

Effect of Electrical Outlet Boxes on Sound Isolation of Gypsum Board Walls

by *T.R.T. Nightingale, J.D. Quirt and M.A. Sultan*

This Update discusses the effect of electrical outlet boxes on the sound isolation of gypsum board walls and provides recommendations with respect to box type and location, and methods for improving existing boxes. The information is based on the results of an industry-supported research project conducted at the NRC's Institute for Research in Construction.¹

The National Building Code (NBC) requires partition walls that separate units in multi-family dwellings to be both fire- and sound-rated. The Canadian Electrical Code requires these and other walls in the dwelling to have a certain number of electrical outlet boxes per unit length of wall. However, penetrations associated with electrical outlet boxes can decrease the sound isolation or acoustical privacy offered by the wall. Until IRC researchers conducted a systematic study, the effect of outlet box type and location, and sound-absorbing material (such as building insulation made from glass fibre, mineral fibre or cellulose fibre) in the cavity on the sound isolation of gypsum board walls was not known. The study also quantified the effectiveness of several practical retrofit methods.

Test Method and Specimens

The study examined walls constructed with single, staggered and double wood studs.

The findings and recommendations pertaining to staggered and single-stud assemblies were in fact similar to those for double-stud assemblies.² The effect of electrical outlet boxes in steel-stud walls with similar framing (i.e., single stud, staggered stud and double stud) is expected to be comparable to that for wood-stud assemblies.

In some of the test walls, the space between studs was filled with glass-fibre insulation while in others it was left empty. It is expected that walls containing fibrous sound-absorbing material other than glass-fibre insulation, with similar thickness, will exhibit comparable performance.

This Update focuses on double-stud walls because this type of wall a) is most likely to be used to achieve maximum sound isolation between dwelling units and b) allowed more configurations of the sound-absorbing material to be tested.

Basic Wall Configurations Tested

The three types of double-stud walls tested were as follows:

1. Walls with no sound-absorbing material in the cavity (see Figure 1, No Insulation)
2. Walls where the sound-absorbing material is pushed aside so it does not cover the box, thus only partially blocking the path between the outlet boxes (see Figure 1, Displaced Insulation);
3. Walls with the sound-absorbing material in the cavity completely covering the back of the outlet box (Figure 1, Fitted Insulation), so sound must travel through the sound-absorbing material to get to the other box.

The electrical outlet boxes, each with a duplex outlet, plastic faceplate and all wiring necessary to simulate typical field installation, were positioned in three different ways:

1. Back-to-back, with zero horizontal offset (Figure 1, Back-to-Back Condition)
2. Within the same stud cavity, with a horizontal offset of 350 mm (Figure 1, Same Stud Cavity Condition)

Double-Stud Construction Used in Study

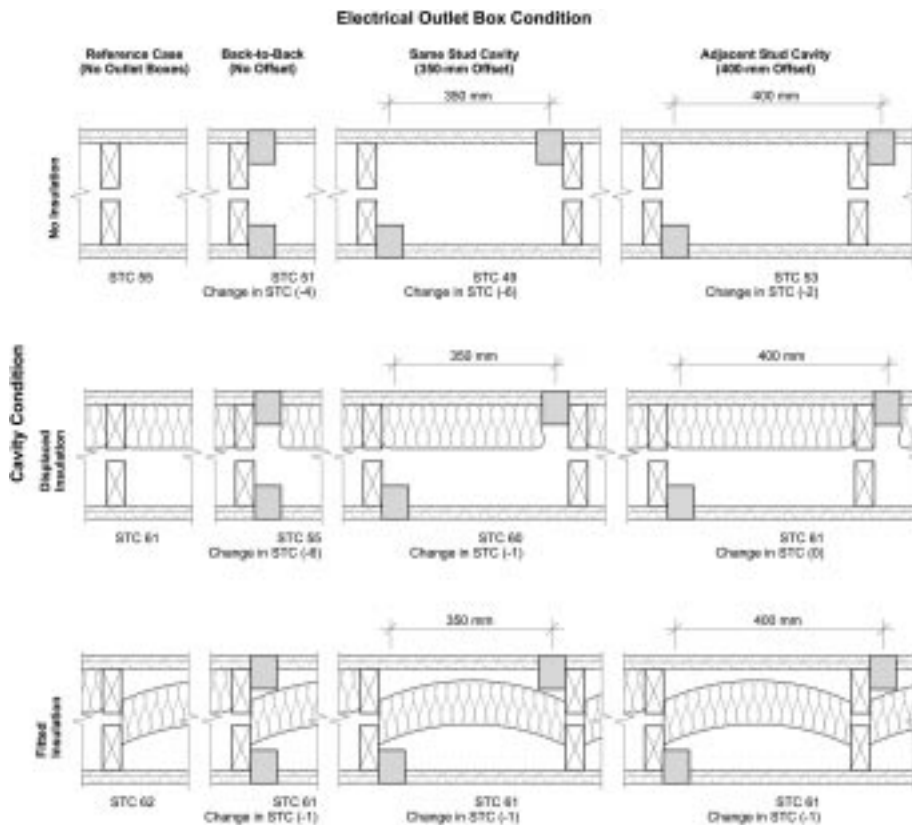


Figure 1. Sketches of the double-stud constructions used in the study indicating the locations of the electrical outlet boxes, and the presence and method of installation of the sound-absorbing material in the cavity. The sound isolation is expressed as STC, or a change in STC (in parentheses), relative to the reference wall, which did not have any penetrations. All walls are constructed with 2 rows of 38-mm x 89-mm wood studs set 25 mm apart and 2 layers of 12.7-mm Type X gypsum board on each side.

Rating the Sound Isolation

Sound isolation is the ability of a partition to stop the transmission of airborne noise, and hence its ability to provide acoustical privacy. In this Update, each wall assembly is assigned a single number rating, STC (sound transmission class). STC is a standardized rating scheme (ASTM E413) that allows assemblies to be ranked according to their ability to stop airborne noise with a spectrum similar to that of speech or the noise from office equipment. The higher the STC rating the greater the sound isolation or acoustical privacy. When comparing results in this Update, a change of one STC point should not be considered significant; a change of two or more points should be considered significant.

3. In adjacent stud cavities, with a horizontal offset of 400 mm (Figure 1, Adjacent Stud Cavity Condition).

Effect of Different Types of Outlet Box

There are two basic types of electrical outlet box: standard metal boxes and plastic vapour-barrier boxes. The tests conducted on the assemblies with no sound-absorbing material in the cavity (Figure 1, No Insulation) demonstrated that when plastic vapour-barrier outlet boxes were used, the effect of penetrations on the sound isolation of the wall assembly was negligible (see Table 1).

The two types of box perform differently (see Table 1) because of the difference in the number of penetrations in each. Standard metal boxes have many holes to allow a) electrical wires to enter the box and b) the box to be fastened to the stud. In contrast, plastic vapour-barrier boxes have closed-cell foam gaskets, which form an airtight seal where the wires enter the box, as well as tabs on the outside of the box, which are used to fasten the box to the stud so that there are no holes in the box. Plastic vapour-barrier boxes also typically have a backer plate at the mouth to seal the box to the gypsum board. These airtightness features impede the transmission of sound as well as the flow of air, and can compensate for problems caused by box proximity and/or poor insulation placement.

Because there was virtually no change in the sound isolation of the wall assemblies with plastic vapour-barrier boxes, irrespective of where the boxes were located, the effect of adding sound-absorbing material to the cavity was investigated for metal boxes only.

Effect of Box Placement and Sound-Absorbing Material in the Cavity

Figure 1 shows the change in sound isolation relative to the reference case (the wall with no penetrations) for metal outlet boxes located in various positions. The effect of electrical boxes on the sound isolation of a gypsum board wall assembly can be large — in the worst cases, the STC decreased by 6 points.

Table 1. Measured sound isolation expressed as an STC rating for metal outlet boxes and plastic vapour-barrier outlet boxes in the double-stud wall without sound-absorbing material in the cavity (Figure 1, No Insulation)

Box Type	STC Rating		
	Reference Wall (No boxes)	Electrical Box Location (see Figure 1)	
		Boxes located back-to-back No horizontal offset	Boxes separated by at least one stud 400-mm horizontal offset
Plastic Vapour-Barrier	55	55	55
Metal	55	51	53

The change in sound reduction depends on several factors:

- the separation (horizontal offset) of the electrical boxes
- the construction of the wall assembly
- the location of the sound-absorbing material in the cavity.

These factors cannot be fully separated, but general trends can be identified:

- The greatest reduction in STC occurred when there was a short unimpeded path between boxes; that is, when the sound did not have to travel through the sound-absorbing material or through the narrow gap between opposite studs into the adjacent stud cavity. This is confirmed by the STC ratings (see Figure 1) for:
 - boxes in the back-to-back position with no sound-absorbing material in the cavity;
 - boxes in the back-to-back position with displaced sound-absorbing material in the cavity;
 - boxes located within the same stud cavity with a horizontal offset of 350 mm or less with no sound-absorbing material in the cavity.
- When the sound had to travel through the sound-absorbing material, the effect of the boxes was greatly reduced when compared to the case in which it did not have to pass through the material.

- Very little reduction in STC was noted for walls with the electrical boxes located in an adjacent stud cavity and at least 400 mm apart. The presence of sound-absorbing material further ensures that the electrical boxes have a negligible effect on STC.
- The trend of increased sound isolation with increased separation breaks down only when comparing the conditions with both boxes within the same stud cavity and no sound-absorbing material. This lack of improvement in sound isolation with increased separation of boxes is likely due to standing-wave patterns in the cavity, which are most pronounced when there is no sound-absorbing material present.


The figure shows that for boxes located in back-to-back positions, installing a layer of sound-absorbing material between them greatly improves the STC. Where possible, the sound-absorbing material around the boxes should not be displaced because its effectiveness will be reduced.

*Possible Remedial Measures:
Box Treatments*

When an existing wall has decreased sound isolation because of improperly located electrical boxes, there are several possible remedial measures, all of which involve modifications in and around the outlet box. Measures investigated in the study are as follows (see Table 2 where they are ranked in order of increasing effectiveness):

Caulking. A bead of caulk can be used to fill the gap between the electrical box and the gypsum board.

Table 2. Improvement in sound isolation expressed as the mean change in STC for various treatments applied to two wall types (double stud and single stud) when the outlet boxes were located back-to-back.

Treatments		Mean Improvement in STC	Ease and Efficiency
Worst  Best	None	0	
	Caulking (gap)	+1	Simple
	Draft stopper (under faceplate)	+3	Simple
	Caulking (gap) and box insert	+3	Difficult
	Mastic-type material (lining)	+5	Moderate
	No penetrations	+5	

This simulates the flange and seal that form the airtight seal to the gypsum board in a plastic vapour-barrier box.

Draft stopper. A draft stopper is a closed-cell foam gasket, commonly sold in hardware stores, which is placed between the gypsum board and the faceplate covering the electrical outlet. Draft stoppers are easy to install, but the improvement in sound isolation was found to be variable because an adequate seal cannot be formed if the gypsum board opening has been poorly cut or the box skewed so it protrudes beyond the face of the gypsum board.

Electrical box inserts. These inserts, made from thin rubber or plastic, reduce airflow if they are tightly fitted inside the box. The degree of airtightness and resultant improvement to the sound isolation of the wall is largely determined by a) how well the holes or slits for the electrical wires are sealed with caulking and b) how well the insert is sealed to the gypsum board. (If poorly cut openings in the gypsum board do not allow the insert to be properly sealed to the gypsum board, a bead of caulk should be applied.)

Mastic-type materials. Lining the interior of an electrical box with a mastic material that is impervious to air will increase the

sound isolation of the wall, especially if the material can be sealed to the gypsum board. While a wide range of materials, e.g., caulking, can provide the necessary acoustical properties, it is possible that they may have other properties, such as electrical conductivity, that make them unsuitable for this application. Before installation, the suitability of the material for placement in electrical boxes should be confirmed by the local electrical authority.

Conclusions

Poorly placed electrical outlet boxes can significantly decrease the sound isolation of gypsum board walls — a decrease of up to 6 STC points was observed. This can be minimized by:

- ensuring that (untreated) metal boxes are offset by 400 mm or more in adjacent stud cavities rather than being placed within the same stud cavity, or
- using plastic vapour-barrier boxes, or
- using retrofit techniques that emulate the attributes of plastic vapour-barrier boxes.

The presence of sound-absorbing material in the cavity helps to further minimize the effect of poor placement, especially when installed so that the material blocks the line of sight between the boxes (see Figure 1, Fitted Insulation).

References

1. The project was supported by Canada Mortgage and Housing Corporation (CMHC).
2. T.R.T. Nightingale, "Effect of electrical outlet boxes on sound insulation of a double leaf wall," IRC-IR-772, National Research Council, October 1998.

Dr. T.R.T. Nightingale is a research officer in the Indoor Environment Program of the National Research Council's Institute for Research in Construction.

Dr. J.D. Quirt is a senior research officer and group leader of the acoustics activity in the same program.

Dr. M.A. Sultan is a senior research officer with IRC's Fire Risk Management Program.

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Electrical Outlets and Fire Resistance

This Update shows that while the presence of electrical outlet boxes need not significantly affect the sound reduction of gypsum board walls, it may adversely affect the fire resistance of these walls. Three non-standard tests were performed at IRC on non-load-bearing, small-scale gypsum board wall assemblies with wood studs 400 mm o.c., to determine the fire-resistance rating of the wall when a single electrical box was installed. The results of these tests were as follows:

Reference wall assembly (no outlet box)	142 min
Wall assembly with metal box	121 min
Wall assembly with plastic vapour-barrier box	130 min

These results are not conclusive and cannot be applied directly to full-scale assemblies or to cases where there are boxes on both faces of the wall, but they suggest that the presence of electrical outlet boxes may be of concern with respect to the fire-resistance rating of walls. In the absence of any data for full-scale wall assemblies, one should avoid placing electrical outlet boxes in fire-rated assemblies, where possible. However, if outlet boxes must be placed in the wall, use the smallest number permitted by applicable codes, spaced as far apart as possible.

Further work is needed to assess the effect of number, type and location of electrical outlet boxes on fire resistance in full-scale wall assemblies.

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For more information, contact Institute for Research in Construction,
National Research Council of Canada, Ottawa K1A 0R6
Telephone: (613) 993-2607; Facsimile: (613) 952-7673; Internet: <http://irc.nrc-cnrc.gc.ca>