Control Room Design

By

Philip Newell

Studio Sound

December 1993

OUT OF CONTROL?

Philip Newell examines the contradictions of studio control room design


Philip Newell's design for the control room at Front Row Studios in London

I once read a specification for a new television studio in a European capital city. It quoted design reverberation times in octave bands, which were to be shown mathematically when the plans and tenders were submitted.
The specification stated that the reverberation times were to be calculated according to the Sabine formula, yet in the same sentence went on to say that the Sabine formula did not necessarily have direct relevance to achieved results. This contradiction grew more apparent to me when I was told by many in that same country's television industry that sound was not of the greatest importance and that the emphasis was on visual effects. Yet, I personally know of TV companies which have gone to great lengths to provide the finest sound quality. Clearly, inconsistencies in design theory accompany those of industry commitment to the rooms themselves.

You need specs

There are two obvious reasons for this state of affairs—and a third less obvious reason which casts its shadow over the concept of acoustic specifications in general. The first reason is that the overwhelming majority of people who watch television listen on equipment with poor sound reproduction. And while it is true that a growing number of people now own 'hi-fi' video systems, the percentage is still small. The second reason is that the human visual sense is so dominant that when hearing and seeing at the same time, sensory emphasis is on visual material.

The third and last reason has held back television sound for some time. Most people consider high quality TV sound worthwhile, however, few enough consumers buy hi-fi TV systems to make the financiers of the TV manufacturing industry consider improving the system as a matter of urgency. It is this which leads to the third point: who of these is in control?

There are TV visionaries (no pun intended) who look to a future of 'more hi-fi television', and commit themselves now to the installation of sound studios of the first order. Their companies will be the first to be able to take advantage of the new boom. Acousticians, technicians and musicians may also consider them visionaries come what may, but if the boom does not materialise, then their accountants, chairpersons, bank managers and lawyers may not be so enthusiastic. This third important point is that the power in the television world often lies quite apart from pro-audio people.

TV studios cost a truly enormous amount of money to set up, and when such projects are undertaken, no one person usually has the cash in their pockets. Almost without exception there is an involvement with banks, institutions or shareholders who are considering the venture in purely financial terms. Such large amounts of money usually come with many legal restraints and require business plans to be submitted in such a way that everyone involved has the 'protection' of a specialist set of figures and qualifications. The intention is there should be nothing arbitrary in the assessment of the finished project. Under such circumstances, the provision of room acoustics which cannot be truly specified tend not to figure in a project unless someone within the management structure has the experience to take care of sound and to ask the financiers to back an area lacking provable specs.

Large sums of money may be involved in the sound recording or music industry in general, but its history has been a story of the development of previous successes rather than of written specifications. This is partly a function of evolution because many successful recordings have been made in low-budget studios, and partly because the hierarchy of the industry appreciates the artistry of the music. In radio and television, football matches, drama, documentaries and political events—the programming—are the majority of the work and for these current television sound is usually deemed 'good enough'. I wonder if Neil Armstrong's moon landing would have been quite so dramatic *without* the noises, bleeps and the strangled sound from the mic within his space helmet?

Sound personnel in the broadcast companies strive to achieve the best results, but it is in the music business that companies gamble readily with designs of an innovative nature.
The divide between broadcast and record companies as discussed here is really one of priorities; music people choose to gamble because they face competition in terms of original, ▶

creative music output, whereas broadcasters largely deal with music which has already been created and is merely (or not so merely) being reinterpreted or presented complete.

Correlation

A strange situation exists, whereby (in many instances) the greater importance the sound assumes, the less possible it becomes to specify acoustic parameters in meaningful objective terms. The further one progresses towards subjective acoustics, the further one moves from provable facts. In the above design proposal, the consultants had opted for the Sabine Formula which requires a diffuse, reverberant soundfield such as can be approximated in some large halls and reverberation chambers. When absorbers are introduced, however, the diffuse nature of the soundfield is lost and the Sabine Formula becomes at best approximate, and at worst, very misleading. Indeed, a totally diffuse soundfield could not exist as it implies a totally random energy flow with a net energy flow of zero, whereas in reality there is always an energy flow away from the source of the sound. Nevertheless, in a highly reverberant space, a good approximation can be achieved via the above formula.

In small acoustic spaces, Sabine formulations may tend to fail because of higher levels of clearly definable reflections or echoes. Plus the fact that anything introduced into the room (such as a carpet or a person), has a greater influence on the acoustics of a smaller space than a larger one.

Furthermore, five live rooms built to identical reverberation time characteristics, (especially in terms of RT60 alone) if built, one of wood, one of smooth stone, one of concrete, one of rough stone, and one of plaster, will all have radically different timbral characteristics, yet may all have similar written specifications. In such instances, a room may meet a written spec, yet be deemed to be sonically inferior to a room of identical conventional written specifications but built of different materials.

Many designers use controlled specular reflections, or multiple echoes to achieve, or at least to bolster, the reverberation. The principle is similar to the way that old tape echo machines used to synthesise a sort of reverberation using multiple repeats from a number of replay heads and appropriate feedback loops. When this synthetic reverberation is mixed with the true reverberation, it is not easy to find any readily accessible or easily understandable process which specifies the perceived sonic performance in such a way that (from the written specifications alone) an identical sounding room could be built. ▶

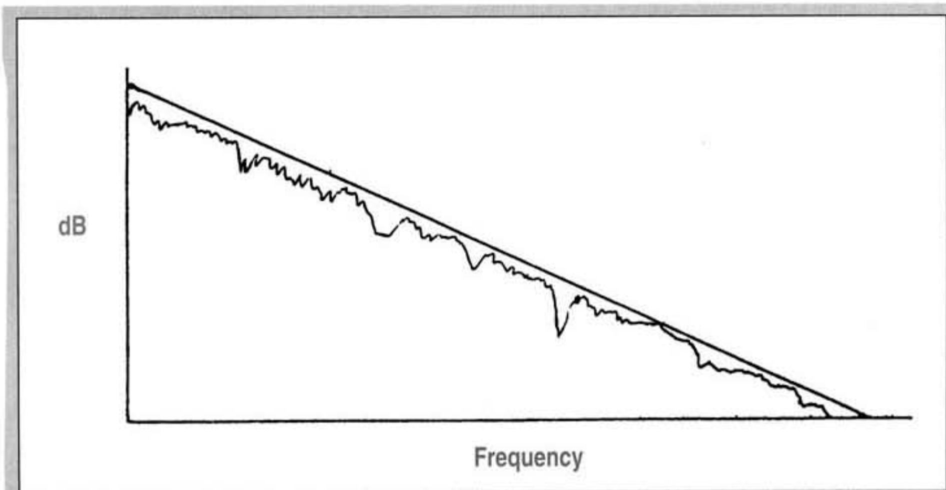


Fig.1a

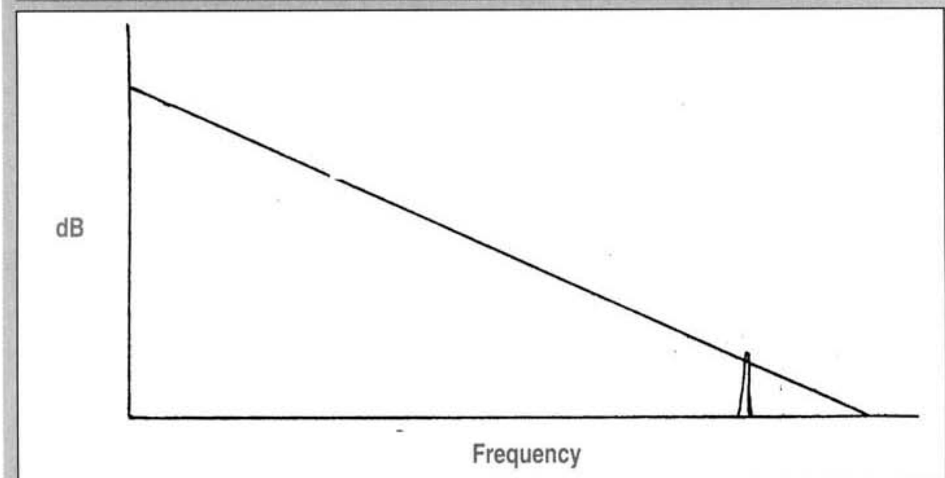


Fig1b

Fig.1: The above plots represent sections of a noise-criteria boundary by which the noise represented in Fig.1a would be numerically acceptable but the noise in Fig.1b would not. Clearly, the noise in Fig.1a would contain vastly greater energy than in Fig.1b, and in many circumstances Fig.1b would be more easily masked in virtually all real situations. Fig.1b would be greatly preferable to Fig.1a. Too strict an adherence to statistics will create absurdity!

DISTRIBUTOR LIST

Australasia & the Pacific Islands
Digital Sound Systems
Unit 5B,163 Stoddard Rd
PO Box 27-159, Mt. Roskill,
Auckland, New Zealand
Tel: 09-6293133

Belgium
Trans European Music
Pontbeeklaan 41, 1731 Zellik, Belgium
Tel: (02) 466.50.10

Denmark
Englund Music A/S, Denmark
Øresundsvej 148 st
DK-2300 Copenhagen S, Denmark
Tel: +45 31 55 48 12

Finland
Englund Music Finland Oy
Muuntotie 1, SF-01510 Vantaa, Finland
Tel: +358 0 870 3730

Germany
S.E.A.
Auf dem Diek 6,
D-4448 Emsbüren, Germany
Tel: (05903) 7805

Holland
TM Audio
Zonnebaan 52
3606 CC Maarssenbroek, Holland
Tel: 030-414070

Italy
Digimedia
Via T. Gulli 54, 20147 Milano, Italy
Tel: +39 2 48702843

Middle East
Empire Cassette Co
18, Maamal El Sokar Str
Garden City, Cairo, Egypt
Tel: (202) 3550403

Norway
Englund Music A/S, Norway
Box 150, N-1341 Bekkestua, Norway
Tel: +47 67 14 80 90

Portugal
Diapasaö Instrumentos Musicais
Av João XXI 45A
1000 Lisboa, Portugal
Tel: (351)-1-805028/805203

South Africa
EMS
24 Napier Road, Richmond 2092
Johannesburg, PO Box 1026
Melville 2109, South Africa
Tel: +27 011 4824470

Spain
Micro Fusa
Industria,244, 08026 Barcelona, Spain
Tel: (93) 455 36 95

Sweden
Englund Music AB, Sweden
Box 3050, S-127 03 Skärholmen
Sweden
Tel: +46 8 97 09 20

USA
Nelson Associates
446 Sunnyslope Ave, Oakland,
California 94610, USA
Tel: (510) 658 4212

RT60 measurements only show the time for the reverberation to decay to a point 60dB below the initial sound pressure levels. While it is true that in most genuinely reverberant spaces this decay is relatively uniform, in more complicated or less homogeneous rooms, the RT20, RT40 projections may be very different. The energy–time curves of the different rooms can be very dissimilar indeed.

On the subject of sound isolation, similar caveats exist. More specification conscious broadcast industries usually work to Noise Criteria (NC) figures. These give an envelope of maximum levels of noise against frequency which must not be exceeded if the specifications are to be met. Yet from ***Fig.1*** it can be seen that if a single spot frequency in a relatively unimportant part of the spectrum exceeds the NC, the result is deemed unacceptable. If, on the other hand, a broad-band signal remains 0.5dB below the NC at all frequencies, the specification is met. In most circumstances the much greater energy of the sound in the second case would be more objectionable than the relatively innocuous failings of the spot frequency. But to rectify this, the cost of the building could be greatly increased if the NC figures were rigidly adhered to—even though in practice no problem existed. Conversely, where NC figures are used for justifying digital data compression techniques, a broadband noise slightly exceeding the NC can be less obtrusive than a spot frequency in a sensitive area which does not exceed the NC, but conditions vary with masking effects.

A problem often arises when acoustically inexperienced architects specify to 'known' criteria without referring to acousticians. Under these circumstances, errors of judgment can easily be made in terms of subjective results, despite objective acoustic specs being satisfied.

Subjective acoustics is much like an iceberg, with 90% beneath the surface and not perceived. A change of 50% to what is perceived, may seem significant, but this may only represent a change of 5% to the whole structure. Any such change to an iceberg would alter its balance and hence the angle of flotation, revealing unseen sections, and submerging parts which were formerly visible. Without a precise knowledge of what lies beneath the surface, no change can be entirely predictable. Such is the capricious nature of acoustics: the deeper one gets, the deeper one's awareness needs to be.

In an address to the 72nd AES Conference in Anaheim in 1982, Ted Uzzle summed things up by saying: 'No sound system, no sound product, no acoustic environment can be designed by a calculator, nor a computer, nor a cardboard slide-rule, nor an Ouija board. There are no step-by-step instructions a designer can follow; that is like Isaac Newton going to the library and asking for a book on gravity. Design work can only be done by designers, each with his own hierarchy or priorities and criteria. His three most important tools are knowledge, experience, and good judgment.'

Quoting Lettinger from his book *Studio Acoustics* (Chemical Publishing Co, New York 1981): 'Nothing is gained by specifying the noise level limits in a room using an NC curve. According to this method, a noise is not acceptable when any part of the spectrum exceeds the limiting curve, no matter how narrow the frequency band which surpasses it is. But then, a noise is also unacceptable with a spectrum equal to that of the pertinent NC curves but which slightly transcends these curves. Yet the two noises carrying the same rating number, may differ widely in their A-weighted sound levels.'

There is nothing new about any of this, yet it is surprising how many people in the recording industry are still unfamiliar with these aspects of design. Back in 1963, Schultz in his *JAES* paper (Vol. II, pp 301-317) *Problems in the Measurement of Reverberation Time* stated: 'In a large room, if one has a sound source whose power output is known, one can determine the amount of absorption in the room by measuring the average pressure throughout the room. This total absorption can then be used to calculate the reverberation time from the Sabine formula. This method fails badly in a small room however, where a large part of the spectrum of interest lies in a frequency range where the resonant modes do not overlap but may be isolated. In this case, the microphone, instead of responding to a random soundfield (as required for the validity of the theory on which these methods depend), will delineate a transfer function of the room. It does not provide a valid measurement of the RT in the room.'

Evolution

When it comes to designing a control room, the problems described above almost entirely preclude designs based on rigid formulations. Control rooms began in the first days of electric recording as 'control booths'; very small rooms with the monitoring consisting of a very basic loudspeaker. Even 50 years on, control rooms were still largely what would today be considered rudimentary designs. Any acoustic treatment consisted of Helmholtz resonators and absorbent panels and, if one was lucky, some geometrical 'control'. One was very lucky if any two locations in the room sounded similar. Although almost every control room for record production was then stereo, there were still mono disc-cutting rooms and mono broadcast control rooms. Few if any control rooms had been designed with stereo as a prime consideration. Most were updates of old mono rooms and many still had four-speaker monitoring from the early days of four-track multitracking—not the quadraphonic layout of the mid-1970s, but four speakers in a row across the front of the room, one per track. Eight and 16-track machines were routed through these via switching matrices.

These rooms were often inadequate for good imaging or frequency balance when mixing to stereo. 'Good' rooms became renowned—though many of their designers could not pinpoint exactly why one room 'worked' yet another failed to please. Few genuinely good rooms existed even when 24-track machines began to appear in 1973. Around this time, Tom Hidley (then at Westlake Audio in Los Angeles) began to make international waves with a new concept in control room design. This was intended to produce repeatable results around the world, but the claims were too exaggerated and people began to complain that work done in one room of Westlake design did not necessarily sound reasonably similar in another. It was, however, a bold step, and though he did not achieve his goals during the 1970s, Hidley did change the face of recording studio design throughout the world.

Hidley later sold his shares in Westlake, moved to Switzerland and started Eastlake Audio. He later passed Eastlake to David Hawkins who had been his representative in the UK, and moved to Hawaii. Since his return to studio design in the mid 1980s, Hidley has worked alone, nowresiding in the Caymen Islands.

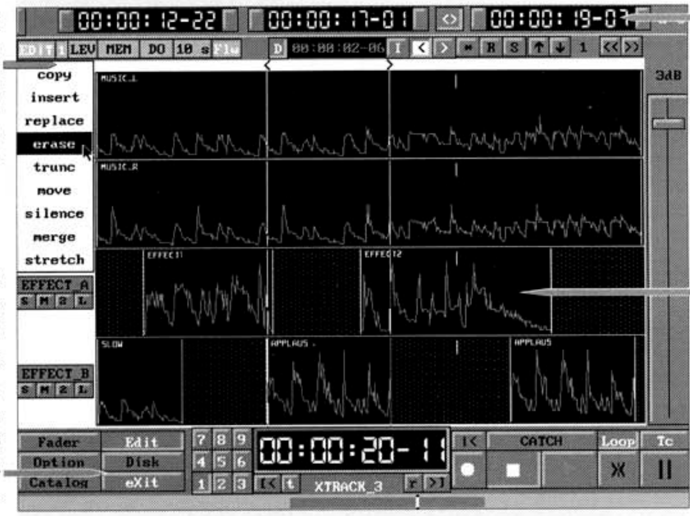
What Hidley did not know—and could not have known at the time—were the implications of the then yet to be defined 'chaos principle'. There were just too many small changes from room to room which would conspire to produce radically different sounds. What Hidley and most other studio designers were using as their major reference, was third-octave spectrum analysis with graphic equalisers on the monitors. Most studio designers now accept that third-octave analysis and monitor equalisation were disasters, but Hidley had conceived a system of control room design and monitoring which, possibly for the first time on a large scale, was enabling wide-band flat amplitude responses without excessive use of equalisation. It was a beginning, and while by no means perfect, some of his rooms of almost 20 years ago are still in use by major record companies: a testament to his achievement.

The problems which fooled people at the time, stemmed from the concept that between reverberation time and the pressure amplitude response around the position of the engineer, the performance of a room could be specified. As we now know, in a well-designed room, it is the culmination of the minor bumps of the response which dictate the overall character, and that a third-octave equaliser is far too crude a tool to do anything but move the bumps around.

Reverberation time affects the steady-state response of the room, but the direct signal would only be affected by the monitor system and its method of mounting. Each affects the other in terms of perceived responses, but act differently on steady-state and transient signals. In 1974 when I first approached Tom Hidley about building a studio for Virgin Records (for whom I was Technical Director at the time) we had been using JBL and Tannoy monitors. Hidley told me that the Westlake systems which I had heard were using JBL drivers. In those days, JBL monitors sounded hard—or so I thought. Hidley suggested that we used Gauss drivers for the low and middle frequencies. Once completed, the room measured identically in third-octave, pink noise terms as the JBL-equipped room in Los Angeles, yet the two sounded very different, and could not be equalised to sound similar.

What was going through our minds in those days was short of concepts of phase response. Though many papers had been published indicating its importance, classical acoustics was still largely adhering to Helmholtz' philosophy of phase being imperceptible by humans, which we now know not to be so. But even then, the fact that I had asked for Gauss instead of JBL drive units in an equalised room, should have lit a beacon in our minds—if the Gauss and JBL units could be equalised to sound alike, then no preference should exist. This was missing from our concepts of achieving similarity via 'repeatable' room designs and third-octave equalisers. I remember Hidley finally saying to me in the late 1970s, 'It's phase distortion; that's what produces fatigue and inconsistency!'

Looking back he was right, though what could have been done about it at the time is uncertain. Since then, however, as the general requirements for control rooms have multiplied, so have the approaches of different designers, most of whom attempt to produce a relatively neutral acoustic. By definition, neutral implies that it neither adds nor detracts anything, and hence, moving from one neutral control room to another—even of different design—one should enjoy a consistent sound character. This is still not the general case; in ▶



reality, many rooms sound so different, and even identical rooms with different equipment in different locations can sound very different. This is one of the major reasons for the widespread adoption of nearfield monitors (or more properly 'closefield' as 'nearfield' is an acoustical term for the zone immediately in front of a sound source where the air acts as a 'lumped element' and the sound does not decay by the usual 6dB with doubling of distance).

With a small monitor so close to the listener, the room plays less of a role in the perception of this sound, but necessarily, desk reflections and reduced frequency range mean that there is a price to pay for their use.

Acoustic control

There have been many approaches to the problem of linearising the response of a control room by acoustical means. The first attempts were based on 'tuning' the room by means of resonators and absorbers to produce a uniform reverberation time over frequency. The problem with this approach is that even if different rooms of different designs achieved the same measured response with frequency (for example 0.4s from 50Hz to 10kHz) then, as discussed earlier in the context of live rooms built from different materials, their construction will substantially change their perceived sonic performance. What is more, if they had either different monitor systems with different directivity characteristics, or areas of different tuning or absorption (or both), they would be perceived to be very different.

This was discussed above with regard to the broadcast industry, working to predetermined specifications. It necessitates each company's own set of 'golden ears' having to make their individual assessment of fine tuning.

Another approach towards linearising the performance of a room is to use a technique of geometrical control, providing many nonparallel surfaces and selected areas of absorption and reflection. In a rectangular room there are three types of resonant modes; axial, between parallel walls and parallel to four other walls; tangential travelling round four walls and parallel to the other two; and oblique, travelling round all walls and parallel to none. The axial modes are the strongest in terms of energy, whereas the oblique and tangential modes lose more energy both by striking more surfaces per given distance travelled, and because surfaces tend to absorb better when the incident sound strikes them obliquely rather than at right angles. In such rooms, the spread of the modes can be changed, generally levelling the response to some degree, but at low frequencies angles cannot be made large enough, so low frequency control is again achieved by absorption; often by 'bass traps' placed strategically at the suitable points of problem modes. Such was the early Westlake approach which produced some very pleasant rooms to work in—but they were not identical as intended. They never could have been because, again, specifications could not take into account the effect of differing shapes, sizes, decorations and equipment. However, they could, and were, built to be capable of providing uniform third-octave pressure amplitude responses, but the phase, and hence transient responses were different. These rooms could never be accurately assessed until built.

The ear has an ability to detail as separate events the early and late arrival of sounds. If a sufficient time delay exists between the direct sound from the loudspeakers and the first reflections from the room prior to any general 'pseudoreverberation', then ears, especially 'trained' ears, can usually begin to 'lock' on to the incident sound quite soon, and allow the brain to consider the room separately . This relies on the Haas effect, named after its first proponent. Taking into account this phenomena were the 'Live End, Dead End' rooms, as proposed by Wrightson & Berger, having the front half of the room made very acoustically dead, and the rear half of the room made reverberant to the desired degree, sometimes by means of Schroeder diffusers. The concept prevented early reflections from reaching the mixing position. Thus the 'first pass' of the incident wave from the loudspeaker from the effects of the room. Once again, consistency was uncontaminated by reflections for a sufficiently long period of time for the ear to clearly differentiate the direct sound from the loudspeaker and depended upon both the monitor system (for the direct sound) and the design of the rear of the room (for reverberant sound). As with other approaches, there are inconsistencies between measured and perceived performance, though it must be said that this need not be a problem for engineers familiar with certain rooms and *can* offer consistent results.

The seemingly obvious choices, if the rooms are to be entirely consistent to one another, are: to standardise on room shape; size; equipment location and design. Sadly, this is impractical given the differing requirements of different people, and the suitability of available property.

The second option is the anechoic chamber, but such rooms are not pleasant to be in. Indeed, some people find them disturbing as all normal auditory cues on wall positions are missing—you do not hear the room which your eyes see. Such rooms also run against the long-held concepts of rooms bearing some general similarity to the 'average' domestic room, though by now, it is generally agreed that any average is itself so unrepresentative of the majority of rooms, especially from country to country, that little relevance exists between the concept and the reality. What has further strengthened the argument against the representation of domestic rooms is that many listeners now use cars or personal stereo systems, where no reproduction room exists at all.

Dead end

When Tom Hidley returned to studio design around 1984, he returned determined to achieve the room-to-room consistency which had eluded him in his first decade and a half of trying. It does not require many reflections to make a person feel comfortable in an anechoic chamber—two or three restore a sense of ease. He thus concluded that by making the front wall and the floor the only reflective parts of the room, other than the equipment such as the mixing console, the remainder of the room could be 'trapped' to as low a frequency as possible without producing any unpleasant characteristics. If the front wall is the only vertical hard, reflective surface, it provides an effective monitor baffle extension but cannot produce any reflections of the music. Further, reflections from the floor have to arrive at the listener in the same vertical plane as the direct sound, so no disturbance of the stereo image can occur. In practice, a soft back to the mixing console effectively stops all but the low frequency floor reflections from reaching the engineer's ears. When one adds to this concept the use of only one type of monitor system, it is easy to see how a great degree of consistency can be achieved from room to room. Significant differences arise with the sound of speech within the room, which varies with the distances to reflective surfaces, and the responses below 40Hz or so, dependent upon the amount of trapping space available for low frequency absorption. This approach has probably come the closest yet to achieving room-to-room consistency.

After becoming familiar with Hidley's concepts, he and I cosponsored further research from Brazilian acoustician Luis Soares, at the Institute of Sound and Vibration Research at Southampton University, England. This was an attempt to find mechanisms by which to achieve similar absorption in smaller rooms, or more effective absorption in larger rooms. Hidley himself refuses to drop below certain room sizes as he is rightly very conscious of previous criticisms of his claims of uniformity of listening conditions for the pre-1980 rooms. These concepts are so powerful, however, that I have used them to great effect even in quite small rooms, although these rooms are very demanding of their monitor systems, requiring specifically designed units. They soak up almost all of the incident wave, so little reinforcement of loudness is delivered; furthermore, off-axis irregularities of the monitor system are heard off-axis with ruthless accuracy. Effectively, the rooms need high power, smooth, wide-band, coincident source monitor systems. Such systems are not easy to locate commercially, so most come specifically with the rooms.

It is ironic that these rooms which have begun to achieve consistency on a subjective basis, have only done so by having a dual specification. They are 'monitor dead'—in other words, the monitors drive into a largely anechoic termination, hence the rooms have no specification in terms of reverberation time as they are approximating to a free field. There is, however, a second specification which could relate to the direction and distance of echoes or specular reflections from a sound source inside the room, such as from the listening position, but this relates only to the ambience of the room from the point of view of persons within it. It has no bearing on the monitoring, except in some extreme psychological concept of 'comfort factors'. Not surprisingly Tom Hidley refers to these rooms as 'Nonenvironment Environments'. You feel as though you are inside a room, yet you listen to the music as though you are in a field. The logic behind this is that even if small changes in terms of specifications can have what would appear to be disproportionately large subjective repercussions, then the only way to make the practical differences approach zero, is to make the specification approach zero; ±20% of error on two dead rooms is still two dead rooms!

Subjectively, there are no rights and wrongs in control room acoustics. Some people have made great recordings in 'difficult' acoustics, but this is no justification of haphazard approaches to design. Many 'difficult' rooms have either been built by people who thought that they knew more than they did, or designed by designers working under constraints from their clients.

Too much has sometimes been expected from technical specifications alone and, without a demonstrable relationship between subjective and measured results, many studio owners have understandably shied away from what they have seen as 'the black art of acoustics'. Hopefully a clearer understanding of the degree of complexity involved in acoustic interactions can be achieved in the future—and a better relationship between studio designer and owner built upon it. In the meantime, Ted Uzzle's comment should be taken as the golden rule: there is absolutely no substitute for experience in such a capricious 'science'. ■