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AN EVALUATION OF SOME PROCEDURES TO CONTROL PLUMBING NOISE IN LIGHTWEIGHT CONSTRUCTION

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Noise from plumbing systems is a common source of annoyance in all kinds of housing from single to multi-family homes. From time to time in North American literature, articles have appeared detailing steps to take to control noise due to plumbing fixtures. The advice given is usually to avoid all solid contact by wrapping pipes with resilient materials wherever they come in contact with the structure of the building. Sinks, toilets, and showers are also supposed to be resiliently mounted. To our knowledge, there has been no study of the effectiveness of some of these recommendations when they are used in typical North American lightweight building structures. This paper presents some of the results from a series of measurements made in the Acoustics laboratory of the Institute for Research in Construction (IRC) at the National Research Council of Canada (NRCC). The research was funded by Canada Mortgage and Housing Corporation and was intended to provide some data to allow builders to make informed choices about which plumbing noise control procedures to follow.

PLUMBING NOISE GENERATING SYSTEM

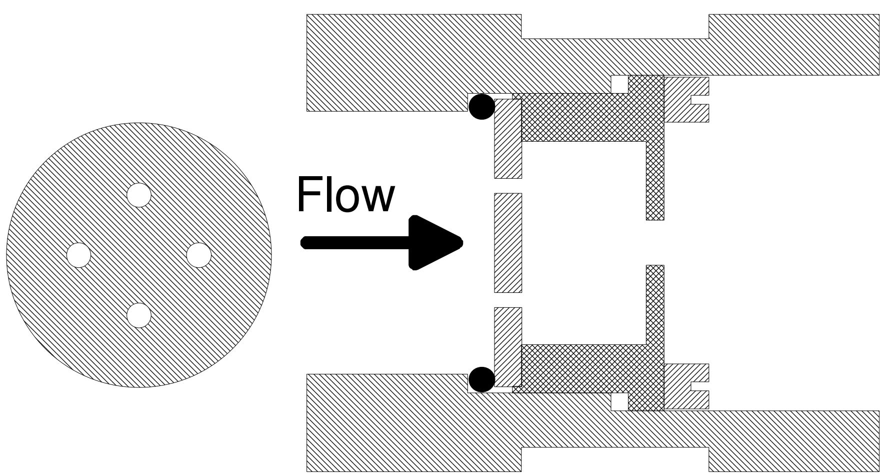

Figure 1: Cross section through ISO hydraulic noise generator. The flow passes through two plates: one at the front with four holes (shown on the left) and one behind that with a single hole.

ISO standard 38221 defines a method for measuring noise generated by plumbing fixtures. The object under test is attached to a standard pipe which is in turn attached to a concrete wall 100 mm thick. Noise levels generated by the test object are compared with those generated by a standard hydraulic noise source shown in cross-section in Figure 1. For the work here it was decided to use the same hydraulic noise source, but pipe mounting techniques and wall types were changed to give a better simulation of typical Canadian construction.

Figure 2 shows the general arrangement of pumps, valves and other devices used to generate flow through the noise source and how they relate to the reverberation room and the test wall. From work reported in the literature, it was known that supply pressure plays a role in determining how much noise is generated in a plumbing system. Thus, where measurements were made using the system shown in Figure 2, sound pressure levels were measured at four different supply pressures: 40, 60, 80, and 100 psi. The radiating side of the wall to which test pipes were attached faced into the 250 m3 reverberation room. Noise levels in the room were measured at nine microphone positions to obtain a spatial average. Measurements were made in one-third octave bands from 63 to 6300 Hz. Reverberation times from 200 to 1250 Hz were in the range 5 to 6 s. The calculated decay rate for A-weighted pink noise was 5.3 s. The area of the radiating wall was 7.44 m2.

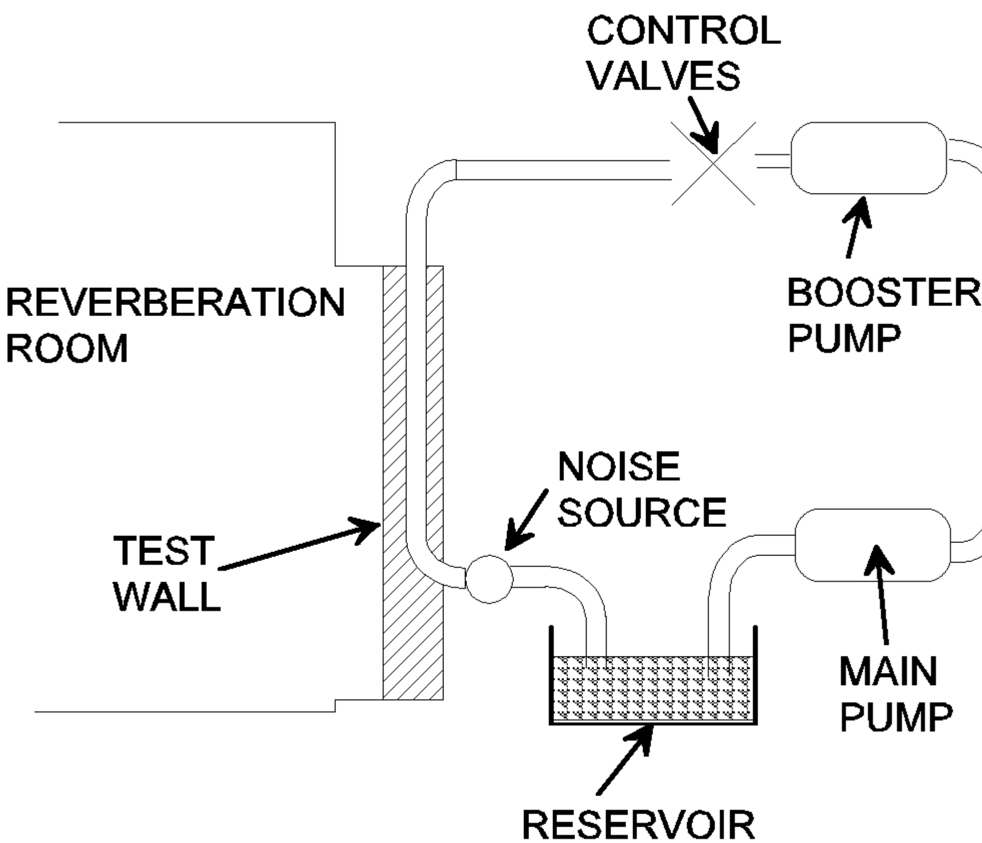

Figure 2: Arrangement of pumps, valves reservoirs and noise source used to study effects of mounting, wall type and pipe type.

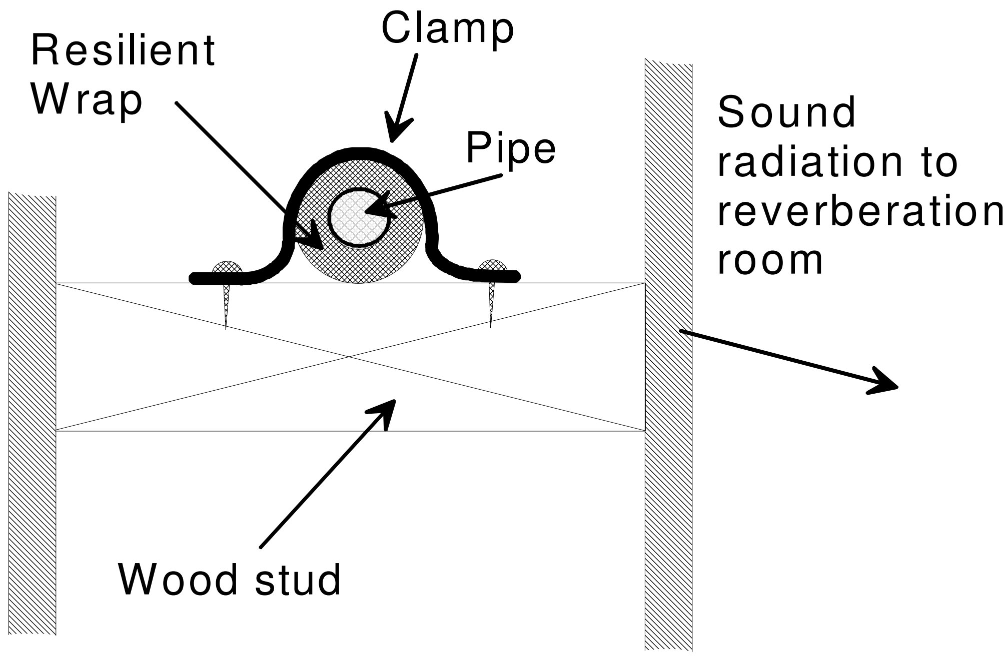

Figure 3: Attachment of pipe to stud for evaluation of resilient materials.

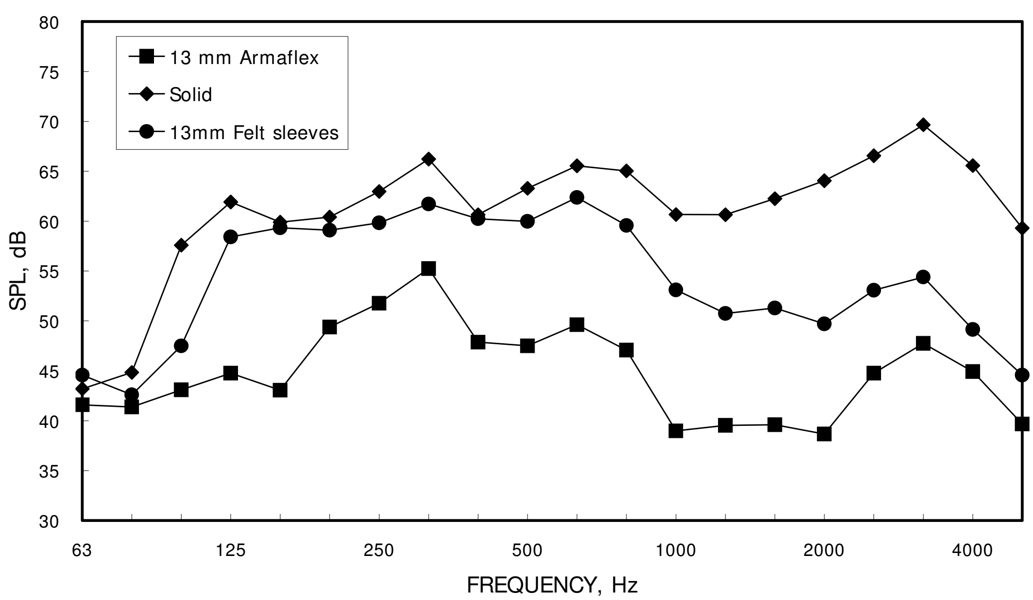

Figure 4: Noise spectra produced with direct contact of pipe to wood stud and with two types of resilient material.

RESILIENT PIPE WRAPPINGS

Perhaps the most common procedure recommended for control of plumbing noise is to wrap the pipes with some resilient material in such a way that the pipe does not come into solid contact with the structure. The general principle is sketched in Figure 3. During the measurement series, pipes of different diameter and material were attached to studs using several resilient materials. It is to be expected that the spectrum of the noise generated would change markedly when a resilient material is interposed between the pipe and the structure. Figure 4 shows the measured spectra for three cases. In the space available in this paper, it is only possible to present an overview of the results and, for the rest of this paper, results will only be given in terms of A-weighted levels. Levels presented in tables are averages for all the supply pressures measured. A-weighted noise levels were found to increase linearly with pressure by about 5 dB when supply pressure was increased from 40 to 100 psi; thus, the levels presented may be thought of as representing values at 70 psi. Levels at other supply pressures can be estimated by adding a correction term (p - 70)/12 dB where p is the supply pressure in psi.

Table 1 lists A-weighted noise levels generated in the reverberation room by the ISO noise source for several types of resilient material and three pipe diameters. Cork and felt carpet underpad were used as resilient wrappings as well as one material commercially available for air conditioning work (Armaflex) and commercial mounts for the control of plumbing noise (Acousto-Plumb). The Armaflex material is a closed cell foam rubber sold in tubular form. It had a wall thickness of 13 mm and turned out to be the most resilient material used. The Acousto-Plumb mounts integrate the resilient material with the clamp to secure the pipe. Examination of Table 1 reveals that the more resilient the material, the lower the noise level achieved. It is interesting to note that in this application the product sold specifically for the control of plumbing noise did not give as much noise reduction as the Armaflex material.

Table 1: A-weighted noise levels generated by ISO source with different resilient materials wrapped around a 13, 19, and 25 mm diameter copper pipe. Pipes were attached to a 38 x 89 mm wood stud by three clamps. The resilient materials were wrapped completely around the pipe under the clamps. A single layer of 13 mm drywall was attached to the wood studs on each side.

Resilient	Pipe diameter		
material	13 mm	19 mm	25 mm
rigid clamps	73.4	70.8	71.7
2 mm Cork	68.2	63.8	63.4
13 mm Felt	64.4	59.2	56.1
Acousto-Plumb	58.6	58.0	57
Armaflex	53.9	54.1	49.5
No clamps	47.2		
Armaflex			
+ 1 wedge	61.6		
+ 2 wedges	64.6		
+ 3 wedges	65.2		

To give some indication of the importance of installation error, Table 1 includes three cases where the resilient material was deliberately "short-circuited" by introducing one, two, and then three wedges between the pipe and the drywall. This would simulate debris or some other fault. The noise increase due to even a single wedge is considerable. Table 1 also shows a general trend to lower noise levels when larger diameter pipes are used.

Different wall systems

As an alternative to resilient mounting of pipes, or in cases where noise reduction is required in an existing installation, one might consider changes to the wall system. Several possible means of improving the basic wall were investigated and Table 2 shows the improvements obtained. In all cases in this table, the pipes were directly attached to the wood studs; no resilient materials were used. To save space, a coded description of the wall is used in this table and in following tables. The codes used are as follows: G - gypsum wallboard, GFB - glass fibre batts, RC - resilient metal channels, CFL - blown-in cellulose fibre. Numbers following the codes denote thickness in mm. The constructions are described from the wood studs to the radiating side of the wall. Thus, the last wall in Table 2 is finished with two layers of 13 mm gypsum wallboard mounted on resilient metal channels and there is 90 mm of glass fibre batt in the cavity. To save space, the coded description for the wood studs and the drywall on the side away from the reverberation room are not included in the tables. Table 2 shows that even though the pipes are directly clamped to the wood studs, it is possible to get substantial noise reductions through the use of sound-absorbing material and resilient metal channels. The lowest noise level given in Table 2 is about the same as that given in Table 1, ignoring the case there where there was no contact at all with the studs. It is tempting in problem situations to consider blowing sound absorbing material, either glass or cellulose fibre, into the wall. This table shows that both materials give about the same noise levels and that best results are obtained by introducing resilient metal channels to support the drywall.

Resilient mounting of the pipes and improving the wall structure can be combined to obtain best noise reduction. Table 3 gives results for several types of wall where the pipes were supported using 13 mm thick Armaflex resilient wrapping. The last two entries in the table are for two cases where the pipes ran horizontally through notches cut in three of the studs. The pipes were still wrapped in Armaflex. There is no significant difference between these cases and those of similar construction where the pipes ran vertically along one stud.

Table 2 A-weighted noise levels generated by ISO source with 13 mm and 25 mm copper pipe attached directly to wood stud with three clamps.

Wall finish	Pipe diameter 13 mm	Pipe diameter 25 mm
G13	73.4	71.7
GFB90_G13	72.6	68.1
G13_G13	70.3	66.3
CFL90_G13		66.9
GFB90_G13_G13	68.1	65.5
GFB90_RC13_G13	63.5	61.6
GFB90_RC13_G13_G13	55.7	56.5

Table 3: A-weighted noise levels produced by ISO source when wall improvements are combined with 13 mm thick Armaflex resilient mounts.

Wall finish	Pipe diameter 13 mm	Pipe diameter 25 mm
G13	53.9	54.6
GFB90_G13	50.7	49.5
G13_G13	50.5	51.2
GFB90_G13_G13	48.0	47.1
GFB90_RC13_G13	43.7	43.8
GFB90_RC13_G13_G13	41.6	42.8
Horizontal pipes		
G13	55.1	
GFB90_G13_G13	47.5	

Non-load-bearing steel studs are usually regarded as resilient enough to decouple layers of drywall attached on each side. One might therefore expect that walls with pipes attached to steel studs would radiate less sound than similar constructions using wood studs. Table 4 gives noise levels measured with some steel stud walls. In these cases, the supply pipes ran horizontally through three studs and rested on them with only a thin plastic skin as support, or Armaflex was used to wrap the pipes. The case with the hard support and a single layer of drywall mounted on the radiating side of the wall is about 7 dB quieter than the corresponding wood stud wall and is comparable to what one would expect from a wood stud wall where resilient metal channels are used to support the drywall. This case was, unfortunately, not measured. The second and third rows in the table may be compared with corresponding entries in Tables 2 and 3 where resilient metal channels are used. The values from those tables are repeated in Table 4 for convenience. It can be seen that only in one case do the two systems give comparable results. It appears that the wood stud and resilient metal channel combination on average gives better performance.

Plastic and copper pipes

Different pipe materials may be expected to transmit sound energy differently. Measurements were made with two commonly available materials used for supply pipes, copper and plastic. The plastic pipe was Schedule 80 pipe with a wall thickness of 4 to 5 mm depending on diameter. Comparisons are given in Table 5 for three diameters of these two types of pipe with and without a resilient wrapping. The plastic pipes are significantly quieter than the copper pipes when no resilient wrapping is used.

Table 4: Average A-weighted noise levels generated by ISO noise source with 13 mm copper pipes running horizontally through three steel studs. The radiated surface of the wall is coded in the first column of the table.

Wall Finish	Hard Support	Armaflex
G13	66.4	56.9
GFB90_G13	63.0	51.8
GFB90_G13_G13	62.1	49.3
Wood stud walls		
G13	73.4	53.9
GFB90_RC13_G13	63.5	43.7
GFB90_RC13_G13_G13	55.7	41.6

Table 5: Comparison between copper and plastic pipes. A-weighted noise levels generated by ISO source. Pipes are clamped to the wood studs in the standard wall, G13_WS90_G13, with 3 rigid clamps or are wrapped in 13 mm Armaflex as indicated.

		Diameter		
Material	Attachment	13 mm	19 mm	25 mm
Cu	3 clamps	73.4	70.8	71.7
Cu	Armaflex	53.9	54.1	54.6
Plastic	3 clamps	62.3	62.7	59.9
Plastic	Armaflex	49.1	53.3	53.9

Faucets

The ISO source is designed to be noisy. Faucets ought not to be. During the measurements, five faucets of the type used in baths were used in place of the ISO source. Noise levels were measured for three flow conditions: maximum flow, half-maximum and quarter-maximum. The results are shown in Table 6. All are about equally noisy when fully opened but there are significant differences when they are only partly open.

Noise from waste pipes

The data presented so far are for supply pipe noise. Noise from waste pipes is also a severe annoyance in many cases. During the measurement series, peak A-weighted noise levels were measured for toilet flushes and for sinks draining. Waste pipes are not usually tied to the wood studs so in these measurements no clamps were used. Where there was contact between the waste pipes and the structure, this was achieved using wedges to simulate construction errors or inadvertent contact. Table 7 shows results for two types of waste pipe: cast iron and plastic. Both were 75 mm in diameter. It is clear from the table that the cast iron pipe is much quieter, presumably because of its weight.

Conclusions

This has been only a brief overview of the measurement series. A more thorough report is in preparation. The data strongly suggest, however, that resilient channels should be used more frequently in buildings. They may not appear to be necessary when the only transmission path considered is airborne transmission through the wall or floor; however, when flanking paths are considered, they can be seen to have benefits. In control of plumbing noise they have similar benefits. Even where resilient mounts are used for pipes, resilient metal channels provide an additional level of noise control and protection against construction errors.

Table 6: A-weighted noise levels generated by 5 common faucets. The pipe was copper with a diameter of 13 mm and was attached to the wood studs with three rigid clamps. The wall construction was G13_WS90-_G13.

Faucet number	1/4 Max	1/2 Max	Max
1	64.9	67.0	64.1
2	59.3	60.7	66.4
3	50.6	58.4	63.6
4	56.0	63.2	67.1
5	56.3	67.6	65.9

Table 7: A-weighted noise levels generated by toilet flushes. Waste pipes were 75 mm diameter and of plastic or cast iron. For the cases with contact, wedges were pushed between the pipe and the drywall. For the case marked with an asterisk, contact was with the resilient metal channels. The wall was constructed using 90 mm wood studs.

Wall finish	Plastic Mean	With contact	Fe Mean	With Contact
G13	44.4	47.1	36.4	37.0
CFL90_G13	39.1		31.2	
GFB90_G13	40.4	42.9	30.7	37.0
GFB90_RC13_G13	39.8		30.6	32.2*
G13_G13	42.8		33.6	34.8
GFB90_G13_G13	37.5		30.1	
GFB90_RC13_G13_G13	37.8		29.0	

Reference

1. Laboratory tests on noise emission from appliances and equipment used in water supply installations - Part 1: Method of measurement. ISO 3822