KVERNSTOEN, RÖNNHOLM & ASSOCIATES, INC.
CONSULTANTS IN ARCHITECTURAL ACOUSTICS

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City of Minneapolis
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RE: TARGET CENTER ACOUSTICAL MODIFICATIONS

Andrea:

It is our recommendation that you accept the bid from The Chicago Flyhouse for $925,988.92 for the installation of the acoustical modifications to Target Center. This bid is in line with our earlier estimates obtained from a different contractor.

This recommendation is the latest step in a long process of acoustical testing, analysis and design, as follows:

1. We were retained by Leo A Daly to test the existing space, analyze the test results, and make recommendations for improving the acoustical environment to make it a more desirable space for musical acts and other large scale events.

2. We tested the acoustics in the space to learn what the existing Reverberation Times (RT's) were (see Appendix for an explanation of RT's). With those data and the existing plans/sections of the space, we made a computer model to ascertain how much additional absorptive material would be required to reduce the RT's to levels equivalent or better than other well-regarded arenas. In addition to reducing reverberation, we also studied how we could reduce echoes in the space.

3. We developed several possible treatment options that would meet the acoustical goals that we had developed for the space. These options are outlined in an accompanying document of 1/16/08. We discussed these options with a fire-protection engineer to understand which ones

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would be acceptable for this specific space. One option was selected as being acceptable in meeting fire codes, so we further developed that option. Leo A Daly developed biding documents and the project was put out to bid with three qualified selected bidders. Two declined to bid, citing workload and the difficulty of the project for their decision not to bid. The Chicago Flyhouse offered a bid of $925,988.92 for the project.

4. Briefly, the bidding documents called for absorptive treatment on the following surfaces:

    A. Horizontal part of the deck, with 4" thick absorptive blankets hanging vertically from the underside of the joists – 107,000 SF
    B. Canted areas of the ceiling (Bowl ends), with 6" thick glass fiber panels attached directly to the deck – 14,000 SF
    C. Under catwalks and platforms – 20,000 SF
    D. Ring Beam and column faces – 8,000 SF
    E. Total treatment area is approximately 149,000 SF.

With the above treatment scenario we will accomplish a large improvement in the acoustical environment at Target Center, as follows:

1. Reduction in Reverberation Times (RT's) in the entire space, leading to better speech and musical clarity throughout the space, whether using the house sound system or the flown systems that touring musical groups bring with them.
2. Mitigation of specific long-delayed sound reflections to the audience, which also degrade clarity. These long-delayed echoes are more difficult to characterize by a metric such as RT, as they will change from seat to seat. However, the elimination of these echoes also is important to the success of this endeavor, having an impact on approximately 20% of the seating area.

All of the recommended treatments contribute to the reduction of reverberation. The canted areas of the ceiling (14,000 SF), the horizontal surfaces under the catwalks (20,000 SF), and the ring beam/column faces (8,000 SF) also contribute to the mitigation of long-delayed echoes.

I have shown the expected RT's with the recommended treatment in Table 1 below, along with the earlier tested RT's.

Table 1

	125	250	500	1K	2K	4K Hz
Target (old)	4.1	3.2	3.0	2.4	2.3	1.7
Target (new)	**3.1**	**2.0**	**1.8**	**1.6**	**1.6**	**1.6**

As can be seen from Table 1 above, the expected reductions in the RT's are significant. We show the RT's only down to the 125 Hz octave band, where we expect to reduce the RT by a full second.

The above RT figures projected after treatment are modeled with advanced modeling techniques, but are still only models of reality. As such, the tested figures after treatment may vary somewhat from the projections.

Steve Kvernstoen

RT – Reverberation Time

Quick Explanation

RT is a number describing the amount of time it takes, in seconds, for an impulsive noise, such as a hand clap to decay 60 dB in a space. For practical purposes, this is the amount of time it takes for an impulsive sound to become inaudible. RTs are typically measured in noise spectra that are one octave band wide, with centers ranging from 125 Hz to 4,000 Hz. The RTs can vary greatly from one octave band to another. When one number is given for the RT in a space, it is usually the RT at 500 Hz. RTs can vary from small fractions of a second up to several seconds.

More Than You Wanted to Know

The formula for computing the RT at a given frequency is the following:

RT = (.049 x Volume)/(Surface Area x Average Absorption Coefficient)

Thus, to calculate the RT at any given frequency you must know the cubic volume of the space, along with the absorption coefficient (at that frequency) of each material in the space.

RTs vary considerably with room volume and acoustical absorption. The larger the room, and the more reflective the surfaces are, the higher the RTs will be.

Generally speaking, shorter RTs are better for speech intelligibility, while longer RTs usually make music sound better. For example, ANSI S12.60 recommends an RT of 0.60 seconds or less at 500 Hz for classrooms of 10,000 CF or less. On the other hand churches may have an RT of several seconds at that same frequency. Long RTs can have a very negative effect on speech intelligibility in a space.

Caveats

Two spaces that have the same RTs can sound very different, if the spaces are different sizes. Generally speaking, larger spaces can support longer RTs, while smaller spaces may sound more reverberant even with shorter RTs.

When only one number is given for the RT of a space it can sound exceedingly different from another space with the same RT. One of the spaces might have a much longer RT at the lower frequencies while the other might have very little low frequency reverberation but a great deal of high frequency reverberant energy. Yet, the two may have the exact same RT at 500 Hz, which is the frequency band often used to characterize a space.