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HOTEL SOUND CONTROL RETROFIT WINDOW PERFORMANCE EVALUATION

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Abstract

An older urban warehouse to hotel renovation suffered excessive environmental traffic noise intrusion via poorly sealed casement windows. A simple retrofit sound control window system that could be installed in finished rooms without disturbing adjacent guest rooms was needed. A prototype was measured for sound transmission to evaluate acoustic performance.

The practical noise criterion was to lower intrusive noise to within 10 dBA of the continuous ambient guest room sound level.

A perimeter frame installed inside existing window mullions allows large removable sound control glass panes to be set into place from inside the guest room without a glazing gasket or other means of securing.

The sound transmission loss was measured with and without the retrofit windows, using an outdoor broadband amplified noise source. Conditions affecting the measurement included an outdoor point sound source aimed at an oblique angle to the glass and variable outdoor ambient traffic noise.

Measurement showed substantial sound transmission loss improvement, from 36 dBA to 66 dBA, over the entire audible frequency span. Spectral analysis curve fit to an STC showed change from FSTC 20 to FSTC 44. This paper shows photographs and details of the existing and retrofit window conditions with tabular and graphic results.

1.0 INTRODUCTION

Homewood Suites division of the Hilton Corporation undertook an adaptive reuse renovation of an old pharmaceutical warehouse and sales facility into an urban hotel. Upon completion, the owner determined that the original windows permitted excessive traffic noise intrusion into guest rooms. They were metal mullion divided light windows with operable casement sections. Traffic noise intrusion transmitted through the single layer glass and poorly sealed operable sash joints. In order to maintain the historic appearance of the building, the hotel decided to add retrofit window in lieu of modifying existing windows.

Although window noise transmission measurement and ratings variations have been discussed by Quirt,[1] and predictive analyses has been discussed by Price, Crocker,[2] Brekke,[3] and others, the hotel owners desired hard data for renovation investment economic cost-benefit analysis. The demonstration installation evaluation provided greater reliability than predictive analysis, because the test automatically included flanking paths and other difficult to predict variances from theory.

JEAcoustics was retained to determine (a) the effectiveness of the retrofit window, and (b) whether it was acceptable for normal hotel occupancy. Based on findings, the hotel would order replacement windows for other hotel rooms or seek alternatives.

A fixed removable sash retrofit glazing system was installed as a secondary window, on the guest room side of the existing window. In the renovation project a new ceiling was installed that is lower than top of the existing window, with an upper window pocket created by the furrdown. The retrofit system included a perimeter frame or sash, extending from the windowsill, up to the ceiling. Large glazing panes that quickly and easily fit into the frame with a gasket sealing system that required no bolts or screws to secure glass.

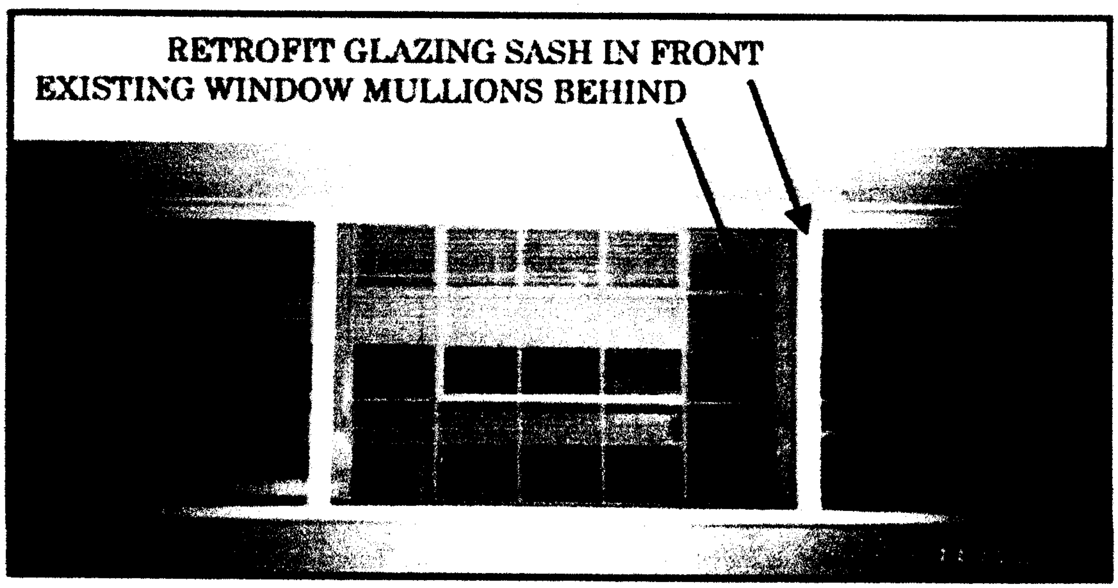

FIGURE 1: VIEW OF THE TEST WINDOW INSIDE THE HOTEL GUEST ROOM

Outside to inside noise reduction improvement was determined by comparing measurements for the existing window versus the existing window with retrofit glazing. The retrofit window was then measured with acoustically absorbent liner installed on the sill and sides of the cavity to determine improvement with cavity absorption.

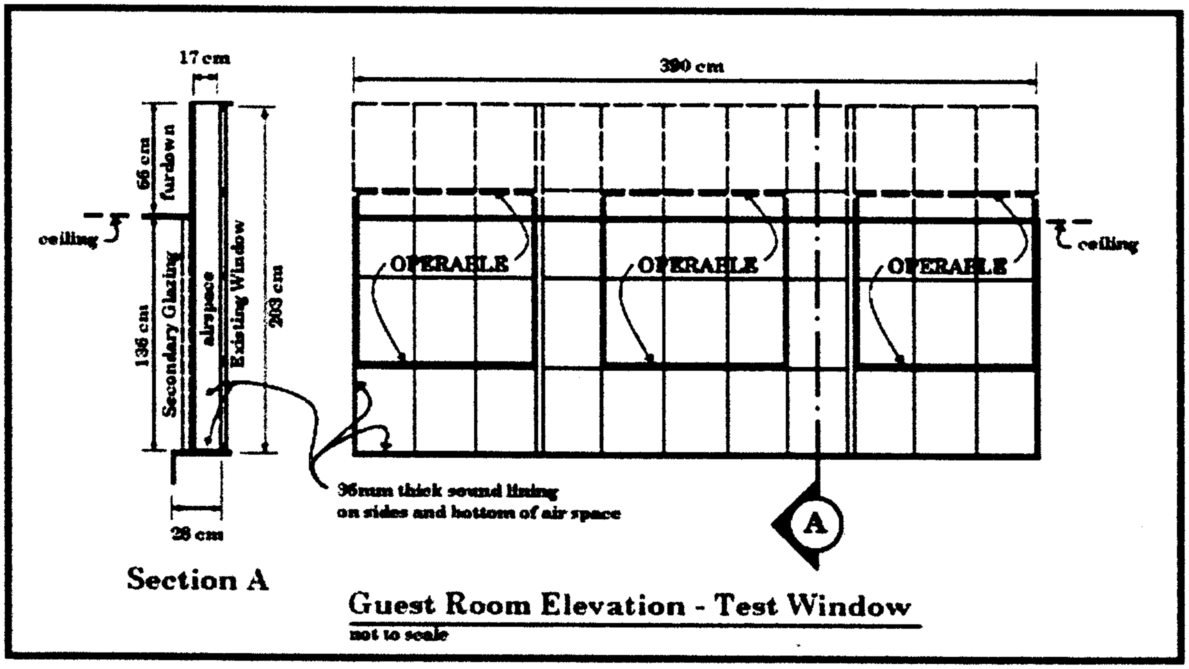

FIGURE 2: CROSS-SECTION VIEW (LEFT) AND ELEVATION (RIGHT) OF THE TEST WINDOW

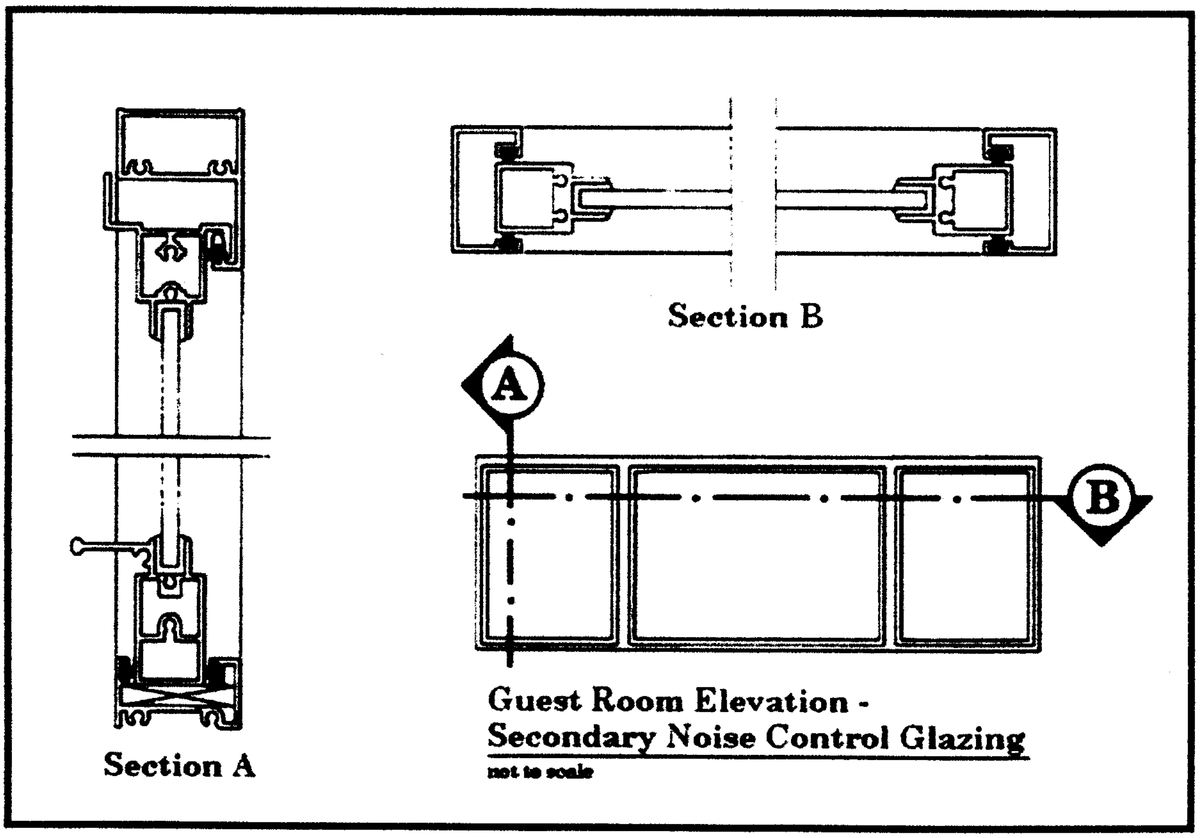

FIGURE 3: CROSS-SECTION VIEWS (LEFT AND RIGHT TOP) AND ELEVATION (RIGHT BOTTOM) OF THE RETROFIT GLAZING

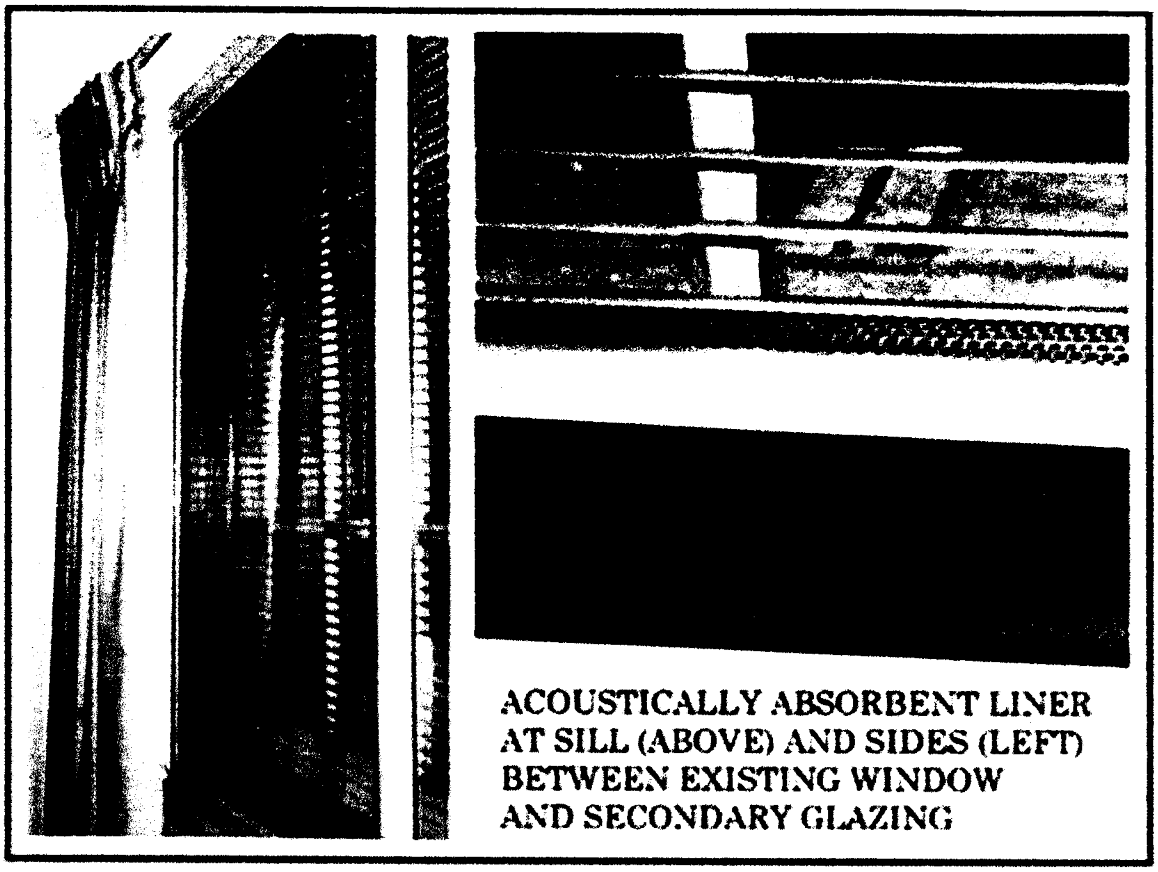

FIGURE 4: VIEWS OF ABSORBENT LINER

2.0 PERFORMANCE CRITERIA

No objective acoustical criterion was established by the hotel owners. The hotel corporation's money back guarantee for dissatisfied guests was the basis for a subjective performance standard. Our own acoustical consultation experience with intrusive noise and reviews of community noise research[4,5] indicate a tolerance in residential areas of intrusive noise up to 5 dB above ambient, but annoyance when 6-10 dB above ambient, and serious reaction when intrusive noise is more than 10 dB above ambient. Therefore, we determined that the retrofit window system would be acceptable if it restricted most traffic noise intrusions to less than 10 dB above the continuous interior ambient sound level.

Assuming ambient continuous air conditioning noise (in any room of the hotel) meets design criteria of NC 30-35 (39-44 dBA), and is approximately 40 dBA near the window, intrusive noise levels should not be allowed to exceed 50 dBA (ambient + 10). Therefore, minimum required improvement in window performance is equivalent to the difference between 50 dBA and peak transient intrusive levels.

The hotel room is exposed to brief transient traffic noise peaks over 60 dBA. The acceptability criterion requires peak noise reduction to ambient + 10, or $\leq$ 50 dBA.

Therefore, the minimum window transmission loss improvement had to exceed 10 dBA when air conditioner fan is on, and greater improvement desired for when fan is off.

3.0 METHODOLOGY / OUTLINE OF THEORY

Measurement of noise reduction was set up in general conformity with ASTM standards for field measurement of outside to inside sound transmission and sound insulation ratings[6], to the extent feasible. Measurements were conducted with a Larson-Davis 2900 real-time analyzer, with an ANSI Type I precision microphone and pre-amp. The microphone was moved over the window area during sound data acquisition (inside and out), and integrated over the sampling period, to obtain a space and time average. The motion minimized room effects, and the integration allowed transients to be averaged down, resulting in a more reliable field result.

The test guest room is on the second floor, above an entry canopy roof, overlooking a multi-lane one-way street. Traffic is controlled by a signal light at the nearest street corner, resulting in alternate periods of accelerating traffic and no traffic. Exterior traffic noise levels are variable, but have high transient peak sound levels (reinforced by reverberant buildup between tall buildings on either side of the street).

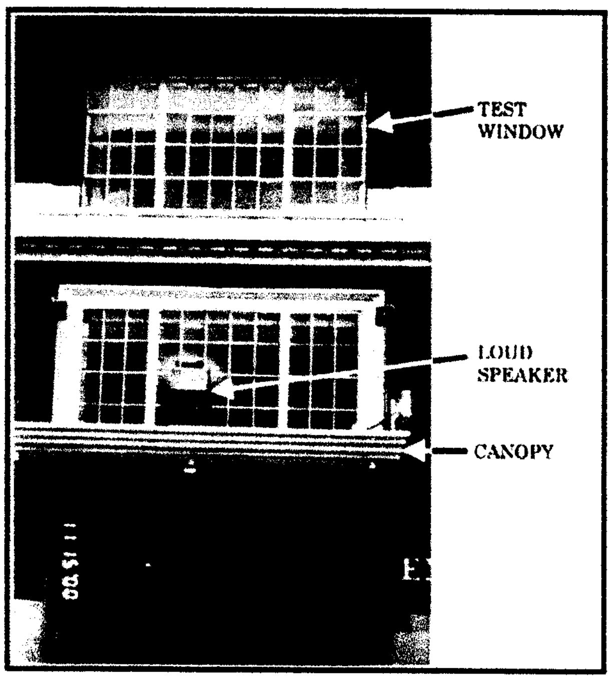

FIGURE 5: FRONT VIEW OF THE TEST WINDOW FROM STREET LEVEL

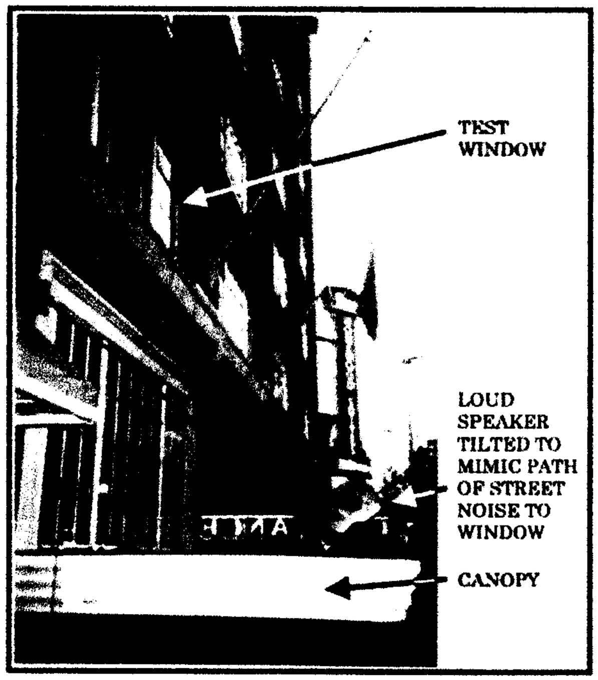

FIGURE 6: SIDE VIEW OF THE TEST WINDOW AND LOUDSPEAKER AT CANOPY LEVEL

The existing divided light, single pane windows are fairly stiff and damped somewhat by the mullions, but poor seals on operable sections permit flanking. Intrusive traffic noise through the existing window was significant; partly due to transmission through the glass, and partly due to flanking. During normal occupancy, hotel windows are closed and air conditioning is on, providing a moderate amount of masking sound from the fan. Traffic noise intrusion through the existing window is audible above the background fan noise. The air conditioning fan coil unit is in a ceiling furring, at the opposite side of the room from the window. It does not contribute to flanking as through wall units might in another facility.

A loudspeaker was placed on the canopy, below the test room window, and tilted up toward the window at an angle similar to the street noise propagation path. The outdoor sound source was equalized over a broad frequency span. The exterior sound level was set to approximately 106 dBA outside the window (much louder than traffic noise) in order to minimize the variability of noise due to alternating traffic conditions. Inside, the loudspeaker source was more than 10 dB above receiver room ambient, eliminating the need to correct results for ambient contribution.

With regard to rating standards, full spectrum results over a broad frequency span are relevant to hotel occupancy, since occupants might be disturbed by any of a variety of noise sources. Sound Transmission Class (STC)[7] is an industry standard for rating glass performance, but the frequency span is limited to 125 Hz - 4000 Hz 1/3 octaves. Outside to Inside Transmission Class (OITC)[8], was considered because it extends to include one lower octave, but ultimately not used, because it calls for A-weighted results, that are difficult to directly compare with STC. Small room volumes make lower frequency results less reliable. However, since most of the guest rooms in the facility have similar volumes, the test room measurement results can be expected to be representative. Therefore, 1/3 octave test results are reported over a range of 63 Hz - 5000 Hz, with STC contours overlaid (within their operative frequency span).

4.0 RESULTS & CONCLUSIONS

Measurements[9] showed existing window noise reduction (NR) performance to be NR 23. Corrected for room conditions, the window rated FSTC 20. Performance was limited by poor seal conditions around the operable portions of the window and the characteristic coincidence dip[10] in glass in the 2 KHz octave. After installation of the secondary window glass, the retrofit window performance was NR 42, FSTC 39—an improvement of 19 STC points. The acoustical absorption panels were added in the perimeter of the cavity, and measured performance increased to NR 48, FSTC 44, or another 5(+) points (cavity absorption was effective because of the exterior window high frequency deficiencies).

The retrofit window noise reduction improvement met desired performance requirements. The window transmission loss improved from FSTC 23 to FSTC 44 with the retrofit system (including absorption). The difference between peak transients and ambient decreased from as much as 25 to only 3 - 5 dB. Maximum peak levels remain audible, but they are less frequent, and are within an acceptable range, relative to continuous ambient sound levels.

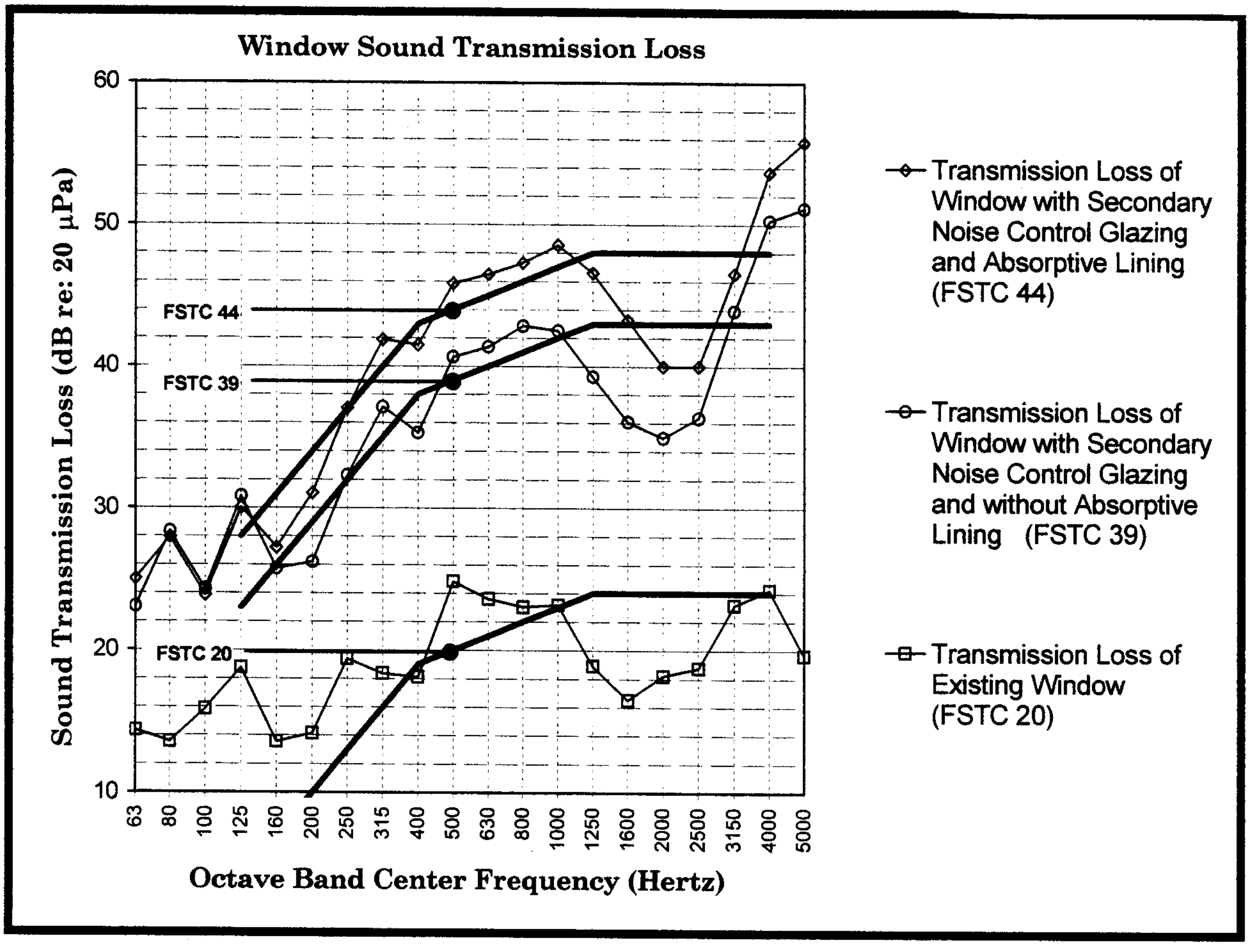

FIGURE 7: EXISTING AND RETROFIT WINDOW PERFORMANCE

Performance deficiencies included partial flanking via the ceiling and wall furring. The existing casement window would perform better if mullion seals were installed, to limit leakage. Secondary window performance could be improved if laminated glass were substituted for plate, to limit coincident dips in 250 Hz and 2 KHz octaves.

JEAcoustics deemed the retrofit window system adequate to limit intrusive environmental noise to an acceptable level over a broad frequency span, based on minimizing the potential of hotel guest noise complaints.

5.0 ACKNOWLEDGEMENTS

We wish to express appreciation to St. Cloud Window, Inc., St. Cloud, MN USA the manufacturer of the SCW 380 retrofit window system, for permission to use retrofit window details and specifications, and Ed Flume Building Specialties, Inc., San Antonio, TX USA, the installer, for in-situ test logistical assistance, and to Homewood Suites by Hilton for permission to use photographs of the hotel.

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