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Alert To Danger

Optical microphone improves plant monitoring

Avoid Interruptions — The automation of technical processes in the natural gas and oil processing industry is already well advanced and the operation of unmanned conveying, transportation and storage systems is common practice. However, in order to guarantee the safe operation of the plant and equipment involved, regular inspections by expert staff are essential even in this day and age. During these inspections, the acoustic assessment of the various processes is extremely important.

Motors, transmissions and compressors as well as plant components that are used to transport gas, generate specific noise patterns at the individual operating points and variations or deviations from the normal state provide experienced operating staff with important indications of the condition of the equipment. Personnel with highly trained hearing are able to hear emerging or existing faults in the system and, even though the process itself is not yet seriously interrupted, can assess and classify possible damage and dangerous events. Early recognition of abnormal plant noise can avoid extensive downtime and cut costs.

The detection of leaks in natural gas processing equipment is extremely important. Whereas large leaks (blowouts) can be easily detected by changes in conventionally measured data (pressure loss, loss of quantity) and by the high noise level they cause, it is very difficult — or in some cases even impossible — to detect small quantities of leaking gas with the aid of standard technology, especially in outdoor processing plants. Gas sensors that can quickly and safely detect contamination in the air inside buildings very often fail in outdoor facilities, as the leaking gases do not reach the sensor head due to air motion and rapid dilution. Leaks in auxiliary systems, such as compressed-air control systems, cannot be detected by gas sensors at all, as these are sensitive only to the target gas methane. This also applies to

IR monitoring systems. Leaking gases, particularly when only small quantities of gas are involved, generate frequencies in the ultrasound range (above approximately 18,000 Hz) and are not audible to human beings. Therefore, ultrasound monitoring systems are used for monitoring leaks, but these have the disadvantage that they are unable to detect machine noise patterns that lie within the frequency range that is audible to humans.

The change from temporary personal monitoring to continuous monitoring using an automatic audio system would therefore be an important step towards optimising the monitoring of outdoor processing plants for natural gas production. Until now however, this has not been possible due to the lack of a suitable sound transducer that not only has the necessary acoustic properties but also meets the requirements of the ATEX Directive for use in potentially explosive atmospheres. The introduction of the IAS MO 2000 Set optical microphone from Sennheiser now means that these requirements can be fully met.

Operating Principle

The optical microphone works on the basis of a patented optical transmission principle in which only light instead of electricity is conducted to the microphone through a 200 µm fibre-optic cable. Infrared light from a light-emitting diode is coupled into a transmitter fibre-optic cable connected to the microphone, which can be up to 200 metres away. This means that there are no electric signals inside the safety-relevant zones.

In the microphone head itself, the light beam is focused and reflected into the receiver fibre-optic cable via a 3.5 µm thin diaphragm. Any sound waves that enter the microphone will cause the diaphragm to move, thus modulating the intensity of the light that is returned via the receiver fibre-optic cable. The transducer unit, in which the light signal is directed onto a photodiode, is located outside the danger zone. In the transducer unit, the variations in light intensity are converted into electric signals and are now available for further processing and analysis as AF signals.

The acoustic transmission range starts at 20 Hz and has been optimised to more than 40 kHz for noise pattern analyses in monitoring applications in order to detect hissing and whistling noises in the ultrasound range. As a result, the microphone can "hear" slow leaks that are otherwise too small to cause a pressure loss or to trigger an alarm message in other monitoring systems.

First Commercial Applications

In one application, the overground components of an underground natural gas storage system, as well as the auxiliary units of a gas dehydration plant at the natural gas pumping facilities were to be fitted with automatic monitoring systems that ensured that leaking gas and mechanical faults on the rotating equipment were detected immediately and reported to higher-level control centres that are constantly manned. The process pressure is in both the low-pressure and high-pressure ranges and therefore, in the case of small leaks, extremely low noise amplitudes were to be expected. Due to the geographical location, parts of the plant are subjected to extreme fluctuations in weather conditions.

In order to examine in advance whether and to what extent microphones with a downstream noise pattern analysis were able to fulfil the expectations of the plant operator, Sesamtec Engineering carried out preliminary audio studies of the processing equipment concerned. These included:

- Recording the noise of the processing equipment and the ambient noise at strategically important plant components using special measuring microphones in the frequency range between 20 and 40,000 Hz and storing the noise patterns on a digital recorder;
- Studying the recorded sound patterns in the measuring laboratory to determine any special features;
- Mixing the recorded plant noise patterns with stored acoustic fault events to determine the achievable detection limit of individual fault scenarios;
- Determining the achievable separation between normal plant noise and ambient noise; and
- Determining the locations for setting up the stationary monitoring microphones.

The resulting implementation plan included not only the microphones required for audio monitoring and their locations but also a recommendation on whether event-oriented or condition-oriented noise pattern recognition should be used for the planned audio monitoring.

Setting up the optical microphones and putting them into operation is unproblematic provided that the utmost care is paid to laying the fibre-optic cables between the microphone capsules and the light/current transducers. Due to the attenuation properties of the fibre-optic cable, a cable length of 250 metres should not be exceeded. In addition, the weather protection housings must be mounted on vibration-damping stud mounts. The protective housing guarantees optimum protection for the actual microphone capsule even in the most severe outdoor conditions.

Summary

Sennheiser had already supplied the optical microphone to Sesamtec Engineering before its official market launch for projects in the natural gas industry. This allowed the microphone to be used at various facilities from the end of 2004 onwards and to be subjected to intensive testing to prove its reliability in continuous operation. As a result of the positive practical experience gained with the systems installed, further audio monitoring systems are currently being planned and implemented.

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