Museum Acoustics

Ideal Values

Some of the parameters that can characterize a good acoustic behavior of a museum room are: Reverberation Time (RT), STI or RASTI, the sound level of HVAC background noise and the corresponding noise criteria curves and the background noise with visitors. In Table 1 are the values that can be considered ideal for these parameters in exhibition rooms.

These ideal RT ranges of values attempt to fit the acoustic needs of different museums, which may, in case of existence of multimedia systems, to choose the value of 0.8 s and in other circumstances, go to 1.4 s. It is further recommended that the RT values, even if framed in those ideal values, should be within the expectations of visitors, i.e., larger rooms shall have a slightly higher reverberation than smaller rooms, because this is the feeling that visitors subjectively expect.

The study of the requirements for the levels of background noise made in this work led to recommend a 45 dB(A) maximum value, which should correspond to maximum levels of NC-35 and NR-37.

As regards RASTI or STI values they should be within the range of 0.45 to 0.65 to create good speech intelligibility conditions for near field but not for remote field intelligibility. Trying to balance those criteria of speech intelligibility and privacy, the value 0.45 prioritizes privacy, while the 0.65 privileges intelligibility.

Table 1: Ideal values for museum exhibition rooms and for several acoustical parameters.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>RT (s)</th>
<th>RASTI</th>
<th>$L_{A_{eq}}$ - background noise level with HVAC (dB)</th>
<th>NC</th>
<th>NR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ideal values</td>
<td>[0.8 ; 1.4]</td>
<td>[0.45 ; 0.65]</td>
<td>$\leq$ 45</td>
<td>$\leq$ 35</td>
<td>$\leq$ 37</td>
</tr>
</tbody>
</table>

Excerpt from the paper:

Acoustics of Modern and Old Museums

Presented at:

NOISE-CON 2013
Denver, Colorado
2013 August 26-28

Presented by:
António P.O. Carvalho
Hélder J.S. Gonçalves
Luísa M.M. Garcia
Laboratory of Acoustics, College of Engineering, University of Porto
4200-465 Porto, Portugal
carvalho@fe.up.pt

This article was published in the September/October 1998 issue of Exhibit Builder magazine.  
http://www.xbuilder.com/

**Museum Acoustics:**

*How localizing, isolating and diffusing exhibit sound can vastly improve the acoustical environment of your museum.*

With the growing reliance upon multimedia presentations in museums there has been an increasing availability of information on designing and including sound into exhibits. Feature and background sounds - along with other audio enhancements of visual exhibits, are infusing our museums with better and clearer presentations of information. The joyful results of this is that compared to hushed institutions of a decade ago, current museums are literally singing with interesting, enticing and engaging displays - allaying the early concerns that multi-media home entertainment centers and technically dazzling theme parks would eclipse the public's desire to visit museums by including the very multi-media technologies that originally posed the threat. The results of this are that our museums are becoming fantastic assemblages of sound and presentation technologies - in a scale only possible in public institutions, through the imagination of curators and exhibit designers, and by the enthusiastic support of the public.

But we still have some catching up to do. The museum architectural environment continues to be predominantly focused on visual perception. Long standing institutions were originally designed for visual presentation and many current designs are sold on paper on the merits of how they look. Museums new and old still retain the common visual features found in public spaces - large atriums, vaulted ceilings, stone, glass and masonry finishes and tile floors. Somehow the acoustical considerations for exhibit sound have escaped a good part of the design process, leaving us with buildings and exhibit spaces that do not serve - and in some cases are outright hostile to comfortable and acceptable sound presentation.

This situation is made painfully apparent when, as we add more sound to our exhibits, we find that museum noise levels are increasing as well - sometimes to an intolerable level. How do we meet the challenge of including more active information in a museum without creating an cacophonous environment where speech is unintelligible and the effect of visiting a museum is akin to climbing into an acoustical washing machine?

One of the fundamental difficulties in coming to terms with an acoustical problem is that unlike spilling a bucket of paint where the problem is immediately apparent, noise problems sneak up on us - we often don't realize that there is a noise problem until it has taken up permanent residence. Noise and acoustical problems often accumulate over time with the gradual inclusion of more sounds in exhibit spaces. As new exhibits enter the museum, sound spillage from each exhibit slowly seeps into the common environment. Finally at some point the sound of each exhibit becomes hard to hear; though in more terrifying instances, an acoustical problem does not raise its ugly head until opening day when the museum is populated by 3000 visitors for the first time - after the long and arduous task of constructing a building and installing the exhibits has occurred.

Faced with noise that seems to emanate from everywhere, it is hard to remember that the source of the noise - and the focus of the exhibit - is usually right where the individual visitor is. If we focus our solutions to this area, many of the larger problems will diminish. Fortunately, with a
little consideration in the design phase and careful planning of retrofits, many of the noise problems that are plaguing our current exhibit spaces can be designed out or ameliorated. What is important to keep in mind is that while sound is complex - and hard to see - solutions to sound problems are often relatively simple. Some museums are meeting this challenge through the use of personal listening devices or "audio docents" in their over-all exhibit strategy. While this does solve many noise problems, it also transforms the museum from a community sharing of information into a more private experience. For museums that have not considered using audio docents, it is important to include acoustical considerations when incorporating sound into exhibits.

Audio fidelity notwithstanding, the two primary factors responsible for lousy sound and noise problems are "too much sound," and reverberation, and these tend to feed each other in a bad way. Reverberation is the result of a characteristic that sound has of hanging around until all of the acoustical energy is spent. It is the lingering splash you hear after clapping your hands in a large open space. It is also the cacophonous smear of noise you hear in that same space when other sounds are introduced. As this smear builds up and dwells in a museum, individual exhibit sounds get buried - they can't be heard. The most common solution to this is to turn up the volume on the individual exhibit sound source. While this may improve the intelligibility of the local sound source in the short run, it also increases the overall sound smear in the environment, compromising the fidelity of all other exhibit sounds. As each of these local problems are "corrected" by turning the volume up, the overall environment becomes noisier, putting "too much sound" into the museum and threatening an acoustical "runaway."

**Localizing the Sound**

An exhibit is often designed as a complete presentation on paper, in a studio. The typical design criteria are whether the exhibit is attractive, informative, interesting and easy to see. The visual and audio elements are produced for content and the presentation technologies are designed for operative practicality, reliability and safety. Once all of these factors have been included, the exhibit is fabricated and installed, along with all of the other exhibits in a museum. The missing step in this process is the consideration of how the sound space of the exhibit is shaped. Just as viewing positions, sight lines and lighting are carefully identified for visual clarity, the envelope of audibility or the "listening envelope" should also be designed. Sound should be focused into the exact area where it is needed and excluded from where it is not needed.

A typical example of oversight in exhibit sound occurs while using of commercial video monitors in an exhibit. Many of these monitors have integrated speakers, and it seems logical to use these speakers to deliver exhibit sound; but often this cost saving measure will create unforeseen acoustical problems. These speakers may work well in the enclosed spaces that the monitors are designed for - studios and living rooms - but they are not designed to be mounted in a display wall in an open plan museum. They do not direct all of their sound specifically to the viewing area; much of the sound will exit out the rear of the display, ending up in places where it is not useful. This is aggravated by the characteristic that sound has of making things vibrate, so that the flat exhibit panels and monitor mounting frame all become a vibrating body, radiating sound into the environment at large and putting even more sound where it is not wanted. A simple solution to this problem is to use independent speakers, mounting them so that the sound is focused directly into the listening area and excluded from the rear of the exhibit. A
clarification of this strategy is to mechanically isolate the speakers from the exhibit structure, mounting them so that their vibration does not make the exhibit vibrate.

Another method for localizing sound is to make the listening envelope sound absorptive: placing sound absorbing panels on the exhibit surfaces, especially the surfaces where the speakers are mounted. This may seem counter-intuitive until you consider that the desired sound ideally leaves the speaker and goes directly to the visitor's ears. When the sound bounces off of "non-ear" surfaces, it usually ends up where it is not wanted. Sound absorptive panels will improve sound emanating from the exhibit as well as absorb sound coming in from outside of the exhibit listening envelope. If the local listening envelope absorbs all unwanted sound, sound from the speakers has unobstructed access to the visitor's ears.

Fortunately there are many durable and presentable sound absorptive materials available for this purpose, from stretched fabric panels and acoustically translucent vinyl surfaces to sound absorptive stone and masonry products, as well as perforated metals, sound-porous concrete and spray-application cellulose.

**Isolating Sound Areas**

If museums were designed specifically for sound, each exhibit might be contained in an independent sound controlled cubical that the visitor enters, exiting for the next cubicle when finished. This would provide ample opportunity to isolate the sounds and noises of each exhibit. It would also provide an inducement to leave the museum and find something more comfortable to experience, but this scenario points out the second strategy for creating workable acoustical environments - isolation. If the sound cannot be localized to the listening envelope, it can be isolated from adjacent areas. This strategy still requires paying attention to where the sound is and isn't wanted and "aiming" the sound sources accordingly. It also takes into consideration the larger areas within which the sound occurs.

Isolating sound areas is consistent with isolating thematic areas of a museum, and appropriate sounds within that thematic area may enhance the overall experience. As examples: an exhibit on an indigenous culture may be enhanced by the sounds of regional music from an adjacent display; a dinosaur exhibit's traffic and circulation may be improved if the sounds of creatures draws visitors through the exhibit area. Conversely, the sounds of dinosaurs leaking into an indigenous culture exhibit would probably compromise both exhibits.

A time honored technique for isolating sound is the strategic use of partitions and boundaries. Boundaries can be sound blocking and/or sound absorbing depending on the desired results. Sound will radiate from a sound source until it hits a boundary - a floor, wall or ceiling - at which point it either gets absorbed, or bounces off to find the next boundary. Sound absorptive boundaries are easy to come by. For floors, carpet is quite common and very effective; in fact carpet is so effective that if your museum is carpeted, chances are you are not attentively reading this article. There are many ceiling treatments as well that go far in improving an acoustical environment - from the boring drop frame acoustical ceiling tiles to the more innovative frame and suspension systems. There are also some useful sound absorbing spray on products for ceilings that are not too unsightly.

Absorptive partitions pose a bit more of a challenge, and while there are a number of durable and presentable sound absorbing metal, masonry and stone-like products, they are considerably more costly than the typical gypboard walls found in contemporary construction. Some sound
absorbing wall finishes such as stretched fabric sound panels, while reasonably priced, are not as
durable as painted sheetrock. In most cases it is more cost effective to consider the sound
blocking characteristic of partitions rather than designing them as sound absorbing elements. To
this end, the geometry and placement of a wall will have considerable bearing on its
effectiveness, keeping in mind that sound will bounce off of a reflective wall as a billiard ball
would; sometimes changing a wall angle by a few degrees will make vast improvements in its
performance.

**Sound Diffusion**

Isolating sound areas presupposes that a museum's spaces can be freely modified and that
carpeting and ceiling treatments are acceptable options. It also presupposes that all of the sounds
and noises generated in the environment are from the exhibits only. In dramatic architectural
spaces with marble floors, glass atriums and black slate walls, the inclusion of partitions and
carpet, or spray on ceilings would seriously compromise the beauty of the edifice. It may also be
that much of the noise generated in the space may be from the enthusiastic voices of the visitors
rather than from the exhibits.

To a large extent, once finished, these spaces are at the mercy of the architecture, but there are
some strategies for improving the nature of the sound and how it behaves within. The
reverberation time in large reflective spaces is long. The larger the volume of the space, the
longer the reverberation time - and the longer the time that sound and noise gets to accumulate
and smear. If a sound has clear paths to reflective surfaces it is less likely to dissipate before
bouncing around and annoying everybody. If sound waves are broken up or diffused prior to
reaching a hard reflective surface, it dissipates some of its energy and tends to be less annoying
on its return trip. If the first hard surface that the sound hits is fluted, textured and variegated, the
reflections become more diffuse and more agreeable. This accounts for why the reverberation in
an old gothic style cathedral is more pleasing than the reverberation in less detailed voluminous
spaces.

There are many visually subtle ways to break up sound in these large volumes. While sound does
travel freely in air, it dissipates proportionately with the distance from the source of the sound;
but when sound hits a hard reflective floor, it tends to travel along the floor retaining much of its
energy. This is why carpeting is so effective as a sound treatment - it absorbs sound as it travels
along the floor. A sound wave moving across a marble floor will be pretty strong when it hits the
first reflective wall. If the floor wave can be broken up with long planters, standing pools,
perimeter carpet paths, split levels or even strategically placed sound traps, a good portion of it
will not reach a reflective wall to bounce back into the environment.

Many of the techniques for localizing, isolating and diffusing sound and noise are often
relatively simple and can be incorporated after an acoustical problem has been identified, though
it is always better and more cost effective to plan for them early in the design phase of a project
rather than wait for the ugly questions to arise. I hope I have given the reader some things to
consider in the design of their next project, and consoled the reader with an accruing noise
problem that some possible solutions exist. In lieu of all of the above considerations we could
always turn the volume down on everything, give everyone headphones and tell the visitors to be
quiet, but that wouldn't be half as fun.

Michael Stocker
© May 1998