SOUND QUALITY, PART FOUR: SOUND QUALITY PROJECTS MOTIVATION, INTENT AND SCOPE

By Steven J. Orfield

In Part three of this series, the concept of sound quality diagnostic testing and computerized modelling analysis was examined. The concept underlying Part three was that technical acoustical and vibrational diagnosis is essential once sound quality standards are in place even on a preliminary basis.

While the listener constitutes the beginning and the end of the sound quality analysis chain, measurement constitutes a very significant, complex and expensive portion of the ongoing analysis.

In Part four, we will discuss the motivation of the corporate researcher in using sound quality analysis, and some project applications of sound quality analysis. While the results of many of these projects are considered to be confidential corporate research, a general narrative on the problems, scope and process is useful in understanding how the typical corporate research project proceeds. Some of these projects are underway at this time, and therefore, the final benefit of these projects is unknown. Some projects have been undertaken by Orfield Associates and some are published in the literature without identifying consulting/engineering teams.

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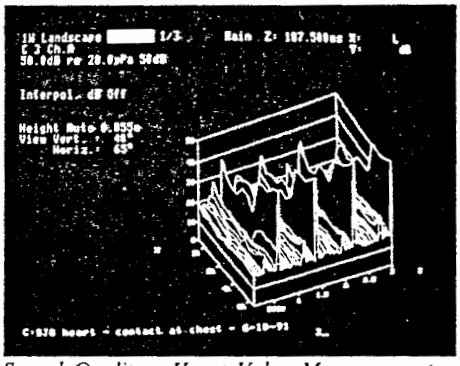


Sound Quality - Heart Valve Measurement.

Of specific interest in this process is the corporate dynamic which is generating interest within the respective firm,

MUCH OF THE MOTIVATION TO BEGIN THESE PROJECTS IS FOUND ORIGINATING IN EUROPEAN AND ASIAN DEVELOPMENTS.

and so, the relationship between research and marketing departments will be discussed in some detail. This foundational interest may be driven by such concerns as competition, legislation, product complaints or by market research. Much of the motivation to begin these projects is found originating in European and Asian developments, the former being based on the origination of sound quality in Europe and the often strict noise legislation there, and the latter being based on Asian sensitivity to noise (due in part to the limited size of living environments) and to the particular propensity, on the part of the Japanese, toward very finely focused product design, the "elegance" of which is the constant subject of the international industrial design community.

It is important to understand that sound quality is an issue which is dealt with remedially in existing products and via initial design and modelling in new products. While the former is generally an added cost, the latter is often accomplished at some engineering cost but little or no product cost. Thus, the speed with which any competitive industry "cycles" product change, particularly with regard to new generations of product development, directly affects the implementation of sound quality to that industry. (Once one significant manufacturer implements effective sound quality work in his product design, it is highly likely that the competitive manufacturers will have sound quality implemented in their next introduced and competitive model.) It is also important, from the standpoint of understanding the entry of sound quality into any field, to remember one of the fundamental rules of budgeting innovation. The first firm to introduce an innovative feature generally recoups its investment very quickly, as there is little competition; as competition comes on stream, this firm

is often able to reduce product cost because it has already recovered its investment in initial sales.

SOUND QUALITY MOTIVATION — THE CORPORATE DYNAMIC

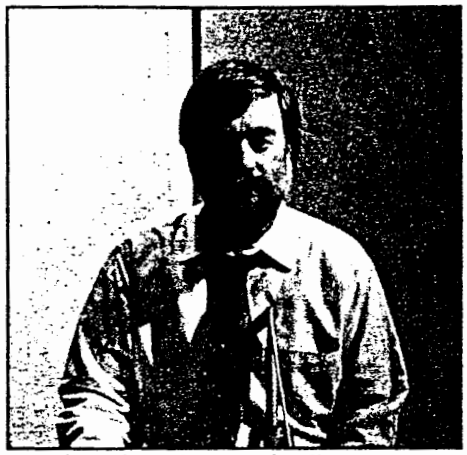
There is often a great gulf in understanding between the engineering research staff of a given corporation and its marketing and market research staff; a brief look at this situation can quickly elucidate much of the motivation behind the sound quality movement. The engineering staff, which is generally very capable with regard to acoustics and vibration, has a history of working with marketing in the identification and removal of sound problems which generate complaints. Thus, the marketing staff of a large auto maker may be responding to numerous client complaints or to an article in an auto magazine regarding the negative aspects of sound quality. An interesting case is the following review in the November 1990 *Car and Driver* regarding the Saturn automobile (this example was used in a recent Sound Quality Analysis seminar by Gordon Ebbitt of Bruel and Kjaer):

> Everything about the car prepares you for a pleasant driving experience. And then you start the engine. The power plant is in a word, noisy. We're referring not simply to decibels — at a 70 mph cruise the Saturn is only about as loud as a Civic four-door we tested — but sound quality. As the revs climb past 4000 rpm a chorus of Osterizers begins to play. By the 6500 rpm red line, the engine sounds intense enough to liquefy New York City.

If the auto maker accepts as valid the above critique, the marketing staff will note this as an imperative change. A meeting will be held with the R&D staff, and the acoustical personnel will then proceed to "eliminate" the problem. An effective fix will result in a change in consumer behavior (*i.e.*, the discontinuance of the complaint), and the problem will thus be resolved. Interestingly, there will be no "evidence" of this solution except on a historical basis; in real time, consumers will

not respond to the absence of this problem.

This is the crux of most past acoustic product engineering. As these same engineers and marketing managers enter into the advanced sound quality field, one of the crucial differences is that they are starting to emphasize the "positive" attributes of product acoustics, such as "high quality," "powerful," "smooth," "expensive." The distinction here is that after the engineering work, there is clear evidence for the consumer; if the sound quality work has been well executed, the consumer will hear it, notice it and be able to describe in common language his or her characterization of it. Thus, the distinction between the traditional corporate product "noise control" and a full sound quality effort is partially the distinction between the absence of negative acoustical attributes and the presence of positive ones.



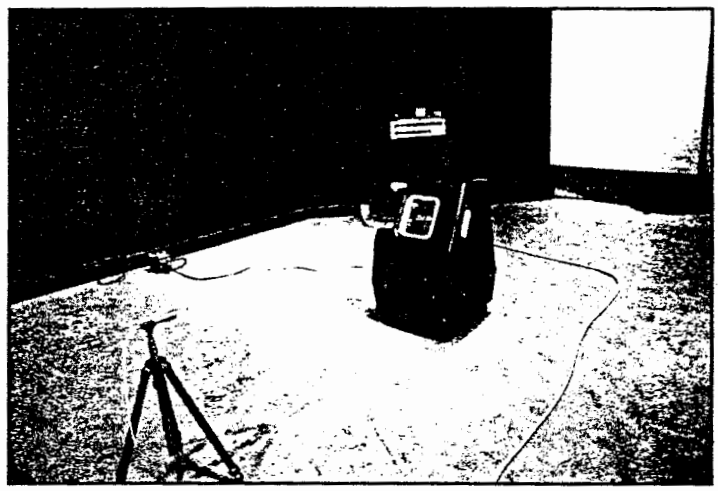
Sound Quality - Heart Valve Testing

PROJECTS — AUDIO QUALITY

A number of years ago, Orfield Associates was involved with the evaluation and design of "drive-thru" intercoms for the restaurant industry. The problem, which most of us are too well familiar with, is the consistently awful sound of these products.

On the one hand, customers and comedians are constantly referring to the lack of intelligibility of these systems. On the other hand, these same parties make repeated reference to the quality of the sound, usually by performing imitations of the nature of the sound to characterize the background noise, the harshness and roughness of the sound, as well as the lack of clarity. Thus, the problem had the two dimensions of a typical sound quality problem, the need for "noise control" and the need for quality control.

If this had been a typical noise control problem, it would have been defined and resolved in the engineering department. On the contrary, the problem was con-



Sound Quality - Medical Device Testing.

sidered to be a market-based problem which could potentially influence customers to stay away from the particular restaurant due to communications difficulty and to errors. Since the client base of this industry is broad both in age, in communications skills and literacy, this problem had to be defined in terms of a population demographic which characterized all significant population groups.

As a result of joint interest between engineering and marketing, consumer behavior observation studies were completed to elicit problems caused by or enhanced by the communications system, and the limits of the system were then clarified in terms of consumer response. Jury testing and objective intelligibility testing were performed, and a performance specification was developed dealing with both objective intelligibility criteria and subjective quality criteria. All criteria were developed based not on percentage performance increases but rather on significant benefit analysis (*i.e.*, Are each of the product improvements a significant benefit for the consumer based on jury testing?).

The result of this process was the design of a new generation of drive-thru audio systems which was tested repeatedly during design and prototyping, and the final version of this product met or exceeded all performance criteria.

PROJECTS — MEDICAL DEVICE QUALITY

Orfield Associates has been working for about a year with a medical device supplier who provides products for use in a home bedroom application in the United States and worldwide. As their products began to be offered in Japan, acoustical comments began to come back from their Japanese distributor. This gentleman explained that the Japanese made versions of the product were far quieter, and were thus more acceptable for use in the small Japanese living space.

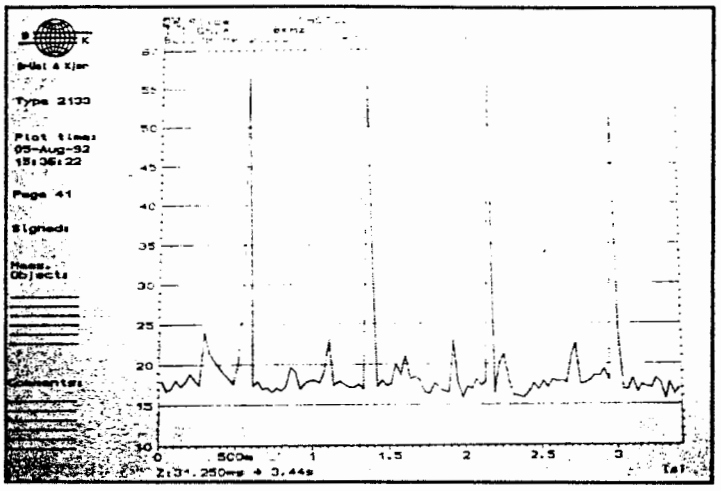
Having been retained to measure the American product, our immediate goal was to reduce the noise levels; as we began to investigate, it became quickly apparent that the noise levels of the competitive products were very similar and that this was not the issue. The American product had a sound quality problem of a whining fan noise, and had the manufacturer simply listened to the complaint by his distributor and decreased the noise level in dBA (A-weighted decibels), he would have met the criteria and failed to solve the problem at the same time.

This manufacturer has now performed a number of jury tests of his products, and we are now beginning to run sound quality calculational software analysis of the products to establish an objective base of measurement information which has a high degree of correlation with the subjective jury responses to the product's acoustical performance.

PROJECTS — MEDICAL IMPLANT DEVICE QUALITY

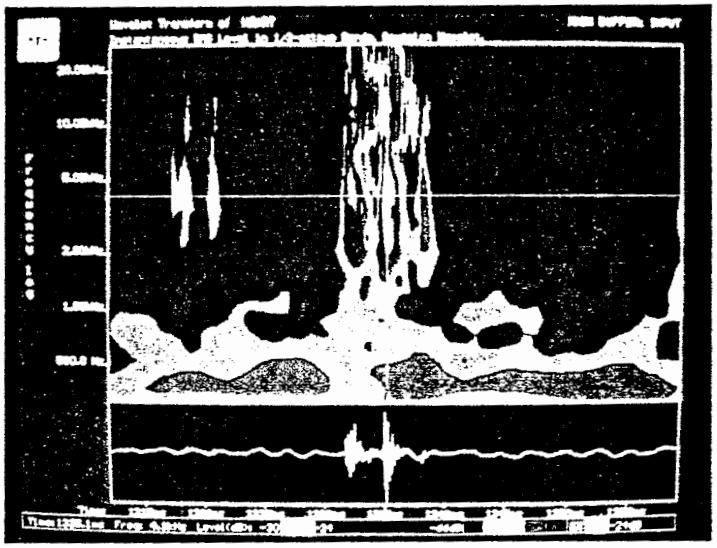
A personal experience has introduced our firm to a new area of interest highly related to sound quality. When I was in my twenties, I found out that I was born

with a defective heart valve; at the time, I was classified 4F by the military during the Vietnam war, due to my probable need for an artificial heart valve later in life. Two years ago, this need became a reality with the implantation of a mechanical heart valve. Past discussion of heart valves had suggested that noise might be an important issue in terms of annoyance; having picked a valve which was anecdotally reported to be quieter than others, the significance of noise quickly became a central issue. During normal daytime activity, there was a modest perception of the noise of valve closure, but at bedtime, there was a very clear signal-to-noise and sound quality problem with the valve.



Heart Valve at 8000 Hz.

In order to begin to quantify this, a measurement procedure based on both near field miking and on vibrational measurement of valve levels was employed. Additionally, a classical auditory threshold experiment was performed in our acoustical laboratory to quantify the perception on the valve. The experiment, an active listening threshold test, employed pink noise as a background signal. The noise level was slowly increased from about 40 dBA until the perception of the valve noise was doubtful, with the outer ear covered to simulate closure during sleep and uncovered to simulate open listening. The resultant level for full masking was 81 dBA under closure and 42 dBA under an opening listening condition, suggesting very little problem for normal daytime listening but a significant one during nighttime at-



Wavelet Transform of heart.

tempts to sleep. (A review of the medical journals confirms this view.)

Using the normal SQ paradigm considering other factors which will affect the interpretation of the noise, both acoustical and non-acoustical issues came into play. On the level of analytical Sound Quality, the valve was rated high on the sharpness scale, as the impulse was very strong in the high frequencies. On the loudness scale, the valve was also significant, as the signal had a very high signal-to-noise ratio in many of the higher frequencies. (It was narrow-band in nature.)

Considering the expectation set in use by a valve patient, a problem began to clarify. In listening to an implanted valve, a feedback loop is set up between the expectation of hearing the valve as associated with proper heart function and the actual heart pulse rate function. As the valve seems to sound inappropriate or different, due to such common heart functions as overbeats and skipped beats, the resultant listening response is an increase in heart rate due to anxiety. As the heart valve begins to sound faster, this same feedback loop again recurs.

This puts the valve patient in a peculiar position similar to listening to a stethoscope constantly as the environment becomes quiet. Thus, the subject in the case of heart valves is essentially in a biofeedback loop and must learn not to respond to unusual heart valve sounds or changing pulse rates, as this tends to produce a self-generated anxiety and increases in heart rate. Having met with a number of major manufacturers of heart valves, I find there is much denial of this problem, with such off-handed medical discussion of noise as being insignificant when compared with proper valve mechanical function. With this in mind, it has been interesting to prepare a live simulation of this sound in our Acoustic Simulation Room. The responses of heart valve company executives, upon hearing the actual sound of wearing their product, is quite telling. Finally, it is interesting to note that with regard to mechanical sounds produced by this product, it is often true that louder sounds suggest greater stress on the product; quieter products, conversely, tend to have fewer mechanical problems. It is important to remember that noise is often a symptom of structural stress and increased probability toward failure.

SUMMARY

It is clear from the preceding that there is a movement in manufacturing to begin to consider the residual quality of the sound of a product, both from the standpoint of affect (*i.e.*, pleasantness) and from the standpoint of appropriateness and secondary effects. While this movement is being established in Germany and in Japan, it is our hope that the Sound Quality Working Group will assist in making the United States a more focused and effective player in this revolution.

In our next article, we will discuss a specific analytical tool, Sound Quality analysis software. ■