**MANUFACTURING IN CHINA**

**By Steve Mowry**

Many small- to mid-sized loudspeaker companies believe that they must now look to Southern China for transducer (speaker driver) manufacturing in order for their products to remain competitive in the lucrative markets in the US and the EU. The large loudspeaker companies have long since established manufacturing operations there. However, 2007 was a year of toxic recalls of Chinese products and stories of alarming working conditions for migrant factory workers. This included a report of labor abuse from Apple's iPod manufacturer in Shenzhen that resulted in a lawsuit against the Chinese investigative reporters who broke the news.

Other troubling reports came from the BBC and PBS, with other articles appearing in the press from Pulitzer Prize authors on this controversial topic. A colleague in Southern China told me recently that a facility manufacturing transducers for a famous US company was not paying workers for several months at a time, and those who left out of protest would forfeit their pay. He alleges that he himself was cheated one-month's wages by the management at this facility.

Things have become so controversial lately that the call for boycotts and/or taxation of products manufactured in Southern China is now being heard. Are these issues more important to the Western consumer than being able to purchase high-performance loudspeakers at low cost or more important than the quest of Western companies for cheap labor and high margins? I seriously doubt it! Thus, I will ignore these distractions and briefly look at loudspeaker manufacturing in Southern China and present an overview of a simple but powerful systematic

approach to Remote Quality Control (RQC) using reliability testing and comprehensive documentation and specifications as controls.

**BENEFITS OF THE MOVE**

When I began working in the loudspeaker industry in 1995, the industry capital was considered to be Taipei, Taiwan. However, I have subsequently watched the capital of the loudspeaker industry move to the "mainland"—Southern China. There are several reasons for this transition:

1. Raw materials including magnets and steel typically are sourced from China regardless of where the transducers are manufactured.
2. In spite of political tensions, Taiwanese companies moved their manufacturing operations to the mainland to reduce costs, including labor. There were essentially no language and/or cultural barriers. Air travel to and from Hong Kong is convenient.
3. China has an abundance of unskilled but stable artisan labor—the migrants from within the vast countryside. It is interesting to note that whether the manufacturing is performed in Westborough, Mass., San Diego, Calif., Tijuana, Mexico, or Guang Dong, China, it will be a person of the lowest relative socioeconomic status at the respective location assembling the transducers.
4. China has a business-friendly environment with government-subsidized land and buildings, tax incentives, and few environmental restrictions. The Chinese government wants to put people to work and typically looks the other way when controversy concerning worker rights arises.
5. There are convenient and essentially unregulated financial- and travel-related services available in neighboring Hong Kong. Also, the typical Hong Kong native is fluent in English.

**SHORTFALLS**

1. There is a lack of skilled labor within China. The recovery from Chairman Mao's Cultural Revolution is ongoing.
2. The academic standards of the universities in Southern China were quite low.
3. English language barriers—English is the language of science and technology, and most technical information sources including the Internet and the United States Patent and Trademark Office (USPTO) database are in English.
4. Chinese management can be more focused on deception as a method of avoiding problems rather than on sharing information. This common phenomenon seems to have cultural roots.
5. Shipping conditions, quantities, and timing require careful consideration, approximately 30 days on the sea from China to LA. Transducers are best shipped in containers, with a small container being the minimum.

Manufacturing is facilitated through the processes related to the formation of raw materials into a finished product. At the high end of the manufacturing technology spectrum is "Lean Manufacturing," made famous by Toyota. This system aims to eliminate waste from the process with a systematic and continuous approach; while at the low end of the manufacturing technology spectrum is the labor-intensive manufacturing in Southern China.

**SOLUTIONS**

There are ways to make manufacturing in Southern China more consistent and trouble-free. First and foremost, design quality into the

transducer and identify and resolve issues early on in the development project. Defining specification and processes should be at the very top of the list of project tasks. If the processes required to assemble a product are unstable, variable, uncontrollable, and/or random in nature, then this product will be problematic to manufacture regardless of location.

However, Southern China, as noted, also has “new” challenges and opportunities. If assembling transducers in the US or the EU is a struggle in the lab, then please think twice about moving production to China. It would be wise to revisit the transducer design under such circumstances applying DFMA methodology. It would be unwise to expect the Chinese manufacturer to resolve such issues during production.

This does not mean that the designers’ or engineers’ creativity and innovation are constrained by manufacturing in Southern China. Frankly, my experiences have been to the contrary.

When I was employed in Framingham, Mass., and manufacturing was 20 minutes away in Westborough, what could be implemented within a design was constrained by the manufacturing processes. The “Quality Control” was very good, but the designer needed to keep his design within the existing processes. The implementation of new processes was a huge task that could only be initiated by upper management, whereas the labor-intensive processes utilized in Southern China allow for more flexibility and a “you show us and we will try” methodology, but still with some inherent resistance to change. However, the designer must still keep his design within the capabilities of the manufacturer. This task is a challenge and can benefit from experience in problem solving and good communication.

Once the design is in manufacturing, you apply a stress test, a very powerful yet convenient check on manufacturing's effectiveness for most transducers. A stress test example template can be defined as follows:

1. A stress test shall be performed on each transducer manufacturing lot before shipment of the transducer order or final system assembly can be completed.

2. The DUT (device under test) sample size shall be determined with regard to the manufacturing lot size. Specifically, on lots of 0 to 50 transducers, the sample size shall be two. On lots of 51–250, the sample size will be three. On lots of 251–500, the sample size will be four. On lots of 501 to 1000, the sample size will be five. On lots of over 1000 pieces, the sample size will be ten. A manufacturing lot is defined as the number of identical transducers built in succession for any time period without any change in manufacturing process or materials. Regardless of lot size the samples must be chosen randomly from each manufacturing lot.

3. The excitation signal for low-frequency transducers (spider(s) and surround) shall be a 50 or 60Hz sine wave. This excitation signal can be the AC line voltage reduced by an appropriate Variac (infinitely variable stepdown AC transformer) or equivalent such that the displacement is ±Xmax.

4. The excitation signal for high-frequency transducers (surround only) shall be high-pass filtered at 12dB/octave at TBD Hz, diode clipped pink noise with a 6dB crest factor, at TBD volts. This requires a signal generator and audio power amplifier(s).

5. The duration of the test shall be 24 hours or until failure, whichever comes first.

6. A sweep test must be passed after the 24-hour stress test is completed.

7. The pass-fail criteria shall depend on the sample size. For sample sizes of less than five, all samples must pass the test to be considered a pass. Therefore, if more than one sample fails to pass, then the test shall be considered a fail and the lot must be reworked or scrapped. For sample sizes of five, if one sample fails, then retest. However, if more than one sample fails, then the test shall be considered a fail and the complete lot must be reworked or scrapped. For sample sizes of ten or more, no more than one sample may fail to pass and the test shall be considered a pass. If two samples fail to pass, retest. However, if more than two samples fail to pass, then the test shall be considered a fail and the complete lot must be reworked or scrapped and R&D shall be notified of all test fails within one day (24 hours).

The stress test for low-frequency transducers is very simple to implement. It does not even require audio power amplifiers or a signal generator. The transducers can be driven in parallel from the AC line voltage. The stress test is intended to determine whether the manufacturer has performed the manufacturing processes within acceptable limits by driving the transducer in free air to approximately ±Xmax for 24 hours at 50 or 60Hz.

Even a 50mm full-range twiddler with an *fo* of 100Hz can be stress-tested to verify the manufacturing processes. The benchmark for this test is a pass. Thus, if a failure is detected, then something has drifted out of specification. It could be part, adhesive, and/or process related.

High-frequency transducers require a noise type (broadband) excitation signal. Thus, a signal generator(s) and audio power amplifier(s) are required. The stress test for high-frequency transducers is similar to a power or life test; however, the duration is reduced to 24 hours and for some high-frequency transducers this can be further reduced to 12 hours. Either way, the stress test inherently imposes high QC and reliability standards; however, I rarely, if ever, see it being utilized in Asia!

**CHECKLIST**

Here's my ten-point plan for dealing with manufacturing in Southern China:

1. Know your suppliers' capabilities. Design within the capabilities of the manufacturer(s). Practice Design for Manufacture and Assembly (DFMA). "The simpler the better"; "less is more."
2. Utilize Failure Modes Effects Analysis (FMEA), and assume worst case. Design-out potential failure modes.
3. Use self-locating part features and soft and hard part gauging while avoiding orientation of parts. Use self-gauging/locating modular assembly of soft part and hard part subassemblies if possible. The objective is to foolproof the assembly process.
4. Utilize comprehensive documentation such that manufacturing processes and specifications are clearly defined and if troubleshooting is required, corrective action can be quickly and effectively identified and implemented.
5. Require manufacturing to stress-test each and every lot of transducers and make passing a condition of sale. The stress test can be performed again as a control check at the final assembly destination in the US or EU, for example, with only the destruction

of a few units, and in 24 hours the results are available. This is a powerful deterrent from shipping “bad” product related to the ability to detect defects.

6. Formulate the test specifications such that clear and reasonable performance limits related to QC are identified along with clear and meaningful testing methodology. Specify limits and tolerances and use statistical process control (SPC) to monitor processes.
7. Use Design Of Experiments (DOE or Taguchi’s method) on successive prototype manufacturing runs with a matrix of process variables including but not limited to adhesive selection, location, and quantity dispensed to quickly determine the most robust manufacturing options.
8. Practice realistic planning; just in time is too risky in this case.
9. Share information and documentation freely. Make the manufacturers and suppliers development team members, include them in the decision making process, and listen to them carefully, through an interpreter if need be.
10. Use audits, preferably unannounced, to verify manufacturers’ process control compliance. A careful examination of manufacturers’ gauges and review of SPC data along with stress test results and teardown of sample DUTs.

The larger companies have resolved issues by staffing facilities with some key skilled personnel from the US and/or the EU within the manufacturing facilities in Southern China. These include companies such as Harman and B&W. The skilled staff acts as observers, management representatives, and technical problem-solving resources for the Chinese management and labor.

However, this option may not be practical or cost-effective for the small loudspeaker company. There are also competent independent consultants that can support the implementation of a manufacturing RQC system within Southern China and perform follow-up audits for the small- to mid-sized loudspeaker companies. Formulating a checklist, maintaining comprehensive specifications and documentation, and implementing a stress testing based RQC strategy are reasonable and intelligent options to be considered for most loudspeaker companies manufacturing in Southern China.

Steve Mowry, president of SM Audio Engineering (www.s-m-audio.com), has a BS, Business Administration, from Bryant College, and a BS and MS, Electrical Engineering, from URI with highest distinction. Steve has worked in R&D at BOSE, TC Sounds, EASTECH, and P.Audio. Steve is currently an independent researcher, consultant, and lecturer in project management/transducer and system design along with being a frequent contributor to *Voice Coil* and *Multi Media Manufacturer* magazines.