CMSS 786M SEE/AEE Sensor Mounting for On-line Systems

Introduction

The purpose of this SKF Application Note is to provide the reader with the necessary information to mount the CMSS 786M SEE/AEE sensor so it acquires the best quality data to assess the lubrication condition and other bearing defects whilst in service. In this Application Note, the CMSS 786M through a dual accelerometer and acoustic emission (AE) sensor shall be referred to as the *AE sensor*.

The SKF Acoustic Emission Enveloping (AEE) technology is an AE measurement method where the signal from a suitable AE sensor is band-pass filtered (100 to 500 kHz), rectified and demodulated to provide a suitable signal for acquisition and analysis with standard vibration analysis equipment [1][2].

There are many factors that affect the transmission of AE energy from its source to the sensor, and many ways in which this differs with respect to vibrations. Therefore, a basic understanding of these factors is required when assessing where and how to mount AE sensors on a machine. **Fig. 12** provides an overview of the most common influencing factors.

Sensor location

The most common purpose for adopting the SKF AEE technology is to monitor the lubrication condition and health of a rolling element bearing; hence, in most cases, the AE sensor would be mounted on the bearing housing or the machine casing. The casing material and the distance between source and sensor can have a significant effect on the attenuation of the AE wave. Some common attenuation figures are:

- 10 dB/m for annealed steel
- 100 dB/M for cast iron

Hence, for a simple comparison, 150 mm thick cast iron bearing housing will have an attenuation of 15 dB, whilst if it was of steel attenuation would only be a negligible 1.5dB. Therefore, in cast iron casing/housings, the proximity of the AE sensor to the source of the AE must be considered.

Discontinuities of material also affects the transmission of AE. For example, a split bearing housing would cause much of the AE energy to be reflected back and the remainder attenuated by the split interface coupling, resulting in only a small fraction of the AE energy being transmitted into the other half of the split housing. **Figs. 1** to **4** provide some guidance as to the best AE sensor locations.

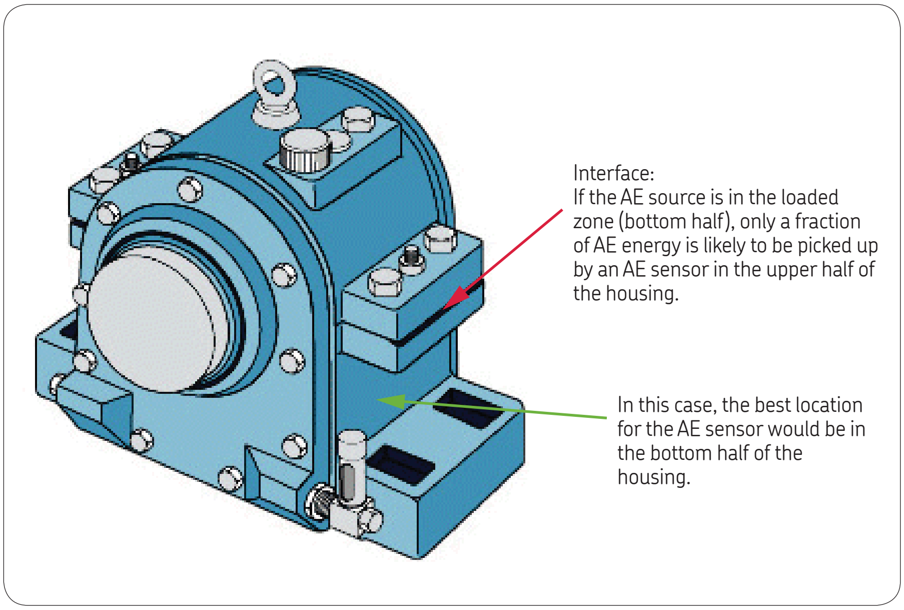


Fig. 1. Split bearing housing.

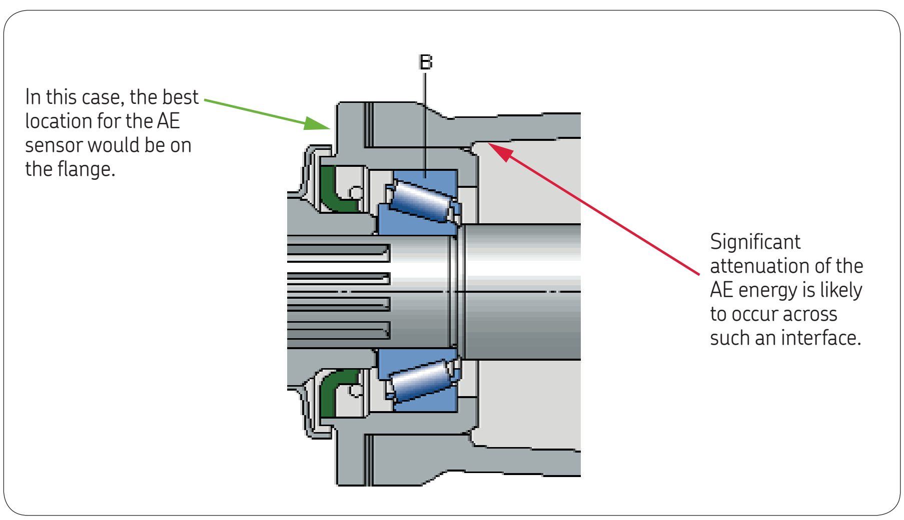


Fig. 2. Bearing cartridge.

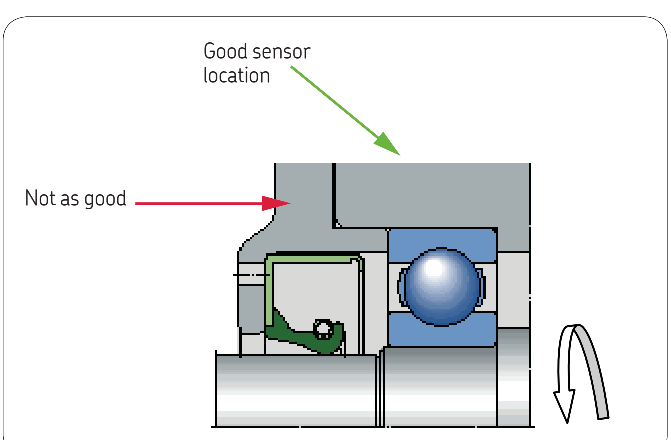


Fig. 3. Normal application.

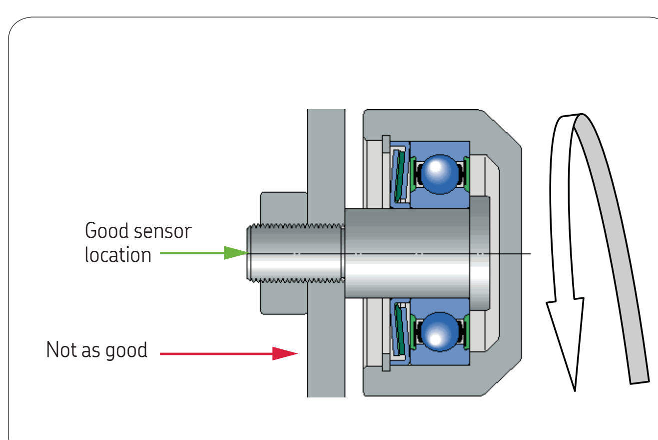


Fig. 4. Rotating outer ring application.

Large slew type bearings are often accessible directly, but can be constructed out of a few separate components. In **fig. 5**, the outer ring is made up of two separate rings bolted together. The interface between them can significantly attenuate the AE transmitted between them. Hence, separate AE sensors are required to be fitted to each ring.

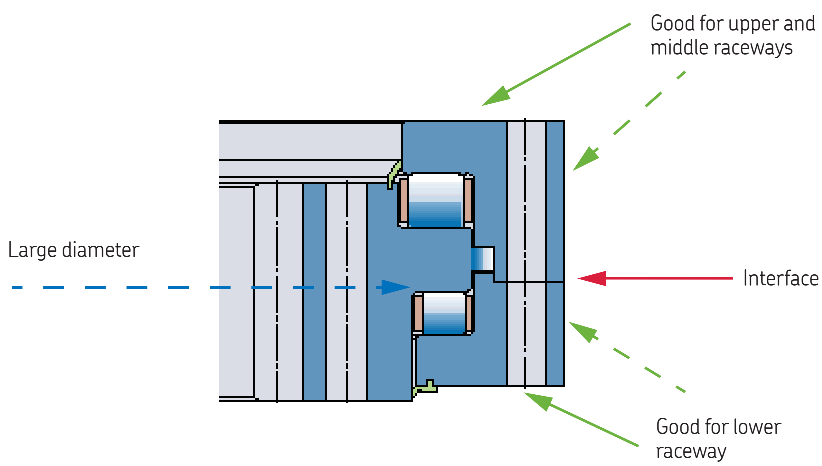


Fig. 5. Typical slewing bearing.

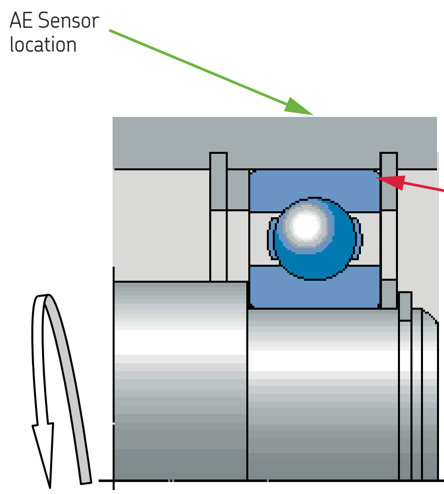
If a bearing, such as a slew bearing, has a very large diameter, more than one sensor for each ring may be required to provide adequate monitoring coverage, as the AE will attenuate over distance. This attenuation is due to both the attenuation properties of the steel and obstacles such as bolt holes and machined features. In a 2,5 m diameter slew type bearing, the AE attenuation 180° around the bearing was measured to be in the order of –10 dB.

Do not place an AE sensor directly in line with a transmission obstacle such as a bolt hole, but if possible, select a location between such obstacles.

Unless the AE sensor can be placed directly onto a bearing ring, which is uncommon, one interface the AE generally must cross is that between the bearing outer ring and the housing (→ **fig. 6**). There are many factors that influence the AE transmission across such a boundary, including:

- A loose or an interference fit
- Surface roughness (machining)
- Defects: moisture and fretting corrosion, pitting, deformation, wear
- Coupling: dry (air), oil or grease

An interference fit between smooth surfaces with oil or grease coupling to remove air from between the metal-to-metal asperity contacts provides the least amount of attenuation. Just by not having an oil or grease coupling present will attenuate the AE by about another –10 dB or more, as shown in **fig. 6**. Unfortunately, the nature and condition of the bearing to housing interface will often be unknown and may change over time and between identical applications. The worst scenario is a loose dry fit with a rough, uneven surface, as little AE from the bearing will be transmitted across it and fretting due to the relative movement will produce a significant amount of AE masking from the bearing raceway.



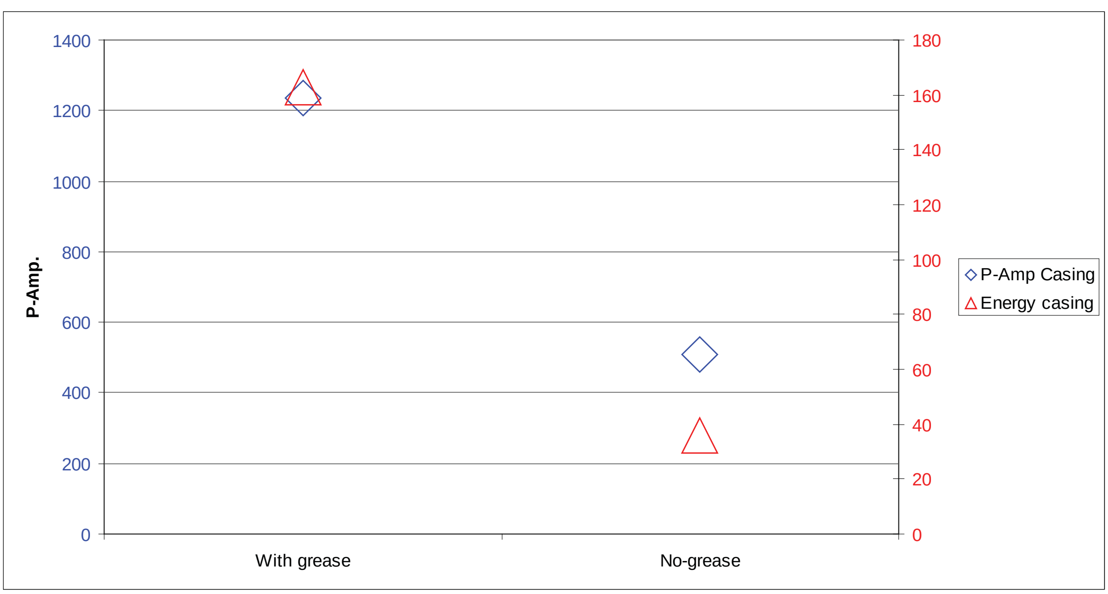


Fig. 6. Difference in raw AE strength on the casing surface between having a greased or a dry interface between bearing outer ring and housing bore.

When an AE wave hits an interface, the more perpendicular the direction of travel to the interface surface, the less the AE will be reflected and more will be transmitted. Therefore, since most of the AE activity is expected to originate in or at the edge of the load zone, it makes sense if possible to locate the AE sensor on the housing corresponding to the load zone, in particular with a cast iron housing. Note that the sensor itself does not need to be placed perpendicular to the loaded zone interface. **Fig. 7** shows the amount of AE strength variation when measuring at various angles around a casing with respect to the AE source location (on the outer ring raceway).

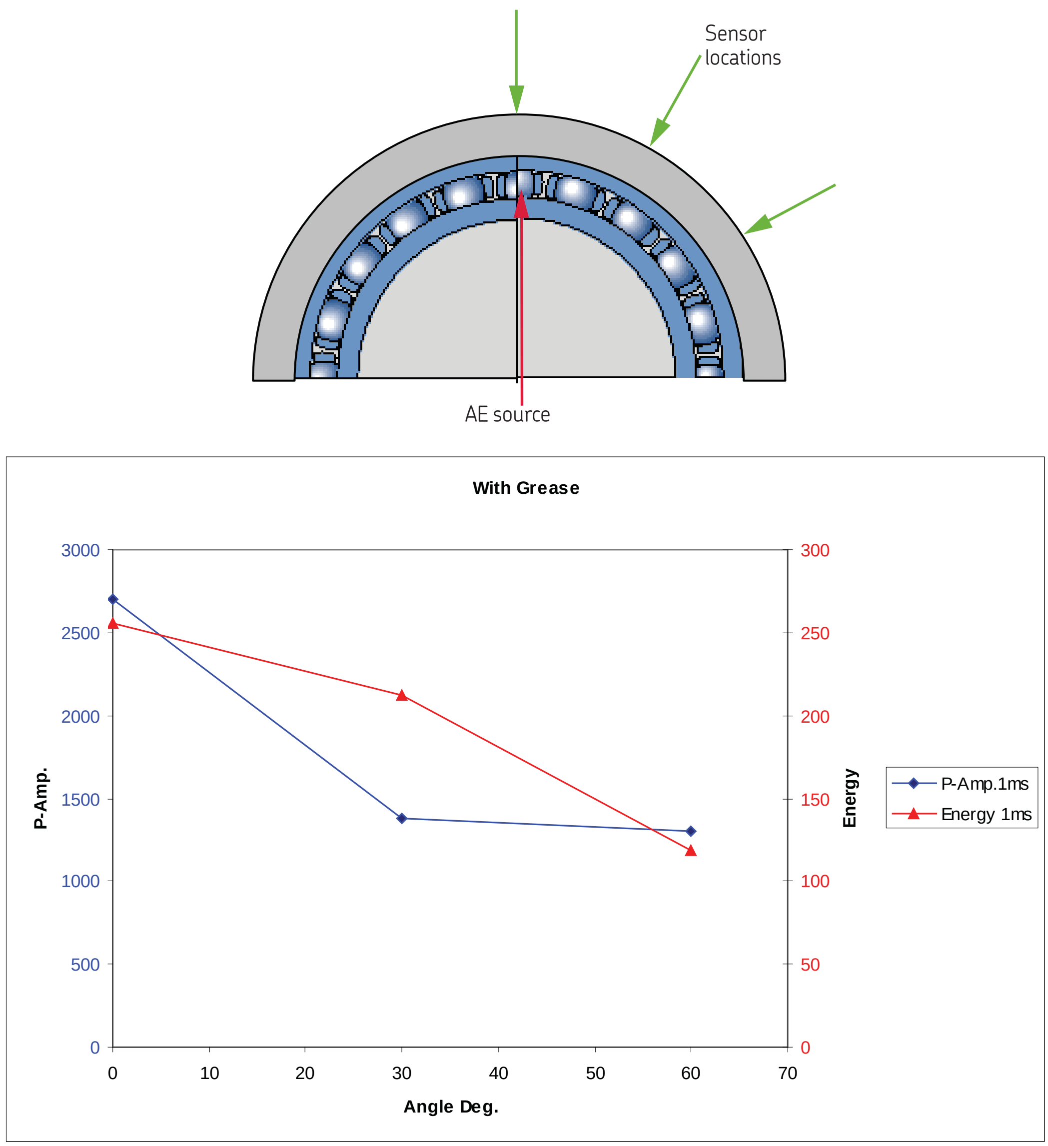


Fig. 7. Raw AE strength on casing at various angular locations from source on outer ring raceway with a greased interface.

Sensor mounting

Mounting the AE sensor in an appropriate manner is of utmost importance to provide a good and consistent transmission of the AE from the bearing or machine housing to the AE sensor. Note that many issues or inconsistencies in measuring SEE/AEE, in particular with off-line measurements, can be directly attributed to the inappropriate mounting of the AE sensor.

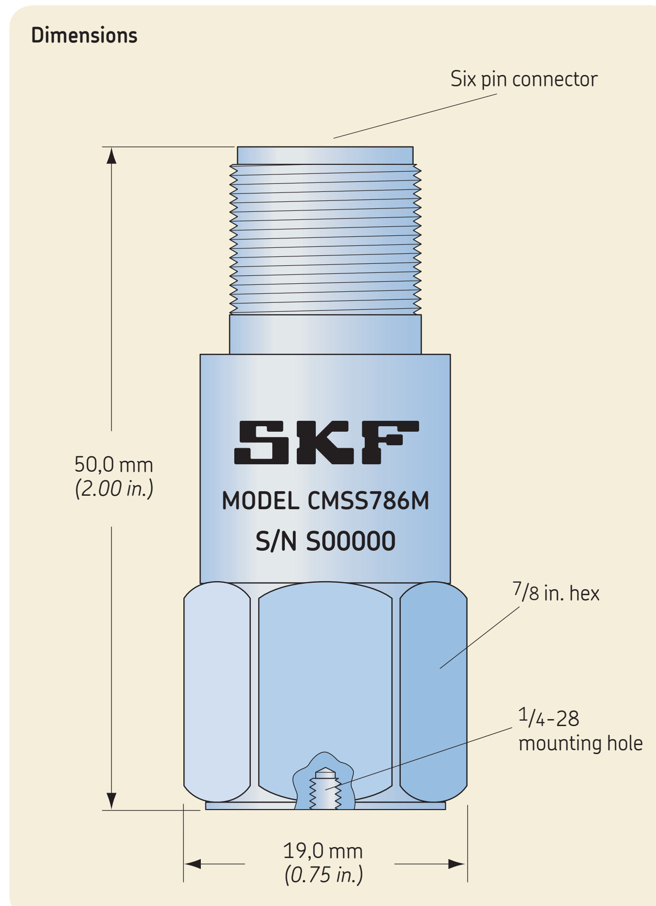


Fig. 8. CMSS 786M dual accelerometer and SEE/AEE sensor.

The surface onto which the AE sensor is to be mounted should be free of paint, coatings or rust and have a smooth machined finish. **Fig. 9** displays four methods of mounting the sensor. The right choice of couplant and adhesives between the interfaces are vital in order to avoid attenuation of AE.

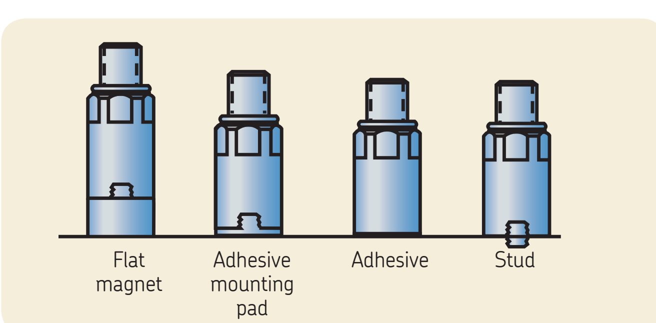


Fig. 9. Applicable AE sensor mounting methods where the "stud" method with suitable couplant is preferred.

It is imperative to remove all traces of air between all the mating surfaces even on the smoothest by means of a couplant whose impedance to AE closely matches that of steel and will last for the required period of the installation in that particular working environment [3]. **Table 1** provides a list of couplants, of which some are only appropriate for short duration or limited environmental conditions. The medium viscosity couplants are good on smooth surfaces, but may dry up or flow away with time. The high viscosity and elastic couplants are ideal for the rougher surfaces, but may deteriorate over time in certain environments. The hard couplant washers require smooth, even surfaces, but can last for long periods and survive higher temperatures. Thus, for a permanent installation on a flat, smooth surface, the PTFE washer is the SKF couplant of choice for the “stud” mount method.

Table 1

Suitable couplants

Couplant	Type	Viscosity hardness	Temperature range
Glycerin	Liquid/Gel	Medium	Medium
Ultrasonic gel	Gel	Medium	Low
Brown grease	Grease	High	Low
Silicone grease	Grease	High	Medium
Petroleum jelly	Grease	High	Low
Silicone compound	Elastomer adhesive	Elastic	Medium
Hot melt glue	Elastomer adhesive	Elastic	Low
Rubber	Washer	Elastic	Medium
Nylon	Washer	Hard	Medium
PTFE	Washer	Hard	High

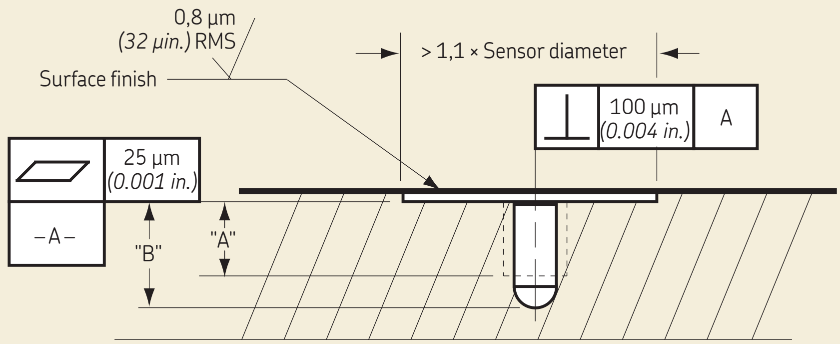
The “stud” method provides the best results (least attenuation of the AE) and also has the benefit of only one interface and it does not require any adhesive. The mating surface on the bearing or machine housing should be prepared in accordance with the specifications provided in **fig. 10**. As the CMSS 786M sensor has a 1/4”-28 mounting hole, it is common to prepare the surface with the same size of threaded hole, however, various threaded mounting studs are available; the casing is threaded with M6 or M8 holes.

Table 2

SKF threaded studs and respective surface preparation toolkits

Stud model	From	To	Surface preparation toolkit
CMSS 30168700	1/4"-28	1/4"-28	CMAC 9600-01
CMSS 30168701	1/4"-28	M8	CMAC 9600-02
CMSS 30168703	1/4"-28	M6	CMAC 9600-10

Stud mounting surface preparation



Stud	Stud size	"A" Dimension	"B" Dimension	Torque
SF1	10-32	4,78 mm *(0.19 in.)*	6,35 mm *(0.25 in.)*	20 Nm *(2.3 lbf. in.)*
CMSS 30168700	1/4-28	6,35 mm *(0.25 in.)*	8,90 mm *(0.35 in.)*	24 Nm *(2.7 lbf. in.)*
1/4-28 captive screw		6,35 mm *(0.25 in.)*	8,90 mm *(0.35 in.)*	30 Nm *(3.4 lbf. in.)*

Fig. 10. Surface preparation for "stud" mounting of a CMSS 786M sensor.

Occasionally, it will not be permitted to machine, drill and tap the bearing or machine housing, particularly in Class items or ATEX approved equipment; therefore, alternative mounting methods involving the use of adhesives is required. The issue with adhesives is that they age and/or are reduced in strength due to chemical attack and high temperatures. **Table 3** provides a list of some common adhesives considered suitable along with their temperature ranges (at 50% strength), though for longevity and good AE transmission, it is recommended that the typical surface temperature does not exceed two thirds of the quoted temperature ranges.

Table 3

Suitable adhesives

Adhesive	Adhesive type	Viscosity	Temperature range
Hot melt glue	Elastomer	Elastic solid	Low
Cyanoacrylate	Instant	Rigid	Low
Loctite 3450	Epoxy	Solid	~100 °C *(~212 °F)*
CMSS WIND-200			
Loctite 9497	Epoxy	Solid	~180 °C *(~356 °F)*
Loctite 480	Instant (toughened)	Rigid	~80 °C *(~176 °F)*
Loctite 407	Instant	Rigid	~100 °C *(~212 °F)*
Loctite 4204	Instant	Rigid	~120 °C *(~248 °F)*

For example, for good shock resistance, high strength and good AE transmission, even over uneven surfaces, Loctite 480 is recommended due to its rubber filler; however, it has a relatively poor temperature range that generally limits its use. Regardless of the type of adhesive utilized, it is recommended to keep the thickness of the adhesive as thin as possible whilst making sure that all air gaps are eliminated between mating surfaces by the adhesive.

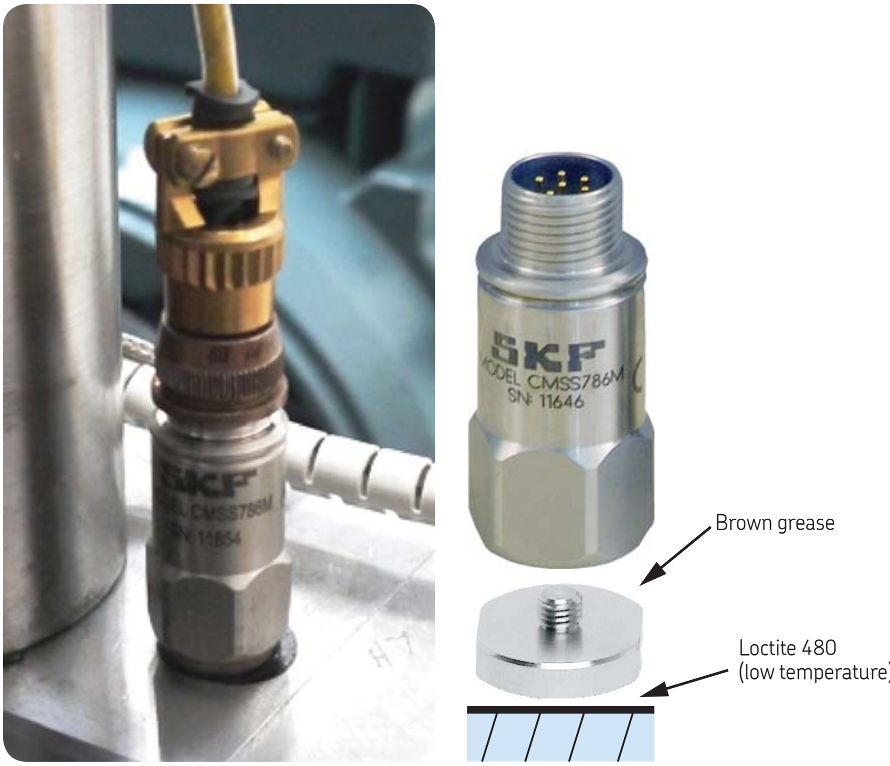


Fig. 11. A CMSS 786M AE sensor mounted on an adhesive mounting pad with a 1/4"-28 stud for short term monitoring (three months).

For most applications where adhesives must be used (because you cannot machine the equipment), it is preferable to utilise the "adhesive mounting pad" method by adhering a CMSS 910M cementing stud with 1/4"-28 male to the surface of the bearing or machine housing and then use a suitable couplant between it and the AE sensor. This allows the sensor to be easily removed for replacement or during machine maintenance. The alternative direct "adhesive" method can make it difficult to remove the sensor without damaging it.

For short term use, the "flat magnet" (CMSS 908-RE) method can use a medium to high viscosity couplant between the magnet and the surface and under the base of the AE sensor, but this is only applicable to a flat machined surface with a strong magnetic pull. Consideration must be given to significantly different AE attenuations across identical magnetic mounts due to slight differences in their internal assembly, so it is recommended that you test several of them and then use only those providing the best results.

Cable

Variable speed drives can interfere with the AE signal, so care should be taken to keep the cable connecting the sensor to the monitoring equipment as far away from any variable speed drives as possible.

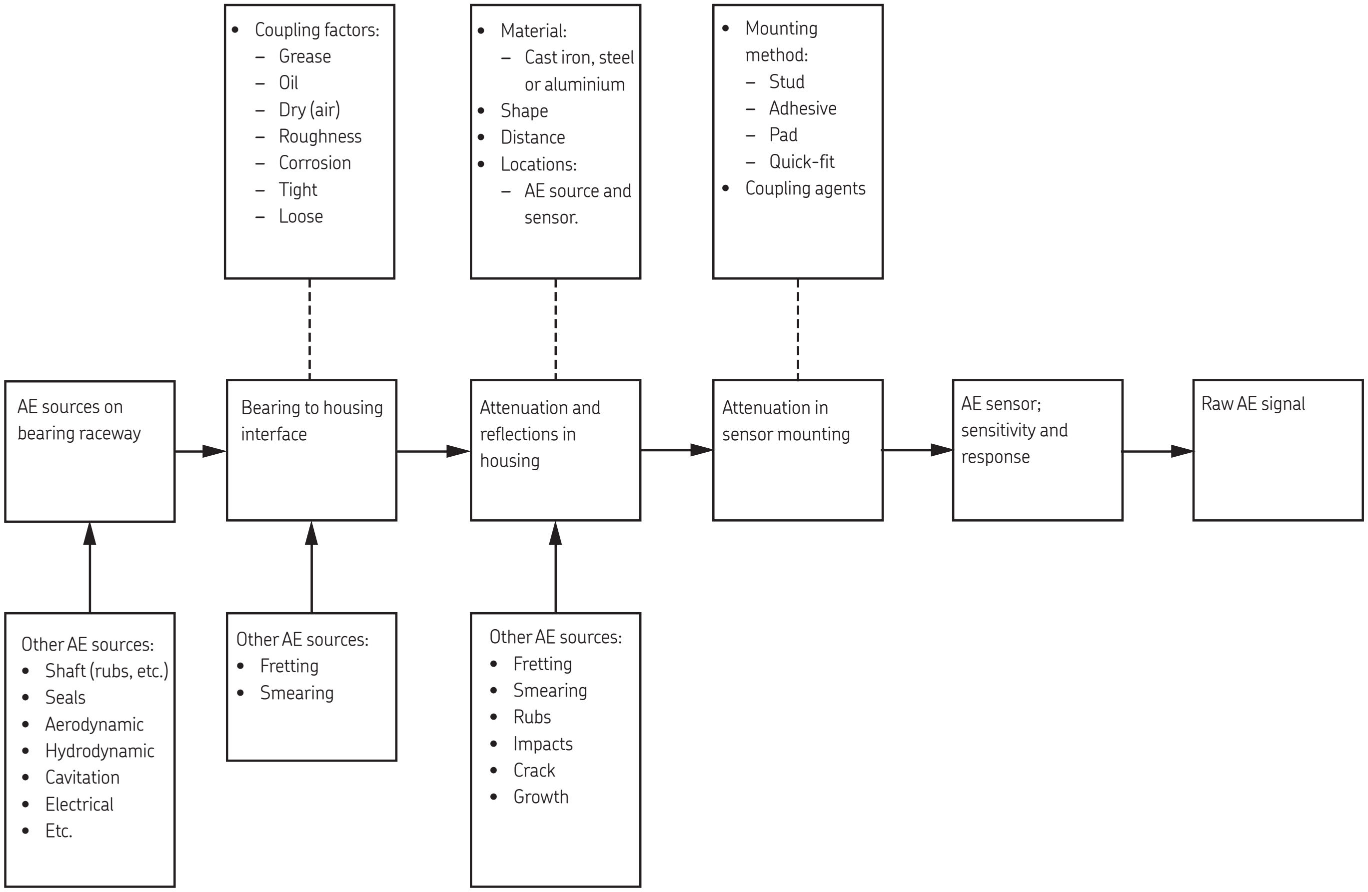


Fig. 12. Influencing factors from source of AE in the bearing to the AE sensor mounted on the housing.

References

[1] CM3154 Application Note – Analyzer Configurations for SKF Acoustic Emission Enveloping (AEE) Measurements. SKF.
[2] CM3155 Application Note – Analysis and Interpretation of SKF Acoustic Emission Enveloping (AEE) Measurements. SKF.
[3] http://www.npl.co.uk/acoustics/ultrasound/research/guide-on-acoustic-emission-sensor-couplants

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