A method for testing and rating the acoustic performance of caulking compounds

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ABSTRACT

Inadequate sealing of edge gaps of building partitions (walls, ceilings etc.) can adversely affect the acoustic insulation of a building partition, with consequent loss of amenity to building occupants. Measuring and rating the effectiveness of caulking compounds to protect against such adverse effects is somewhat problematic for a variety of reasons. This paper proposes a method based on ISO 10140-1 Amendment 1 Annex J, and AS/NZS ISO 717.1:2004 to enable laboratory measurement of sound transmission through controlled gaps sealed with the compound under test, and determination of the suitability of such compounds for use in sealing building partitions with specified acoustic insulation requirements. Some examples are provided, from laboratory experiments with test-gaps sealed by different means, demonstrating the outcome of the proposed method in a variety of circumstances.

1 INTRODUCTION

The National Construction Code of Australia specifies requirements, including sound insulation requirements, for building partitions (walls and floors), depending on the classification of the building and the nature of the air spaces being separated by the partition in question. Additional sound insulation requirements may also be specified by other authorities. The sound insulation performance of such building partitions should not be compromised by transmission of sound through poorly sealed gaps, penetrations, or other accessories whose presence is incidental and which tend to occupy a relatively small area in comparison with the partition itself.

Laboratory standards for measurement of airborne sound insulation, such as AS 1191-2002, and similar international standards, are written with testing of the primary building element or partition in mind. They require the partition under test to occupy an area of at least 10 m^2, except for building elements such as windows and doors which are tested in their normal sizes, but which still tend to be 2 m^2 or more.

Gaps occurring at the edges of partitions or between adjacent panels of modular construction elements, or at the edges of service penetrations, and accessories installed in service penetrations tend to occupy quite a small area compared with the remainder of the partition. In the case of edge gaps, their presence may be incidental rather than by design, and consequently may not be well defined dimensionally. Measuring the contribution they make to sound transmission and evaluating the effect on the performance of the partition itself, has historically presented a challenge for manufacturers, acoustic consultants, and acoustic laboratories. For example, building a wall with well-defined gaps to be sealed, and allowing time for the sealant to cure fully before performing an acoustic test is an expensive exercise. Furthermore, building the identical wall without any such gaps would then be required; variability of construction and variability associated with the acoustic measurement methodology might result in different acoustic indices being measured for the two walls regardless of actual transmission of sound through the sealed gaps under test.

In 2012, an application rule was issued within the ISO 10140 series of acoustic measurement standards, ISO 10140–1:2010; Amd 1:2012 *"Guidelines for the determination of the sound reduction index of joints filled with fillers and/or seals"*. The method described therein, involves preparing the test specimens in the form of 'cassettes', with a well-defined gap, sealed by the method under evaluation. The cassettes are then installed in a compatible filler wall and tested twice: as prepared, and 'fully sealed'. For the 'fully sealed' test, additional sealing is applied to ensure that leakage of sound past the seal under evaluation, has been reduced to a negligibly low level. The two measurements are then used to determine sound transmission attributable to the seal under evaluation. The results are presented as sound reduction indices, per metre of sealed gap. The sound reduction indices may then be used in conjunction with AS/NZS ISO 717.1:2004 (or equivalent), to determine single number indices such as R_w, C_{tr} etc, 'per metre of sealed gap'.

In this paper the measurements carried out are presented as ‘sound *transmission* per metre of sealed gap’ (negative decibels), rather than sound reduction indices. Overall performance is evaluated by combining the sound transmission attributed to the sealed gap, with the sound transmission of a defined ‘reference wall’, with single number indices then being determined conventionally according to AS/NZS ISO 717.1:2004.

The objective of this work was to establish practical methods for measurement and analysis, by which conclusions could be reached as to the suitability for use where particular acoustic requirements have been specified, of sealants and other small-area inclusions in building partitions. But at the same time, the methods should not be vulnerable to an unreliable conclusion being reached as a result of normal measurement variability, construction variability, or the particular acoustic characteristics of the partition in which testing is carried out.

2 Measurements

In order to subject several linear metres of sealed gap to testing, ‘cassettes’ were made by routing a series of 10 mm wide slots through sheets of wall cladding material, and then sealing those slots with a caulking compound. For the first series of tests, the cladding material chosen was 13 mm thick fire rated gypsum plasterboard. For the second series of tests, the cladding material chosen was two layers of 6 mm thick fibre-cement sheet laminated together, backed by a third layer of similar material with 25 mm wide ‘clearance slots’ routed through it.

The laboratory used for all measurements was the reverberation chamber suite at CSIRO in Clayton, Victoria, Australia. The horizontally adjacent pair of vibration isolated transmission chambers were used. The nominal volumes of the chambers were 200 m^3 and 100 m^3, and their general construction was of 300 mm thick reinforced concrete, with a 60 mm wide air gap between the chambers. The flanking limits of the test suite have not yet been explored but R_w = 78 dB (R_w+C_{tr} = 72 dB) has been measured in the facility for a gypsum plasterboard based wall.

Measurements in all cases were carried out in accordance with AS 1191-2002, with each room being used as both source and receiving in turn, and with three loudspeaker positions being used in each room, giving six spatially independent measurements each time, arithmetically averaged to give the figures reported herein.

The sound transmission index per linear metre of slot length, T_s, is calculated using the equation (1)

$$T_s = L_2 - L_1 + 10\,log\;\left(\frac{A\;l_n}{S_n\;l}\right) \qquad (1)$$

where

- L_2 is the energy average sound pressure level in the receiving room, in decibels;
- L_1 is the energy average sound pressure level in the source room, in decibels;
- l is the length of the slot under test, in metres;
- S_n is the reference area in square metres (S_n = 1 m^2);
- l_n is the reference length, in metres (l_n = 1 m);
- A is the equivalent absorption area in the receiving room, in square metres.

Total sound transmission measured includes not only sound power transmitted through the slot under test, but also the sound power transmitted through flanking paths (chamber flanking, filler wall, and the remainder of the test cassette). The contribution of flanking transmission can lie anywhere between insignificant and dominant, depending on its own magnitude and the magnitude of slot transmission. If the sealant under test forms an effective acoustic barrier to transmission of sound through the slot, flanking transmission is liable to be dominant. Consistent with ISO 10140–1:2010; Amd 1:2012, attempts were made to measure flanking transmission and subtract its contribution from the overall measurement, in order to determine net slot transmission. But if flanking transmission is dominant, such correction cannot be relied upon, and slot transmission can therefore be claimed only as being no greater than the total sound transmission measured. A discontinuity in the rules for limiting flanking corrections given in ISO 10140–1:2010; Amd 1:2012, is liable to result in a step change of 1.8 dB/m in the sound reduction index of the test specimen for a 0.1 dB change in measured sound transmission. In this series of measurements, equation (2) with specified limiting conditions has been used to calculate slot transmission, avoiding an equivalent step change.

$$T_{s,specimen} = 10\,log\left[10^{T'_s/10} - 10^{T_{s,covered}/10}\right] \quad (2)$$

where

$T_{s,specimen}$ is the sound transmission index attributed to the test slots after applying any applicable corrections, in decibels per metre, rounded to one decimal place.

T'_s is the sound transmission index measured with the test slots sealed with the sealant under test, in decibels per metre, rounded to one decimal place.

$T_{s,covered}$ is the sound transmission index measured with the test slots fully sealed (ie either with the test specimen cassette replaced by an unslotted cassette, or with the sealed slots of the test specimen covered by other means intended to reduce transmission of sound through the slot to a negligible level), in decibels per metre, rounded to one decimal place.

If T'_s is within $T_{s,covered}$ + 3 dB, the upper limit of $T_{s,specimen}$ is set at T'_s or $T_{s,covered}$, whichever is the smaller (more negative) value, accompanied by the symbol ≤ to indicate that measurement was limited by flanking transmission.

2.1 Series 1 measurements, March 2018

A filler wall with an opening measuring 1802 x 1202 mm was used for this series of measurements. The filler wall was of discontinuous timber frame construction with 90 mm of 27 kg/m^3 glass wool in the frame each side; the 590 mm deep total air cavity being clad with two layers of 16 mm thick fire rated gypsum plasterboard (GPB) each side. A wall of equivalent construction has previously been measured at this facility, achieving R_w = 75 dB.

The test cassette consisted of a pair of sheets of 13 mm thick fire rated GPB, with 75 mm thick 11 kg/m^3 glass wool batts behind, mounted approximately 620 mm apart on opposite sides of the filler wall described above. The first test was carried out prior to routing slots through the GPB, but the sheets were each screwed to a pair of standard 92 mm steel studs, to enable the sheets to be kept intact after slotting, and to retain the glass wool batts behind the exposed face of each GPB sheet.

The first test (Test 1.1), using unslotted GPB sheets, was intended to establish the flanking limit of the test arrangement, against which measurements with slotted panels would be compared. As shown in Table 1, however, panels in the slotted and sealed state showed lower sound transmission than the unslotted panels.

After being tested in the unslotted state, the panels were removed from the filler wall and a set of six slots at 300 mm spacing, was routed in each panel; each slot being 10 mm wide and 900 mm long, resulting in 5.4 linear metres of slot each side. Once slotted, the panels were reinstalled in the filler wall and sound transmission retested with the slots unsealed (Test 1.2), with 15 mm thick closed cell polyethylene foam backing rod inserted into the slots (Test 1.3), with the backing rod removed and paper masking tape (106 gsm) closing off the slots (Test 1.4), and finally with the panels removed and generic acrylic caulking compound dispensed into the slots against the masking tape and then scraped off flush with the surrounding paper face of the GPB; the panels were reinstalled into the filler wall and sound transmission measured after approximately 8 hours' curing of the caulking compound (Test 1.5) and again after approximately 70 hours' curing (Test 1.6). The masking tape remained in place for tests 1.5 and 1.6, the reasons for which are discussed in section 5 of this paper (Other Observations).

Results of Series 1 measurements are presented in Table 1.

Table 1: T'_s results from Series 1 tests

Freq (Hz)	Test 1.1 Unslotted (dB/m)	Test 1.2 Open slots (dB/m)	Test 1.3 Backing rod (dB/m)	Test 1.4 Masking tape (dB/m)	Test 1.5 Acrylic caulking @ 8 hours (dB/m)	Test 1.6 Acrylic caulking @ 70 hours (dB/m)
100	-35.5	-20.2	-34.8	-34.4	-35.3	-36.4
125	-44.5	-21.3	-43.8	-43.1	-45.0	-45.2
160	-47.6	-24.8	-47.2	-47.7	-49.4	-49.4
200	-51.6	-25.9	-51.2	-51.6	-52.9	-53.1
250	-52.3	-25.8	-51.8	-52.0	-54.2	-53.9
315	-53.8	-26.5	-52.7	-52.9	-56.8	-56.1
400	-57.3	-31.7	-56.2	-56.5	-61.8	-60.7
500	-61.3	-36.3	-60.9	-60.6	-66.0	-65.9
630	-61.1	-40.6	-61.0	-60.3	-63.2	-64.0
800	-58.0	-42.5	-56.0	-55.4	-60.3	-61.9
1000	-56.8	-43.6	-54.0	-53.5	-61.8	-63.3
1250	-59.6	-45.5	-57.4	-56.5	-66.2	-67.3
1600	-62.7	-46.6	-60.5	-59.0	-68.0	-68.8
2000	-61.7	-48.3	-59.6	-58.1	-64.5	-65.3
2500	-57.5	-49.1	-56.5	-55.1	-62.9	-63.7
3150	-59.4	-50.1	-57.6	-55.1	-66.4	-66.7
4000	-60.2	-49.8	-57.4	-54.8	-65.2	-63.9
5000	-58.3	-49.9	-57.3	-55.5	-68.2	-67.7

2.2 Series 2 measurements, June 2018

Seeking to reduce the effect of flanking transmission observed in Series 1 measurements, a filler wall with an opening measuring 1291 x 2460 mm was used for this series of measurements. The filler wall was of equivalent construction to that used for the measurements of Series 1, but the design of the cassette was changed to reduce flanking transmission and to increase the linear metres of sealed slot under test.

The test cassettes again consisted of slotted cladding panels either side of a large air cavity containing sound absorbing batts, however in this case the cladding panels were of 6 mm thick fibre-cement sheet (FC sheet); 10 mm wide slots being routed through two layers of the FC sheet, and subsequently sealed with the caulking compound under test, with a third FC sheet behind, with 25 mm wide clearance slots. The FC sheets of the test cassettes were screwed to the stud frames at the perimeter and to the horizontal noggins placed at approximately 600 mm vertical centres. The sound absorbing batts used were of 90 mm thick 32 kg/m^3 polyester wool. The array of slots routed through the panels of the cassettes consisted of eight slots per panel, each slot 1.0 m long and at alternating 200 mm and 400 mm spacing (giving 8.0 linear metres of slot per side).

Illustrations depicting the filler wall and test cassette used in Series 2 measurements are given in figure 1. The general construction of the filler wall was as per Series 1, with the cassette redesigned to reduce the effect of flanking transmission. In both series of measurements, the filler wall was already installed in order to carry out unrelated measurements at the laboratory, hence different sized cassettes were used in the two series.

For Series 2, cassettes were prepared in advance, with slots filled with each of three different fire-rated caulking compounds (polyurethane, silicone, and acrylic); the caulking compounds having had 6~8 days' curing time prior to the acoustic measurements. After sound transmission measurement with each cassette, all of the caulked slots were each covered with a slat of FC sheet, approximately 40 mm wide, screwed on top of the slot and sealed with another caulking compound. Sound transmission measurements were then carried out again to provide the covered-slot reference. Additional measurements were carried out with an unslotted cassette, with an open-slotted cassette, and with the slots of the open-slotted cassette taped over with paper masking tape (106 gsm).

Results of Series 2 measurements are presented in Table 2.

Table 2: T'_s results from Series 2 tests (≤ denotes measurements limited by proximity to background levels)

Freq (Hz)	Test 2.1 PU caulking (dB/m)	Test 2.2 FC Slats over PU (dB/m)	Test 2.3 Silicone caulking (dB/m)	Test 2.4 FC Slats over silicone (dB/m)	Test 2.5 Acrylic caulking (dB/m)	Test 2.6 FC Slats over Acrylic (dB/m)	Test 2.7 Unslotted (dB/m)	Test 2.8 Open slots (dB/m)	Test 2.9 Masking tape (dB/m)
100	-36.1	-36.1	-36.3	-35.9	-35.9	-36.2	-36.1	-18.3	-36.1
125	-45.2	-45.5	-45.0	-45.2	-45.1	-45.0	-44.9	-22.9	-44.7
160	-49.0	-49.4	-49.4	-50.0	-50.0	-50.3	-50.0	-23.8	-49.9
200	-56.4	-56.2	-56.5	-56.4	-56.3	-56.0	-56.4	-27.1	-55.6
250	-60.7	-61.1	-60.6	-60.8	-61.0	-61.2	-61.1	-27.9	-59.9
315	-62.4	-62.8	-61.9	-62.4	-62.6	-63.2	-62.6	-26.4	-62.3
400	-67.1	-67.2	-66.7	≤-65.9	-67.3	-67.4	-67.5	-30.7	-66.6
500	-70.3	-70.3	≤-70.0	≤-68.3	-71.2	-70.9	-71.4	-35.4	-64.3
630	-69.4	-68.9	-69.1	≤-68.4	-70.4	-70.1	-71.3	-38.4	-58.1
800	-70.6	-70.1	-70.4	-69.5	-70.1	-69.0	-70.9	-42.0	-56.3
1000	-74.5	≤-74.1	-74.2	-73.4	-74.1	-73.2	-72.6	-43.5	-58.4
1250	-77.3	-77.3	-77.1	-77.1	-77.2	-77.3	-76.7	-44.9	-62.2
1600	-76.6	-76.5	-76.7	-76.6	-76.6	-76.7	-76.6	-46.3	-64.1
2000	-72.6	-72.5	-72.7	-72.6	-72.6	-72.7	-72.8	-48.3	-66.3
2500	-76.3	-76.1	-76.3	-76.3	-76.3	-76.3	-76.4	-48.7	-67.1
3150	-79.4	-79.0	-79.5	-79.6	-79.6	-79.6	-79.7	-49.6	-67.8
4000	≤-81.3	≤-79.4	≤-80.4	≤-80.5	≤-81.4	≤-81.1	≤-81.8	-50.7	-68.8
5000	≤-80.2	≤-77.3	≤-79.3	≤-79.4	≤-80.4	≤-80.5	≤-81.1	-50.1	-70.7

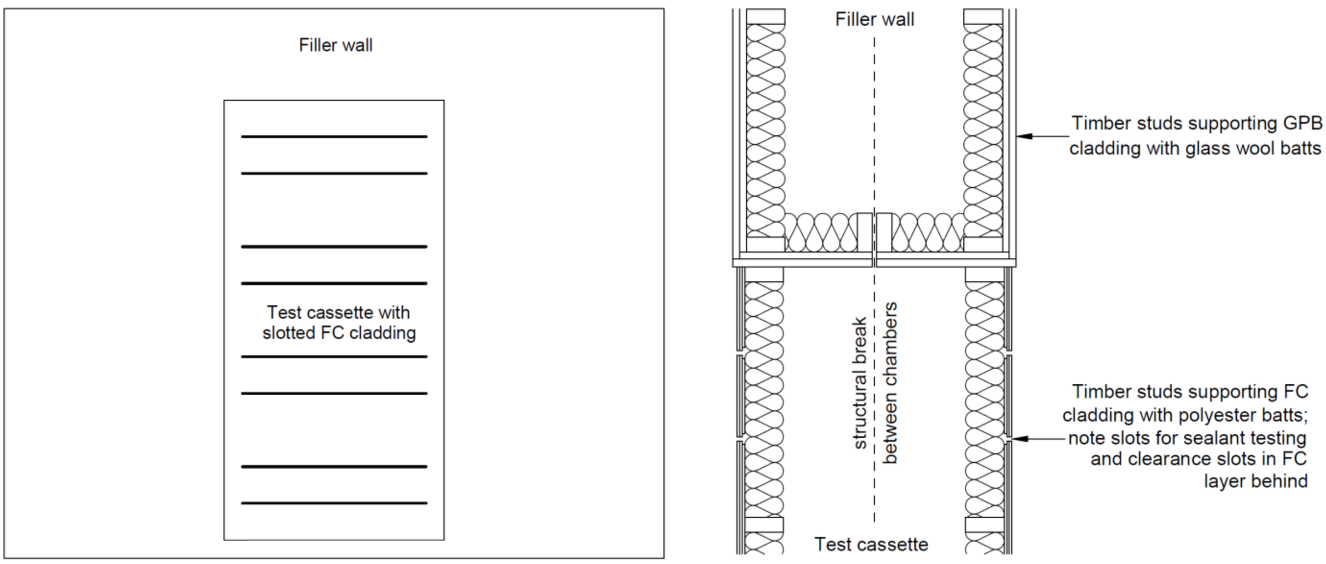

Figure 1: Filler wall and test cassette used in Series 2 measurements; left: frontal view, right: sectional view

3 ANALYSIS AND DISCUSSION

Series 1 measurements showed greater sound transmission with a test cassette of unslotted GPB panels installed than when the panels had been slotted and then sealed with generic acrylic caulking compound. Several hypotheses may be advanced to explain such observation, but the laboratory has not investigated them at this time. Hypotheses to explain the observation (Series 1 only) of lower sound transmission through slotted-and-caulked GPB panels than through unslotted GPB are:-

- Sealing of the cassette in the filler wall around the perimeter of the unslotted cassette may have been deficient.
- Glass fibre batts inside the cassette may have become dislodged during installation from where they were originally positioned between the steel studs before being installed. It was observed upon removal of the first GPB panel of the cassette after test 1.1 that the glass fibre batts from that panel had fallen to the bottom of the cavity, however the removal process had been somewhat violent; after the perimeter seal and the fastening screws had been removed, several impacts were delivered to the panel in an attempt to prompt it to topple out of the filler wall into the awaiting hands of the staff.
- The slotting and caulking of the GPB may have changed its acoustic behaviour by altering its natural vibrational characteristics. The GPB panels of Series 1 were installed with minimal structural support and fixings.

In the Series 2 test arrangement, sound transmission measured with the unslotted cassette was not significantly different to that measured with the caulking test cassettes.

The measurement data reveal that in both series of tests, flanking transmission was dominant over sound transmission through the sealed slots under test, across the entire frequency range from 100 to 5000 Hz, in all measurements where slots were sealed with a caulking compound. Comparisons of the acoustic performance of the caulking compounds are therefore not able to be made.

Series 1 and Series 2 both included tests with open slots and with the slots covered with the same masking tape. A comparison of those results is presented in table 3, and graphically in Figure 1. Included in the comparison figures are the flanking limits applicable in each case.

Table 3: $T_{s,specimen}$ (dB/m) comparisons between Series 1 and Series 2.

Freq (Hz)	Test 1.2 (Open slots in GPB)	Test 2.8 (Open slots in FC sheet)	Test 1.4 (Masking tape on GPB)	Test 2.9 (Masking tape on FC sheet)	Series 1 Flanking limit	Series 2 Flanking limit
100	-20.3	-18.4	≤-36.4	≤-36.3	-36.4	-36.3
125	-21.3	-22.9	≤-45.2	≤-45.5	-45.2	-45.5
160	-24.8	-23.8	≤-49.4	≤-50.3	-49.4	-50.3
200	-25.9	-27.1	≤-53.1	≤-56.5	-53.1	-56.5
250	-25.8	-27.9	≤-54.2	≤-61.2	-54.2	-61.2
315	-26.5	-26.4	-55.2	≤-63.2	-56.8	-63.2
400	-31.7	-30.7	-58.0	≤-67.5	-61.8	-67.5
500	-36.3	-35.4	-62.1	-65.2	-66.0	-71.4
630	-40.6	-38.4	-62.7	-58.3	-64.0	-71.3
800	-42.6	-42.0	-56.5	-56.5	-61.9	-70.9
1000	-43.6	-43.5	-54.0	-58.5	-63.3	-74.5
1250	-45.5	-44.9	-56.9	-62.3	-67.3	-77.3
1600	-46.6	-46.3	-59.5	-64.3	-68.8	-76.7
2000	-48.4	-48.3	-59.0	-67.4	-65.3	-72.8
2500	-49.3	-48.7	-55.7	-67.6	-63.7	-76.4
3150	-50.2	-49.6	-55.4	-68.1	-66.7	-79.7
4000	-49.9	-50.7	-55.2	-69.0	-65.2	-81.8
5000	-50.0	-50.1	-55.7	-71.1	-68.2	-81.1

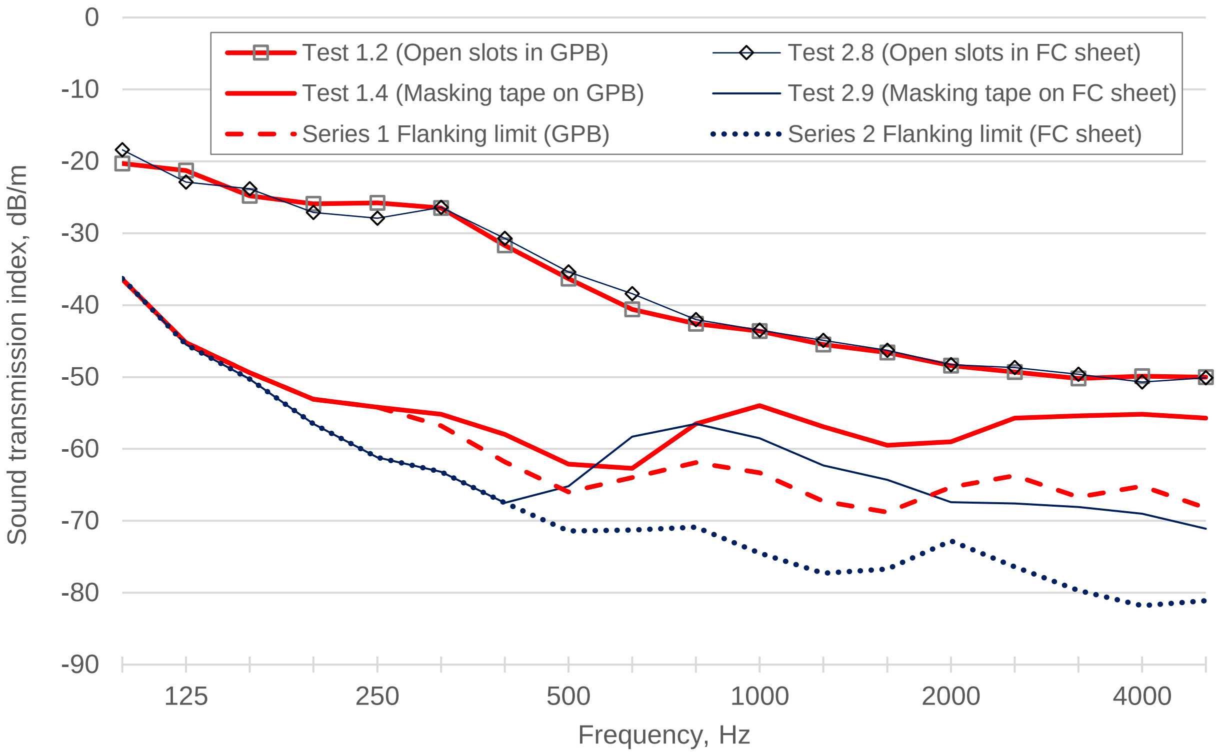

Figure 2: $T_{s,specimen}$ (dB/m)

The comparison between the open slot measurements of both series show very similar sound transmission per linear metre of slot across the frequency spectrum; sound transmission through the slots being clearly above flanking transmission in all cases, and tending to increase with frequency.

The comparison between the taped slot measurements of the two series shows some similarity at the lower end of the frequency spectrum, but significant differences at higher frequencies. In all frequency bands up to and including 250 Hz, measurements with only masking tape covering the slots achieved the flanking limit of the filler wall and cassette combination in both test series. In Series 1 measurements, sound transmission through the taped slots became measureable above the flanking limit from 315 Hz and beyond, thereafter showing no significant overall frequency dependent trend, averaging -57.4 dB/m from 315 Hz to 5000 Hz. In Series 2 measurements, sound transmission through the taped slots remained flanking limited through 400 Hz (-67.5 dB/m @ 400 Hz), then rose gradually to a peak of -56.5 dB/m at 800 Hz before declining gradually thereafter at higher frequencies, reaching -71.1 dB at 5000 Hz. To date, no further study has been done into the differences between masking tape measurements from the two series of measurements; the purpose of the masking tape measurements having been to include measurements of a partially effective sealing method somewhere in between the extremes of open slots and fully caulked slots.

4 APPLICATION OF MEASUREMENTS

In order to enable the effectiveness of a sealing method to be evaluated, the sound transmission determined for the sealing method, may be combined with the sound transmission of a defined reference partition. A precedent for such a method exists in *AS ISO 717.2–2004*, whereby impact noise reduction indices measured for a set of floor covering materials are combined with the defined impact noise levels of a reference floor in order to determine single number acoustic indices for the set of floor covering materials. In this case, the reference partition is defined as having R values 1.6 dB lower than the R_w reference values given in AS/NZS ISO 717.1:2004, shifted up or down in whole decibels as required in order to establish the highest sound insulation of the reference partition whose indices R_w, C and C_{tr} are not compromised when sound transmission attributable to the sealing method under evaluation, is combined with the sound transmission corresponding to the R values of the reference partition in the ratio of 1 linear metre of seal to 1 square metre of partition. Reference partition values are set 1.6 dB below the corresponding R_w reference values so that none of the R_w, C and C_{tr} indices are excessively sensitive to small changes. Sound transmission attributed to the sealing method is combined with the sound transmission of the reference partition according to equation (3)

$$R_{test} = -10\log(10^{-R_{ref}/10} + 10^{T_{s,specimen}/10}) \quad (3)$$

where

R_{test} is the sound reduction index of the reference partition, with allowance for sound transmission through the seal under evaluation added, in decibels, rounded to one decimal place.

R_{ref} is the sound reduction index of the reference partition, in decibels.

$T_{s,specimen}$ is the sound transmission index attributed to the test slots after applying any applicable corrections, in decibels per metre, rounded to one decimal place.

In the measurements of Series 2, all of the measurements with slots sealed with caulking compounds were within 3 dB of the flanking limit and are all therefore attributed with the flanking-limited sound transmission values. Table 4 demonstrates the application of equation (3), and the rating method described, with the flanking-limited sound transmission values attributed to the sealants tested in Series 2, with sound transmission attributed to the seal added to sound transmission of the reference partition in the ratio of 1 linear metre of seal per square metre of partition area.

Table 4: Application of test results.

Freq. (Hz)	Series 2, all sealants (flanking limited) $T_{s,specimen}$ (dB/m)	Reference partition, set at R_w 54 level R_{ref} (dB)	R_w 54 reference partition, with seal transmission added R_{test} (dB)	Reference partition, set at R_w 55 level R_{ref} (dB)	R_w 55 reference partition, with seal transmission added R_{test} (dB)
100	≤-36.3	33.4	31.6	34.4	32.2
125	≤-45.5	36.4	35.9	37.4	36.8
160	≤-50.3	39.4	39.1	40.4	40.0
200	≤-56.5	42.4	42.2	43.4	43.2
250	≤-61.2	45.4	45.3	46.4	46.3
315	≤-63.2	48.4	48.3	49.4	49.2
400	≤-67.5	51.4	51.3	52.4	52.3
500	≤-71.4	52.4	52.3	53.4	53.3
630	≤-71.3	53.4	53.3	54.4	54.3
800	≤-70.9	54.4	54.3	55.4	55.3
1000	≤-74.5	55.4	55.3	56.4	56.3
1250	≤-77.3	56.4	56.4	57.4	57.4
1600	≤-76.7	56.4	56.4	57.4	57.3
2000	≤-72.8	56.4	56.3	57.4	57.3
2500	≤-76.4	56.4	56.4	57.4	57.3
3150	≤-79.7	56.4	56.4	57.4	57.4
Indices of partition R_w (C; C_{tr})		54 (-2; -6)	54 (-2; -6)	55 (-2; -6)	55 (-2; -7)

The above example shows that one linear metre of seal per square metre of partition area would not compromise any of the indices R_w, C and C_{tr} at the R_w = 54 dB level, but at the R_w = 55 dB level, sound transmission attributed to the seal would cause the C_{tr} index be degraded by 1 dB. In this series of tests, measurement of seal acoustic performance was limited by flanking transmission; actual transmission of sound through the seal would be expected to be significantly lower.

In Australia, a critical sound insulation benchmark is $R_w + C_{tr} \geq 50$ dB. In these two series of tests, the combination of flanking transmission and the linear metreage of seal length resulted in the flanking-limited sound transmission attribution per metre of seal being too high to avoid compromising the reference partition at the level of R_w (C; C_{tr}) = 56 (-2; -6) dB, necessary to achieve the $R_w+C_{tr} \geq 50$ dB requirement. This is not evidence of a shortcoming of the sealant, but shows that the laboratory needs to reduce the flanking transmission and/or increase the linear metres of seal per test in order for this method to be able to produce evidence of a sealant's suitability for use sealing an $R_w+C_{tr} \geq 50$ dB partition.

5 OTHER OBSERVATIONS

Preparation of the test cassettes for Series 1 was carried out by the laboratory. When the caulking compound was applied to the test cassette, a bead of compound was also applied to a smaller test panel so that the state of curing of the caulking could be evaluated. The masking tape was to be removed from the caulking compound of the test cassette before the test at 70 hour's curing, if the test-piece showed that tape could be removed without disturbing the caulking compound. At the 70 hour mark, the caulking compound had not cured sufficiently so the masking tape was left in place for the test at 70 hours' curing. The test cassette was retained by the laboratory afterwards, and several weeks later, the masking tape was able to be removed. When the masking tape was removed, the generic acrylic caulking compound was observed to have shrunk to the extent that gaps between the caulking compound and the routed edges of the GPB were visible throughout the test cassette. To date, the laboratory has not had the opportunity to reinstall the cassette into a filler wall to measure the transmission of sound with the shrunken caulking compound.

Following the Series 2 measurements, the laboratory applied a bead of acrylic caulking compound to the edge of a sheet of cladding to evaluate its adhesion in three different circumstances:- 1) a score-and-snapped GPB edge, 2) a score-and-snapped FC sheet edge, and 3) a routed FC sheet edge. After curing, the acrylic caulking compound remained securely adhered to the routed FC sheet edge, unable to be peeled off. But the compound easily peeled away from the score-and-snapped edges of both GPB and FC sheet test pieces.

6 CONCLUSIONS

It is likely that gaps and other penetrations through walls, ceilings etc., will not compromise the acoustic performance of partitions as long as they are sealed effectively. But to verify such by the method described herein will require careful attention to the following:-

a) Minimising flanking transmission.
b) Building a test fixture to enable many linear metres of seal to subjected to the test, so that total sound transmission measured can be divided by more linear metres.
c) Designing the test specimen cassette so as to simulate a practical worst case for adhesion of the sealant under test to the edges of the gap being sealed,
d) Ensuring full curing (and shrinkage) of the sealant test specimen before carrying out the acoustic test. To date, the laboratory has not investigated how to verify full state of curing of sealants.

In practice, it is not expected that flanking transmission can be reduced sufficiently for it to cease to be a limiting factor in future measurements of this type. However only a modest reduction of flanking transmission (2 dB or more), and/or only a modest increase in the linear metres of seal subjected to the test (50 % increase or more), would enable this method to verify a sealant's suitability at the $R_w+C_{tr} \geq 50$ dB level.

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REFERENCES

AS 1191-2002: Acoustics–Method for laboratory measurement of airborne sound insulation of building elements. 2002. Sydney, Australia: Standards Australia International Ltd.

AS ISO 717.2–2004: Acoustics–Rating of sound insulation in buildings and of building elements, Part 2: Impact sound insulation. 2004. Sydney, Australia: Standards Australia International Ltd.

AS/NZS ISO 717.1:2004: Acoustics–Rating of sound insulation in buildings and of building elements, Part 1: Airborne sound insulation. 2004. Sydney, Australia and Wellington, New Zealand: Standards Australia International Ltd. and Standards New Zealand.

Australian Building Codes Board. 2016. *'National Construction Code, Volume 1'.* Canberra, Australia.

ISO 10140–1:2010; Amd 1:2012: Acoustics – Laboratory measurement of sound insulation of building elements – Part 1: Applications rules for specific products, Amendment 1: Guidelines for the determination of the sound reduction index of joints filled with fillers and/or seals. 2012. Geneva, Switzerland: International Organization for Standardization.