Leeds Metropolitan University - Design and Build of new Acoustic Laboratory Suite

Introduction

Leeds Metropolitan University (LMU) is a well established and respected centre for education in acoustics. This is a brief account of the building of their new acoustic facilities.

The existing acoustic laboratory at LMU consisted of a large reverberation chamber coupled onto an anechoic chamber. A transmission panel was present between the two chambers but, in order for the chambers to be used for transmission tests, all of the anechoic chamber wedges had to be removed first! Also present, were an audiology booth and a workshop area. However these premise were reaching the end of their serviceable life and additionally, the entire laboratory had recently been flooded and so an alternative site was required.

Thanks to an unexpected grant, enough funding was available to refurbish an entire section of the 9th floor of C building on Caverly Street, with a number of classrooms able to be converted into an entire acoustics laboratory suite. The move to a more elevated position was welcomed by all in light of the recent flooding incident.
The proposed new suite would consist of a large reverberation chamber, coupled to a small reverberation chamber as a transmission test facility, an anechoic chamber, an audiometry booth, a human acoustics area, a phonetic room and a general workshop area. The layout for the new suite is shown on figure 1.0.

The aim of this report is to give a brief account of the design process to ensure that the performance specifications were met, but more importantly to highlight the practical elements of the project, assisted through the use of photographs taken during site inspections. The entire project has been documented as part of my MSc dissertation, however for the purpose of this article I will concentrate purely on the construction and performance of the two reverberation chambers.

Design Criteria

Philip Dunbavin Acoustics Ltd. (PDA) were approached to ensure that the acoustic performance targets of the new suite were successfully met.

The fundamental acoustic design aims were largely based on the performance of the existing facilities and compliance with international standards.

Large Reverberation Chamber

The main design criteria for the large chamber were as follows:

Volume to be a minimum of 200 m3 to ensure accurate measurements can be made down to 125 Hz octave band or 100 Hz third octave band as per BS 4196 Part 1.

Reverberation Times, seconds:-

100 Hz to 630 Hz greater than 5 seconds

800 Hz to 2500 Hz greater than 4 seconds
3150 Hz to 5000 Hz greater than 2.5 seconds
6300 Hz to 8000 Hz greater than 1.0 second.

Maximum acceptable background noise levels to be the same as existing chamber.

Small Reverberation Chamber

Maximum acceptable background noise levels to be the same as large reverberation chamber.
Reverberation Times to be as close to, but not to exceed 2 seconds.

Initial Survey Work

A background noise and vibration survey was conducted in order to determine the feasibility of the proposed project. As expected, noise from road traffic was virtually inaudible on the ninth floor, with the main sources of noise being wind noise and occasional overflying aircraft.
However, a certain amount of low frequency structure- borne noise was detected as a result of operation of the lifts. The effect of this lift vibration noise meant that without suitable remedial measures, the background noise level within the large reverberation chamber would exceed target. However, the only solutions would have been to either prevent the lifts from being used, introduce a vibration break to the structural slab or to construct the entire chamber off a floating slab. Unfortunately, the structural strength of the building would not have been able to cope with the loading of floating slab of the magnitude required and the other options were completely impractical.
It was therefore agreed, that since the large chamber would be the source room for any transmission tests, that a higher level of background noise would be acceptable.

This therefore meant that the small reverberation chamber i.e. the receiving room, must be fully isolated from the building structure and also from the large chamber in order to avoid coupling and noise transmission due to flanking. The solution to this was to build the small chamber off a floating slab.

Design Specification

Large Reverberation Chamber.

To prevent the build up of standing waves, the chamber was constructed with opposing walls and ceiling built at a 5° angle in order to present the sound source with non parallel surfaces throughout. A detail that caused considerable consternation to the guy who was fitting the wooden framework for the ceiling. Apparently, after agonising for hours since he believed that the chamber would need to be rebuilt he finally summoned up the courage to point out to site manger that some idiot had not built the room square!

Engineering constraints due to structural limitations means that the roof of the chamber could not be concrete. Therefore, a twin layer plasterboard ceiling with a minimal void was constructed. A 25mm layer of sand pugging was fitted into the void in order to introduce mass to the system and to prevent the ceiling acting as a panel absorber.

Small Reverberation Chamber

To be built off a 100mm reinforced concrete floating slab with a 50 mm air gap.

The roof of the chamber must be accessible to enable impact sound insulation tests to be conducted by students. Therefore, the roof was designed to try to recreate the construction of a typical floor, without compromising the performance of the chamber.
The roof construction consisted of 18mm thick floor grade chipboard on 50 x 195 floor joists with 80 mm Gypglas 1000 infil with MF5 ceiling section with 12.5 mm thick Gyproc wall board and skim.

Material Selection and Build Quality

The fundamental construction for all of the chambers was a solid blockwork wall. Good quality blockwork is vital to the acoustic performance of any normal wall, but is absolutely paramount in the construction of any chamber within an acoustic laboratory. Correct block selection is the key, with all blocks being complete with no cracking or pitting. Mortaring must be to an almost fair faced standard with joints being completely filled. Photograph 1.0 shows a fully mortared joint.

Photograph 1.

Photograph 2.

However, problems can still occur even with correctly filled joints. Photograph 2.0 shows a joint where the mortar has been subject to shrinkage, through no fault of poor workmanship. Although this doesn't appear to be a major problem, photograph 3.0 shows that the gap extends for over 80mm, almost the entire depth of the block!

Photograph 3.

Laboratory Construction

Photograph 4.0 shows the initial construction of the floating floor for the small reverberation chamber. This photograph highlights the difficulties associated with ensuring that debris does not accumulate and bridge the isolation system. However, photograph 5.0 shows that the floor installation was clean. This photograph also underlines the importance of site inspections at critical phases of the construction. In this case, if the inspection had been performed a day later, the floor would have been complete and ready for the pour, as shown in photograph 6.0. In which case, the only proof that would exist that the installation was clean, would be the word of the installers!

Photograph 4.

Photograph 5.

Photograph 6.

Photograph 7.

Photograph 7.0 shows the pouring of the concrete slab. The concrete could not be pumped up to the ninth floor, and so the only alternative was to use barrows. Unfortunately, the lift could only accommodate two barrows at a time and therefore the pour took approximately five hours! A point worthy of note on this photograph, is the use of a protective boarding placed on the reinforcing steel work, to ensure that the spacers were not damaged as a result of a direct point load.

Photograph 8.

Photograph 9.

Photograph 8.0 shows blockwork built off the floating slab, with a good clean cavity present thereby ensuring complete isolation.

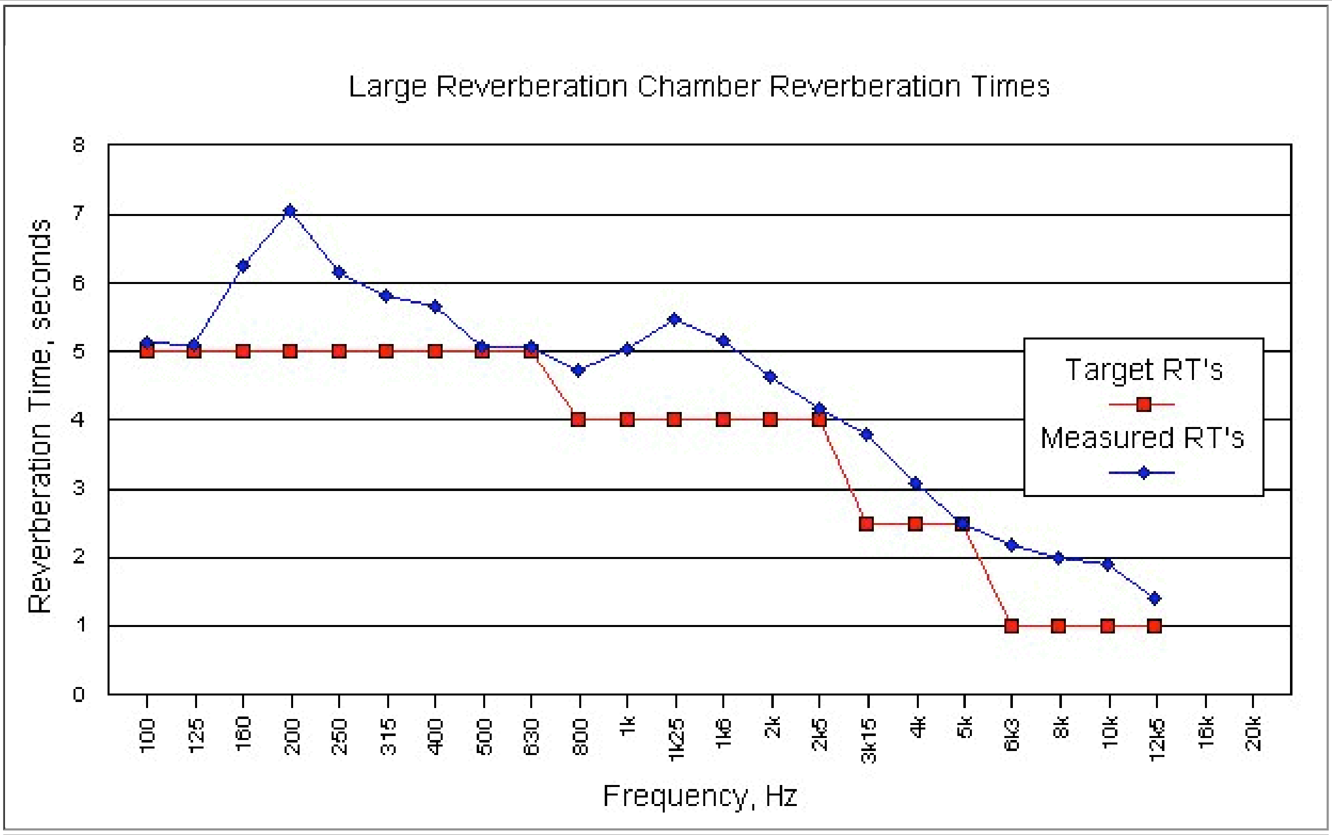
Photograph 9.0 shows the ongoing construction of the small and large reverberation chambers approaching completion. Note the good quality of blockwork throughout.

Test Results

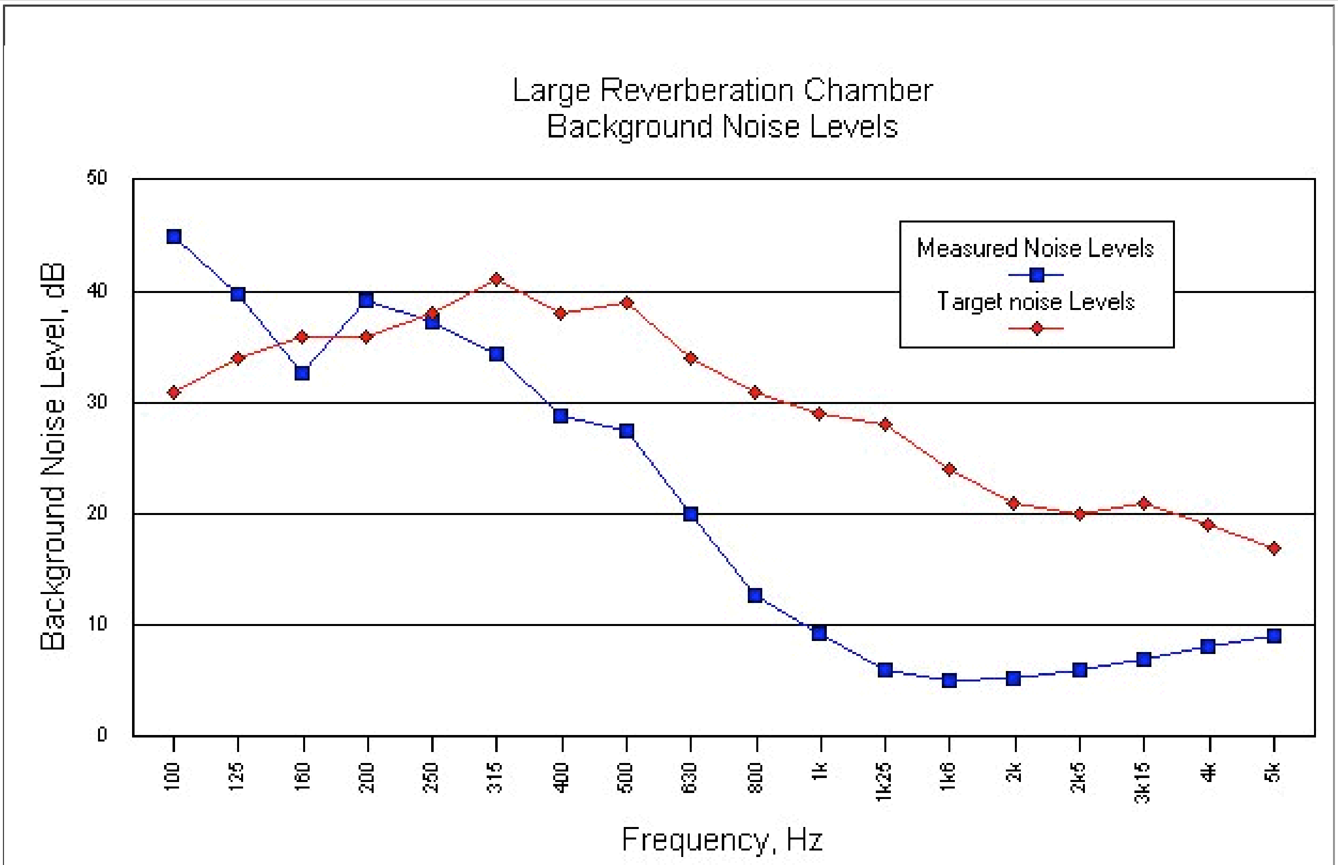
Graphs 1 - 4 detail the RTs and background noise levels present within the two reverberation chambers.

Graph 1.0 shows the RT of the large chamber and it can be seen that the performance criteria has been met or exceeded in all third octave bands. However, slightly longer times were expected at the lower frequencies and it is likely that the reason for the RT drop off is a result of the ceiling acting as an absorber despite the sand pugging.

Graph 2.0 shows the ingress of low frequency noise as predicted, from structural vibration from operation of the lifts. However, the level of noise is not excessive and does not restrict the capabilities of the laboratory.



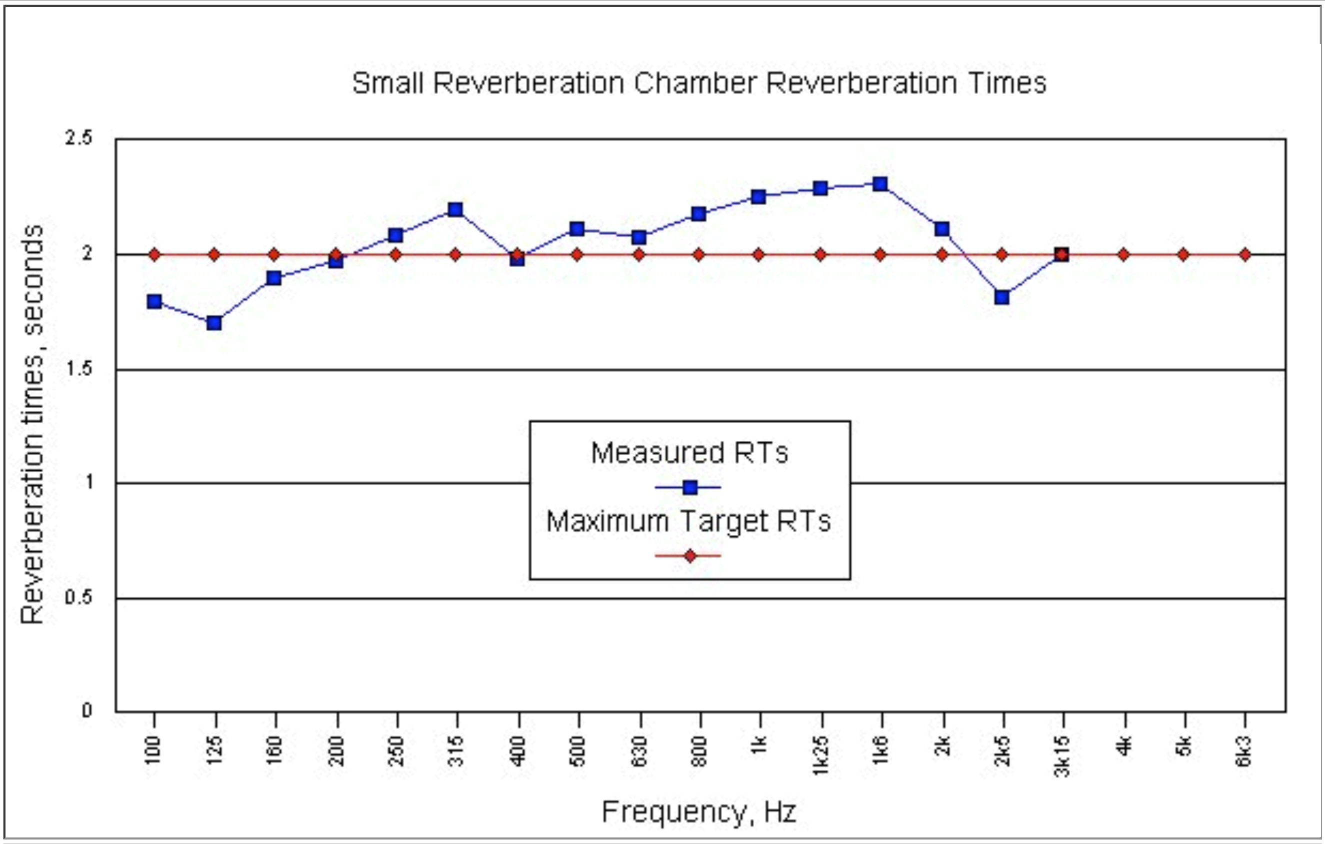
Graph 1.



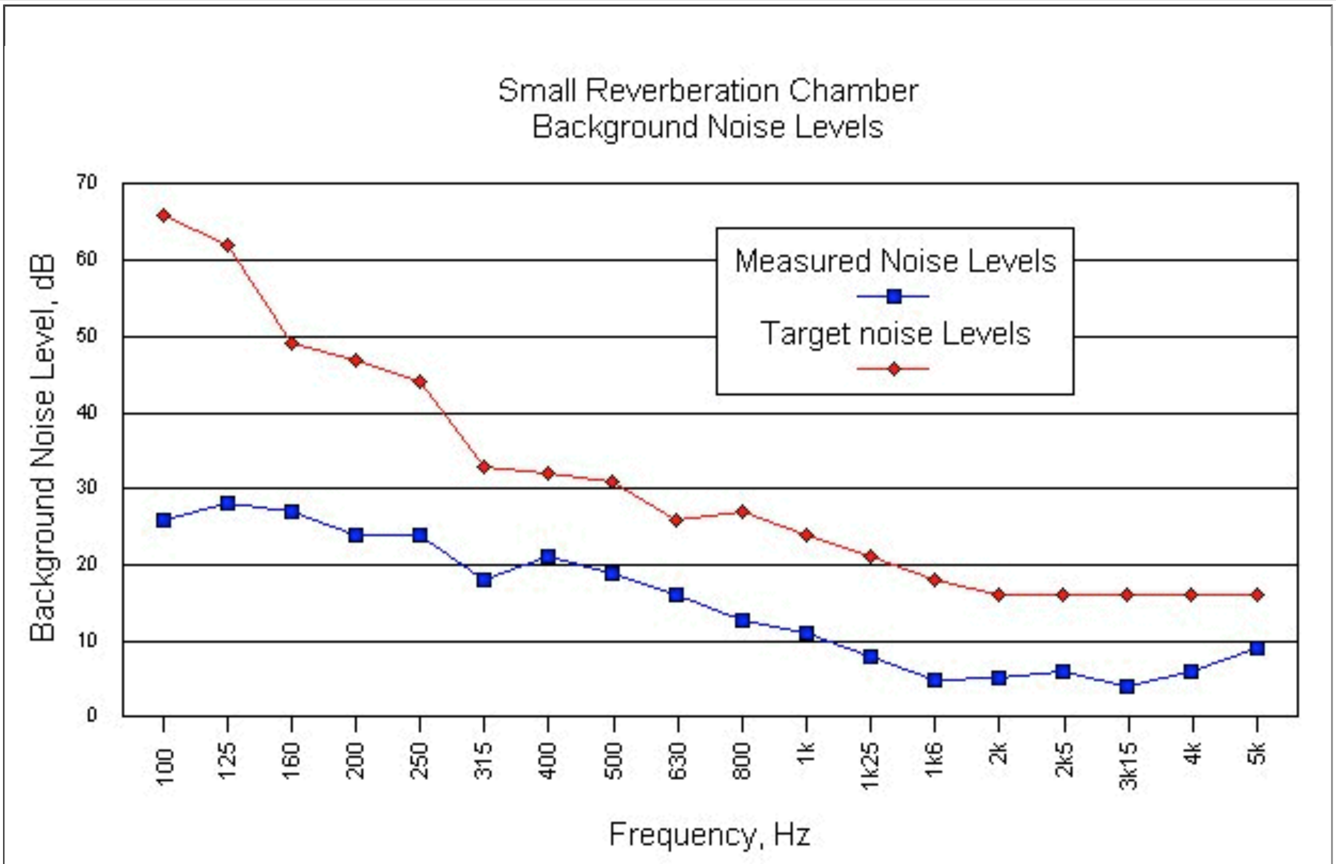
Graph 2.

Graph 3.0 shows the RTs for the small chamber. It can be seen that the maximum target value is exceeded in the majority of frequency bands. This was intended, with the view that additional absorption could be introduced in order to "fine-tune" the chamber.

In practice, this additional absorption is in the shape of an additional student, since students work in pairs within the chamber. The background noise levels within the chamber are shown in graph 4.0. On comparison with graph 2.0 the isolation effect of the floating floor is apparent, and demonstrates that the floor is performing correctly with no breaches in the isolation existing.

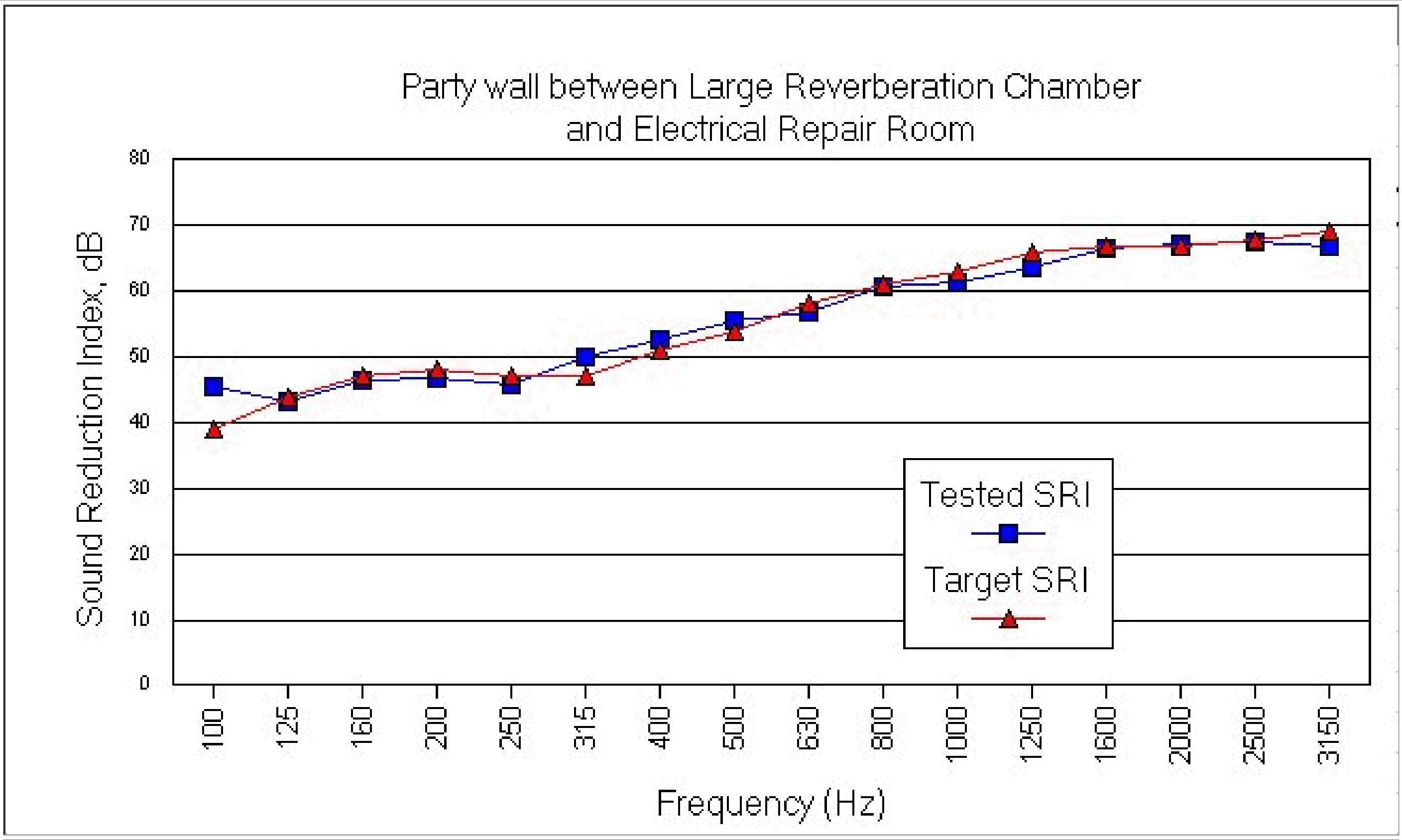


Graph 3.



Graph 4.

Graph 5.0 details the Sound Reduction Index (SRI) of one of the walls of the large chamber. This wall was tested for practical reasons since it was the only non-composite façade.



Graph 5.

The results for this wall performance show almost an exact match between the tested and target values and are testament to the high quality of workmanship that existed throughout the project.

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