Advancements in Noise Reduction Techniques for Medical Equipment Manufacturers

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Noise Reduction Techniques for Medical Equipment Manufacturers

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Introduction

Medical technology continues to evolve towards diagnosis and treatment devices that are closer to the patient or even in the patient's home; examples include point of care diagnostics, dialysis, and portable oxygen concentrators.

Medical equipment manufacturers are responding to this trend by designing smaller, more portable equipment that is adaptable to the users' personal environment. Non-intrusive attributes related to aesthetics and size reduction are important considerations as new equipment is brought to market.

Within this scope, the noise generated by the equipment should be carefully assessed to assure it does not present a negative condition in the adoption and assimilation of these devices into everyday life. This white paper discusses the impact of noise-generating equipment on patients, sources of noise, challenges faced by original equipment (OEM) manufacturers, and sound mitigation solutions.

Patient monitor in neonatal ICU.

Impact on Patients

Minimize the disruption

Users want to maintain their normal living conditions while realizing the health benefits of their medical equipment. It is important that sound, as one of the five senses, is addressed in a manner that assures the equipment operates without unpleasant and embarrassing side effects.

For example, in compression therapy, a common application of medical technology is applied to prevent clotting in the users' legs and feet during hospital stays and surgery. The devices designed for this treatment use pumps that cycle on and off over long stretches of time, including periods of rest and sleep. If the pump's sound level is too loud, it can create a counter-productive environment for the user. Sound attenuation measures can address this in simple ways that will be discussed below.

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> — Aylin Tumer, design engineer, Parker Precision Fluidics Division

Sources of Noise

In medical equipement

In pump engineering, these are two main sources of sound generation:

- **Structure borne noise** - this includes vibration and other physical structure-generated sound.
- **Pneumatic noise** - sound emitted by flow or movement of air.

Noise is generated by several components common to medical equipment, including:

- Diaphragm pumps
- Solenoid valves
- Fans

Diaphragm pumps tend to be the most substantial source of noise. Their motors rotate a crank that moves a connecting rod up and down, flexing the diaphragm. This action builds pressure or vacuum and generates flow. As the pump operates, it emits vibration across the body of the device.

Solenoid valve and fan noise accompanies sound generated by diaphragm pumps during operation. This is caused by the normal actuation of solenoid valves and rotation of the fans as they oscillate the air to keep the equipment cool.

Since pumps often cycle, their noise levels can be intermittent. This creates a notable change in the environment when the equipment engages, and breaks the normal sound conditions. Unwanted attention, annoying sleep interruption and embarrassment due to the sound often result in increased anxiety for the users of the equipment. It is easy to see how this can be a negative impact on their overall well-being and counterproductive to the equipment's sustainable positive impact.

Challenges for OEMs

Reduced equipment size

Some advances in equipment design that enhance the user's experience, can actually exacerbate the challenges associated with sound attenuation. Vibration mitigation, for example, becomes more difficult as the overall footprint of equipment get smaller. Less size means there is a reduced opportunity to dampen sound through traditional measures.

Competitive advances

The pressure on OEMs to bring new designs to market leaves little time for manufacturers to contend with the issue of noise attenuation. While new, smaller designs allow for a user to wear the devices on their body or position them near their bedside, they are forced to contend with the annoyance of the sound generated in operation.

Solution

OEMs report that noise generated by equipment is their number one complaint. But to date, few component manufacturers have placed sound reduction as a priority in their product enhancement activities. Sometimes mufflers are recommended as an accessory item. This will offer some sound attenuation, yet could cause an increase in back pressure and overall dimensions of the device.

Parker Hannifin, however, has and continues to direct their engineering teams to find ways to mitigate noise while incorporating other user-friendly concepts into the components that it designs and manufactures.

To this end, noise reduction is a prime focus of Parker's new product development projects. In fact, Parker engineers encourage their partner OEMs to visit their labs to see the testing on sound attenuation that they are conducting and to realize the importance of this focus.

Noise reduction techniques for diaphragm pumps

Testing included five different pumps and methods of sound reduction including:

- Oversizing the pump
- Use of vibration isolating mounts to secure the pump
- Adding a muffler to the pump
- Adding an additional pump enclosure (Acetal Homopolymer, Delrin 150, lined with soft acoustical foam)

All tests were conducted at a distance of 12 inches from a microphone inside a sound chamber. Pumps were tested at two pressure points: 4 and 8 psi. Sound was measured using a Quest Model 2900 Sound Level Meter. Tests used a baseline pump operating at 3100 RPM. This was compared to an oversized pump running at a slower speed (2600 rpm).

Summary of the impact of measures on sound levels:

Technique	Sound Reduction
Oversizing the pump and running it slower	2-3 dB
Adding a muffler	3-4 dB
EZ mount	3 dB
Results of combined above techniques	6 dB
Adding a pump enclosure	9 dB

Key Methods for Sound Reduction

Structure borne noise

- EZ Mount- Plastic mounting plates that incorporate elastomeric feet that reduce the vibration transmission from the pump to the medical device. These mounting solutions result in a 3dB noise reduction for an average Parker Diaphragm pump when measured at 12” from the microphone. Depending on the pump configuration, higher sound reduction is possible. Isolating vibration from the pump can reduce structure borne noise in a device. The Parker EZ-Mount offers this isolation with rubber feet with a variety of screw hardware options.
- Adding a pump enclosure - A customized enclosure can achieve up to 9 dB sound reduction when measured at 12” from the microphone.

Figure 1: Parker EZ-Mount - isolating vibration from the pump can reduce structure borne noise.

Pneumatic noise

- Oversizing the pump and running it slower- By oversizing the pneumatic performance of a diaphragm pump and then running it at a slower speed, a quieter solution is achieved while still maintaining the pneumatic performance. This reduces the number of pulsatile flow peaks, and in certain applications, this technique can result in a 3 dB sound reduction when measured at 12” from the microphone.
- Adding a muffler - Using an expansion chamber muffler can result in a 4 dB sound reduction for an average Parker Diaphragm pump when measured at 12” from the microphone. Simply adding a filter/muffler to a diaphragm pump inlet or outlet can reduce noise level by several dB while also improving sound quality. The combination of reducing vibration and pneumatic noise has a drastic effect on the sound level in an instrument.

Figure 2: Adding a filter/muffler to a diaphragm pump can reduce noise level by several dB.

Conclusion

Enhancing user comfort through medical technology advancements represents the core value proposition for OEMs. Incorporating effective noise reduction solutions into medical device design is key to a positive patient experience and long-term use of the equipment. When the patient feels good, everyone involved in putting their best equipment to work wins.

To find out more about sound reduction techniques for medical equipment and what Parker Hannifin has to offer for accessories and application engineering solutions, **please contact Parker Precision Fluidics at ppfinfo@parker.com**.

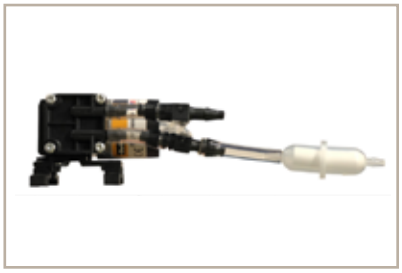

Figure 3: EZ Mount combined with a muffler reduces vibration and pneumatic noise.

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