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Key Acoustical Issues Associated with the Renovation and Restoration of the Southern Theatre

Presented by David Kahn at the

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The Southern Theatre in Columbus, Ohio, first opened as a vaudeville house in the late 1800's. It was later used as a movie theatre. It was recently renovated to serve a broad range of program uses, with a strong emphasis on unamplified music performance. The program of use anticipated staged productions as well, requiring a stage house with a full complement of rigging.

Historically, there are two distinct types of performance spaces that are built to serve unamplified music performance and staged productions, respectively. Unamplified music performances have historically been performed in a concert hall (see fig 1: Musikvereinsaal). This is in contrast to staged productions (opera, musical theatre, drama, etc.) which are performed in theatres, which include a proscenium opening that connects the audience chamber to the stagehouse (see fig.2 Ohio Theatre, Columbus).



Musikvereinsaal



Ohio Theatre, Columbus, Ohio

UK Office

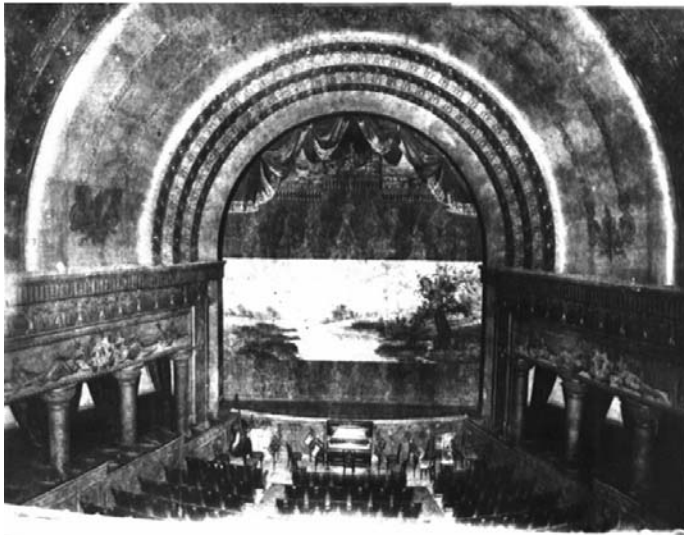
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From the acoustics viewpoint, there is a fundamental difference between these two building types. In a concert hall, the musicians play in the same room as the audience. In the case of some concert halls, the audience wraps clear around the performance platform. This is in contrast to a theatre where the action takes place behind the proscenium wall in the stage. From the acoustics viewpoint, a theatre is two separate acoustical spaces connected through the proscenium opening. The larger the proscenium opening, the stronger the acoustical coupling. However the proscenium opening is typically limited to provide important visual masking for staged productions.



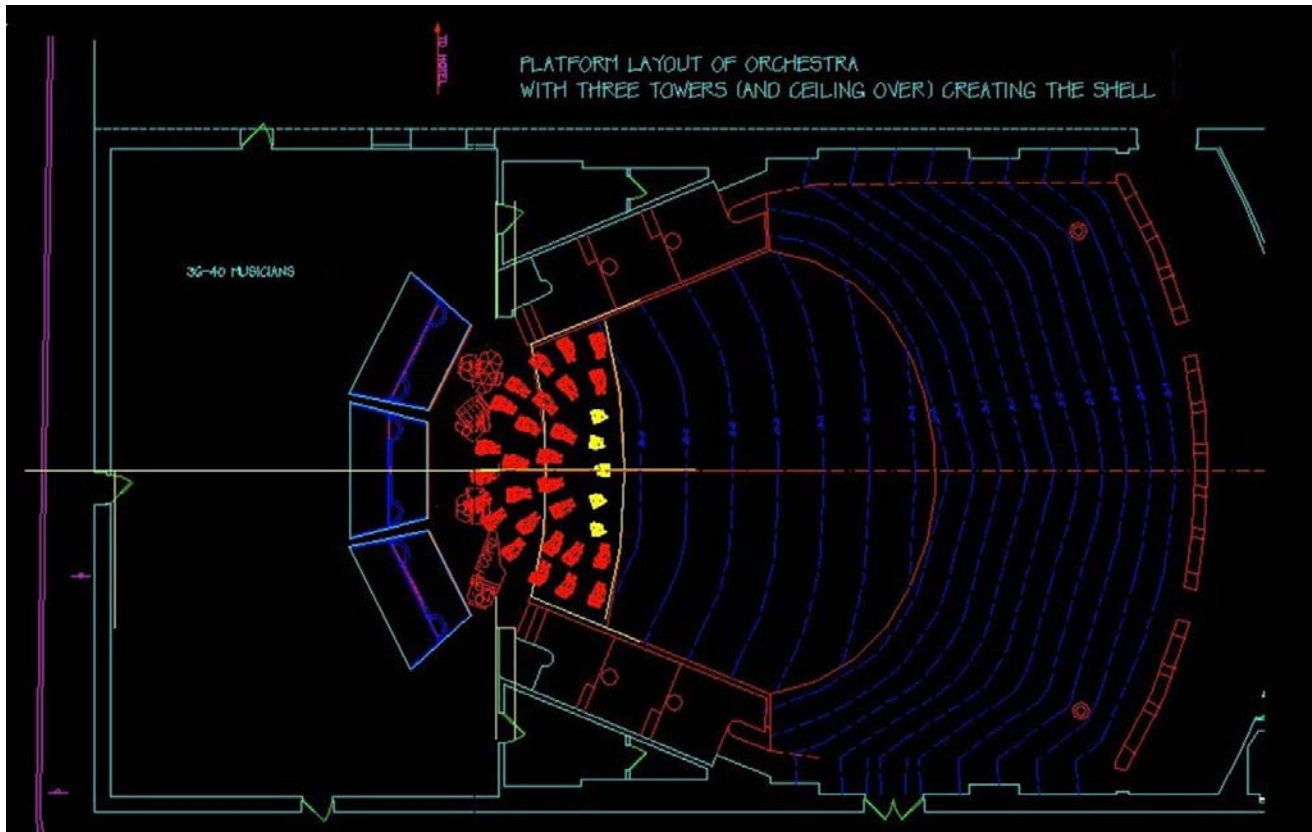
Photograph of original theatre



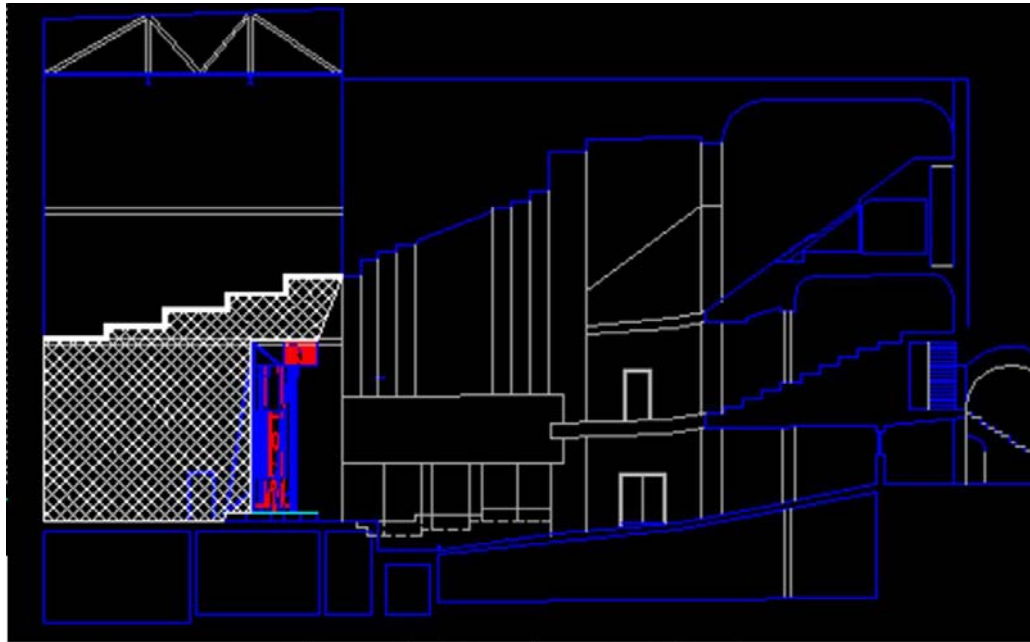
Photograph of new theatre

There are plenty of examples of theatres that are used for music performance. One example is the Ordway Music Theatre in St. Paul, Minnesota. In this case, the orchestra plays behind the proscenium wall in a special acoustical enclosure that prevents sound from getting lost in the wing space to the sides and the fly space above.

As part of the restoration and renovation of the Southern Theatre, we employed a different technique for accommodation of music performance. Figure 5 shows in concept our design approach. Rather than placing all the musicians behind the proscenium opening, we placed most of the musicians in front of the proscenium wall (for smaller ensembles, all of the musicians can be accommodated in front of the proscenium wall). This is practically accomplished by providing a mechanized orchestra pit lift that can be raised all the way up to stage level. The acoustical enclosure is not abandoned, but configured differently. A series of rolling towers are provided as a backdrop behind the musicians. Similar to the traditional concert enclosure, the towers help to project the sound out into the audience seating area, and prevent too much sound from getting lost in the stage area behind.



A ceiling is still provided in the stage house, but it serves a somewhat different function than the ceiling of the standard concert enclosure. In this case, the ceiling extends over the entire footprint of the stage house, and is set at the elevation of the top of the proscenium. Its function is to seal off the upper part of the stage house where all of the sound absorbing curtains and scenery are stored. The lower volume of the stagehouse becomes a large empty volume that contains no sound absorbing materials whatsoever. We refer to this large empty volume as a reverberation chamber. Because the volume of this space is quite large, and because it contains no sound absorbing materials, it is very reverberant. Even though the volume of this space is typically only about one quarter to one third the volume of the audience chamber, sound decays more slowly in this space than in the audience chamber (it has a significantly longer reverberation time than the reverberation time of the theatre). The figure below shows hatching to indicate the reverberation chamber in plan and section, respectively.

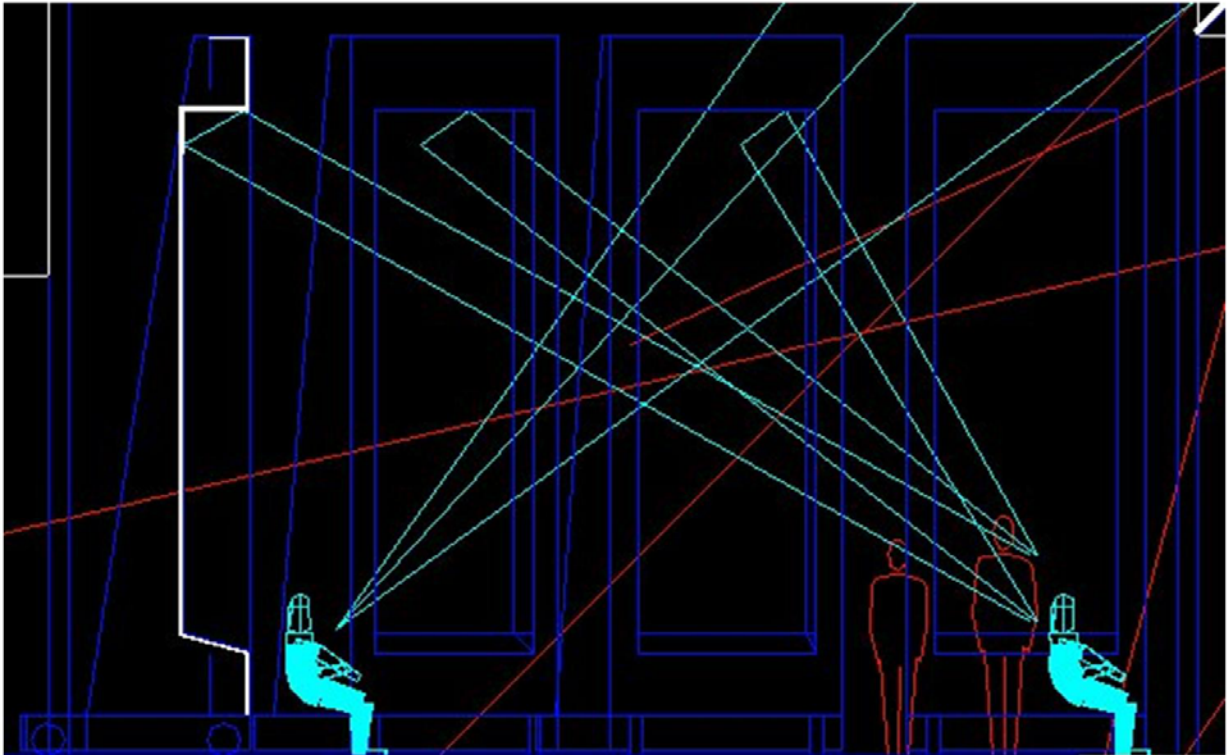


Partially-coupled Reverberation Chamber

The coupling between these two volumes is smaller than the proscenium opening, and depends in part of how the towers are designed and set up.

Because this large reverberant volume is located just behind the musicians, a considerable amount of sound energy is directed into this reverberant volume. Because sound decays in this volume more slowly than in the audience chamber, what happens is that the reverberant energy from the lower volume of the stage house is fed into the audience chamber through the coupling area above and around the towers. Essentially, additional reverberant energy is fed into the audience chamber. As a result, the reverberation in the audience chamber is enhanced, creating a more pleasing acoustic for music.

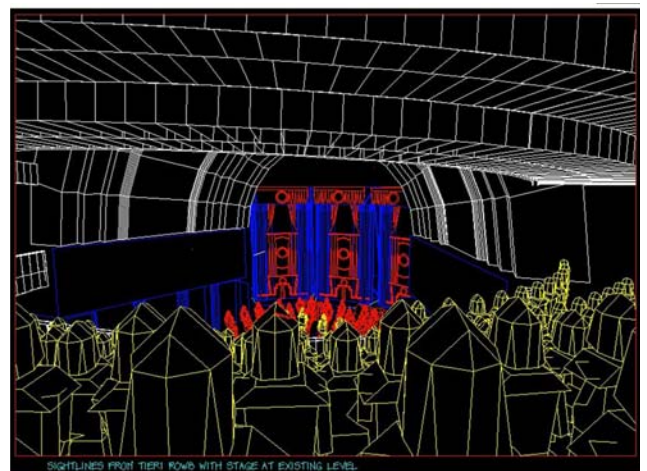
The design of the towers is somewhat unusual, and is designed not only to project sound out into the audience seating area, but to assist the musicians to hear one another better so they can play with better ensemble. In essence, the towers have a soffit that catches sound and sends it back down quickly from one musician to another. The acoustical effect of these soffits is similar to the effect of the side balconies in a concert hall that serve to send sound energy quickly into the main floor seating area, enhancing the sense of clarity and acoustical intimacy in this seating area.



Shelf at top of tower provides reflections to musicians assisting their ensemble.

Sightlines Issues

One of the challenges of the design concept we proposed is that the sightlines need to work not only to the stage at the proscenium opening, but to the stage extension out in front of the proscenium. Since this was not how the theatre was originally designed to function this way, we proposed that the elevation of the stage be raised, bring the stage platform elevation up closer to street level. Below is our sightline study from the back of the 1st balcony showing the sightlines to a small music ensemble out on the forestage extension, both with the stage at the existing level, and again with it raised.





HVAC Noise

In order to support the highest possible level of artistry, we proposed a background noise criteria to be the threshold of human hearing, which is well below some commonly-accepted strict background noise criteria, such as NC 15.

The renovation project included rebuilding the main floor, and spaces were programmed in the basement directly below the main floor seating area. For reasons for thermal comfort, an under-floor air supply system was proposed.

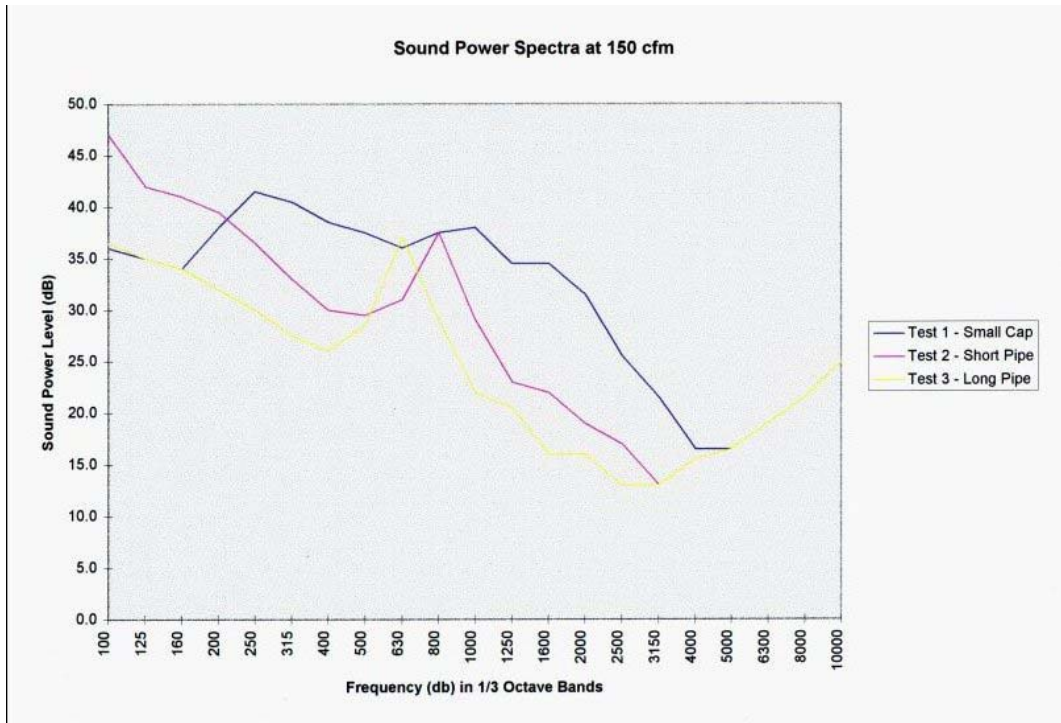
We worked closely with the architect and mechanical engineer to develop a design concept for air distribution to achieve total silence, that simultaneously provided for adequate sound isolation between the basement spaces and the theatre.

A lined supply air plenum was developed that provided both noise reduction for the HVAC supply system, and also sound isolation between the basement spaces and the theatre. To provide some static pressure drop to help with even air balance between outlets, and to provide for more sound reduction, pipes were proposed to be placed underneath the holes in the floor.

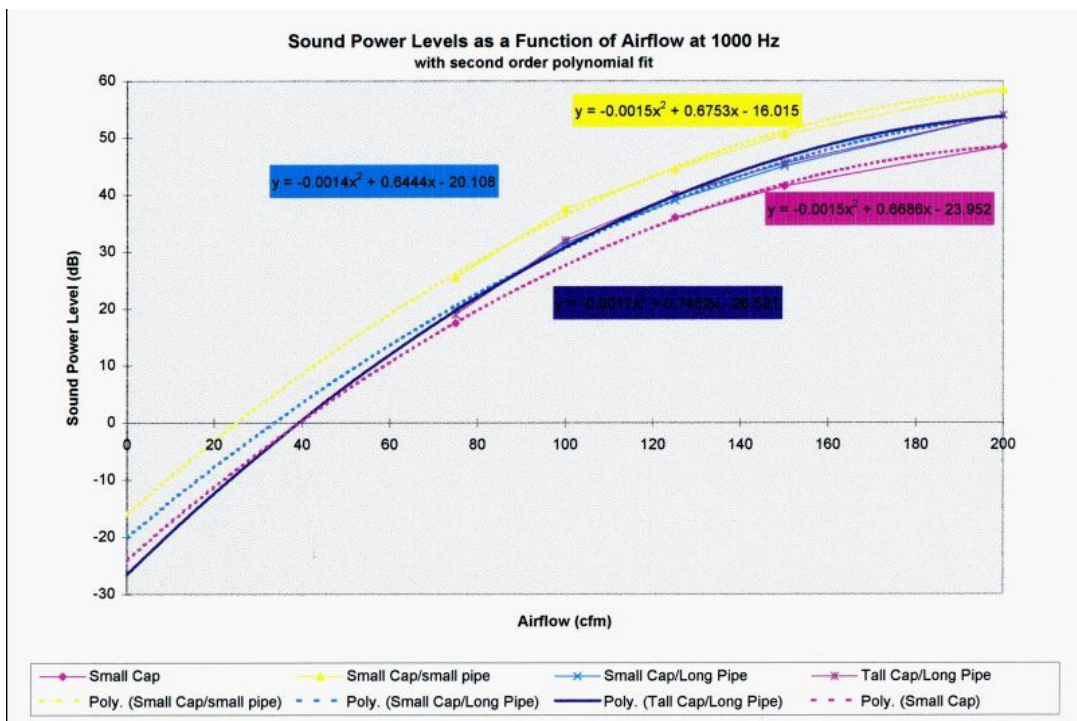


To ensure silence, a full-size mock-up of several pipe and cap options were tested in a laboratory at elevated air quantities to confirm that no noise would be generated at design air quantities. We tested both a short pipe and a long pipe. We also tested a short cap and a tall cap. A photograph of the tall cap and a photograph of the holes in the floor, prior to the installation of the caps, is shown below.

The following image shows the spectra for the cap, and for both the short and long pipe. The noise of the cap is broad band. The noise of the pipes is quite tonal. Not surprisingly, the frequency of the peak energy is a function of the pipe length. Interestingly, the peak of the pipe spectrum does not exceed the broadband noise level of the cap.

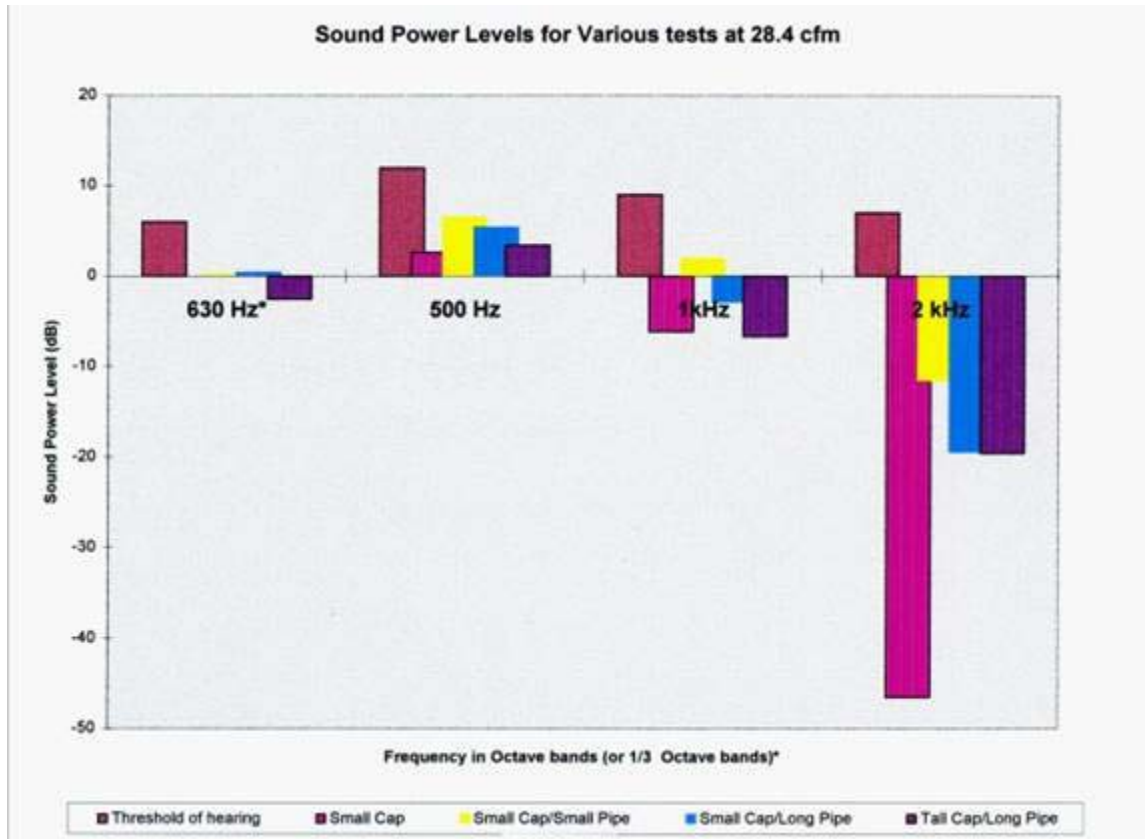


In order to measure the noise of the airflow through the various configurations of pipes and caps, we tested at increased air flows. The attached figure shows how, through 2nd order polynomial extrapolation, we were able to extrapolate with confidence the sound levels at the design air flow.





The following figure shows the final results, comparing the extrapolated sound levels with the maximum allowable sound levels to achieve the threshold of human hearing.



Conclusion

Great attention to detail, and tremendous coordination of acoustician, architect, engineers and owner, resulted in a performance facility that performers and audience continue to rave about, years after opening night. A holistic approach to acoustics consulting, including detailed sightline studies, air distribution studies, coordination of HVAC noise and sound isolation needs, etc. was required to achieve complete success. Solutions to acoustical challenges were cost effective and practical.