TURNING DOWN THE SOUND: IDENTIFYING CAUSES OF AND PREVENTING PUMP NOISE
PART 1: What Is Pump Noise and Where Does It Come From?

Regardless of size, application or medium, noise can be a challenge for anyone using a pump. But what causes this noise in diaphragm pumps? And what, if anything can be done to mitigate it?

Noise from pumps has several different characteristics. Of course, this includes the relative loudness (decibels), which is likely the first characteristic of noise users consider. But other noise characteristics are also at play, like the pitch of the noise and the “type” of noise, be it buzzing, humming or vibrating.

“It’s not always how loud it is. It’s how it feels. How the sound is perceived by the ear,” Alex Baptista, Gas Pump Product Manager for KNF Neuberger, Inc., said. “Volume is only one spectrum of sound that you hear. There are many different dimensions to it.”

Equipment noise can present a variety of problems, which can differ in terms of impact based on the specific application. At the least, noise can be distracting and annoying. But for some applications, noise can impact the ability to communicate, causing potential safety issues in some environments. Prolonged noise can even be detrimental to the health of employees. For bed-side medical applications, noise and accompanying vibration can affect patient sleep and comfort.

Why Do Pumps Make Noise?

First, it’s important to understand why pumps make noise. A variety of pump-related and environment-related factors can contribute to noise generation. Some of these factors include:

Pump-related Factors

- **Motor**
  Every electric pump has a motor, which drives its diaphragm, eccentric and other parts. There are a variety of different motors available, including brushed and brushless. Regardless of type, motors are a source of pump noise. The rotation of the fan and spinning of motor bearings can produce noise. The motor operating can also cause vibration, which can cause noise in conjunction with other sources.

  Motor noise can be limited by reducing motor speed. This will reduce motor RPMs, as well as vibration. Pumps can also be encased in sound-absorbing material to reduce motor noise. Some applications may require a larger pump running at a lower motor speed to meet both noise and performance requirements.

- **Bearings**
  Motor and compressor housing bearings are not as major a noise source as some of the others, but they do still make noise. Bearings can make noise while rolling around inner or outer rings and impacting each other. Using higher grade bearings with tighter tolerances can help reduce noise.

  Altering a pump, both during the design phase and after production, is therefore the first and best approach to reducing noise from pump-related factors.

- **Diaphragm**
  Although their noise profile is closely tied to motor speed, diaphragms can also be a source of pump noise. Some of this noise comes from diaphragms switching from
pressure to vacuum during operation. They also make noise when changing direction or contacting the intermediate plate.

Some of this noise can be prevented by choosing alternative diaphragm configurations, which will be covered later.

• **Valves**

Valves impacting during operation is a common source of pump noise. They hit against their seats as the diaphragm moves them up and down and media is forced in and out. The faster the pump runs, the more frequently they will impact.

The best way to minimize this noise is to choose a different valve material during the design phase. As with diaphragm-related noise, valve noise can be reduced with alternative materials and configurations. Stock valves can be replaced with custom designs that don’t impact as loudly. Elastomeric valves will make less noise when impacting than stainless steel valves. Running the pump more slowly will also reduce the number and type of impacts.

• **Inlet and outlet ports**

Valve and diaphragm noise is common at a pump’s inlet and outlet ports. Adding accessories to either port can greatly reduce that noise. As we will discuss later, accessories can also impact pump performance. Using them to reduce noise from inlet and outlet ports requires a balancing act based on which factors are most critical to the application.

• **Pump load**

Load switching is a frequent source of pump noise, one that can be difficult to avoid in some applications. It occurs when a pump is placed in a system that requires it to switch from one operating mode to another. For example, a pump operating under low pressure then switching to high pressure will experience a drastic change in load and must adjust to compensate. This will most likely cause additional noise from the sudden change in flow and performance.

The best way to prevent this noise is to avoid conditions where load switching will occur. However, this isn’t always possible. Reducing motor RPMs is an option, and different muffler and tubing configurations can help. It may be necessary to use a slightly larger pump run at lower speed to meet both noise and performance requirements.

• **Tubing (as a noise factor)**

Tubing is attached to pump inlets and outlets and can have a major effect on noise levels. A variety of factors can impact the noise generated from tubing, including the material it is made from, its length and its inside diameter. Vibration from the pump and media flowing to the inlets and from the outlets can also cause tubing to shake, creating noise if the tubing then impacts or vibrates against other system components or enclosure.

Environment-related Factors

Not all noise comes from the pumps themselves. The location of a pump within a system and what surface it is placed on are major potential noise sources. The components in these systems and how the pumps are integrated into them can have as big an impact on noise as the pump itself.

• **Enclosure**

The material surrounding a pump can be both a source of or mitigator of noise. Placing more material around the pump allows for greater potential to absorb or deflect noise. Some can actually amplify or carry noise rather than reduce it. Heavier and thicker materials can act upon.

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as harmonic absorbers, reducing unwanted noise. Using a material like rubber can help absorb vibration and reduce noise.

- **Mounting surface**
The surface a pump is placed on can be a major source of noise. Vibration from the pump can be amplified or cause additional noise if the pump is located on a rigid or metallic surface. Because of this, pumps should never be mounted to the exterior shell or cover of a device. The best way to prevent this noise is to keep the pump as isolated as possible and have it properly mounted.

All of these potential noise sources, and the impact of altering them, need to be considered. Because so many factors can contribute to noise generation, there are also several approaches to mitigating it. Even with detailed custom design, it’s impossible to tell how a pump will interact with its surroundings without testing.

### Part 2: Preventing Pump Noise

As alluded to previously, there are several steps that can be taken to mitigate noise. Each different source of noise can be addressed specifically, though there is some overlap. Some steps that can potentially reduce noise include:

- **Custom design**
Mitigating pump noise starts in the design phase. Product development engineers need to discuss any noise requirements with their pump manufacturer partner. The pump manufacturer in turn should lay out possible options and any inherent trade-offs. As with most design parameters, their interplay will also require prioritization.

- **Specialized parts**
Some noise can be mitigated by choosing different parts and materials during the design phase. As previously discussed, using elastomeric valves instead of stainless steel or other metal will help mitigate the noise created by valves slapping against valve seats. Noise from diaphragms impacting intermediate plates can also be mitigated by using different material. Motor choice is also critical, as some motor types are louder than others. Understanding how different materials perform within a pump and choosing the correct ones can greatly reduce noise output.

- **System location and materials**
Proper pump placement and mounting within a system are also important for noise mitigation. Isolating pump and motor-generated vibration from the system will help reduce the potential for added noise from environmental factors. Adding material around a pump can help reduce noise, provided that material is designed to do so. Ensuring the pump is properly mounted will also help, as the pump can be kept from contacting noise-amplifying surfaces within the system.

- **Operational changes**
Changes in how the pump is operating can also mitigate sound from noise factors. Running the pump slower will reduce motor RPMs, leading to reduced noise. It will also reduce the noise from other drive components, including the diaphragm and valves, as reduced RPMs mean fewer impacts. In some applications, running a larger pump at a lower speed is a viable option for noise reduction.

### Adding to the Pump

Accessories can also be added to pumps to further mitigate noise factors. Some popular options include:

- **Mufflers**
Mufflers are a popular and effective accessory for pump noise reduction. They can be attached to pump inlets and/or outlets and suppress sound as it travels through layers of porous materials. This material traps sound waves, as well as some air flow, thus reducing noise. They work in most applications, provided they fit within the system where the pump is to be installed. While mufflers are a relatively inexpensive and efficient way to reduce noise, they aren’t without their drawbacks. While they don’t impact ultimate pressure or vacuum, they do reduce pump flow performance.

- **Tubing (as a muffler)**
Tubing can be a noise-generating factor, but it can also be used to reduce sound output as well. Tubing can be added to the outlet side or the inlet side of a pump pulling vacuum to reduce noise output. Longer tubing and softer materials tend to be more effective at absorbing noise, though this is not always the case. Heavier, more rigid tubing tends to vibrate less in applications where that is an issue. Using tubing to reduce noise also has its challenges, as choosing the correct tubing often comes down to a time-consuming trial and error process. Having tubing that is too long or with too small of an inside diameter will also negatively impact pump flow performance. In some applications, adding tubing may actually make a pump louder.
“It’s all about pressure waves and how they flow throughout your system,” Aman Sharafi, Micro Pumps Product Manager, said. “Some things can basically become a speaker while other things will work as a muffler.”

**Shock mounts**
Shock mounts are ideal for reducing vibration-caused noise. Shock mounts can include anything from simple rubber feet to suspension springs. They are attached to the base of the pump, holding it in place while reducing the transference of vibration to the system. Adding shock mounts to a pump will have no impact on performance. While they will add to the size envelope of a pump, shock mounts should be used in any system that can accommodate them.

Regardless of what methods are used to mitigate noise, it’s important to remember that no two pumps will have the exact same noise profile. Testing is critical to determine what alterations work best for mitigating noise for each unique pump in each specific application.

“From one pump to another, you can’t compare,” Sharafi said. “You can’t say, ‘If I do x or y to two different pumps, they will sound the same.’ Or two exact pumps in different systems. It doesn’t work like that.”

**Part 3: Potential Trade-offs**
Not all of these options are possible with every pump and motor. Sometimes, these changes come at a cost. Sometimes that cost is financial. Other times, it’s at the cost of pump performance. That’s why it’s so critical to create a plan and determine how important noise reduction is for your application.

“In all of this, there are going to be some trade-offs,” Baptista said. “Maybe the trade-off is going to be a slightly reduced performance. That’s why it’s important to test the pumps and know what system they are in.”

**Materials**
Specific materials may not be available for every pump configuration. Some materials may not be viable in every application, especially those dealing with corrosive media or operating in HAZLOC areas. Elastomeric valves are a good option for reducing noise, but they can’t be used in a pump that is moving a highly corrosive media.

Encasing the motor in sound-isolating material will reduce the noise a pump makes. It will also increase motor temperature, potentially causing the pump to overheat. Adding custom materials may result in additional monetary costs, as some materials are more expensive than stock options. Lead times could also increase. While choosing custom materials could result in some potential trade-offs, those trade-offs are often worth it for applications where noise reduction is essential.

**Part 4: Is Noise Reduction Critical?**
Any alterations made to a pump to reduce noise will likely require some performance or financial concessions. In some applications, the reduction in noise may not be worth potential losses in performance. If the pump is going inside a bedside or wearable medical device, reducing its noise profile is critical and needs to be a major consideration in the design of the pump and system. But if a pump is going in an outdoor system where no one is going to be around, or if it’s going into a system in an industrial facility that is already excessively noisy, it’s less relevant. It should be determined early in the design phase if noise is a major consideration for the application.

There may be some applications where noise and/or vibration is actually beneficial. For someone using a handheld gas detector in a dangerous environment, a little noise can let them know their safety-critical device is on and functional. Startup noise can help users determine if their pump or system is working properly or needs maintenance.

Pumps can be extremely complex, and reducing their noise output can be a challenge. However, with smart design, use of accessories and a little bit of testing, it is possible to turn down at least some of the noise. Working with a pump company like KNF, which has decades of experience across a variety of industries, can help users work through application-specific needs and trade-offs.