GRAS

An Axiometrix Solutions Brand

Optimizing production line testing—

With a new microphone and novel technology

GRAS Sound & Vibration
Application Note // By Rémi Guastavio and Kim Boldt

APPLICATION NOTE

Introduction

The new GRAS EQ 40PM EQset™ Miniature Production Line Microphone is a response to a general lack in production line testing. This 'lack' is a result of the traditional thinking where a best-fit solution is put together for an acceptable return on investment. Measurement microphones can be a costly investment, and a production line may need a lot of them, so to minimize the investment, less expensive production test-type microphones with limited stability and no added features (such as transducer electronic data sheets (TEDS)) are used. In the past, these microphones performed the job they were used for, but for current test requirements, they lack stability, precision, and efficiency. They require more time and effort in calibration and corrections to ensure that they return suitable data, and there can still be unacceptable margins of error that result in good units failing and bad units passing. EQset is a reevaluation of what a microphone can do, so that a cost-friendly investment can provide a microphone that meets and exceeds today's much higher quality demands and does not need the extra time and effort spent in calibration, correction, or pre- or post-processing.

This application note addresses aspects of a new microphone technology, EQset, and a new microphone, EQ 40PM, including:

- **What is EQset**
- **Information about the new microphone**
- **How measurement tolerances result in false passes and failures**
- **Optimizing production lines**

What is EQset?

Microphone technology has functioned in the same way for quite a while, combining a capsule and a preamplifier with various features to suit particular measurement scenarios and needs. Over time, the tools added to the preamplifier (TEDS, for example) have made particular tasks easier—identifying microphones, storing calibration, sensitivity, and response/correction data that can be used to automate some processes and reduce the workload, and other useful tasks. However, while these features save time and effort and provide more usable data, they add to the cost of the hardware and software in a setup.

The target set for EQset, before the design phase even began, was a microphone that could provide superior data quality without adding an equivalent increase in expense. This required a rethinking of the design and build process. Rather than a microphone that transmits a signal to an analyzer where the data must then be corrected manually, or a premium system that provides the correction data to a specialized setup that can pre- or post-process the data to correct it, GRAS envisioned a microphone that provides the already correct data. In order to achieve this, the signal is essentially equalized before it leaves the microphone. The result is a single microphone unit that provides a uniformly fixed sensitivity and flat response curves that can be interchanged with any other EQset microphone in a setup without adjusting any setup parameters or making additional corrections.

Why no TEDS?

A mainstay premium feature in the measurement and production line microphone world is TEDS. TEDS is a very useful tool that provides information, particular to the individual microphone, to an analyzer so that the analyzer can identify the particular microphone, use sensitivity data for calibration at one specific frequency (usually 250 Hz), and use the correction curves to correct the output for frequencies in the microphone's measurement range that are not the specifically calibrated frequency. However, because the sensitivity of each EQset microphone is functionally the same across its full frequency range (deviating less than 0.5 dB from 20 Hz to 10 kHz and less than 2 dB from 10 to 20 kHz) there is no need to make individual corrections for each microphone and therefore, no need to store that correction information on the microphones via TEDS.

The upside to not needing TEDS

EQset enabled microphones have an SMB connector that allows them to connect to any CCP-based system already in use on a production line. However, because their accuracy does not rely on calibration and preprocessing or postprocessing corrections based on the response curve, they do not need to be paired with systems that are able to read TEDS. This means that EQset microphones can be used in systems based on audio sound cards using 48 V phantom power (Fig. 1). This provides a number of potential areas of cost savings, covering new production line setup costs and upgrading the quality of existing lines.

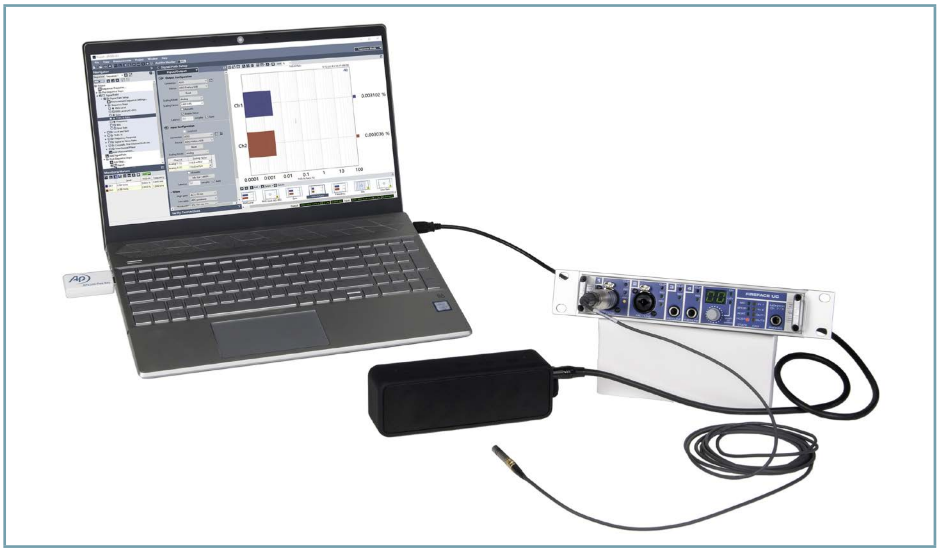

FIGURE 1.

EQset-enabled micro-phones can be used with any CCP-compatible system or audio interfaces that can supply +48 V phantom power and an analyzer (such as Audio Precision's APx500 Flex) .

Calibration

Calibration has a large impact on the cost of operating a production line. In order to calibrate microphones on the production line, that line must stop, and if the line isn't running, revenue is being lost. One alternative is to skip calibration, but that results in its own cost with bad units making their way into the market, reducing customer satisfaction and the expense of dealing with returned products. Another option is to reduce downtime by using a microphone that does not need frequent calibration.

Fixed Sensitivity

EQset microphones have a uniformly fixed sensitivity (25 mv/Pa (-32.04 dB re 1 v/Pa) for EQ 40PM), and the variation between individual microphones varies less than 0.2 dB from nominal sensitivity (Fig. 2). Historically, microphones used on production lines have a sensitivity spread of ±2 dB, or greater. The fixed sensitivity of EQset microphones enables production lines to stay up and running much longer without the fear of shipping bad products.

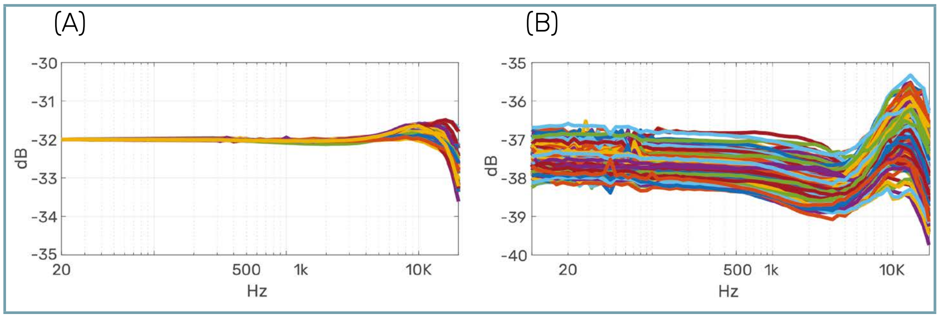

FIGURE 2.

A comparison of (A) 100 EQset microphones and (B) 100 comonly used production line microphones of the same brand and type.

Reduced uncertainty

Flat Frequency Response

Frequency response variation for EQset microphones from 20 Hz to 10 kHz is less than 0.5 dB and less than 2 dB from 10 to 20 kHz. Historically, production test microphones response variation from 50 Hz to 10 kHz is ±2 dB and up to ±3 dB from 10 to 20 kHz. This has a large impact on uncertainty and the risk of false passes and failures, as can be seen in the Pass-fail window section below.

EQset setup simplification

Because of the fixed sensitivity and flat response curve, setup and other tasks are highly simplified. This results in a greatly reduced need for operator training. However, in operation, one of the most important benefits of EQset simplification is the elimination of human-error induced false passes and failures—which is common when using other production line microphones in the market. By using GRAS EQ 40PM with EQset, QA departments can increase confidence in product quality, focusing on the measurement data and not the microphone.

“**By introducing EQset technology**, we are proving our commitment to constantly seek new, cost-efficient and highly accurate testing solutions for production line settings across the world. Innovation is at our heart and GRAS EQ 40PM with EQset **is only our latest step**—the market can expect more to come from GRAS in the near future.”

Dr Rémi Guastavino
Director of Product Management at
GRAS Sound & Vibration

Exploring the EQ 40PM Production Line Microphone

GRAS EQ 40PM, itself, is a 20 kHz pressure microphone with a dynamic range of 30 dB (A) to 120 dB SPL (<3% THD), and its ¼" diameter and 34-mm length make it an industry-standard production line microphone that can fit on any line. The EQ 40PM is the first microphone to include EQset technology. The microphone itself, however, also benefits from a unique design and production process that enables a highly stable microphone with a short delivery lead time.

Environmental stability

Temperature and humidity on a typical production line can vary from 15–30 °C (59–86 °F), and the relative humidity can range from 20–80%. Such shifts in temperature and humidity can have a substantial impact on the sensitivity of a microphone. To ensure that data is valid, recalibration, and time-consuming corrections in post-processing, for each microphone on the line must be performed. But even then, the data will only be valid at 250 Hz (or the calibrated frequency) because as temperature and humidity change the response curve of traditional production test microphones is also affected, allowing only the possibility for an estimated correction.

It is not only the environmental changes over the course of a day that need to be accounted for. With the recent pandemic, and resulting regional quarantines, many companies have had to set up production lines in different areas of the world. These spread-out lines will each have different environmental conditions. Traditional production test microphones will be greatly affected by the different temperatures, static pressure, and humidity, and correlation between the different sites will be poor.

High stability without unnecessary calibration

Historically, production line microphones were based on sensing elements that were not designed to be environmentally stable or even able to maintain stability over a long period of time. This means that the temperature and relative humidity changes in the production environment can translate into severe sensitivity drift. For the current testing quality demands, this is not good enough. The new EQ 40PM solves this stability issue and makes its stability closer in comparison to measurement microphones than standard production line microphones. In fact, the EQ 40PM, even in the most severe cases, has a maximum deviation of 0.3 dB on a typical production line, which means that there is no need to compensate by recalibration or guess at corrections after the data is acquired, locally or across global production lines.

Pass-fail windows

On a production line, the devices under test (DUTs) have a set of specifications from R&D or the customer that they must comply with. This can be viewed as a window on a graph, see Figure 3. During testing, if the response falls within the border of the window, it passes, but if it falls outside, it fails. This is a simple process, until uncertainty is incorporated. Uncertainty can come from a number of areas, but a primary area is tolerances in sensitivity or response curves.

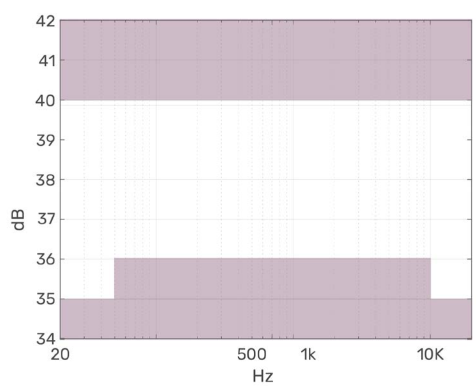

FIGURE 3.

The shaded red areas indicate a simplified hypothetical pass-fail window.

Tolerance, false passes, and false failures

All microphones have a plus/minus to their measurement accuracy, but some are more precise than others. As mentioned previously, most production line microphones have a variation between microphone responses of ±2 dB (Figure 1) between microphones in the range of 50 Hz and 10 kHz. Using a simplified example, this means that if the DUT needs to output a signal between 36 and 40 dB at a given frequency to pass, and the actual signal is 39.5 dB, the spread of results for (for example 100 microphones) will be between 37.5 and 41.5 dB, depending on which microphone in the line is used for the test, that DUT may result in a false failure. This means that good unit wills need to be scrapped or recycled. Similarly, if a DUT has an actual output at 40.5 dB, the spread of results will be between 42.5 and 38.5 dB. This means that a significant number of test stations would report false passes for that unit (Fig. 4).

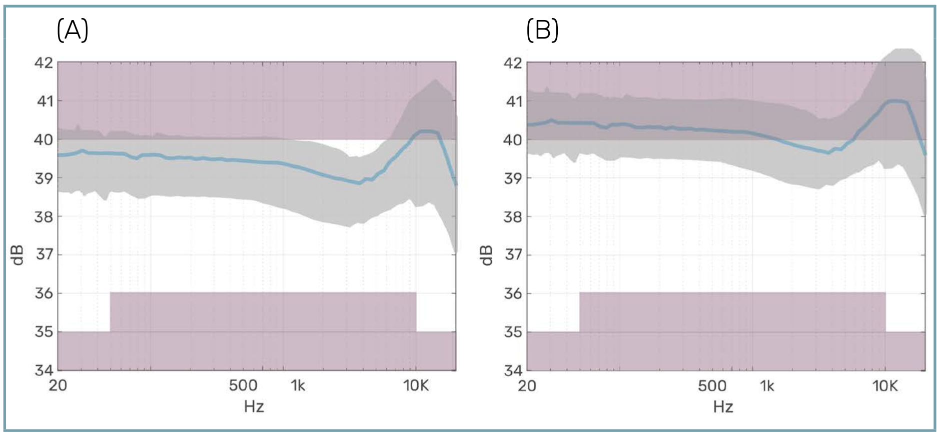

FIGURE 4.

These graphs show a representation of how microphones with a high degree of uncertainty can result in (A) a false failure or (B) false pass. The blue line represents the actual acquired signal and the grey zones are a transparency of the spread taken from Figure 2.

Reducing uncertainty

The only way to reduce the number of false passes and failures from production tolerance is to reduce the uncertainty. EQset microphones have a tolerance of ±0.5 dB between individual microphones. This means that from the example given above, there would have been zero false passes or failures (Fig. 5).

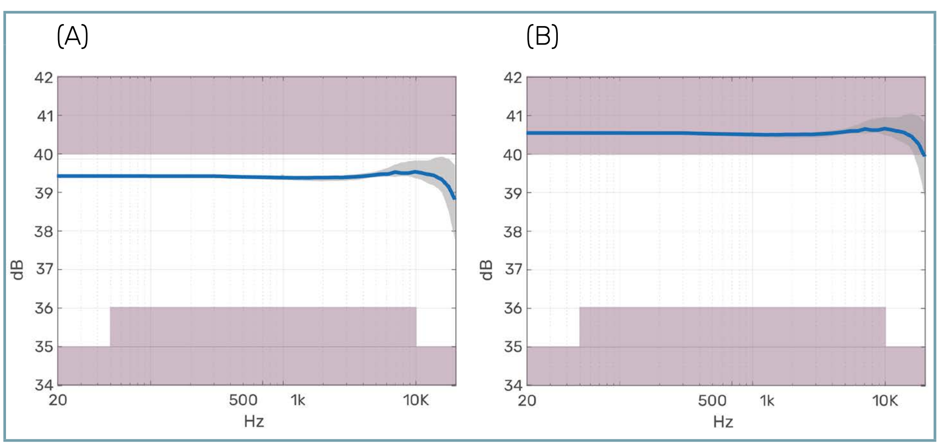

FIGURE 5.

These graphs show a representation of how EQ 40PM with EQset microphones reduce uncertainty and avoid (A) the false failure and (B) false pass from the example in Figure 4. The blue line represents the actual acquired signal and the grey zones are a transparency of the spread taken from Figure 2.

A day **without EQset** versus one **with**

In the following scenarios, it can be easily seen that calibration has a large impact on the amount of downtime for the production line. This has a considerable impact on the cost of operating a production line.

The question is: Can the amount of calibration be reduced? The trade-off for traditional microphones is an increase in bad units making their way into the market, damaging customer satisfaction and adding the expense of returned products. Another option is a microphone that is stable and accurate without frequent calibration.

Setting up a production line **with traditional** production line microphones

John is tasked to set up a line that will be using 90 test stations, so after ordering the 90 microphones, he waits for the microphones to be produced and packed. He eventually receives 90 boxes of microphones to unbox and then store the boxes.

Connection
Once the microphones are unboxed and placed, John individually reads 90 TEDS (if they are TEDS enabled microphones) or individually enters 90 sensitivities carefully noting placement, serial number, and channel. Then he imports 90 correction curves into the analysis software using one of the following methods:

» Individually import data from 90 CDs using a mini-cd reader.
» Import data from an online server.
» Import from USB drives with a comma-separated values (CSV) file.

John then methodically applies the correct corrections to the right microphones, and then he stores the correction curve storage media and any spare microphones along with the boxes.

Measurement, calibration, and maintenance
Once up and running, the line runs smoothly, but with breaks at the beginning and end of each shift for calibration and for any corrections or additional calibration that needs to be performed to reduce the impact of notable temperature or humidity shifts. However, periodic calibration (on top of the normally scheduled calibration) to verify the measurement chain is recommended.

Of course, every now and then a microphone is damaged and needs to be replaced. When this happens, John simply takes one of the spares to the line and reads TEDS (if it is TEDS enabled) or enters the sensitivity, carefully noting placement, serial number, and channel. Then he again imports the correction curve into the analysis software using the same method as before. John then methodically applies the correct correction to the replaced microphone.

Setting up a production line **with EQ 40PM**

John is tasked to set up a line that will be using 90 test stations, so after ordering the 90 microphones, he waits for the microphones to be produced and packed. He, thanks to the short lead time of the EQ 40PM production process, quickly receives four boxes of microphones (24 microphones in each box).

Connection
Once the microphones are unboxed and placed, John enters a sensitivity of 25 mv/Pa for all microphones, regardless of placement, serial number, and channel. The response curves are all uniform and flat, so there is no need for John to import correction curves.

Measurement, calibration, and maintenance
Once up and running, the line runs smoothly, but with no breaks at the beginning and end of each shift for calibration or corrections or additional concerns for temperature or humidity shifts. However, periodic calibration to verify the measurement chain is recommended.

Of course, every now and then a microphone may be damaged and need to be replaced. When this happens, John simply takes one of the spares to the line and replaces it.

Summary

The GRAS EQ 40PM is a highly stable, price-competitive, efficient solution that allows users to perform acoustic measurements without the normal hassles of lengthy setup time, downtime or replacement, while at the same time minimizing measurement error better than any other production line microphone on the market.