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Quantitative comparisons of resilient channel design and installation in single wood stud walls

John LoVerde (1) and Wayland Dong (2)

(1) Veneklasen Associates, Santa Monica, California, USA
(2) Paul S. Veneklasen Research Foundation, Santa Monica, California, USA

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ABSTRACT

The use of resilient channel in stud-framed walls in multi-family residential buildings is common in North America, allowing Building Code requirements to be met with single stud wall construction. There is considerable evidence that the brand and model of resilient channel has significant effect on acoustical performance, as do numerous installation errors such as short-circuits. Unfortunately most of the evidence is anecdotal and there has been limited systematic study. The authors previously published preliminary results of a laboratory testing program [1] that systematically isolated and quantified the acoustical effects of channel brand and model, and of several installation errors. A second testing program has recently been completed with additional brands and models of channel and additional installation errors. This paper summarizes the results of the testing programs, which provide valuable quantitative data of the effect of difference in resilient channel and installation on acoustical performance.

INTRODUCTION

Resilient channel is a common acoustical design element in both walls and floor/ceiling assemblies in multi-family residential buildings in North America. Specifically, the use of resilient channel allows minimum building code requirements for demising walls (such as STC 50 required by the International Building Code) to be achieved with single wood stud construction. Acoustical consultants in North America have developed a body of recommendations regarding the brand, model, and installation method in order to fully realize the acoustical potential. However, most of the evidence that supports these recommendations is anecdotal, and there is only limited objective acoustical for isolated manufacturer's models or assembly types.

In order to address this lack, the authors have conducted two programs of laboratory sound reduction index (R_w) tests, systematically varying the resilient channel manufacturer, model, and installation method. The results of the previous study [1] have been expanded to include additional manufacturers and models, and additional variations in installation methods.

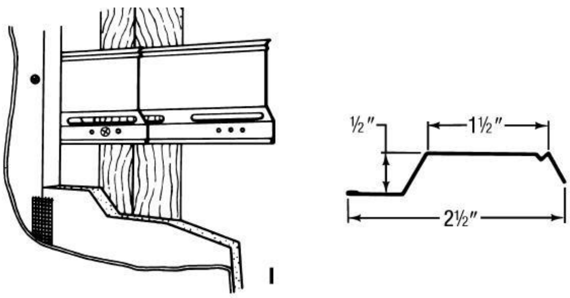
DIFFERENCES BETWEEN BRANDS

Dietrich RC-Deluxe

There are many manufacturers of a metal furring channel marketed as "resilient channel," and sometimes as "RC-1." RC-1 was the designation of the original resilient channel developed by United States Gypsum (USG) approximately 50 years ago, but it has become a generic term for resilient channel and not a reference to a particular product. Resilient channels are nominally 25 gauge (0.53 mm) steel, nominally 0.5 inch (13 mm) thick, and have a "Z"-shaped cross section with a narrow flange screwed to the studs, and a wide flange to which the gypsum board is attached. See Figures 1 and 2.

Source: (Lilly, 2002)

Figure 1. A picture of various resilient channel models.



Source: (USG, 2000)

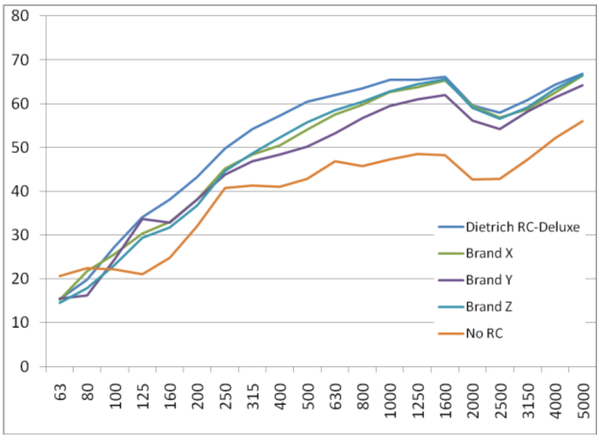
Figure 2. A sketch showing dimensions of resilient channel and typical installation on wood studs beneath drywall.

The currently manufactured channel that is closest to the original USG RC-1 design is manufactured by Dietrich Metal Systems and marketed as "RC-Deluxe" with product code RCSD. RC-Deluxe is easily identified by the distinctive "dogbone" shape of the slots in the web, whereas other brands and models have various patterns of slots and holes. In possibly the only previously published direct comparison of resilient channels, Lilly [2] reported that USG RC-1 performed 3 STC points better than two unidentified resilient channels for one single wood stud construction having one layer of gypsum board on each side and fiberglass insulation in the stud cavity.

Review of previous results

The previous study [1] compared RC-Deluxe to three other unidentified manufacturers (Brand X, Y, and Z). The base assembly was a nominal 2x6 wood stud wall, with studs at 406 mm (16 inches) on center and R19 batt insulation in the cavity. On one side was one layer of 15.9 mm (5/8-inch) type "X" gypsum board over one layer of 9.5 mm (3/8-inch) plywood shear panel. On the opposing side of the studs was either one or two layers of 15.9 mm (5/8-inch) type "X" gypsum board directly mounted to the studs or over the resilient channel models mounted at 24 inches (610 mm) on center. This assembly was selected since it is a common wall in multi-family construction where shear panels are required to meet structural building code requirements.

In these tests, the measured R_w rating for the walls containing the Dietrich RC-Deluxe were between 3–6 points higher than the other channels, with differences in transmission loss of up to 10 dB at some third-octave bands. Figure 3 shows representative results from the previous program.



Source: (LoVerde and Dong, 2009)

Figure 3. Transmission loss vs. third-octave band center frequency (Hz) from the previous study [1] with a "1+2" configuration and various resilient channel models

Both the previous and the current studies were performed at Western Electro-Acoustic Laboratory in Santa Clarita, California, which is accredited in the United States to perform the ASTM E90 and ISO 140-3 test procedures. In order to minimize the uncertainties in the test procedure, the assemblies were constructed, demolished, and tested on consecutive days in the same testing laboratory with the same personnel. The studs, gypsum board and other materials were all purchased at the same time from the same production lots. The overall dimensions of the wall assembly evaluated for all of the tests was 2.4 m (96 inches) wide by 2.4 m (96 inches) high.

Comparison testing

For the current study, the 9.5 mm (3/8-inch) plywood shear panel was not used. All assemblies had either one or two layers of 15.9 mm (5/8-inch) type "X" gypsum board on each side, either mounted to resilient channel or directly to the studs. As before, the base assembly was a nominal 2x6 wood stud wall, with studs at 406 mm (16 inches) on center with R19 batt insulation in the cavity. As part of the current study, the RC-Deluxe was retested as the standard, and RCUR (a different channel design also by Dietrich) and another manufacturer (Brand W) were added. We also tested two "hat channels," sometimes referred as "double leg" resilient channel, one each of 20 and 25 gauge thickness (approximately 0.91 mm and 0.53 mm, respectively). (In this paper, we use the term "resilient channel" to mean single leg and "hat channel" to mean double leg, with the unqualified "channel" referring to both categories.) See Figure 4. Hat channel would normally be rejected out of hand by an acoustical consultant as obviously inferior to resilient channel, but we included it as there is practically no objective acoustical data on such products.

Source: (Dietrich, 2010)

Figure 4. From left to right, Dietrich RCUR, RC-Deluxe, and hat channel.

In all cases, the results with the various resilient channel models and installation methods were compared to a "control" wall with the same number of gypsum board layers on each side of the wall, but installed directly to the studs without resilient channel. The control assembly ratings were measured to be R_w 35-40.

There were some differences between nominally identical assemblies with the RC-Deluxe between the previous and current studies. The third-octave transmission loss values for the walls tested for the current study were lower by as much as 5 dB between 1000 and 2000 Hz, and the resultant rating was slightly lower (0-2 R_w points). The difference was not investigated at this time.

The results of the testing are shown in Table 1, arranged by configuration of gypsum board (for example, "1+1" means 1 layer on each side). The spectra of transmission loss values for the "1+2" configuration is shown in Figure 5. The spectra are similar for the other configurations and are not shown.

Table 1. R_w ratings of resilient channel assemblies

RC Brand	1+1	1+2	2+2
None	35	38	39
RC-Deluxe	53	56	60
RCUR	49	53	56
Brand W	51	55	59
25 ga. hat	43	46	49
20 ga. hat	43	46	48

Discussion

As before, the Dietrich RC-Deluxe was the highest-performing model. The Dietrich RCUR model performed similarly to Brand X, Y, and Z from the previous study, and 3-4 R_w points lower than the RC-Deluxe. The Brand W channel performed nearly as well as the RC-Deluxe. Comparison of the transmission loss spectra of the two products shows that the measured transmission loss of the RC-Deluxe is 2-5 dB higher below 500 Hz, but the transmission loss of

Brand W is 1-3 dB higher above 1000 Hz. The R_w rating changed by just 1-2 points. Of the five alternative models tested, the Brand W channel is the only one to closely match the performance of the RC-Deluxe.

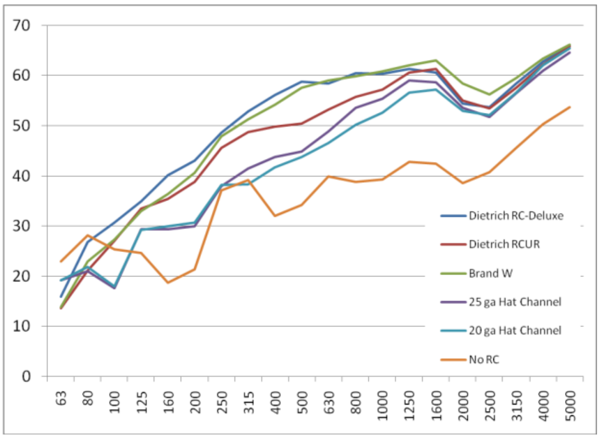


Figure 5. Transmission loss vs. third-octave band center frequency(Hz) for the tests in the "1+2" column of Table 1.

As expected, the performance of the double-leg or hat channels were significantly worse (at least 6 R_w points) than all of the single-leg channels, and 10-12 R_w points lower than the RC-Deluxe. However, they still provided a significant (8 point) improvement compared to the control wall assembly with no channel. It seems reasonable to treat hat channel as the limiting worst case of resilient channel design (this is further supported by the short-circuiting study in the following section).

The differences between channel designs become much smaller at high frequencies. At 1600 Hz and above, the transmission loss values measured for all of the channel designs including the hat channel are within about 3 dB of each other, and 10-15 dB better than the control wall. Therefore, the testing indicates that the specifics of the channel design or its resiliency do not affect the acoustical performance at high frequencies.

Between about 100-1600 Hz, however, the design of the resilient channel is very important, which the best channel measured (RC-Deluxe) having third-octave transmission losses up to 15 dB higher than the hat channel.

SHORT CIRCUITING

Results

A common installation error occurs when the gypsum board is installed using screws that are too long, so that the screws penetrate into the studs. This is commonly referred to as a "short-circuit." It is both obvious and generally accepted that this significantly reduces the acoustical performance, but prior to this study there was very limited systematic data documenting the effect.

The testing used the same base assembly as described above with 2 layers of gypsum board on each side. The wall had a total of 35 25mm (1 inch) screws securing the gypsum board to the resilient channel. To create a short circuit, screws were removed and replaced with 40mm (1-5/8 inch) screws that penetrated into the wood studs. The wall was retested with 5, 10, 20, 30 and 35 short circuits.

The previous study [1] showed that the R_w rating decreases nearly linearly with increasing percentage of short circuits, to a maximum reduction of about 20 percent when fully short-circuited, which is 8 R_w points for the assembly with RC-Deluxe. The current study replicated these results. See Table 2 for results. Figure 6 shows the transmission loss spectra for the set of short-circuit tests using the RC-Deluxe.

Table 2. R_w ratings of 4 layer resilient channel assemblies with various amounts of short circuits

RC Brand	0	5	10	20	30	35
RC-Deluxe	60	58	56	54	52	51
RCUR	56	55	54	52	50	49
Brand W	59	57	54	52	50	50
25 ga. hat	49	48	48	47	46	46
20 ga. hat	48	48	48	48	47	47

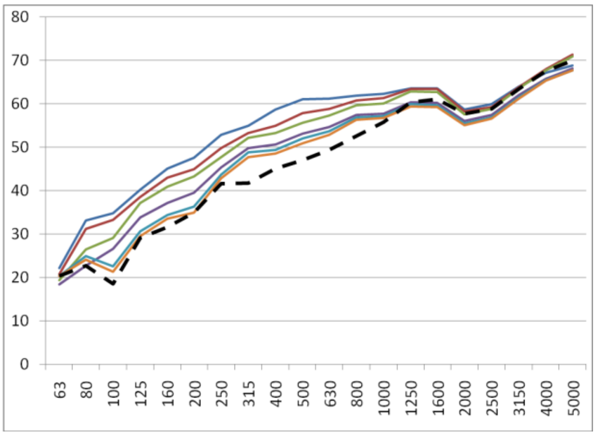


Figure 6. Transmission loss vs. third-octave band center frequency (Hz) for a "2+2" wall with RC-Deluxe and (from top down) 0, 5, 10, 20, 30, and 35 (100%) short circuits. The dashed line shows the same wall with 20 gauge hat channel instead of resilient channel.

Discussion

There were a number of interesting features of these results. First, at high frequencies above about 1250 Hz, the short circuits had only a small effect, decreasing the third-octave band transmission loss by 0-2 dB. This is consistent with the results in the previous section, which found that there were only small changes between all different channels at these frequencies. Since the resiliency of the channel does not affect the performance at these frequencies, it is reasonable that acoustical differences from short-circuiting the assembly would be small..

Second, short circuiting most of the channels (except the RC-Deluxe in Figure 6) actually improved the performance at the lowest frequency bands measured (63 and 80 Hz). This can be understood by noting that the use of resilient channel decreases the transmission loss at the lowest bands (for example, see Figure 3). Whatever the cause of this effect, it is reasonable to expect that it will revert to the non-resilient condition as the resiliency of the channel is decreased due to short circuits.

Third, the fully short-circuited condition for any of the (single-leg) resilient channels is similar to the hat channel. This confirms the supposition made in the previous section that the hat channel is a limited worst case of resilient channel design.

SANDWICH INSTALLATION

Results

Another installation error is installing the resilient channel on a solid substrate (such as gypsum board or plywood) instead of on the studs. The resilient channel is therefore sandwiched between two solid panels, creating a small, nominally ½-inch deep airspace. This is another common installation error that is widely believed to be significant but for which there is very little published data.

The previous study tested the assembly using a nominal 2x6 wood stud wall with batt insulation and 2 layers of 15.9 mm (5/8 inch) thick type X drywall on one side. A layer of nominal 1/2-inch (12.7 mm) plywood shear panel was installed to the studs, RC-Deluxe was attached to the shear panel, and 1 layer of gypsum board installed. The results were compared to the same wall with the resilient channel installed correctly beneath the two layers of gypsum board on the other side of the studs. That study reported that this installation error almost completed negated the acoustical benefit of the resilient channel, with the resulting transmission loss values unchanged from the control for all but the highest frequencies.

The current study used a similar nominal 2x6 wood stud wall with batt insulation and the resilient channel sandwiched between two layers of 15.9 mm (5/8 inch) thick type X drywall. Either one or two layers of drywall was attached to the other side. The test was repeated with each model of resilient channel. The results are shown in Table 3 for the 3 layer wall (one layer of drywall on the other side) and Table 4 for the 4 layer wall (two layers of drywall on the other side). A representative spectrum is shown in Figure 7.

Table 3. R_w ratings of 3 layer resilient channel assemblies for sandwiched vs. correct installation

RC Brand	No RC	Sandwich	Correct
RCUR	38	40	56
Brand W	38	40	55
25 ga. hat	38	40	46
20 ga. hat	38	40	46

Table 4. R_w ratings of 4 layer resilient channel assemblies for sandwiched vs. correct installation

RC Brand	No RC	Sandwich	Correct
RCUR	39	43	60
Brand W	39	44	59
25 ga. hat	39	43	49
20 ga. hat	39	43	48

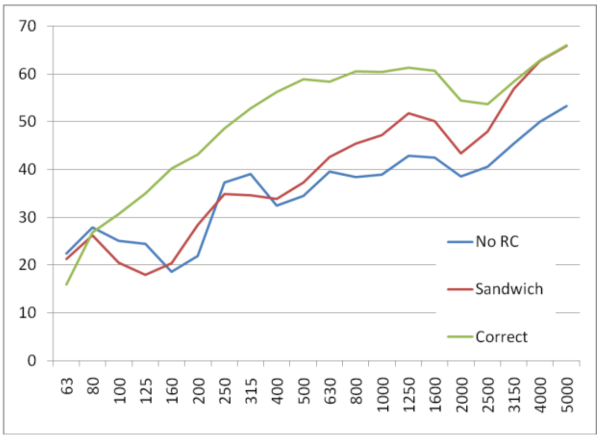


Figure 7. Transmission loss vs. third-octave band center frequency(Hz) for the tests with RCUR in Table 3.

Discussion

The results with the resilient channel broadly replicate the results of the past study. There is very little difference between the sandwich assembly and the control assembly up to about 800 Hz. Above this frequency, the sandwich assembly a small benefit of about 5 dB vs. the control, but 10-20 dB less than the correct installation. At the highest frequencies (3000 Hz and up) the performance is similar regardless of installation method.

Note that the sandwich assemblies all had the same rating regardless of type of channel used. Further, the tests had virtually identical spectra (the red trace in Figure 7), with variations of 1 dB or less between the products. This is somewhat surprising given the large difference between these products when installed correctly. Therefore, the properties and resiliency of the channel does not affect the performance of the sandwich assembly.

Comparison of the sandwich and control assemblies (the red and blue traces in Figure 7) appears to show that the addition of the small sandwich airspace shifts the resonance of the assembly lower by 1-2 third-octave bands which improving the transmission loss by 6-10 dB at frequencies above 800 Hz. The model of the channel makes no difference, which implies that in this assembly the channel is behaving as simply a spacer.

EXCESS SCREWS

Testing

A less common installation error is using an excess number of screws to install the drywall to the resilient channel. There is some plausibility that the number of screws and hence the spacing can affect the performance, as there is data indicating that screw spacing can affect the transmission loss of walls without resilient channel [3].

The assembly was a nominal 2x6 wood stud wall with batt insulation and two layers of 15.9 mm (5/8 inch) thick type X drywall on one side. On the other side of the studs, one layer of drywall was installed over the resilient channel under test. The screw spacing was 200 mm (8 inches) on center on the edges of the gypsum board and 300 mm (12 inches) on center in the field. This corresponds to the most common screw spacing used in North America. After the assembly was tested, additional screws were driven through the gypsum board into the resilient channel at arbitrary locations. The assembly was retested with 10, 20, and 30 additional screws. The excess screws were then removed and the assembly tested a fifth time.

Results

For all models of channel tested, the R_w ratings did not change by more than one point between the tests as the excess screws were added. Therefore, there is no significant effect.

Closer inspection of the transmission loss spectra shows no difference between the tests for the resilient channel walls. For the walls with hat channel, there is some evidence of a small decrease in transmission loss around 500 Hz, up to 2.5 dB when 30 excess screws were used. The transmission loss reverted to the previous value when the excess screws were removed, indicating that this was a real result. However, this was only observed in hat channel, not the single leg channel. It was only measurable with 30 extra screws, and affected the R_w rating by only one point.

CONCLUSIONS

When combined with the previous study [1], the results of our testing have for the first time quantified the effects of changes in resilient channel brand and installation methods. We do not anticipate that this data will dramatically change the way the North American acoustical community designs or evaluates resilient channel walls. However, the data now exists to scientifically support or refute much of the body of conventional wisdom regarding resilient channel.

1. The Dietrich RC-Deluxe channel continues to be the channel with the best acoustical performance. The Brand W channel was the first channel to our knowledge that has been shown to be nearly equal to the RC-Deluxe for walls, not only in R_w rating but in all third-octave bands. The Dietrich RCUR and Brands X, Y, and Z achieve ratings 3-6 R_w points lower, and up to 10 dB lower in some third-octave bands. Double-leg hat channel, which can be seen as a worst-case resilient channel, achieves ratings 10 points lower than RC-Deluxe, but still 8 points better than the wall without channel.

2. Short-circuiting the resilient channel results in a linear decrease of performance with number of short-circuits, up to 8 R_w points and 12 dB in some third-octave bands. A fully short circuited resilient channel performs similarly to hat channel.

3. Sandwich installation results in very large reductions compared to proper installation, and only small benefits compared to not using any channel. All of the channel designs performed similarly in the sandwich configuration, indicating that resilience of the channel is not significant for this installation.

4. Using excess screws to secure the gypsum board to the channel did not have a significant effect.

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