MSA
The Safety Company

White Paper on the Sound-Level Performance of PASS Devices

The new NFPA 1982-2007 edition standard on Personal Alert Safety Systems stresses the importance of sound-level performance at elevated temperatures, and now requires PASS devices to emit no less than 95 dBA following a 5-minute exposure to 500° F. Several new SCBA with integrated PASS products are on the market, and in this paper, MSA highlights their principles of operation and safety considerations.

Principles of Operation:

PASS devices use piezoelectric sound generators to emit sound. When introduced to an electrical signal, the piezoelectric sound generator (a ceramic disc bonded to a brass or stainless steel plate) will oscillate and produce sound. The efficiency (and volume) of the sound depends upon the tuning (the dimensions and geometry) of the acoustic amplification chamber in which it resides to match the properties (resonance frequency) of the piezoelectric disk component.

As temperature rises, several changes can occur that detune the device and reduce the sound output. With conventional piezoelectric devices, the resonance frequency of the piezoelectric disk changes with heat, due to mechanical changes associated with the disk. The ambient air (an important factor in alarm design) becomes less dense. However, the geometry of the acoustic amplification chamber typically remains unchanged. Therefore, the properties of the disk can become unmatched with the sound chamber and air density, resulting in a less efficient device that produces a lower volume.

(Photo, right: a typical PASS alarm acoustic amplification chamber with flat piezoelectric disk)

Two mechanical changes commonly occur with conventional piezoelectric emitter designs at elevated temperature, causing detuning and reduced sound output. The bond between the piezoceramic disk and adjacent brass or steel plate, typically made with a polymer adhesive, will often degrade with heat and change the properties of the piezoelectric emitter. Second, the interface (known as boundary conditions) of the brass or steel plate with the housing of the device can soften or change dimensionally, causing the sound emitter to lose efficiency. Conventional flat piezoelectric disks (as shown above) are typically dependent upon being rigidly clamped in a fixed mass (housing) to function properly. These mechanical changes (together or independently) can cause a reduction in alarm volume at elevated temperatures.

To meet the new NFPA standard, MSA worked with industry experts to develop a custom piezoelectric sound generator (now patent-pending) that remains mechanically stable at elevated temperatures to prevent detuning problems. In fact, it has been tuned for maximum performance at temperatures between 200° F and 500° F (common firefighting conditions). *(Photo, left: MSA's custom piezoelectric sound generator)*

In principle, MSA's design achieves mechanical stability at elevated temperatures by two means. First, a ***unique metal bonding*** material is used to join the ceramic disk with the brass plate, allowing it to withstand high temperatures (unlike the polymer adhesives that may deteriorate in conventional designs).

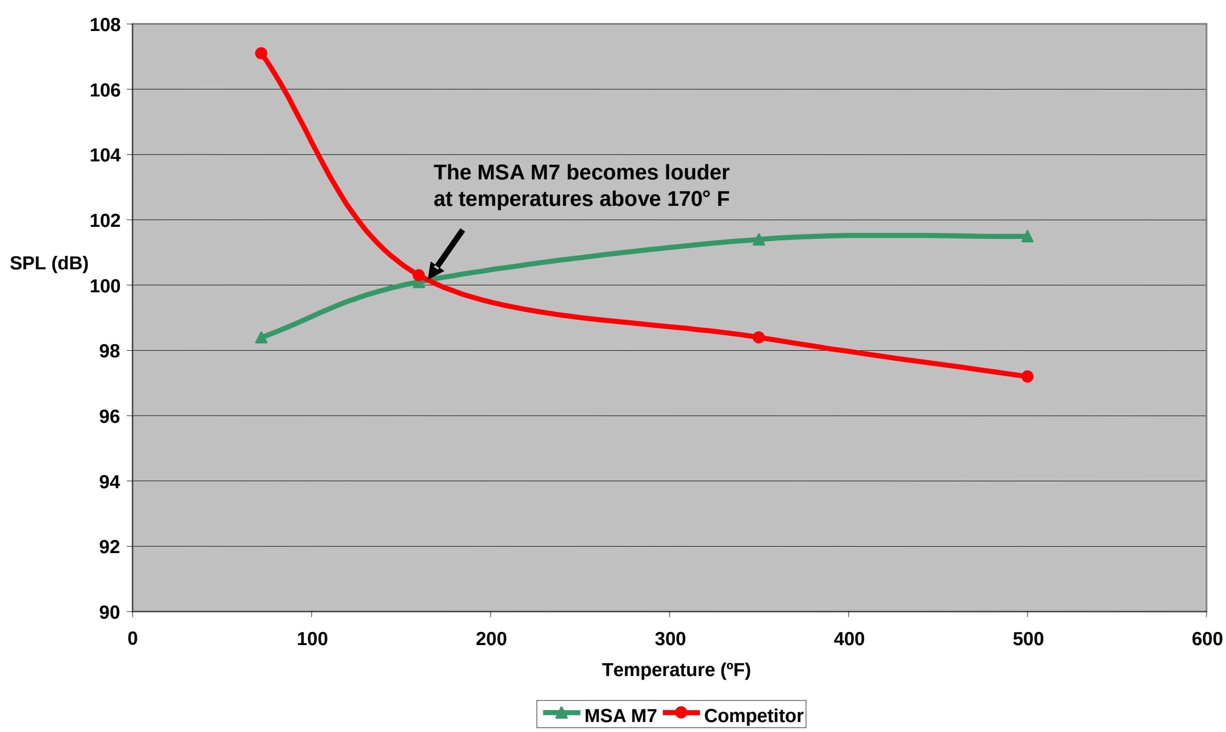
Second, the piezoelectric emitter is designed with an ***integrated boundary condition*** to operate independently of the housing. The piezoelectric component is not flat and lightweight, like a conventional piezoelectric disk. Instead, it is shaped like a cup with a weighted perimeter (mass) to serve as the boundary condition, enabling it to be separated from the housing with a flexible rubber diaphragm. The piezoelectric element is now completely independent of the housing and unaffected by mechanical changes to the housing.

Fundamentally, the MSA alarm design is inherently separated from detuning issues that occur with conventional alarms at elevated temperatures.

(Photo, right: MSA's patent-pending piezoelectric component (left) compared to a conventional flat piezoelectric disk)

The graph below shows the sound output at various temperatures for MSA's M7 PASS device and one competitive integrated PASS device. Although both products are compliant to NFPA 1982–2007, the sound level versus temperature performance is very different. The competitive product shows the expected performance of a conventional piezoelectric emitter, which ***loses sound output*** at elevated temperatures, while ***the MSA PASS device becomes louder*** at elevated temperatures. It is likely that the competitive design needs to be driven to an excessive sound level (107dBA) at room temperature to meet the NFPA minimum requirement of 95 dBA after exposure to 500° F, due to degradation in sound output. As shown in the graph, ***MSA's M7 is louder at any temperature above 170° F.***

PASS Alarm Sound Output vs. Temperature



Note: Data represent average peak values from multiple tests. Units were conditioned at room temperature, 160° F for 1 hour, 350° F for 15 minutes, and 500° F for 5 minutes (according to NFPA test protocol).

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In terms of perceived difference in loudness, due to the logarithmic decibel scale, it is known that a change of 6 dBA represents a factor-of-2 change in the SPL (sound pressure level). However, this is not a precise correlation to human hearing. Acoustic experts have documented (Ref. 1) that a change of 10 dB is similar to doubling of the perceived loudness by the human ear, and a 5dB increase represents a 42% increase in perceived loudness. Because the MSA M7 is nearly 5 dB louder than the competitive unit at 500° F, it will be perceived / detected by the human ear as being approximately ***40% louder.***

Summary:

It's easy to assume that a PASS alarm that sounds the loudest at room temperature is also the loudest in a hot firefighting environment, but we know that is ***not*** always true. At temperatures as low as 170° F, a ***dramatic change*** in sound output can occur.

The MSA M7 PASS alarm has been designed for optimal performance in hot firefighting environments, and can be 40% louder than conventional PASS alarms currently on the market. Even in temperatures just above 170° F, test data indicate that the MSA M7 is louder than conventional designs. We encourage departments to get the facts when making important decisions about their safety equipment.

Sincerely,

Mike Rupert
Product Group Manager
First Responder Products

Reference:

1. Stevens, S.S., & Davis, H. (1936). *"Psychological acoustics: Pitch and loudness." Journal of the Acoustical Society of America, 8(1), 1-13.*