

# Low noise by design: a system-based approach

## Publication/ presentation details

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## Introduction

In pursuit of quieter industrial and consumer products, manufacturers must consider numerous factors, such as health, safety, quality, economics, performance, and durability. Tradeoffs must often be made to optimize various factors to meet customer and end-user needs. While considering all of these factors, one common thread provides a consistent opportunity for reducing noise: a system-based approach, rather than a focus on individual components.

## Noise as part of the decision-making process

Quieter products can provide health, safety, and other benefits for end users and society as a whole. To achieve these benefits, manufacturers must consider noise early in the design process of products and systems. By doing so, adjustments can be made to improve the design and generate positive impacts for both the manufacturer and end users.

The National Institutes of Health estimates 15 percent of Americans between the ages of 20 and 69 have suffered hearing loss possibly caused by exposure to noise at work or in leisure activities [1]. Most hearing loss is permanent and cannot be recovered. Quieter industrial and consumer products can significantly reduce the likelihood of hearing loss, resulting in a healthier society.

Quieter products also provide a perception of higher quality to customers and end users. While two different hydraulic systems may perform comparably, most consumers will identify the quieter system as the better-made system. For manufacturers, this can equate to increased customer satisfaction and long-term business benefits.

Regulations also play a key role in noise reduction. In the European Union (EU), directive 2003/10/EC sets limits on exposure to workplace noise and has made employers responsible for assessing and measuring levels of noise to which workers are exposed [2]. The directive also includes provisions for reducing exposure to noise, requiring personal protection for workers, and improving worker information and training.

In the United States, the Occupational Safety and Health (OSH) Act allows state agencies to issue their own regulations, as long as these regulations are at least as protective as those of the federal Occupational Safety and Health Administration (OSHA) [3]. Approximately half the states have issued their own regulations, while the rest rely on federal enforcement. The U.S. Department of Labor also issued a noise regulation (29CFR 1910.95) applicable to all industries engaging in interstate commerce, calling for reduction of noise levels to specified levels through the use of hearing protection devices, audiometric testing, employee training and education, and record keeping. Governmental agencies in other countries have issued similar regulations.

To comply with regulations and optimize product design, manufacturers should consider an iterative approach to predicting, measuring, and improving noise in their products, as shown in Figure 1.

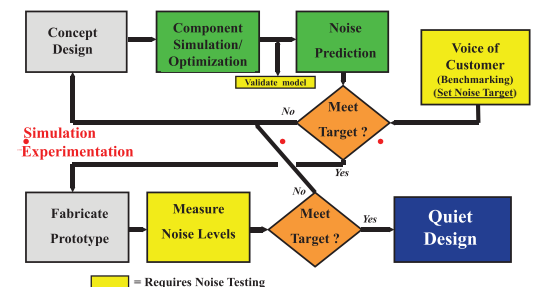


Figure 1. System-based noise reduction

A successful noise control program requires a team effort by individuals in several areas of expertise. In addition to specifying and providing low-noise components, noise must be considered as a system response based on the selected components. For example, a quiet hydraulic pump does not guarantee a quiet system. Other components and their behavior as a system must be

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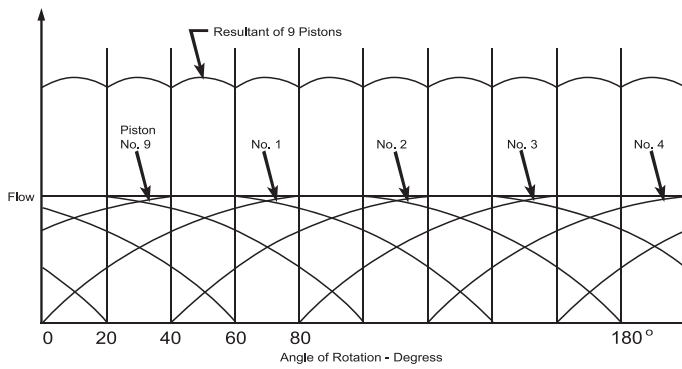
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considered. A team approach involves hydraulic, component, and system designers; parts fabricators; manufacturers; installers; and maintenance technicians. If any team member falls short in considering noise, the entire noise control program can suffer.

## Categories of noise

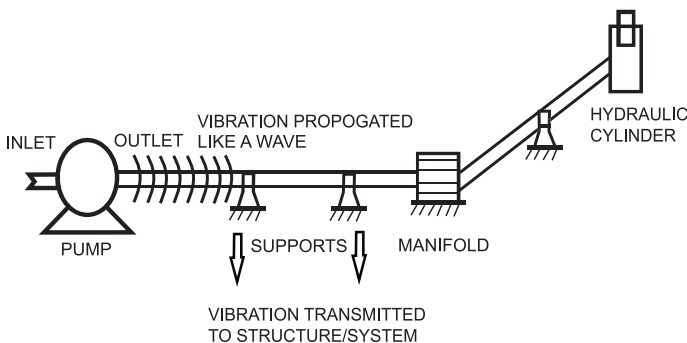
In the design of hydraulic systems, noise can be grouped into three categories: air-borne noise, fluid-borne noise, and structure-borne noise. Air-borne noise, the most commonly understood category, generally travels from its source via the air, to a receiver, the ear. System components such as vibrating shields or panels generate sound waves that are transmitted through the air to the ear.

Fluid-borne noise is transmitted through the fluid in a hydraulic system. It originates from the vibration generated from a pump pressure wave or ripple, which is translated into vibration at the surface of the hose or tube. Figure 2 shows an example of a pressure ripple generated by a positive-displacement piston pump.



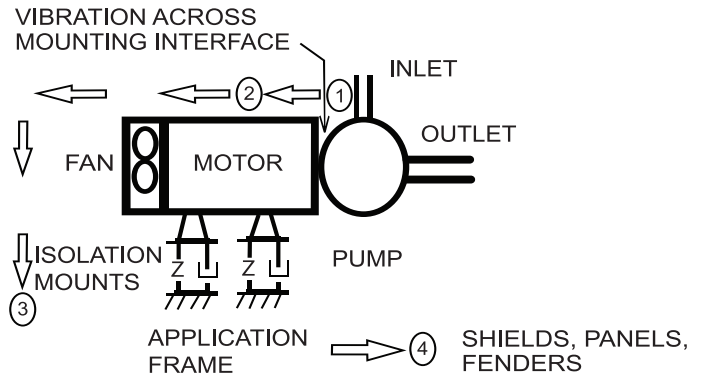
**Figure 2. Pump pressure ripple**

Fluid-borne noise can be transmitted into a hydraulic system via other components, such as hoses, tubes, supports, clamps, manifolds, and motors, as shown in Figure 3. Once the vibration is transmitted into the system, it propagates throughout the system material at the speed of sound within that material, where it can affect objects such as panels, shields, reservoirs, and structural framing.



**Figure 3. Transmission path for fluid-borne noise**

Structure-borne, or equipment-based, noise results when one component of a system generates vibration that propagates through another. It starts with vibration from an external source or component and is transferred directly into the frame or structure of an application. The path can be pump-to-motor interface or motor-to-structure/frame interface, as shown in Figure 4.

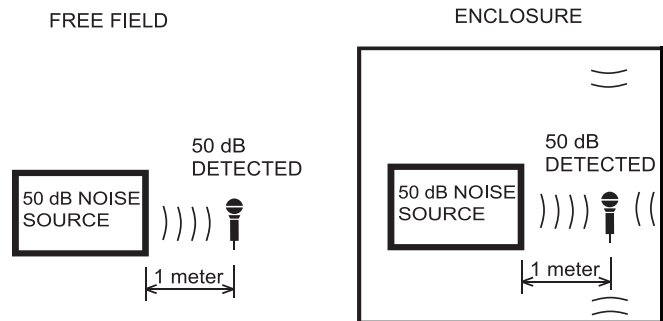


**Figure 4. Transmission path for structure-borne noise**

## Identifying noise sources

Noise can originate from multiple sources and can be affected by numerous factors. There may be a primary source, such as a pump or motor, along with secondary sources, such as hoses, piping, fasteners, and other appurtenances within a hydraulic system that provide transmission paths for noises. Vibration can be transmitted from one source into another component, where the second component can become a resonator or "speaker."

Situational factors can also affect how much noise is detected. When a source is enclosed within a structure, for example, the noise can increase due to reflection of noise within the enclosure, as shown in Figure 5.



**Figure 5. Noise in a free field vs. noise in an enclosure**

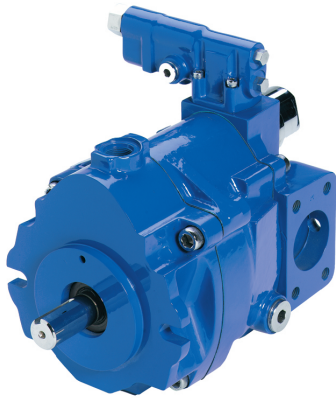
To effectively identify noise sources, noise can be measured at a distance of 1 meter from the external sides of the noise source, and a frequency response analysis performed. This allows identification of the dominant noise frequencies, relating these frequencies back to source components, and ranking the frequencies for source strength.

## Designing quieter products and systems

Noise reduction in hydraulic systems can be achieved by evaluating each component in the system, along with the system as a whole. At the component level, variable-speed pumps can provide a key starting point. In variable speed drive (VSD) systems, the pump speed varies to match the duty cycle requirement. This can result in noise reduction as speeds are reduced when not needed by the system.

Eaton's PVM series axial piston pumps, as shown in Figure 6, offer industry-leading low-noise levels, with optimized shafts, ports, mounting and through-drive options with high torque capability. PVM pumps can reduce noise levels in applications that require a wide displacement range. The three-piece design with high load bearings also provides high reliability and durability.

## Low noise by design: a system-based approach



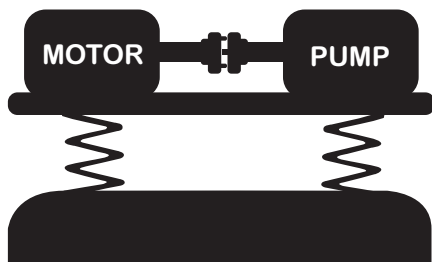
**Figure 6. Eaton PVM series pumps can reduce noise levels in applications requiring high displacement ranges**

Eaton's VMQ Series fixed displacement vane pumps, as shown in Figure 7, offer high performance characteristics at low noise levels. With a unique bi-metallic wafer plate design that allows for the increase in viscosity and pressure rise even during cold start-ups, VMQ Series pumps handle higher pressures than vane pumps of similar design. This makes them effective for discrete manufacturing applications such as metal forming, food processing, plastic injection molding machines, industrial bailers, and more.



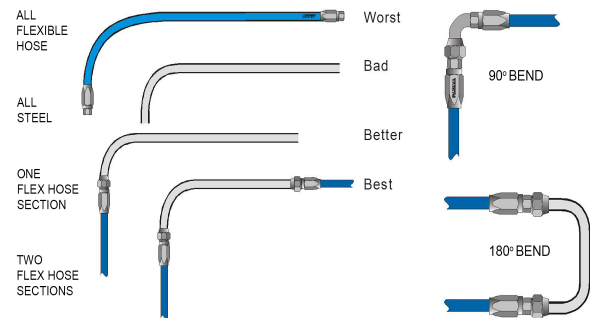
**Figure 7. Eaton's VMQ Series fixed displacement vane pumps offer high performance characteristics at low noise levels**

While quieter individual components can contribute greatly to noise reduction, even greater gains can be achieved by reviewing overall system design for opportunities to reduce noise. Vibration control can be used to minimize transmission of vibration from pumps and drives to machine structures and equipment. This can be achieved by isolating the pump and/or motor from rigid foundations by using subplates or other base isolators, as shown in Figure 8.



**Figure 8. Subplates can be used to isolate pumps and motors from rigid foundations**

Proper hydraulic line configuration can be used to maintain vibration isolation when pumps and motors are mounted on isolators. A proper combination of rigid and flexible conduit, as shown in Figure 9, can provide a more stable configuration, providing reduced vibration and noise.



**Figure 9. : Proper hydraulic line configurations**

Isolation of hydraulic lines and hoses from the application structure (i.e., frame, supports, or panels) provides another opportunity for reducing noise in the design of the machine. Panels and shields can often act as speakers and amplify relatively low vibration levels into high noise sources.

System testing and evaluation can provide additional insight into noise reduction. In properly designed testing areas, components can be isolated from background noise to focus on noise sources, transmission paths, and opportunities for reduction.

At Eaton's Eden Prairie, Minn., facility, components are tested in a hemi-anechoic chamber equipped with industry-leading data acquisition equipment to evaluate noise. The data acquisition equipment records test data from the operating equipment for further analysis and refinement.

## Conclusion

By viewing noise with a systematic approach, the potential for successfully reducing noise is far greater than simply looking at individual components. An informed team, cognizant of the various components and roles in the overall system, can help identify noise sources and design for low noise.

## Sources

- National Institute on Deafness and Other Communication Disorders, National Institutes of Health, Bethesda, MD, USA.
- Directive 2003/10/EC of the European Parliament and of the Council of 6 February 2003 on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (noise).
- "Comparison of Occupational Noise Legislation in the Americas: An Overview and Analysis," Noise & Health, 2014, Volume 16, Issue 72, pp. 306-319, Jorge P. Arenas and Alice H. Suter.

### About Eaton

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