# Sound and Vibration Monitoring for Process Control

**Bill Wright**, Omega Squared Engineering & Design, Inc., Virginia Beach, Virginia

**Monitors – Past and Present.** Two common themes are always present for the successful application of vibration or acoustical monitoring in a production environment.

- A noise or vibration event is currently being judged by workers to be the start or end of a particular process
- By employing an automatic control system initiated by this event, a loss of production can be minimized

There are many examples of this type of application in use today, and we will discuss these later on. First a little history on the products developed to address these situations.

Continuous monitoring of sound and vibration has been used for the control of manufacturing processes for many years. In the early 1980s, Brüel & Kjær introduced the 2505 Multipurpose Monitor shown in Figure 1 for automatic signal monitoring of vibration signals. With this monitor, one could connect a microphone, accelerometer or other piezoelectric device, and set limits to alarm the user when levels were exceeded. Filters were available to band-limit the signal as well as detectors to average a highly fluctuating signal.

*Figure 1. An early process monitoring system designed and manufactured by Brüel & Kjær.*

*Figure 2. PCH Engineering 1008 process monitoring system module.*

There were also relays to interface with process control systems or other instrumentation. With this device, a process control engineer could monitor vibration or acoustic levels automatically without use of expensive analysis systems. These monitors were also used in the machine condition monitoring field as rudimentary overall vibration detectors and could be used to shut down the machine if levels were exceeded.

These early monitors were made up of discrete analog circuit boards housed in a weather-proof enclosure. The end user selected the circuit cards needed for his or her application. Each circuit card performed a particular function, such as signal conditioner, high and/or low pass filter, amplifier or attenuator and an RMS detector. These circuit cards worked in conjunction with the meter module, alarm indicators and relays. The monitors had limited dynamic range so careful attention had to be paid to the circuit cards chosen for each application. One had to know a lot about the particular measurement and the transducers being employed. Once selected, more circuit cards needed to be ordered if conditions changed.

In the late 1980s this product line was separated from the traditional business units at Brüel & Kjær, and PCH Engineering was born. PCH Engineering continued the production of these monitors and other analog circuit designs before developing a new design of this key product with modern electronics. With the development of digital signal processors, the functions of filters, gain/attenuation and RMS detection could be controlled with software. This made the application of these monitors much easier for end users. Each monitor could be programmed in the field to meet the demands of the task at hand. The control and setup of the unit, via the supplied software, avoided the time-consuming analysis of the required settings prior to purchase. One of the first products developed for this application was the PCH 1008 shown in Figure 2.

These new monitors have a PC interface for setting up the unit and displaying the results of the measurements. The programmed data are stored within the unit to enable the monitor to operate independently of the PC and retained in the case of a power failure. The DSP allows for the choice of many low- and high-pass filters as well as true RMS, peak or peak-to-peak measurements.

In addition, there are many built-in test functions and voltage references for checking out new test set-ups as well as system failure indicators and relays. The built-in relays are used to interface with PLCs (programmable logic controllers) and other instrumentation and are triggered upon user-defined threshold levels. In addition, there are electrical outputs for conditioned and unconditioned AC signals for additional spectrum analysis or waveform storage. These monitors are ideal for real-time detection and control of vibration and acoustic events.

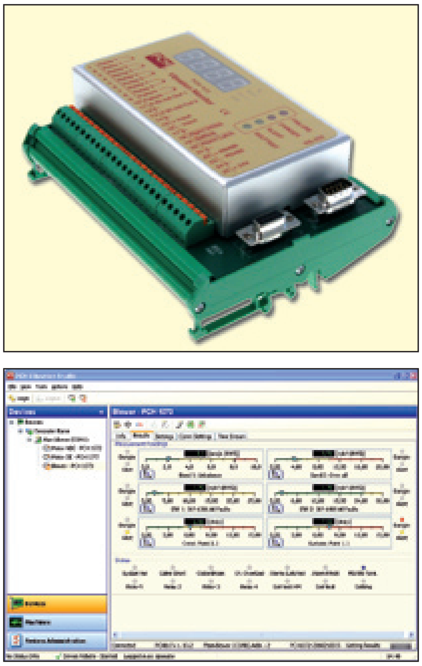

*Figure 3. Multi-channel process monitoring system and typical alarm-band display.*

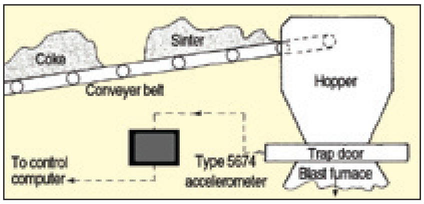


*Figure 4. Hopper monitoring system at a steel plant.*

PCH Engineering has also developed a range of monitors for multichannel measurements using FFT analysis on an incoming vibration or acoustic signal (see Figure 3). The FFT analysis can be defined by the end user to meet the particular needs of the application. The sampled time block is chosen to reflect the bandwidth of interest. Alarm limits can be set on particular bands of interest within the FFT and are user selectable. Several frequency bands can be chosen and defined by the upper and lower frequency. The resulting FFT calculations, updated for every time block, are displayed with the alarm bands highlighted while the PC is attached to the monitor for setup and testing.

**Examples of Monitoring for Process Control.** One of the earliest applications was at an iron and steel plant. A hopper is used here to empty, alternately, sinter and coke into a blast furnace controlled by a computer. The blast furnace needs to know when

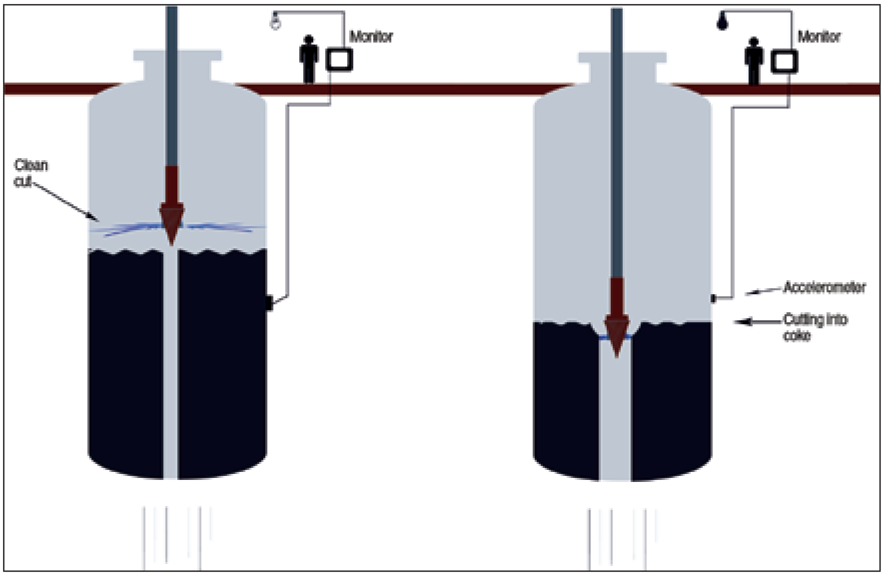


*Figure 5. Coke vessel monitoring system at an oil refinery. The system determines when the vessel is empty, cleaned and ready for the next batch to be loaded.*

the hopper empties completely to ensure that nothing is left; the computer controls this. The computer needed to know when the emptying process completed without too long of a delay, which would mean a loss of production. A worker could tell immediately when the hopper was empty simply by listening to it. A well placed accelerometer was able to measure the vibration when the hopper was being emptied, and when the vibration stopped, the hopper was empty (see Figure 4). There are many more applications like this, where product is being moved from one place to another in a manufacturing environment.

Another application was found at an oil refinery. After refinement of the oil into various gasoline products, the leftover sludge is pumped into very large vessels or drums. Once there, the sludge is pressurized and heated until most hydrocarbons are extracted. The material that is left over is called coke and has the consistency of charcoal.

This leftover coke has to be flushed out of the drums with high-pressure water jets so that the next batch of sludge can be pumped in. This is a 24/7 operation, and the faster the coke can be flushed out, the faster the next batch can be processed. When the operators flush out the coke with the high-pressure jets, there is a noticeable noise when the jets cut through the coke and is hitting the side of the drum. This is referred to as a clean cut and the sound is very much like the sound the spray of a garden hose on an empty metal trash can.

When the jets are into the coke, or cutting the material, there is a noticeable quieting of the sound. It is important for the operators to know when there is a "clean cut" so that they do not waste time here and can maneuver the jets to a lower level to cut into the material. The operators should spend as much time as they can cutting the coke and less time at the clean-cutting positions. An accelerometer mounted in an ideal location on the side of the drum is able to pick up this cutting noise when the jets are hitting the side of the drum. The monitor shown in Figure 5 is able to close relays to illuminate lights to let the operator know when there is a clean cut. The light turns off when the jets are cutting into the coke material.

These low cost, autonomous monitors are very useful in situations where an acoustic or vibration event needs to be detected and acted upon to save time and expense.

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For more information on Omega Squared products, please visit: www.omegasquared,net.

## Roofing Assemblies Achieve High STC and OITC Ratings

**Reinhard Schneider**, Georgia-Pacific Gypsum, Atlanta, Georgia

Georgia Pacific Gypsum continues to innovate in the roofing industry with its DensDeck® Roof Boards, which are the first gypsum roof boards tested to contribute to sound transmission class (STC) ratings of up to 61 and outdoor-indoor transmission class (OITC) ratings of up to 49 in roofing assemblies for commercial framed construction. (*Testing of the new assemblies was completed at Riverbank Acoustical Laboratories in 2011.*)

These high levels of sound attenuation are especially important as new code and building programs call for sound mitigation in wall and roof-ceiling assemblies, especially in high noise areas around airports, expressways, light rail and railroads and military bases.

"The new roofing assemblies we've configured and tested are an industry first. We achieved a 61 STC (49 OITC) performance with one specific assembly for commercial framed construction and used standard roofing installation techniques for all of the tested assemblies," said Reinhard Schneider, technical manager, DensDeck, Georgia-Pacific Gypsum. "In addition to providing the durability and long-term performance customers have come to expect from DensDeck, we have verified significant sound remediation benefits."

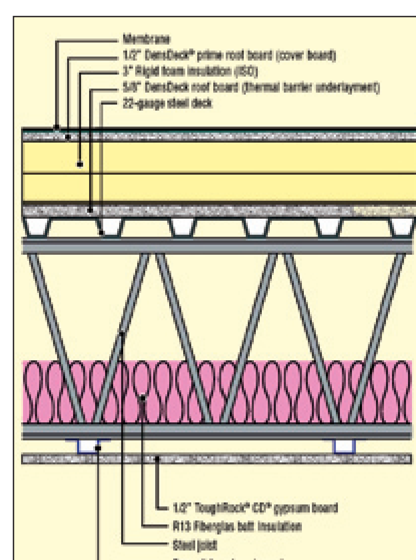
Introduced to the market 25 years ago and with hundreds of millions of square feet on the market, DensDeck Roof Boards are the number-one architecturally specified fiberglass mat gypsum roofing boards. Recent testing showed that in specific assemblies, DensDeck can help obtain superior STC and OITC ratings and can help meet UL Class A fire ratings, the highest rating for fire resistance under ASTM E-108.

STC and OITC ratings are measures of resistance of a building element (e.g., roof) to sound penetration based on different assumptions regarding the frequency content of the sound. Higher STC and OITC ratings indicate better sound resistance for the specific assumptions of the rating.

"Excessive noise indoor can interfere with sleep and voice communication, including television and telephone, or simply be a distraction and annoyance," said Noral Stewart , of Stewart Acoustical Consultants and a spokesperson for Georgia-Pacific. "Controlling sound is an essential part of any plan to provide a more comfortable environment for building occupants."

Schneider added that the tested assemblies can be specified for new construction, as well as for remediation projects on existing buildings. For optimum sound isolation, the roofing configurations used in new construction include added layers of ToughRock® gypsum board or DensArmor® Plus interior panels for interior ceilings.

Many standards, codes, and green build-



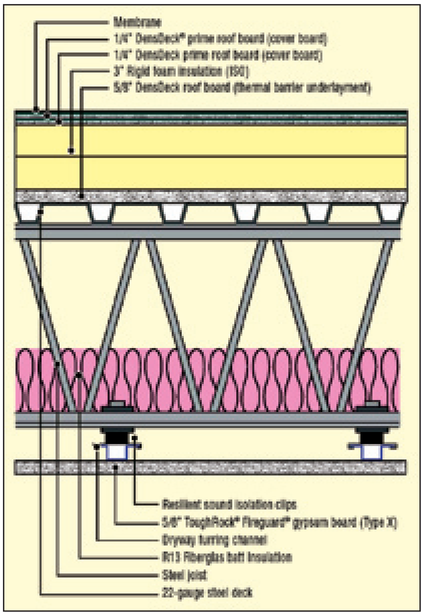

*Roofing assembly with STC 56 rating. Tests per ASTM E90 and ASTM E 413 were conducted in 2011 at Riverbank Acoustical Laboratories. Results are based on characteristics, properties and performance of materials and systems obtained under controlled test conditions.*

ing programs require or give extra credit by improving isolation from outdoor sounds, including:

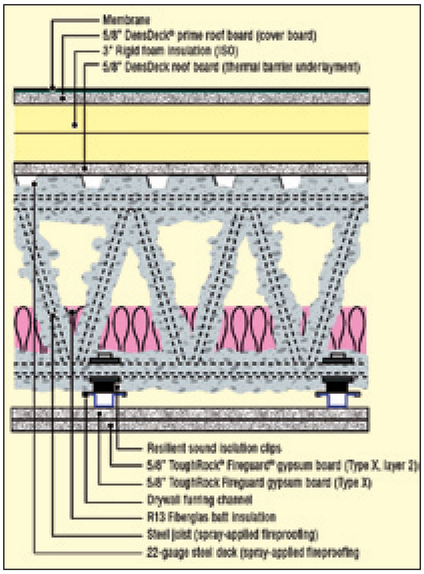
- ASHRAE 189.1
- ANSI S 12.60 for schools
- Facilities Guidelines Institute Guidelines for Design and Construction of Healthcare Facilities
- Housing and Urban Development regulation 24CFR51B
- Defense Department regulations for military housing
- LEED® for Schools
- LEED for Healthcare facilities.

In U.S. Green Building Council LEED® projects, DensDeck may qualify for credit contribution in materials and resources-recycled content (MR4) and materials and resources-regional materials (MR 5). Please visit www.gpgypsum.com and click on the LEED Calculator link to determine credit contribution.

For more information on Georgia-Pacific products, please visit: www.gpgypsum.com.




*Roofing assembly with STC 58 rating.*




*Roofing assembly with STC 61 rating.*