.75 x 8.5)
Capacity [pF]	47	**Weight [g]**	3.5
Integrated Preamplifier	No	**Case Material**	Stainless Steel (1.4571/ 1.4404)
Operating Temperature [°C]	-40 to +125	**Wear Plate**	Stainless Steel (1.4571/ 1.4404)
Vibration – Sinus Sweep	2 Oct/Min, 5 to 180 Hz, 40 g	**Connector**	SMC (top)
Ingress Protection Rating	IP40	**Shield Cross-Talk [dB]**	< -80

Accessories			
Preamplifier	AEP5, AEP3N	**Sensor Cable**	CBL-1-1M2-V15
Mounting Holder	MAG4A1		

5.1.16 VS375-M

VS375-M

The VS375-M is a passive piezoelectric AE-sensor. Its frequency response is characterized by a peak at 375 kHz where it exhibits a resonance. Its frequency response bridges the gap between standard frequency range and high frequency range. It is especially suited for integrity inspection of high energy piping in conjunction with using a waveguide.



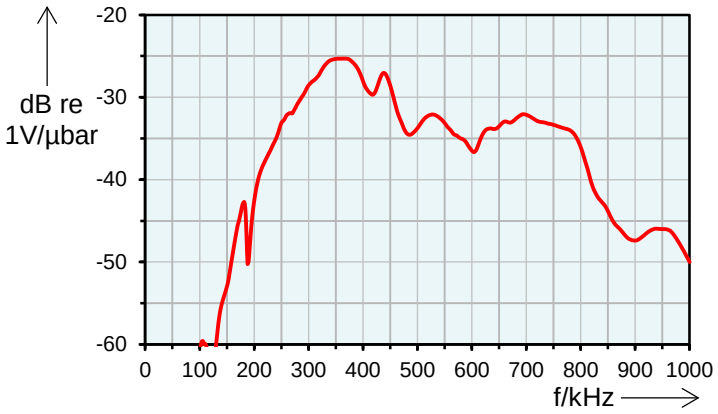
Technical Specification			
Frequency Range (f_{Peak}) [kHz]	250 to 700 (375)	**Size (D x H) [mm]**	20.3 x 14.3
Capacity [pF]	390	**Weight [g]**	21
Integrated Preamplifier	No	**Case Material**	Stainless Steel (1.4571/ 1.4404)
Operating Temperature [°C]	-50 to +100	**Wear Plate**	Ceramics
Vibration – Sinus Sweep	2 Oct/Min, 5 to 180 Hz, 40 g	**Connector**	Microdot
Ingress Protection Rating	IP40	**Shield Cross-Talk [dB]**	< -80

Accessories			
Preamplifier	AEP5, AEP3N	**Sensor Cable**	CBL-1-1M2-V5
Mounting Holder	MAG4M		

5.1.17 VS375-RIC

VS375-RIC

The VS375-RIC is a piezoelectric AE-sensor with integrated preamplifier. Its frequency response is characterized by a peak at 375 kHz where it exhibits a resonance. Its frequency response bridges the gap between standard frequency range and high frequency range.
The integrated preamplifier has 34 dB gain and supports pulse through for automatic sensor testing.



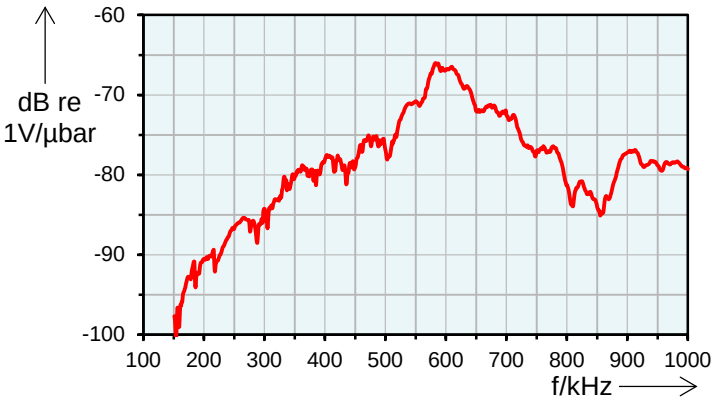
Technical Specification			
Frequency Range (f_{Peak}) [kHz]	250 to 700 (375)	**Size (D x H) [mm]**	28.6 x 31.5
Power Supply [v_{DC}]	28 ± 2	**Weight [g]**	80
Typ. Power [W]	0.56 / 2.5 @ Signal 0% / 100%	**Case Material**	Stainless Steel (1.4571/ 1.4404)
Integrated Preamplifier	Yes	**Wear Plate**	Ceramics
Preamplifier Gain [dB]	34	**Connector**	BNC
Pulse Through	Yes	**Shield Cross-Talk [dB]**	< -80
Operating Temperature [°C]	-40 to +85	**Typ. Noise (max. 1/s) [$dB_{AE\ Peak}$]**	28.0 @ 95 - 850 kHz
Vibration – Sinus Sweep	2 Oct/Min, 5 to 50 Hz, 20 g	**Typ. Noise [μV_{RMS}]**	4.5 @ 95 - 850 kHz
Ingress Protection Rating	IP40		

Accessories			
Mounting Holder	MAG4R	**Sensor Cable**	CBL-1-xM-V1

5.1.18 VS600-A1

VS600-A1

The VS600-A1 or -A2 is a passive piezoelectric AE-sensor. Its frequency response is characterized by a peak at 600 kHz where it exhibits a resonance. It is a small foot-print AE-sensor with a threaded housing and a top connector. The VS600-A* is intended for screwing it into a holding mechanism. It is suitable for monitoring the crimping process.



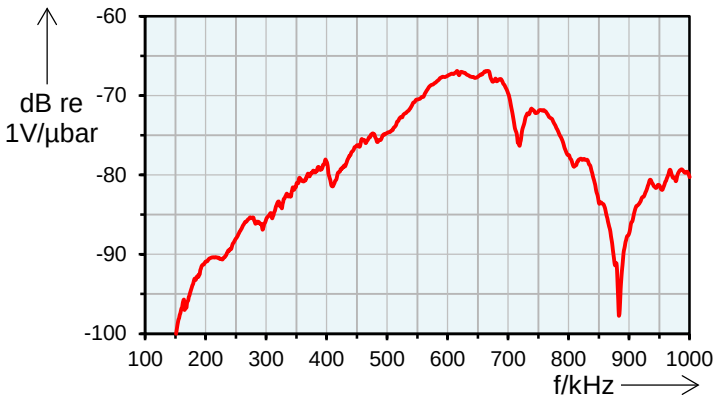
Technical Specification			
Frequency Range (f_{Peak}) [kHz]	390 to 850 (600)	**Size (D x H) [mm]**	7.0 x 13.5 (M7 x 0.75)
Capacity [pF]	109	**Weight [g]**	2.5
Integrated Preamplifier	No	**Case Material**	Stainless Steel (1.4571/ 1.4404)
Operating Temperature [°C]	-40 to +125	**Wear Plate**	Stainless Steel (1.4571/ 1.4404)
Vibration – Sinus Sweep	2 Oct/Min, 5 to 180 Hz, 40 g	**Connector**	SMC (top)
Ingress Protection Rating	IP40	**Shield Cross-Talk [dB]**	< -80

Accessories			
Preamplifier	AEP5, AEP3N	**Sensor Cable**	CBL-1-1M2-V15
Mounting Holder	MAG4A1		

5.1.19 VS600-A2

VS600-A2

The VS600-A1 or -A2 is a passive piezoelectric AE-sensor. Its frequency response is characterized by a peak at 600 kHz where it exhibits a resonance. It is a small foot-print AE-sensor with a threaded housing and a top connector. The VS600-A* is intended for screwing it into a holding mechanism. It is suitable for monitoring the crimping process.



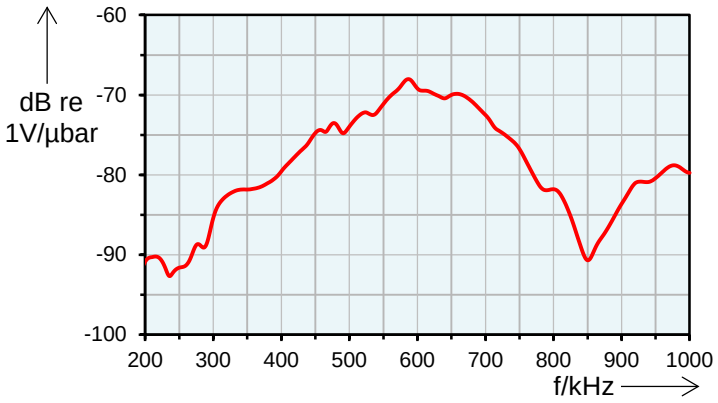
Technical Specification			
Frequency Range (f_{Peak}) [kHz]	390 to 850 (600)	**Size (D x H) [mm]**	8.5 x 13.0 (M7 x 0.75 x 8.5)
Capacity [pF]	109	**Weight [g]**	3
Integrated Preamplifier	No	**Case Material**	Stainless Steel (1.4571/ 1.4404)
Operating Temperature [°C]	-40 to +125	**Wear Plate**	Stainless Steel (1.4571/ 1.4404)
Vibration – Sinus Sweep	2 Oct/Min, 5 to 180 Hz, 40 g	**Connector**	SMC (top)
Ingress Protection Rating	IP40	**Shield Cross-Talk [dB]**	< -80

Accessories			
Preamplifier	AEP5, AEP3N	**Sensor Cable**	CBL-1-1M2-V15
Mounting Holder	MAG4A1		

5.1.20 VS600-Z1

VS600-Z1

The VS600-Z1 is a passive piezoelectric AE-sensor with integrated cable. Its frequency response is characterized by a peak at 600 kHz where it exhibits a resonance. Its small size makes it especially suited for being mounted on small samples where mounting space is restricted.



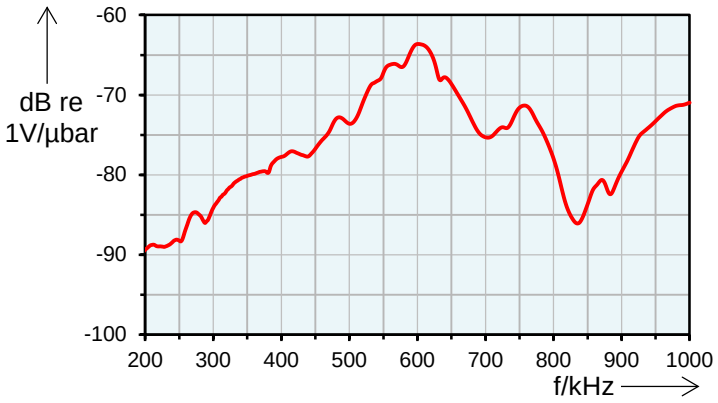
Technical Specification			
Frequency Range (f_{Peak}) [kHz]	550 to 730 (600)	**Size (D x H) [mm]**	4.75 x 5.8
Capacity [pF]	200 (incl. Cable)	**Weight [g]**	20
Integrated Preamplifier	No	**Case Material**	Stainless Steel (1.4571/ 1.4404)
Operating Temperature [°C]	-10 to +110	**Wear Plate**	Ceramics
Vibration – Sinus Sweep	2 Oct/Min, 5 to 180 Hz, 40 g	**Connector**	SMA/BNC
Ingress Protection Rating	IP40	**Shield Cross-Talk [dB]**	< -80

Accessories			
Preamplifier	AEP5, AEP3N	**Sensor Cable**	(integral)
Mounting Holder			

5.1.21 VS600-Z2

VS600-Z2

The VS600-Z2 is a passive piezoelectric AE-sensor with integrated cable and full metal housing. Its frequency response is characterized by a peak at 600 kHz where it exhibits a resonance. Its small size makes it especially suited for being mounted on small samples where mounting space is restricted. Additionally it is ideally suited for gluing to the sample because of the full metal housing.



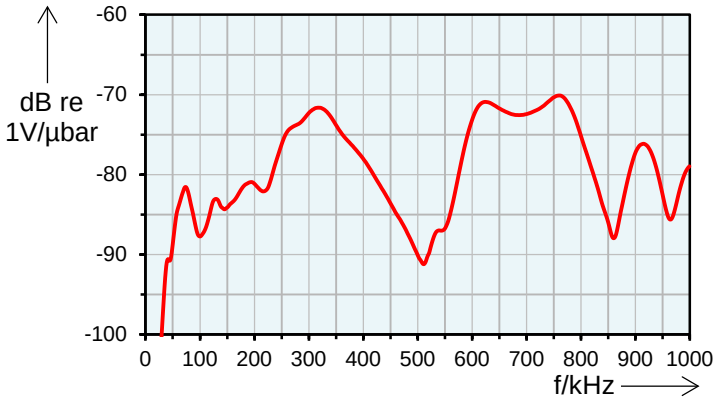
Technical Specification			
Frequency Range (f_{Peak}) [kHz]	400 to 800 (600)	**Size (D x H) [mm]**	4.75 x 5.3
Capacity [pF]	200 (incl. Cable)	**Weight [g]**	20
Integrated Preamplifier	No	**Case Material**	Stainless Steel (1.4571/ 1.4404)
Operating Temperature [°C]	-40 to +110	**Wear Plate**	Stainless Steel (1.4571/ 1.4404)
Vibration – Sinus Sweep	2 Oct/Min, 5 to 180 Hz, 40 g	**Connector**	SMA/BNC
Ingress Protection Rating	IP40	**Shield Cross-Talk [dB]**	< -80

Accessories			
Preamplifier	AEP5, AEP3N	**Sensor Cable**	(integral)
Mounting Holder			

5.1.22 VS700-D

VS700-D

The VS700-D is a passive piezoelectric AE-sensor with integrated cable. Its frequency response is characterized by a series of relatively flat peaks at 350 kHz, 600 kHz and 750 kHz with a limited response at 500 kHz. Its small size makes it especially suited for being mounted on small samples where mounting space is restricted. It was intended for characterizing paper during tensile tests and its mounting mechanism is optimized for this kind of task.



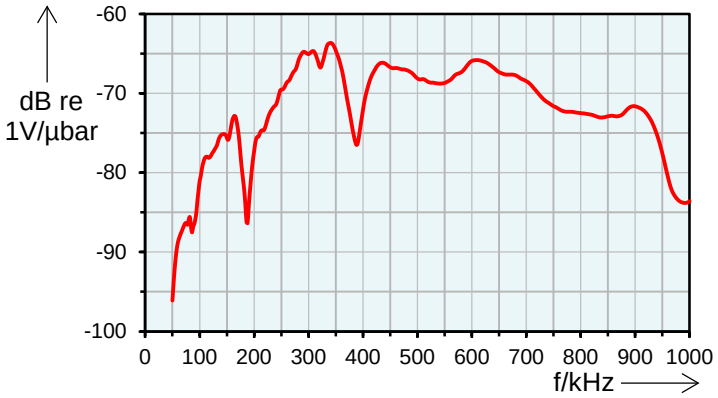
Technical Specification			
Frequency Range (f_{Peak}) [kHz]	150 to 800 (600 to 800)	**Size (D x H) [mm]**	6.3 x 10.0
Capacity [pF]	163 (incl. Cable)	**Weight [g]**	20
Integrated Preamplifier	No	**Case Material**	E-copper, tinned
Operating Temperature [°C]	-20 to +70	**Wear Plate**	Neodyne
Vibration – Sinus Sweep	2 Oct/Min, 5 to 180 Hz, 40 g	**Connector**	SMA/BNC
Ingress Protection Rating	IP40	**Shield Cross-Talk [dB]**	< -80

Accessories			
Preamplifier	AEP5, AEP3N	**Sensor Cable**	(integral)
Mounting Holder	integrated		

5.1.23 VS900-M

VS900-M

The VS900-M is a passive piezoelectric AE-sensor that has a broad frequency response. Its response is characterized by two peaks at
190 kHz and 350 kHz with accompanying anti-resonances at 200 kHz and 400 kHz. Benefits of the VS900-M are a high sensitivity over a broad frequency range with compromises regarding the flatness of response. It combines a good response in the standard frequency - and high frequency range.



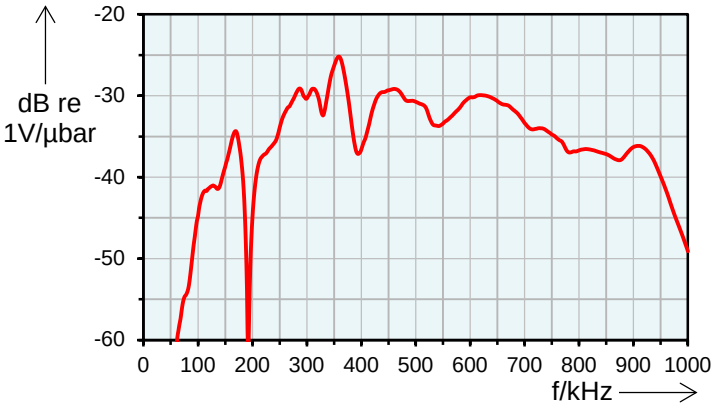
Technical Specification			
Frequency Range (f_{Peak}) [kHz]	100 to 900 (350)	**Size (D x H) [mm]**	20.3 x 14.3
Capacity [pF]	540	**Weight [g]**	22
Integrated Preamplifier	No	**Case Material**	Stainless Steel (1.4571/ 1.4404)
Operating Temperature [°C]	-50 to +100	**Wear Plate**	Ceramics
Vibration – Sinus Sweep	2 Oct/Min, 5 to 180 Hz, 40 g	**Connector**	Microdot
Ingress Protection Rating	IP40	**Shield Cross-Talk [dB]**	< -80

Accessories			
Preamplifier	AEP5, AEP3N	**Sensor Cable**	CBL-1-1M2-V5
Mounting Holder	MAG4M		

5.1.24 VS900-RIC

VS900-RIC

The VS900-RIC is a piezoelectric AE-sensor with integrated preamplifier. Its response is characterized by two peaks at 190 kHz and 350 kHz with accompanying anti-resonances at 200 kHz and 400 kHz. Benefits of the VS900-RIC are a high sensitivity over a broad frequency range with compromises regarding the flatness of response. It combines a good response in the standard frequency - and high frequency range. The integrated preamplifier has 34 dB gain and supports pulse through for automatic sensor testing.



Technical Specification			
Frequency Range (f_{Peak}) [kHz]	100 to 900 (350)	**Size (D x H) [mm]**	28.6 x 31.5
Power Supply [V_{DC}]	28 ± 2	**Weight [g]**	80
Typ. Power [W]	0.56 / 2.5 @ Signal 0% / 100%	**Case Material**	Stainless Steel (1.4571/ 1.4404)
Integrated Preamplifier	Yes	**Wear Plate**	Ceramics
Preamplifier Gain [dB]	34	**Connector**	BNC
Pulse Through	Yes	**Shield Cross-Talk [dB]**	< -80
Operating Temperature [°C]	-40 to +85	**Typ. Noise (max. 1/s) [$dB_{AE\ Peak}$]**	26.9 @ 95 - 850 kHz
Vibration – Sinus Sweep	2 Oct/Min, 5 to 50 Hz, 20 g	**Typ. Noise [μV_{RMS}]**	4.5 @ 95 - 850 kHz
Ingress Protection Rating	IP40		

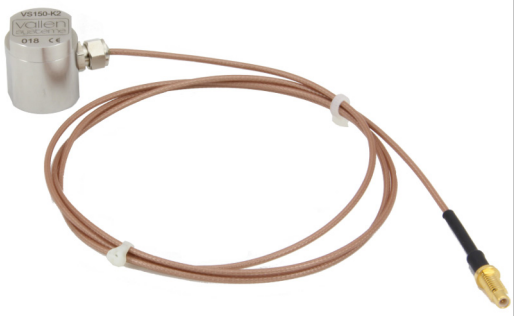
Accessories			
Mounting Holder	MAG4R	**Sensor Cable**	CBL-1-xM-V1

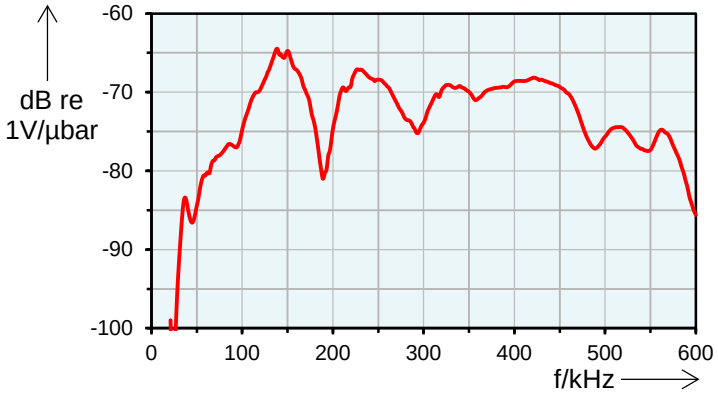
5.2 Watertight AE-sensors

5.2.1 VS150-K2

VS150-K2

The VS150-K2 is a passive piezoelectric AE-sensor with integral cable. Its frequency response is characterized by a peak at 150 kHz where it exhibits a resonance. It is suitable for almost all AE application. The VS150-K2 has a full metal housing and a watertight cap. It is rated IP68 and watertight up to 10 bar (maximum water depth of 100 m). The mechanical design makes it especially suited for adhesively mounting it to a test object.





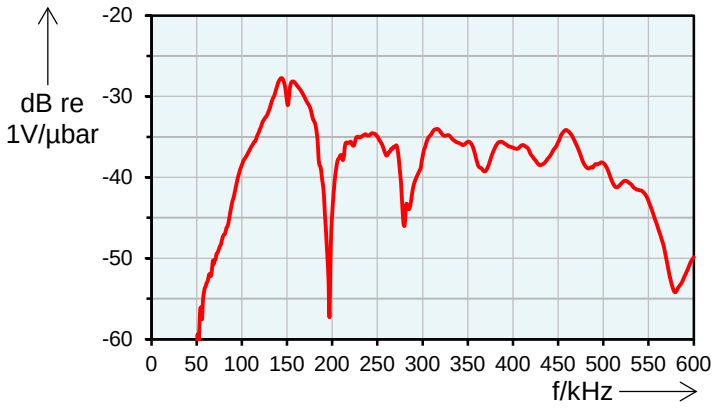
Technical Specification			
Frequency Range (f_{Peak}) [kHz]	100 to 450 (150)	**Size (D x H) [mm]**	20.3 x 22
Capacity [pF]	350	**Weight [g]**	56
Integrated Preamplifier	No	**Case Material**	Stainless Steel (1.4571/ 1.4404)
Operating Temperature [°C]	-40 to +100	**Wear Plate**	Stainless Steel (1.4571/ 1.4404)
Vibration – Sinus Sweep	2 Oct/Min, 5 to 180 Hz, 40 g	**Connector**	SMC @ 1 m RG178 Cable
Ingress Protection Rating	IP68, max. 10 bar	**Shield Cross-Talk [dB]**	< -80

Accessories			
Preamplifier	AEP5, AEP3N	**Sensor Cable**	CBL-1-1M2-V15
Mounting Holder	MAG4H		

5.2.2 VS150-WIC-V01

VS150-WIC-V01

The VS150-WIC is a piezoelectric AE-sensor with integrated preamplifier. Its frequency response is characterized by a peak at 150 kHz where it exhibits a resonance. The VS150-WIC is rated watertight up to 60 bar of water pressure. It is suitable for almost all AE application and especially suited for wet environments or for on-site monitoring of underwater installations.
The integrated preamplifier has 34 dB gain and supports pulse through for automatic sensor testing.



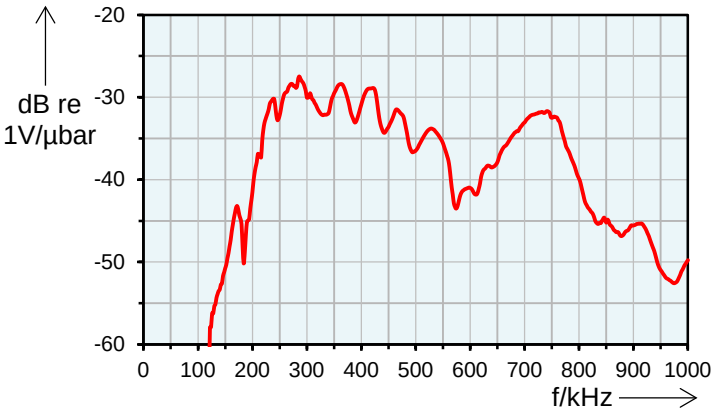
Technical Specification			
Frequency Range (f_{Peak}) [kHz]	100 to 450 (150)	**Size (D x H) [mm]**	32.0 x 48.0
Power Supply [V_{DC}]	28 ± 2	**Weight [g]**	184
Typ. Power [W]	0.56 / 2.5 @ Signal 0% / 100%	**Case Material**	Stainless Steel (1.4571/ 1.4404)
Integrated Preamplifier	Yes	**Wear Plate**	Ceramics
Preamplifier Gain [dB]	34	**Connector**	LEMO 03 Series
Pulse Through	Yes	**Shield Cross-Talk [dB]**	< -80
Operating Temperature [°C]	-40 to +85	**Typ. Noise (max. 1/s) [$dB_{AE\ Peak}$]**	25.2 @ 95 - 300 kHz
Vibration – Sinus Sweep	2 Oct/Min, 5 to 50 Hz, 20 g	**Typ. Noise [μV_{RMS}]**	5.0 @ 95 - 300 kHz
Ingress Protection Rating	IP68, max. 60 bar (with connected cable)		

Accessories			
Mounting Holder	MAG4W-V1	**Sensor Cable**	CBL-1-xM-V11

5.2.3 VS375-WIC-V01

VS375-WIC-V01

The VS375-WIC is a piezoelectric AE-sensor with integrated preamplifier. Its frequency response is characterized by a peak at 375 kHz where it exhibits a resonance. The VS375-WIC is rated watertight up to 60 bar of water pressure. Its frequency response bridges the gap between standard frequency range and high frequency range. The VS375-WIC is suited for wet environments or for on-site monitoring of underwater installations.
The integrated preamplifier has 34 dB gain and supports pulse through for automatic sensor testing.



Technical Specification			
Frequency Range (f_{Peak}) [kHz]	250 to 700 (375)	**Size (D x H) [mm]**	32.0 x 48.0
Power Supply [V_{DC}]	28 ± 2	**Weight [g]**	181
Typ. Power [W]	0.56 / 2.5 @ Signal 0% / 100%	**Case Material**	Stainless Steel (1.4571/ 1.4404)
Integrated Preamplifier	Yes	**Wear Plate**	Ceramics
Preamplifier Gain [dB]	34	**Connector**	LEMO 03 Series
Pulse Through	Yes	**Shield Cross-Talk [dB]**	< -80
Operating Temperature [°C]	-40 to +85	**Typ. Noise (max. 1/s) [$dB_{AE\ Peak}$]**	28.0 @ 95 - 850 kHz
Vibration – Sinus Sweep	2 Oct/Min, 5 to 50 Hz, 20 g	**Typ. Noise [μV_{RMS}]**	4.5 @ 95 - 850 kHz
Ingress Protection Rating	IP68, max. 60 bar (with connected cable)		

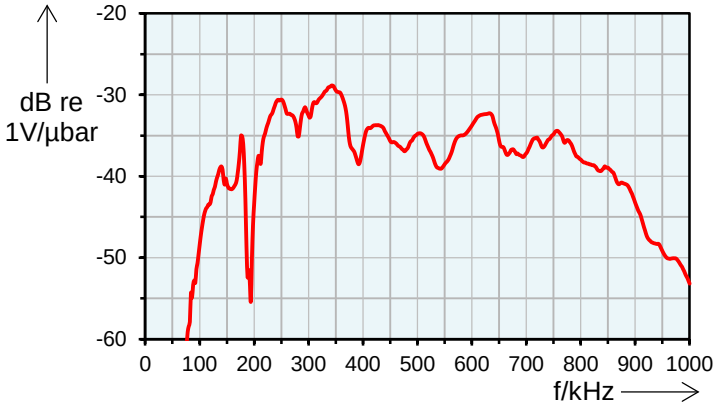
Accessories			
Mounting Holder	MAG4W-V1	**Sensor Cable**	CBL-1-xM-V11

5.2.4 VS900-WIC-V01

VS900-WIC-V01

The VS900-WIC-V01 is a piezoelectric AE-sensor with integrated preamplifier. Its response is characterized by two peaks at 190 kHz and 350 kHz with accompanying anti-resonances at 200 kHz and 400 kHz. Benefits of the VS900-WIC-V01 are a high sensitivity over a broad frequency range with compromises regarding the flatness of response. It combines a good response in the standard frequency - and high frequency range. The VS900-WIC is rated water tight up to 60 bar of water pressure. suited for wet environments or for on-site monitoring of underwater installations.

The integrated preamplifier has 34 dB gain and supports pulse through for automatic sensor testing.



Technical Specification			
Frequency Range (f_{Peak}) [kHz]	100 to 900 (350)	**Size (D x H) [mm]**	32.0 x 48.0
Power Supply [V_{DC}]	28 ± 2	**Weight [g]**	181
Typ. Power [W]	0.56 / 2.5 @ Signal 0% / 100%	**Case Material**	Stainless Steel (1.4571/ 1.4404)
Integrated Preamplifier	Yes	**Wear Plate**	Ceramics
Preamplifier Gain [dB]	34	**Connector**	LEMO 03 Series
Pulse Through	Yes	**Shield Cross-Talk [dB]**	< -80
Operating Temperature [°C]	-40 to +85	**Typ. Noise (max. 1/s) [$dB_{AE\ Peak}$]**	26.9 @ 95 - 850 kHz
Vibration – Sinus Sweep	2 Oct/Min, 5 to 50 Hz, 20 g	**Typ. Noise [μV_{RMS}]**	4.5 @ 95 - 850 kHz
Ingress Protection Rating	IP68, max. 60 bar (with connected cable)		

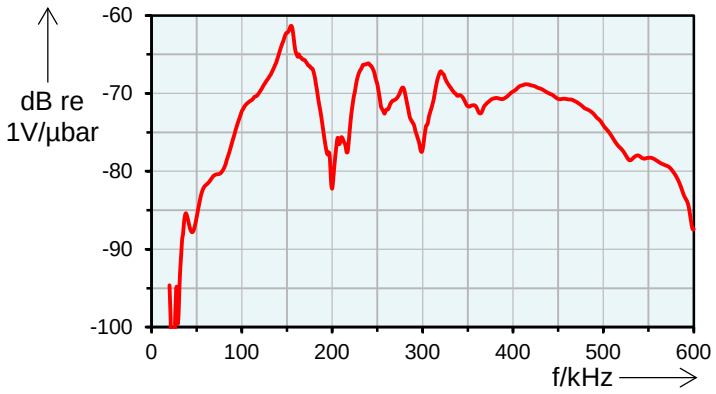
Accessories			
Mounting Holder	MAG4W-V1	**Sensor Cable**	CBL-1-xM-V11

5.3 High temperature AE-sensor

5.3.1 VS160-NS

VS160-NS

The VS160-NS is a passive piezoelectric AE-sensor suitable for hot environments (up to 180°C). Its frequency response is characterized by a peak at 160 kHz where it exhibits a resonance. It is suitable for almost all AE application and especially suited for integrity inspection of metallic pressure vessels.



Technical Specification			
Frequency Range (f_{Peak}) [kHz]	100 to 450 (150)	**Size (D x H) [mm]**	20.3 x 14.3
Capacity [pF]	350	**Weight [g]**	22
Integrated Preamplifier	No	**Case Material**	Stainless Steel (1.4571/ 1.4404)
Operating Temperature [°C]	-50 to +180	**Wear Plate**	Ceramics
Vibration – Sinus Sweep	2 Oct/Min, 5 to 180 Hz, 40 g	**Connector**	SMC
Ingress Protection Rating	IP40	**Shield Cross-Talk [dB]**	< -80

Accessories			
Preamplifier	AEP5, AEP3N	**Sensor Cable**	CBL-1-1M2-V15
Mounting Holder	MAG4NS		

5.4 AE-sensors for hazardous areas

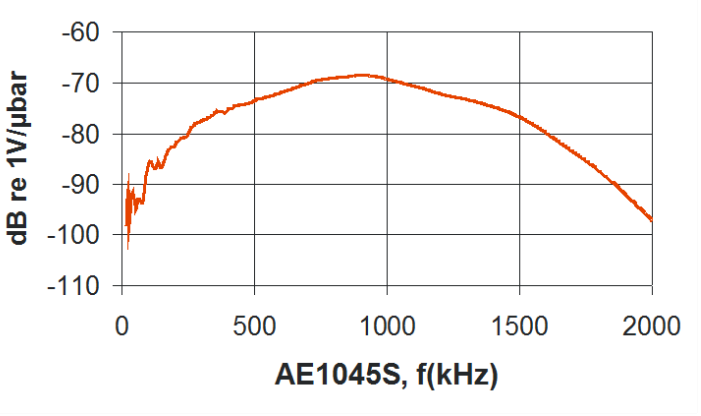
Vallen Systeme offers an intrinsically safe product family (ISAFE3). This product family is ATEX certified and consists not only of a family of AE-sensors but also of special signal isolator to fulfil all safety requirements for hazardous areas of zone 0, zone 1 or zone 2. For more details please see the 'Vallen ISAFE3 Operation Manual' or contact us at info@vallen.de.

5.5 Third party AE-sensors with longer delivery time

5.5.1 AE1045S

The AE1045S is a wideband AE-sensor. Comes with a calibration sheet from absolute reciprocal velocity calibration showing a very flat frequency response from 0.1 to 1.5 MHz.

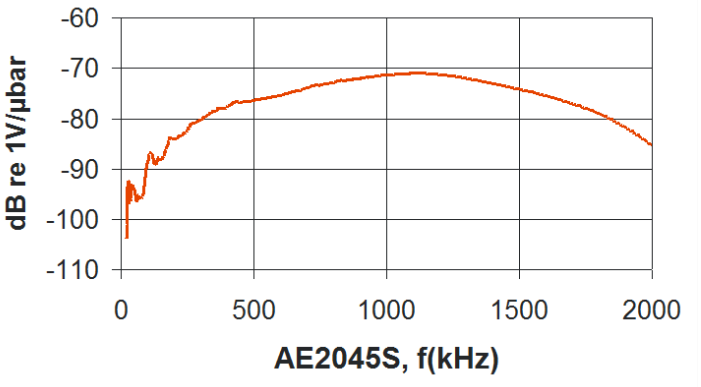
Response measured with 1 m cable (90 pF). 4 dB higher sensitivity with 10 cm cable due to the low internal capacity (90 pF).



5.5.2 AE2045S

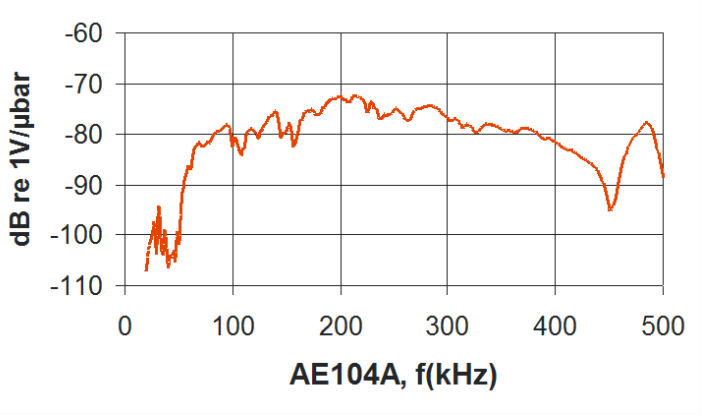
The AE2045S is a wideband AE-sensor. Comes with a calibration sheet from absolute reciprocal velocity calibration showing a very flat frequency response from 0.2 to 2.5 MHz.

Response measured with 1 m cable (90pF). 3 dB higher sensitivity with 10 cm cable due to the low internal capacity (140 pF).



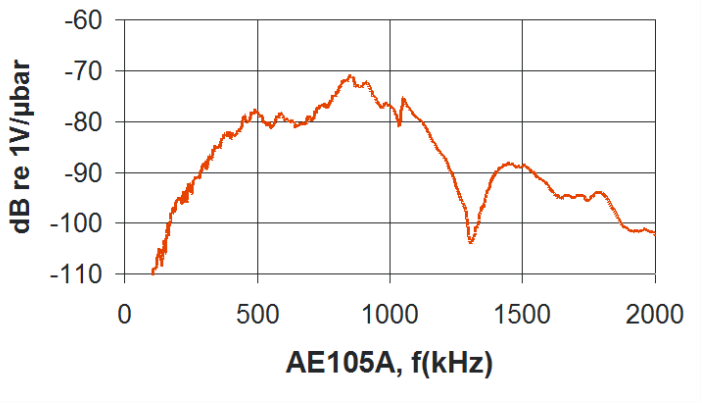
5.5.3 AE104A

AE sensor with a relatively flat frequency response between 100 and 400 kHz. Frequency curve measured with 1 m cable (90 pF). 6 dB sensitivity increase with 10 cm cable.



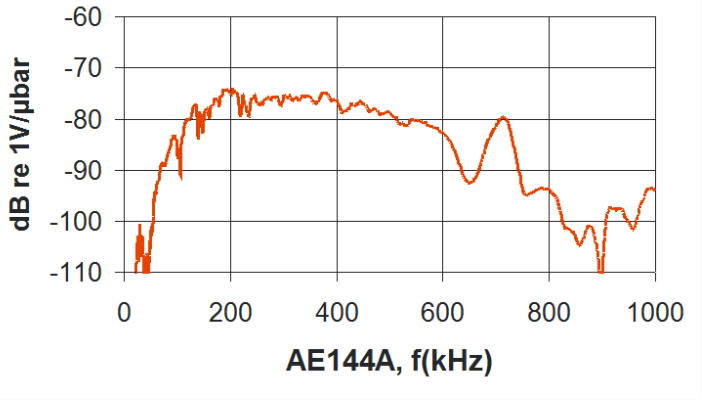
5.5.4 AE105A

AE-sensor for high frequency applications. Frequency curve measured with 1 m cable (90 pF). 5 dB sensitivity increase with 10 cm cable.



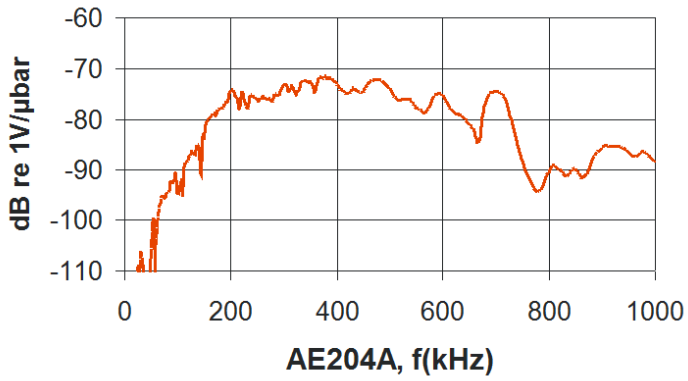
5.5.5 AE144A

AE-sensor with a relatively flat frequency response between 100 and 500 kHz. Frequency curve measured with 1 m cable (90pF). 7dB sensitivity increase with 10cm cable.



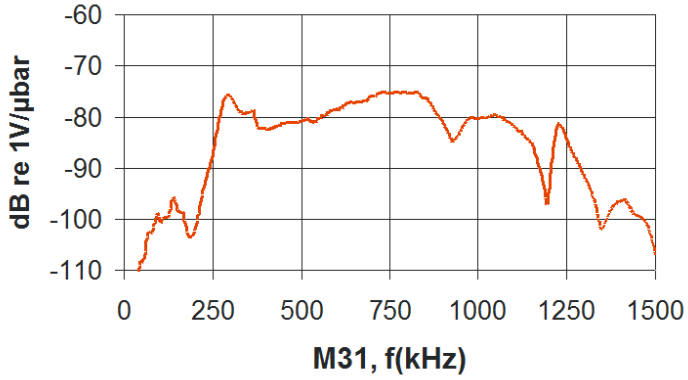
5.5.6 AE204A

AE-sensor with a relatively flat response between 180 and 700 kHz. Frequency curve measured with 1 m cable. (90pF). 6dB sensitivity increase with 10cm cable.



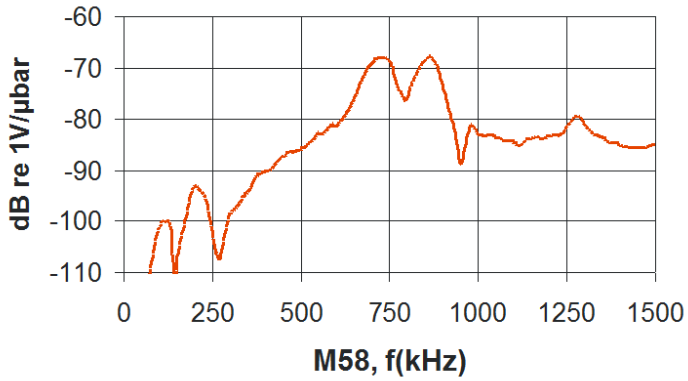
5.5.7 M31

Very small sensor for AE tests on small specimens. For a frequency range from about 300 kHz to 800 kHz. Frequency curve measured with 0.5 m integral cable.



5.5.8 M58

Very small sensor for AE testing of small specimens or for high frequency applications. Frequency curve measured with 1 m integral cable.



6 Warranty

Warranty period for AE-sensors is 3 months, provided the AE-sensors have been correctly handled. Defects caused by mechanical shock are not covered by the warranty. Except of the replacement of defective AE-sensors, we disclaim all other warranties. We warrant that the goods as delivered will conform to the specifications. On notification during the warranty period defective items will be replaced, free of costs and within a reasonable time. If transportation should become necessary, the customer has to provide the permits for export and re-import of replacement parts and bear the costs of transportation. We shall not be liable for any direct, indirect or consequential damage arising out of the use of or inability to use delivered AE-sensors.

7 Appendix

7.1 AE-sensor handling

Vallen Systeme AE-sensors are built for tough field testing conditions. Nevertheless AE-sensors should be handled with care and should not be dropped or subject to excessive mechanical force.

Please make sure that the metal parts of the AE-sensor are electrically isolated against the test object´s surface. If full metal AE-sensor cases are used (-L, -A1, -A2 and -Z2 case) and the surface of the test object is a conductive material use e.g. Flashbreaker® tape as isolating interface.

7.2 Mounting of AE-sensors

An AE-sensor needs to be mounted firmly to the surface of the structure under test. The mounting shall assure that an AE-sensor cannot move during the test and ensure that transmission losses through the interface between test object surface and sensitive face of the AE-sensor is minimal. Methods for mounting can be categorized into two groups: compression mounts and adhesive mounts.

7.2.1 Compression mount

A compression mount holds the AE-sensor in contact with the surface of the test object through the use of pressure.

One of the most popular compression mount methods is using magnetic holders. Magnetic holders (also called magnetic locks) can be used if the test object is ferromagnetic. The compressive force is delivered via the springs attached to the magnet(s). Magnetic holders for Vallen AE-sensors can be found in ‘Accessories for AE Systems’.

Caution: removing AE-sensors

When removing AE-sensors from the structure use the handles of the magnetic holders to slide off the magnet and do not pull on a cable. Pulling cables may result in their damage.

Other popular mounting aids are clamps, adhesive tape or elastic bands. It is strongly advised to use couplant together with compression mounts in order to reduce transmission losses and effectively increase AE-sensor’s sensitivity.

7.2.2 Adhesive mount (bonding)

An AE-sensor may also be bonded directly to the object’s surface. Care should be taken choosing the right adhesive which should not attack the surface it is applied to. The adhesive will also act as a couplant.

Note:

Bonding is a rather rigid way of mounting an AE-sensor to a surface. Surface deformation due to mechanical loading or thermal expansion may cause the bond to crack. These cracks are a source of unwanted AE-signals.

Caution: removing bonded AE-sensor with ceramic wear plate

Most sensors have a ceramic wear plate glued in front of the sensitive area to protect the piezoelectric element. Irreparable damage could be introduced to the ceramic wear plate if this bond breaks before the mounting adhesive during the attempt to remove the sensor from the test object. Similarly the test object (e.g. composite materials) could get damaged when removing a sensor.

The most appropriate way of removing a bonded AE-sensor is to move the AE-sensor sideways to generate shear stress in the bond interface or tab the AE-sensor gently on the side until it comes off.

Special Feature: AE-sensors suitable for bonding

Vallen Systeme supplies also full metal housing AE-sensors (e.g. VS600-Z2, VS150-L) which are particularly suitable for bonding.

7.3 Usage of couplant

A couplant applied between surface of test object and sensitive face of an AE-sensor reduces the transmission losses of elastic wave energy entering the AE-sensor, effectively increasing the sensitivity of the sensor. A couplant should be selected under consideration of the environment (e.g. temperature, pressure, composition of atmosphere or liquid environment). Most important a couplant should be chemically compatible to the test object's surface (e.g. not corroding).

A couplant should be applied with the thinnest practical layer. No voids or entrapped air inclusions should be present. Thick layers of couplant or unevenness of it can reduce the sensitivity of an AE-sensor.

Applying couplant:

A practical way of applying couplant is to place a small amount of couplant on the center of the sensitive face of the AE-sensor. Carefully press the AE-sensor onto the surface of the object under test. The couplant should spread evenly from the center to the outside and ooze a bit out under the AE-sensor.

Most AE-sensors are sensitive to normal surface motion, only. Hence the viscosity of the couplant is not of significant importance under normal conditions. Most liquids or greases will work when they wet the surfaces of both the AE-sensor and the object under test. See document "Accessories for Acoustic Emission Systems" for our couplant product range.

7.4 AE-Sensor verification

We recommend verifying every AE-sensor in certain intervals depending on its usage and application. This verification is especially recommended if an AE-sensor has been dropped, exposed to high temperatures or in any case when the AE-sensor response give reasons to doubt the integrity of it. Vallen Systeme is able to verify most AE sensors available on the market. The verification tool called Vallen Sensor Tester (VST) is also available for purchase. The VST generates frequency response graphs which can be used to identify response changes over time. See document "Accessories for Acoustic Emission Systems" for more information.

7.4.1 Frequency Response Measurement

All Vallen AE-sensors come with a test certificate. The test certificate shows the frequency response of the specific AE-sensor to a reproducible excitation. When comparing the original certificate with the result of a comparative test at a later date possible AE-sensor response changes can be identified. Some aspects of AE-sensor response are not addressed:

- The type of wave (pulse or continuous) may affect the AE-sensor output, especially with resonant AE-sensors. AE-sensor under test is coupled face-to-face to an emitter. Emitter is driven by a continuous sine wave. Response of AE-sensor is recorded at different frequencies and plotted in diagram.
- The surface displacement caused by a wave is three dimensional, the electrical AE signal is one dimensional. How an AE-sensor performs with respect to each displacement direction is not identified in a frequency response curve.
- The AE-sensor's response will be affected by the structure on which it is mounted. Even when the same setup is used, care must be taken to align the AE-sensor and emitter properly to maintain relative reproducibility.

7.4.2 Pressure Excitation

With this testing method the exciting displacement is uniform over the whole crystal face. This is realized by coupling the AE-sensor under test face-to-face with a wideband ultrasonic emitter. The emitter is then stimulated by a continuous sine wave, which frequency is swept over the range of interest. The RMS signal level of the AE-sensor under test is plotted in dB versus frequency, whereby 0 dB refers to a AE-sensor output of 1 V at an excitation of 1 µbar.

This testing method is fast, easy to reproduce (e.g. by the Vallen Sensor Tester, VST) and most standard test certificates are made by this method.

This document shows pressure excitation results.

Customers having the Vallen Sensor Tester (VST) can qualitatively reproduce the frequency response curves with the following settings:

	Pressure Excitation:
Output Voltage	0.1 V_{RMS} (0.05 V_{RMS} if preamplifier gain > 40 dB)
Offset	-114 dB – external gain (+ 6 dB if preamplifier gain > 40 dB)
Cable length used	RG178m 1.2 m, if no other length is stated for the frequency curve.

Olympus V103 (ultrasonic wideband Sensor) is used as emitter. AE-sensor under test is coupled face-to-face to emitter using a suited couplant (e.g. light machine oil).

For the VS30-V and VS75-V an Olympus V101 is used instead of the V103. The other settings can be seen from the legends in the frequency curves.