

September 6, 2020

Hilti

3701 W. Royal Lane, Suite 100
 Irving, Texas 75063

Attention: Matthew Winston

**Subject: Copperwynd Resort; Scottsdale, Arizona
 Hilti CFS-TTS Acoustical Testing
 Veneklasen Project No. 4030-008**

Dear Matthew:

Veneklasen Associates, Inc. (Veneklasen) was contracted to complete field acoustical measurements of demising walls within the subject project to evaluate the acoustical performance of the top-of-wall detail. This project utilized the Hilti CFS-TTS Firestop Top Track Seal in conjunction with a Trim-Tex Wall-mounted Deflection Bead finish trim piece. Acoustical sealant was not used. The top-of-wall joint was protected with a firestop system as depicted in the engineering judgement per Appendix II. The system was used by the installing contractor to help ensure the required fire resistance rating for the joint was achieved (1-hour).

Veneklasen measured the field acoustical performance of guestroom demising wall assemblies using two methods to quantify sound transmission through the top-of-wall detail: Normalized Noise Isolation Class (NNIC) ratings and sound intensity measurements. This report documents our measurements, results, and evaluation.

Sound Isolation Measurements and Results

Veneklasen completed Normalized Noise Isolation Class (NNIC) measurements on demising walls within the subject project. Veneklasen sub-contracted Western Electro-Acoustic Laboratory (WEAL) to perform NNIC tests for the demising walls. WEAL performed six (6) Normalized Noise Isolation Class (NNIC) tests. WEAL tested in strict accordance with the following standards: ASTM E336, "Standard Test Method for Measurement of Airborne Sound Attenuation between Rooms in Buildings" and ASTM E413, "Classification for Rating Sound Insulation."

WEAL is accredited by the United States Department of Commerce, National Institute of Standards and Technology (NIST) under the National Voluntary Laboratory Accreditation Program (NVLAP) for the measurement procedures. WEAL's measurement results are shown in Table 1.

Table 1 – Acoustical Field Testing Results

Test Number	Description	Test Specimen	NNIC
F20-1212	Demising Wall	Rooms 416 and 418	55
F20-1213	Demising Wall	Rooms 420 and 422	52
F20-1214	Demising Wall	Rooms 421 and 419	55
F20-1215	Demising Wall	Rooms 417 and 419	52
F20-1216	Demising Wall	Rooms 418 and 420	54
F20-1217	Demising Wall	Rooms 417 and 419	55

The wall assembly consists of the following materials:

- Two (2) layers of 5/8-inch gypsum board
- 3-5/8-inch Cemco 20-gauge steel studs (16 inches on center)
- Batt insulation
- ClarkDietrich RCD resilient channels (24 inches on center)
- one (1) layer of 5/8-inch gypsum board
- Hilti CFS-TTS product was installed between the top track and the slab
- Trim-Tex Wall-mounted Deflection Bead was installed after the gypsum board on both sides for aesthetics

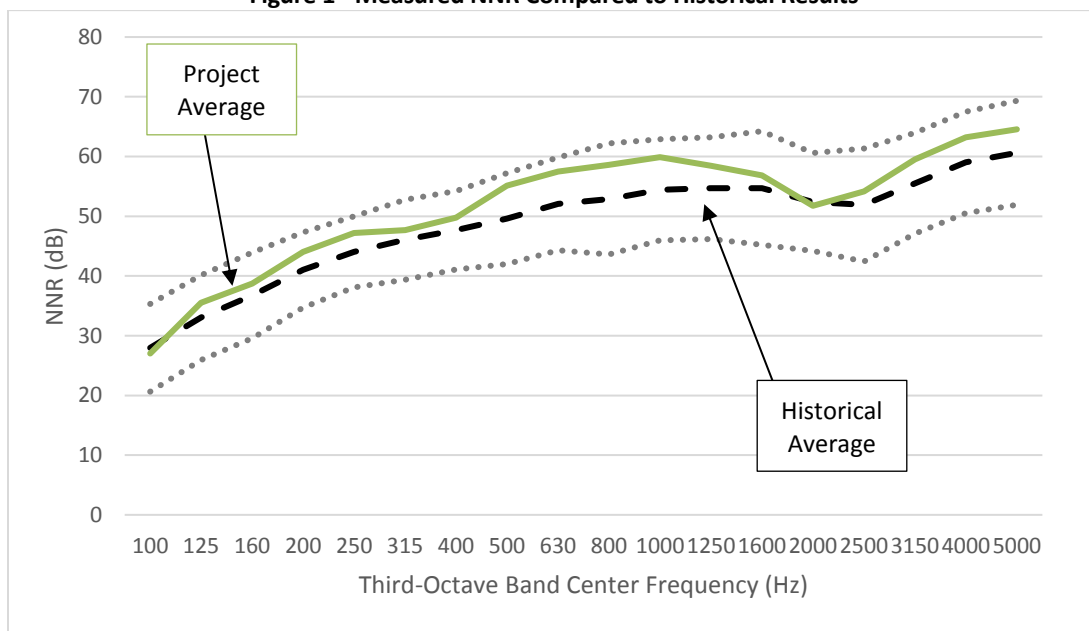
The top-of-wall joint was protected with a firestop system depicted shown in the detail 347764c in the Appendix. This system was used by the installing contractor to help ensure the required fire resistance rating for the joint was achieved.

Refer to appendix for detail of the wall and photos of the test specimens.

Figure 1 below shows the average measured NNR values from this test program as compared to the statistical performance for the same wall assembly based on historical data. A total of 26 test results were used to compile the statistical performance data. The graph depicts the historical average performance (dashed line) and the upper and lower limits (average \pm 2 standard deviations) as dotted lines. The tests included acoustical sealant at the top-of-wall closure instead of the Hilti CFS-TTS product. This comparison is provided to contextualize the performance of the assembly with the Hilti CFS-TTS closure against its performance with traditional sealant closures.

Of note, Veneklasen was the acoustical consultant of record and field education and observations were performed throughout the construction period to ensure QA and QC was maintained during construction.

Figure 1 - Measured NNR Compared to Historical Results



Similarly, the table below presents the measured NNIC ratings for the subject project as compared to historical test ratings.

Table 1 – Statistical Rating Assessment (NNIC)

	Historical Ratings	Project Ratings
Test Count	26	6
Average	52	55
Maximum	57	55
Minimum	46	52
Range	11	3

From the graph we can see that the measured third-octave-band NNR results with the Hilti CFS-TTS closure are consistent with average performance for the wall type with a traditional sealant closure. Similarly, Table 1 also indicates consistency between the project's measured NNIC results and historical results. The project ratings all fall within the historical range of results.

As a result, Veneklasen concludes that the wall construction with the Hilti CFS-TTS closure provides sufficient attenuation to maintain the acoustical performance of the tested wall construction as the same assembly with a sealant closure for this project and QA/QC procedure.

Sound Intensity Measurements

In order to quantify the sound power radiated by the various surfaces, Veneklasen measured the sound intensity (sound power per unit area) using a Bruel & Kjaer type 2270 with type 3654 sound intensity kit. This equipment can separately measure the sound intensity radiating from each assembly’s surface, from which can be determined the sound power radiated by each surface. In this way, the strength of each sound path can be established.

Sound intensity was completed for two demising walls (608/610 and 611/613). The wall was divided into three sections, each scanned individually: the top of wall (15 cm high by the width of the wall), the exterior/demising wall intersection (15 cm wide by the height of the wall), and the remaining field of the wall. The adjacent surfaces (ceiling, floor, and side walls) were also measured by scanning a strip approximately 0.5-m wide immediately adjacent to the wall. The demising wall on the bathroom side of the guestroom was selected for the measurement to minimize flanking energy from guestroom entry doors.

The results of the sound intensity measurements are presented in the table and figures below. The A-weighted sound power radiated by each surface is shown in Table 2. When the sound power level is known, the resultant sound pressure level in the room can be calculated; this is shown in Table 2 for each wall and path. The resultant sound pressure levels for each sound path and total are graphed in Figures 2 and 3. Results for the ceiling, floor, and adjacent walls are not presented since their contributions were not significant.

Table 2 – Sound Intensity Overall Level Assessment

Surface	608/610		611/613	
	Sound Power (dBA re: 10 ⁻¹² W)	Resultant Sound Pressure (dBA re: 20μPa)	Sound Power (dBA re: 10 ⁻¹² W)	Resultant Sound Pressure (dBA re: 20μPa)
Field of Wall	71	63	73	64
Top of Wall (TOW)	60	51	61	52
Exterior Wall Intersection (Ext. Int.)	53	42	56	47

Figure 2 - 608/610 Demising wall sound intensity results

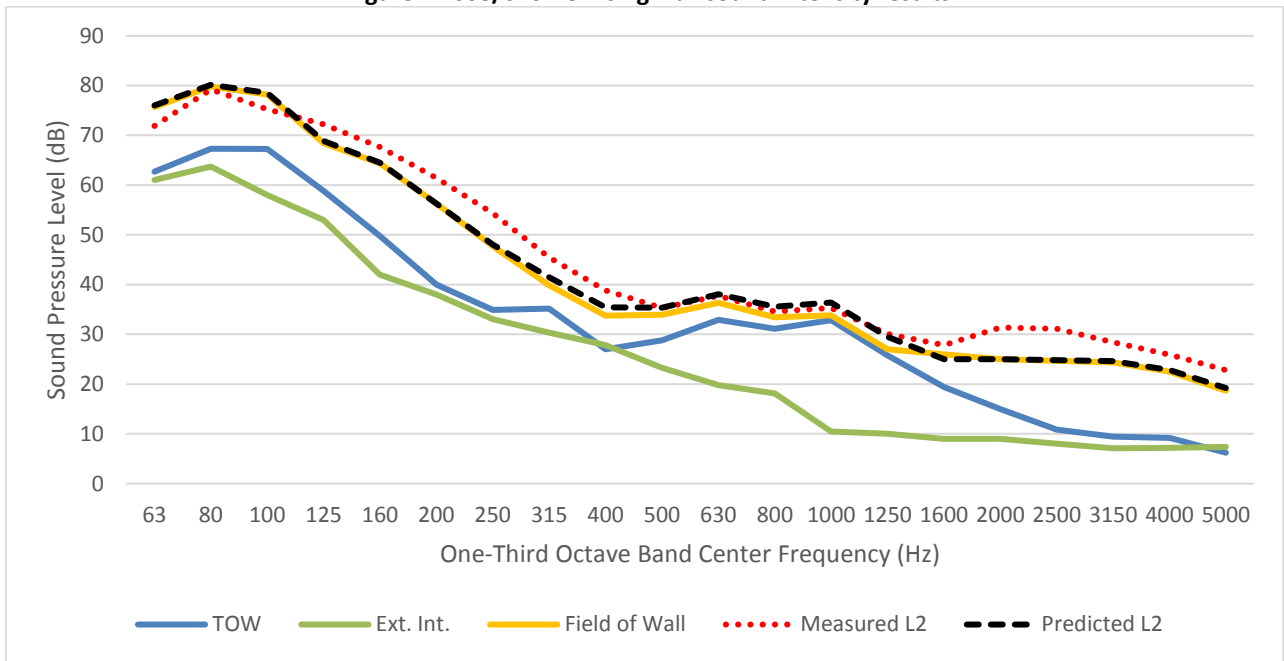
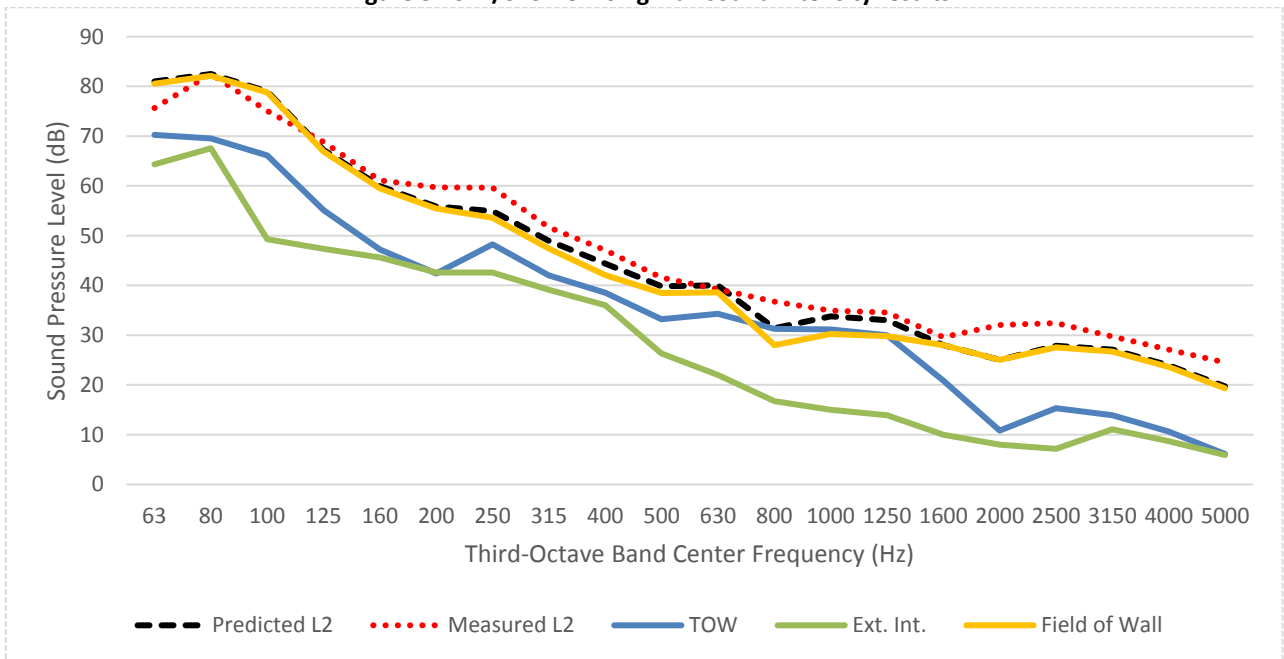


Figure 3 - 611/613 Demising wall sound intensity results



The red dotted line in Figures 2 & 3 is the measured sound pressure level in the receiving room (L2), which was 63 dBA in both rooms (by coincidence). The black dashed line in both figures is the predicted receiving room sound pressure level, which was 63 dBA in 610 and 64 dBA in 611. There is good agreement between the calculated and measured sound levels. This confirms the accuracy of the sound intensity method and provides confidence that there are no significant sound paths beyond those listed.

Review of the sound pressure levels for each path reveals the relative contribution of sound transmission from that path to the overall total. At any given third-octave band, if a path's level is 10 dB or more below the measured receiving room level (L2), then the contribution from that path is not significant at that frequency. Examination of the frequency content in this manner indicates that transmission through the top-of-wall path, which indicates how much sound passes through the Hilti CFS-TTS product, is significant to the total in mid-frequency bands (approx. 250-1250 Hz). In the remainder of the spectrum (low-frequency and high-frequency regions), the contribution from the top-of-wall section is not significant. This is consistent with sound transmission theory based on the size of the gap and the material composition.

Sound Intensity Heat Maps

The sound intensity measurements also provide "heat maps" that show how the sound intensity varies across a surface. Figure 5 shows the heat map for guestroom 610 from 400–1600 Hz; this is the frequency range where the sound power radiated from the top of wall joint approaches that of the overall wall, as can be seen in Figure 2. Similarly, Figure 6 shows the heat map for guestroom 611 in the frequency range of 250–1250 Hz, which again matches the frequency range in Figure 3 where the sound from the top of wall (blue curve) affects the overall sound level.

The different locations of the sound radiation are evident. In room 610 (Figure 5), the sound is radiating from the corners of the walls. One can speculate that TTS was not installed tight against the surrounding structure, but no definitive attribution can be made.

In room 611 (Figure 6), the top of wall joint is radiating from the middle of the wall. Veneklasen observed a gap at the deflection bead at this location (Figure 4). This indicates that the top edge of the gypsum board was not parallel with the slab, which may be due to a lack of flatness in the floor slab. The correspondence with the intensity heat map allows us to attribute the radiation to this gap.

Figure 4 – Gap at top of wall, Guestroom 611



Figure 5 - Sound intensity heat map, Guestroom 610

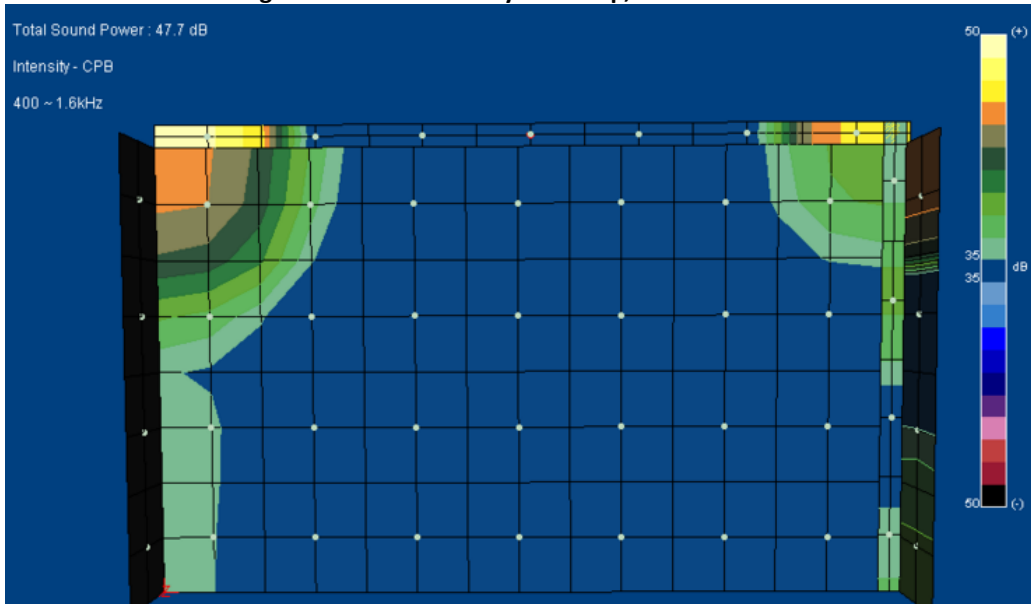
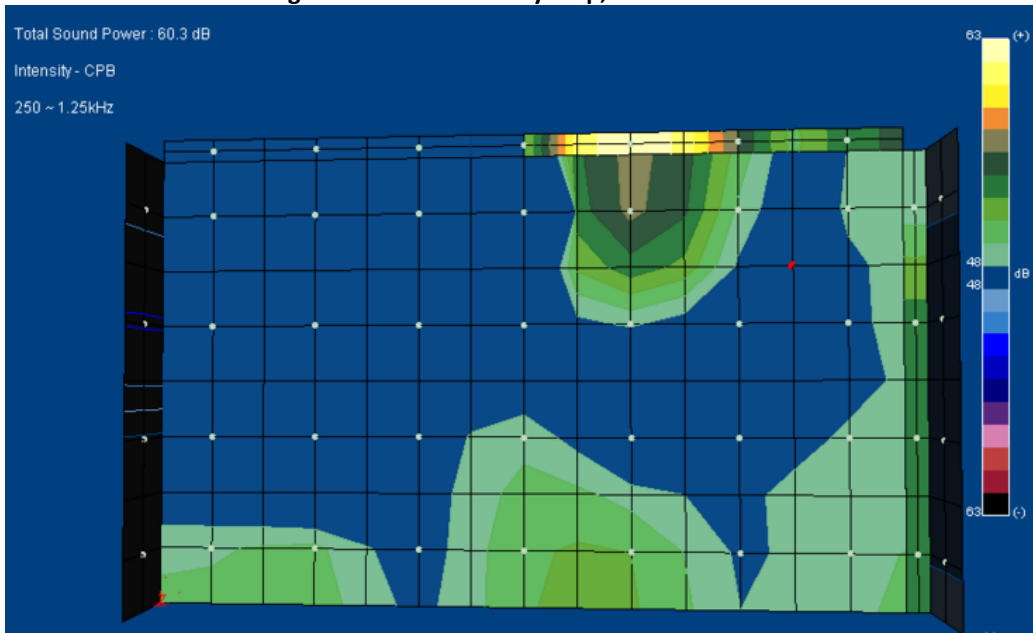


Figure 6 - Sound Intensity Map, Guestroom 611



Note the different scales between Figure 5 and Figure 6. The sound power from the top of wall in guestroom 611 was more than 10 dB higher in this frequency range. This can also be seen by comparing the blue traces in Figure 2 and Figure 3. The effect on the overall A-weighted level and NNIC rating was small.


Conclusions

The purpose of the measurements was to assess the impact on the wall's overall sound isolation based on the use of a Hilti CFS-TTS closure and deflection bead at the top of wall, without the additional use of acoustical sealant. The demising walls in the subject project were constructed in this manner and observed by Veneklasen staff during construction. We have the following conclusions from the measurement program.

- The measured single-number ratings for the demising walls are consistent with statistical performance for the same wall construction using acoustical sealant at the top-of-wall closure, based on historical test results. Hilti CFS-TTS closure are consistent with average performance for the wall type with a traditional sealant closure.
- The measured Normalized Noise Reduction (NNR) values across the frequency spectrum were consistent with the statistical performance of the wall type using acoustical sealant at the top-of-wall closure. All values fell within the statistical distribution expected for the assembly. Hilti CFS-TTS closure are consistent with average performance for the wall type with a traditional sealant closure
- Sound intensity measurements indicate that sound transmission through the field of the wall assembly was the primary sound transmission path across the demising wall. This is at least in part due to the relative areas of the field of wall as compared to the top-of-wall and exterior wall intersection.
- Sound intensity measurements indicate that sound transmission through the top-of-wall closure is significant to the overall result in mid-frequency bands (250-1250 Hz).
- The sound radiation from the top of wall joint is not uniform. The sound intensity method can be used to identify leaks and quantify the effect.

This concludes Veneklasen's assessment. Please feel free to contact us with any questions or comments.

Respectfully submitted,
Veneklasen Associates, Inc.




Samantha Rawlings, LEED AP BD+C
Associate Principal



John LoVerde, FASA
Principal

Appendix I – Engineering Judgment and Photos

JM	<p>ENGINEERING JUDGMENT FIRESTOP DETAIL</p> <p>PROJECT : COPPERWYND RESORT ARCHITECT : ALLEN & PHILP ARCHITECTS & PETE KING F-RATING = 1-HR.</p> <p><u>CROSS-SECTIONAL VIEW</u></p>								
 Hilti Firestop Systems	HILTI, Inc. Plano, Texas USA (800) 879-8000 Designed by <i>Travis Pearce</i>	<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="font-size: small;">Sheet</td> <td style="text-align: center;">1 of 2</td> <td rowspan="3" style="font-size: small; vertical-align: middle;">Drawing No. 347764c</td> </tr> <tr> <td style="font-size: small;">Scale</td> <td style="text-align: center;">7/32" = 1"</td> </tr> <tr> <td style="font-size: small;">Date</td> <td style="text-align: center;">Sep. 04, 2020</td> </tr> </table>	Sheet	1 of 2	Drawing No. 347764c	Scale	7/32" = 1"	Date	Sep. 04, 2020
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<p><i>Saving Lives through Innovation and Education</i></p>									

JM
ENGINEERING JUDGMENT FIRESTOP DETAIL

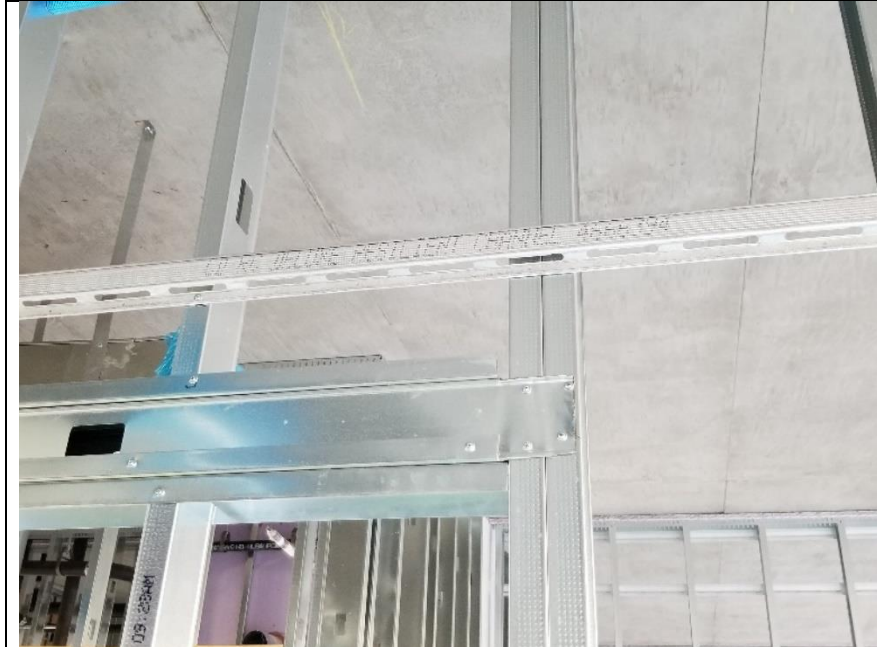
PROJECT : COPPERWYND RESORT
ARCHITECT : ALLEN & PHILP ARCHITECTS & PETE KING
F-RATING = 1-HR.

1. CONCRETE FLOOR ASSEMBLY (MINIMUM 4-1/2" THICK) (1-HR. FIRE-RATING).
2. GYPSUM WALL ASSEMBLY (UL/cUL CLASSIFIED U400 OR V400 SERIES) TO CONSIST OF THE FOLLOWING (1-HR. FIRE-RATING):
 - A. TWO LAYERS OF MINIMUM 5/8" THICK TYPE X GYPSUM BOARD.
 - B. MINIMUM 3-5/8" WIDE STEEL STUDS.
 - C. [OPTIONAL, NOT SHOWN] BATT INSULATION FRICTION FIT BETWEEN STUDS
 - D. MAXIMUM 1/2" DEEP STEEL RESILIENT CHANNEL (MIN 26GA) SPACED MAX 24" O/C AND SECURED TO STEEL STUDS WITH STEEL SCREWS
 - E. ONE LAYER OF MIN 5/8" THICK TYPE X GYPSUM BOARD SECURED TO RESILIENT CHANNEL WITH STEEL SCREWS.
3. CEILING RUNNER (MIN. 25 GA., FLANGE HEIGHT OF CEILING RUNNER SHALL BE MINIMUM 1/4" GREATER THAN MAXIMUM EXTENDED JOINT WIDTH) FASTENED TO UNDERSIDE OF CONCRETE FLOOR WITH MASONRY ANCHORS OR STEEL FASTENERS (SPACED MAX. 24" OC).
4. HILTI CFS-TTS 358, CFS-TTS 600, OR CFS-TTS OS TOP TRACK SEAL INSTALLED OVER CEILING RUNNER PRIOR TO ATTACHMENT TO UNDERSIDE OF CONCRETE FLOOR IN ACCORDANCE WITH THE ACCOMPANYING INSTALLATION INSTRUCTIONS.
5. [NOT SHOWN] WALL-MOUNTED DEFLECTION BEAD BY OTHERS

NOTES : 1. MAXIMUM WIDTH OF JOINT = 1/2".
2. T-RATING MAY NOT EQUAL F-RATING IN ACCORDANCE WITH UL 2079.

THIS ENGINEERING JUDGMENT REPRESENTS A FIRESTOP SYSTEM THAT WOULD BE EXPECTED TO PASS THE STATED RATINGS IF TESTED.
(REFERENCE : UL/cUL SYSTEM NO. HW-D-0757)

 Hilti Firestop Systems	HILTI, Inc. Plano, Texas USA (800) 879-8000	Sheet 2 of 2	Drawing No.
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Resilient channel installation showing product stamp



Top of wall framing showing Hilti CFS-TTS installation



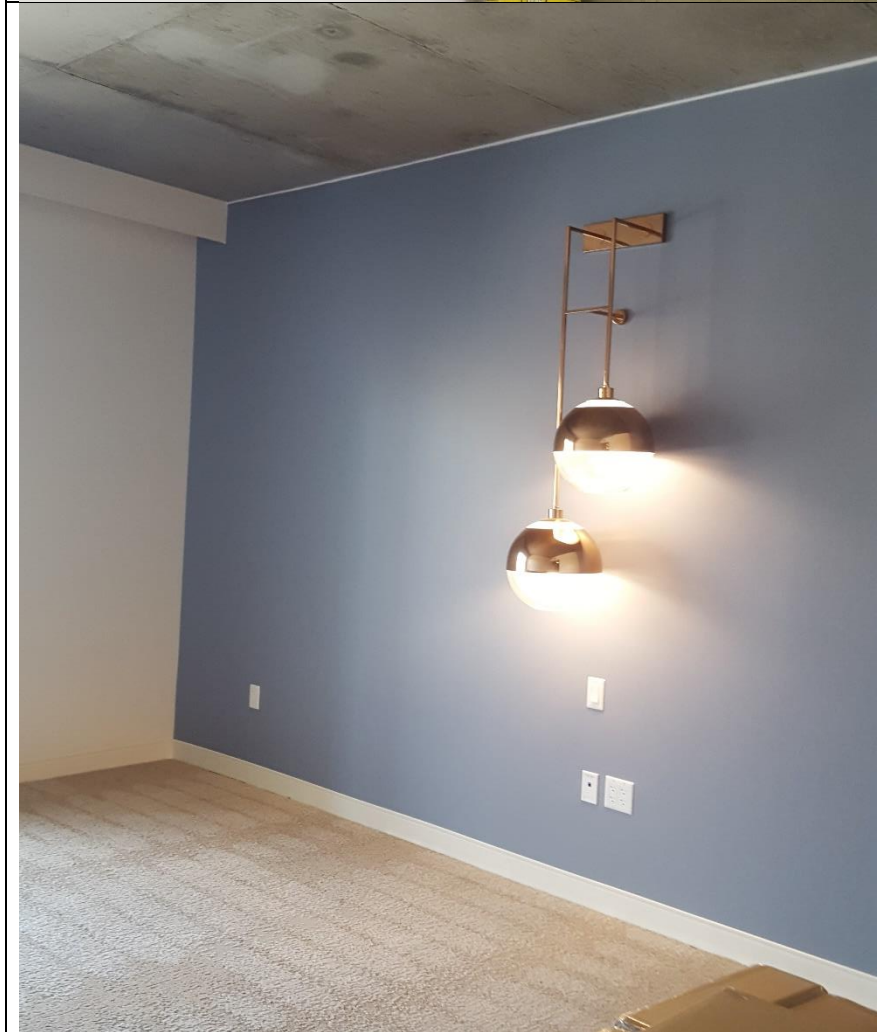
Construction of demising wall in progress showing insulation, resilient channels, Hilti CFS-TTS, and gypsum board





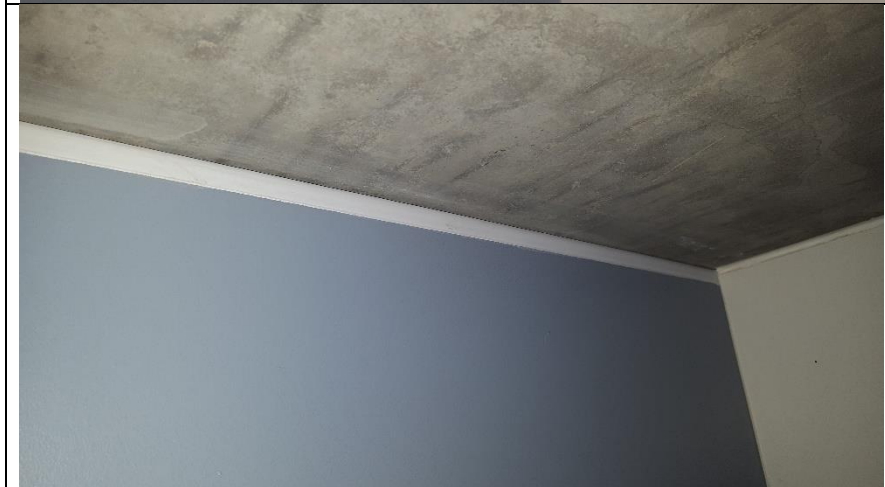
Top of wall showing Hilti CFS-TTS at top of wall



Top of wall showing Hilti CFS-TTS and 1/2-inch clear



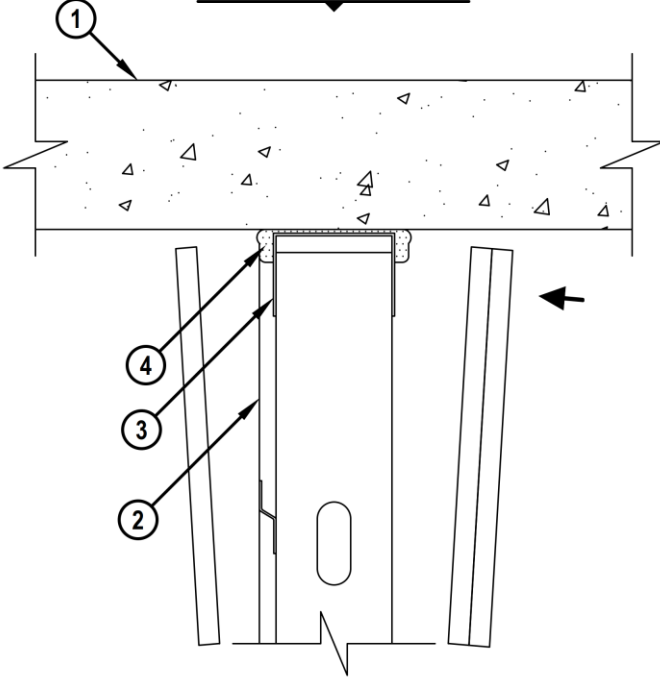

Completed demising wall

	<p>Completed demising wall, opposite side</p>
	<p>Top of wall detail at exterior wall, showing shade pocket</p>
	<p>Close-up of top of wall detail, showing Trim-Tex Wall-Mounted Deflection Bead and exterior wall intersection</p>



Top of wall showing variation in slab flatness and incidental gaps

Appendix II – Joint Engineering Judgment

JM	<p>ENGINEERING JUDGMENT FIRESTOP DETAIL</p> <p>PROJECT : COPPERWYND RESORT ARCHITECT : ALLEN & PHILP ARCHITECTS & PETE KING F-RATING = 1-HR.</p> <p>CROSS-SECTIONAL VIEW</p> 								
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NOTES : 1. MAXIMUM WIDTH OF JOINT = 1/2".
2. T-RATING MAY NOT EQUAL F-RATING IN ACCORDANCE WITH UL 2079.

THIS ENGINEERING JUDGMENT REPRESENTS A FIRESTOP SYSTEM THAT WOULD BE EXPECTED TO PASS THE STATED RATINGS IF TESTED.
(REFERENCE : UL/cUL SYSTEM NO. HW-D-0757)

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