MEASURED PRESSURE EQUALIZED PERFORMANCE OF A BRICK VENEER/STEEL STUD ASSEMBLY

REPORT 4

Progress Report #4
Measured Pressure Equalized Performance of a Brick Veneer/Steel Stud Assembly

Performance of Pressure Equalized Rainscreen Walls
A Collaborative Research and Development Project

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EXECUTIVE SUMMARY

A literature review conducted by the National Research Council (NRC) in 1992 to determine design guidelines for pressure equalized rainscreen (PER) walls concluded that current guidelines were not at all comprehensive. As a consequence, a research and development project was initiated to generate design guidelines for PER walls. Canada Mortgage and Housing Corporation (CMHC) is jointly sponsoring the experimental evaluation task of the project. In addition, several wall system manufacturers are supplying test specimens and providing technical and practical information.

This report presents data from the experimental evaluation of a brick veneer/steel stud (BV/SS) test specimen. The test specimen was 2.44 m high by 2.44 m wide. It consisted of 12 mm plywood fastened to a 89 mm steel stud assembly (studs @ 400 mm OC) which acted as the air barrier system, 12 mm gypsum sheathing fastened to the exterior of the steel studs, a 25 mm air space and 100 mm clay brick veneer which acted as the rainscreen. The steel studs and brick veneer were connected by steel rods located at 400 mm OC horizontally and vertically. The air space extended over the height and width of the specimen. Since the gypsum sheathing was not sealed, the pressure equalization cavity of the specimen consisted of the 25 mm air space plus the 89 mm stud space.

The experimental evaluation task consisted of air leakage, pressure equalization, deflection, and water penetration sub-tasks.

Pressure equalization performance of the cavity and deflection of the brick veneer and steel stud assemblies were measured under dynamic pressure conditions for several leakage and vent configurations, loading scenarios, and excitation frequencies. The following observations were found true for the specimen:

- The pressure difference across the rainscreen decreased under the following conditions:
    - the rainscreen venting increased;
    - the frequency of the specimen pressure difference decreased.
- Pressure difference across the rainscreen changed negligibly with the amount of leakage in the air barrier system and with height or width of the specimen.
- The deflection of the air barrier system had a negative effect on the pressure equalization performance of the wall system.

Water penetration through the brick veneer was evaluated under static and dynamic pressure conditions. The following effects were observed:

- With a static pressure difference across the specimen with a 'defective' face-seal system;
    - 0.09 L/min/m^2 passed through the rainscreen with 0 Pa across the rainscreen;
    - 0.44 L/min/m^2 passed through the rainscreen with 500 Pa across the rainscreen;
- With a dynamic pressure difference across the specimen of $0+1000 \cdot \sin(2\pi f)$ Pa at a frequency of 0.5 Hz:
    - with a 'defective' face-seal system, 0.14 L/min/m^2 passed through the rainscreen;
    - with a drained cavity wall, 0.15 L/min/m^2 passed through the rainscreen;
    - with a PER wall, 0.08 L/min/m^2 passed through the rainscreen (i.e., the same amount as with no pressure difference)

RÉSUMÉ

Une analyse documentaire qu'effectuait en 1992 le Conseil national de recherches (CNR) dans le but d'établir des directives de conception à l'égard des murs avec écran pare-pluie à pression équilibrée a permis de conclure que les directives actuelles ne sont pas du tout complètes. C'est ainsi qu'un projet de recherche et de développement a été amorcé en vue de donner lieu à des directives de conception pour les murs avec écran pare-pluie à pression équilibrée. La Société canadienne d'hypothèques et de logement (SCHL) parraine l'évaluation expérimentale conjointement avec l'Institut de recherche en construction (IRC). De plus, plusieurs fabricants de systèmes muraux fournissent des spéciments aux fins d'essais, en plus d'offrir des renseignements technico-pratiques.

Le présent rapport livre les résultats de l'évaluation expérimentale d'un spécimen de mur à ossature d'acier et placage de brique, mesurant 2,44 m de hauteur sur 2,44 m de largeur. Le spécimen est constitué de contreplaqué de 12 mm fixé à une ossature à poteaux d'acier de 89 mm (disposés à entraxe de 400 mm), qui fait fonction de pare-air, d'un revêtement intermédiaire en plaque de plâtre de 12 mm fixé sur la face extérieure de l'ossature d'acier, d'une lame d'air de 25 mm et d'un placage de brique d'argile de 100 mm qui fait fonction d'écran pare-pluie. L'ossature d'acier et le placage de brique ont été raccordés par des tiges d'acier espacées de 400 mm entre axes à l'horizontale et à la verticale. La lame se prolonge sur toute la hauteur et toute la largeur du spécimen. Puisque le revêtement intermédiaire en plaque de plâtre n'était pas rendu étanche, la cavité d'équilibrage de la pression du spécimen s'entendait de la lame d'air de 25 mm et des espaces de 89 mm entre les poteaux.

L'évaluation expérimentale a porté sur l'étanchéité à l'air, l'équilibrage de la pression, le fléchissement et la pénétration d'eau.

L'équilibrage de la pression de la cavité et le fléchissement du mur à ossature d'acier et placage de brique ont été mesurés dans des conditions de pression dynamique suivant plusieurs configurations de fuites et de ventilation, conditions de charge et fréquences d'excitation. Les observations suivantes s'appliquent aux deux spécimens :

- La différence de pression agisssant sur l'écran pare-pluie a diminué lorsque :
    - la ventilation de l'écran pare-pluie augmentait;
    - la fréquence de la différence de pression du spécimen diminuait.
- La différence de pression agissant sur l'écran pare-pluie se modifiait de façon négligeable selon la quantité de fuites du système d'étanchéité à l'air et selon la hauteur ou la largeur du spécimen.
- Le fléchissement du système d'étanchéité à l'air a exercé un effet défavorable sur l'équilibrage de la pression du système mural.

La quantité d'eau qui a traversé le placage de brique a été évaluée dans des conditions de pression statique et des conditions de pression dynamique . Les effets suivants ont été observés :

- Alors qu'une différence de pression statique agissait sur le système étanchéisé en surface mais présentant un défaut,

    - 0,09 L/mn/m^2 a traversé l'écran pare-pluie à une différence de pression de 0 Pa exercée sur l'écran pare-pluie;
    - 0,44 L/mn/m^2 a traversé l'écran pare-pluie à une différence de pression de 500 Pa exercée sur l'écran pare-pluie.
- Alors que s'exerçait sur le spécimen une différence de pression dynamique de 0 +1 000 • sin $(2\pi f t)$ Pa à une fréquence de 0,5 Hz :
    - pour le système étanchéisé en surface « défectueux », 0,14 L/mn/m^2 traversait l'écran pare-pluie;
    - pour le mur à cavité d'évacuation, 0,15 L/mn/m^2 traversait l'écran pare-pluie;
    - pour un mur avec écran pare-pluie à pression équilibrée, 0,08 L/mn/m^2 traversait l'écran pare-pluie (soit la même quantité qu'en l'absence de différence de pression).

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INTRODUCTION

The pressure equalized rainscreen (PER) principle is considered the most effective design approach to control rain penetration in walls. However, a literature review conducted by the National Research Council (NRC) to determine design guidelines for such walls (IRC Internal Report No. 629) concluded that current guidelines are not at all comprehensive. As a consequence, a collaborative research and development project to develop design guidelines for PER walls was initiated. This project has three tasks, namely computer modeling, experimental evaluation and development of design guidelines. Canada Mortgage and Housing Corporation (CMHC) is jointly sponsoring the experimental evaluation task of the project. In addition, several wall system manufacturers are participating in the project by supplying test specimens and providing technical and practical information.

This report presents results from the experimental evaluation task. It documents air leakage measurements, pressure equalization response, deflection measurements and rain penetration control of a brick veneer/steel stud test specimen that was constructed by NRC.

TEST SPECIMEN

Following is a description of the test specimen.

- The specimen has overall dimensions of 2.44 m high by 2.44 m wide (Figure 1).
- The rainscreen is a 100 mm thick masonry veneer, 2.44 m high by 2.44 m wide. The veneer was constructed with standard clay brick in 1991 as part of a thermal test specimen. It was reclaimed to be used in the PER wall test specimen. Hence, it should be representative with respect to air and water permeability of a brick veneer that has been aged for some period of time.
- The air barrier system consists of two sheets of 12 mm plywood (1.22 m x 2.44 m) fastened horizontally to the interior of 140 mm deep steel studs (20 ga). The joint between the sheets was finished to ensure minimum air leakage. The studs are located at 400 mm OC. Two sheets of 12 mm gypsum sheathing (1.22 m x 2.44 m) are fastened to the exterior of the steel studs to ensure the structural integrity of the studs. The plywood and gypsum sheathing are fastened with double #8 drywall screws located at 300 mm OC. Six holes, each 150 mm diameter, are cut in the gypsum sheathing to ensure that it offered little resistance to air flow (previous field studies of the pressure difference across BV/SS walls have indicated that gypsum sheathing installations can be quite leaky - NRC Report CR6287.2 to CMHC). Six 6 mm diameter leakage holes were drilled through the plywood 100 mm apart and 70 mm from the top to simulate a leaky air barrier system. The area of one hole was of a size that could be detected by visual inspection and the air flow rate was determined to be approximately 0.1 $L/s/m^2$ at 75 Pa for 2 holes open.
- A 25 mm space is maintained between the gypsum sheathing and the brick veneer by steel brick ties, mounted 400 mm apart both horizontally and vertically. This space combines with the empty stud cavity to form a pressure equalization cavity for the test specimen which is 114 mm deep, and with a volume of 0.68 m^3. The steel brick ties were retrofitted to the test specimen - embedded half way into the brick veneer and mechanically fastened to the steel studs. Venting for the cavity is achieved by opening four or eight head joints in the bottom row of bricks. The number of open head joints was chosen to give venting that ranged from less than to more than that required for pressure equalization of the cavity.
- The rainscreen consists of a brick veneer and leakage through the rainscreen is primarily through the interface between the mortar and the clay bricks of the veneer. The water tightness of the rainscreen is anticipated to be typical of a well aged brick veneer. As a consequence, no effort was made to change the water tightness of the rainscreen.

The test specimen was installed in a steel test frame and the test frame was mounted to the Dynamic Wall Test Facility (DWTF) with the air barrier facing the laboratory. The brick veneer was attached to the test frame by steel plates located at the sides of the test frame and sealed using backer rod and silicone sealant. The steel stud/plywood air barrier system was then installed and the brick ties mechanically fastened to the steel studs. The steel studs were also mechanically fastened to the steel frame at the top and bottom. The air barrier system was made continuous to the steel frame using backer rod and silicone sealant in a single stage joint.

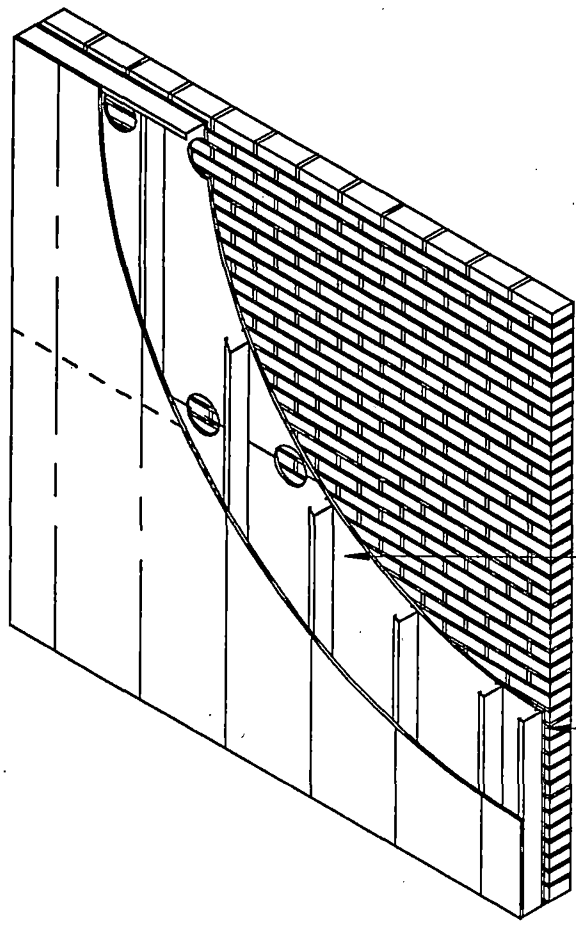

Figure 1. *Details of construction of the brick veneer/steel stud test specimen.*

TEST PROGRAM

Air leakage, pressure equalization, deflection, and water penetration were measured in the DWTF. The sub-tasks are summarized as follows:

1. Air leakage characteristics of all leakage holes and the brick veneer were measured for static pressure differences. The vent holes were too large to determine their leakage characteristics.
2. Pressure equalization response was measured at a range of frequencies for different sinusoidal loading (i.e., mean value and amplitude) scenarios.
3. Deflection of the air barrier system (plywood on steel studs) and of the rainscreen (brick veneer) was measured under several dynamic pressure difference conditions.
4. Water penetration was measured through the rainscreen (as an assessment of rain penetration control) for various leakage hole and vent hole combinations and under static and dynamic pressure differences.

Air leakage

Air leakage was measured with Miriam Laminar Flow Elements (LFE) and Air Limited's Micromanometers (±0.5 Pa) at static pressure differences across the specimen ranging up to approximately 1000 Pa. The measurements were performed with one vent hole open, and for the following conditions:

- *Base Leakage.* Polyethylene was tightly sealed to the steel frame on the laboratory side of the DWTF, covering the specimen and its seal to the frame. The only leakage would be through the seals around the door and piston.

- *Specimen Perimeter Leakage*. All leakage holes in the air barrier system were closed. The polyethylene was removed so that leakage could occur through the specimen perimeter seal.
- *Air Barrier System Leakage*. 2, 4 and 6 leakage holes were opened in the specimen.
- *Rainscreen Leakage*. Flow through the brick veneer, prior to the installation of the air barrier system, was measured.

The *Base Leakage*, *Specimen Perimeter Leakage* and *Air Barrier System Leakage* measured for the experimental setup are shown in Figure 2. The *Specimen Perimeter Leakage* is less than 10% of that measured through two leakage holes.

To determine the air flow characteristics of the leakage holes, leakage rate (L/s) is fitted to the pressure difference across the air barrier system (Pa) by a least squares fit to the following equation:

$$Q = C \bullet \Delta P^n \quad (1)$$

where Q is the air flow through the air barrier system and ΔP is the pressure difference across the air barrier system. Values for C and n determined for each of the *Air Barrier System Leakage* test conditions are also shown in Figure 2. The air leakage characteristic determined for *Rainscreen Leakage* is shown in Figure 3.

Observations: Air leakage through the air barrier system can be minimized by careful design and construction, but it is unwise to ignore the likelihood that some level of leakage will be present. According to a recently prepared guide[1] for the evaluation of air barrier systems, a properly functioning air barrier system should have a flow rate of not more than 0.1 L/s/m^2 at a pressure difference of 75 Pa, or approximately 0.6 L/s for a specimen area of 5.95 m^2. This is approximately what was measured for 2 leakage holes for this specimen.

Pressure equalization

The dynamic component of wind approaching a building over open terrain can be represented by adding together sinusoidal components of suitable amplitude, phase, and frequency, selected from a limited range of frequencies. The higher the frequency, the more difficulty a given PER wall system will have in transmitting the fluctuation into the cavity in time to keep the pressure difference across the rainscreen within desirable limits. An important design issue is the upper bound for frequency content. The main energy content of wind flowing over open terrain is at relatively low frequencies in the range of 0.01 Hz to 0.1 Hz. The amount of energy contained at frequencies of 1 Hz and higher is normally negligible, but designers should be aware that some areas of the building envelope may experience energy at higher frequencies through interaction of the flow with parts of the building or with upwind structures. In the absence of special considerations, it is suggested that results at two frequencies, 0.5 Hz and 5 Hz, be used to evaluate the performance of test specimens.

The response of the cavity of the test specimen was measured for sinusoidal loading at seven frequencies for four leakage hole, two vent hole and three sinusoidal loading (i.e., mean value and amplitude) scenarios (see following table).

Vents	Leakage Holes (Ø 6 mm)	Loading Scenarios[1]	Frequencies[2] f
4	0, 2, 4 & 6	3	7
8	0, 2, 4 & 6	3	7

Notes: 1. The three loading scenarios were $0+500\bullet\sin(2\pi f t)$ Pa, $0+1000\bullet\sin(2\pi f t)$ Pa and $500+500\bullet\sin(2\pi f t)$ Pa.
2. The seven frequencies, f, were 0.05, 0.1, 0.2, 0.5, 1, 2 and 5 Hz.

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[1] Technical Guide for Air Barrier Systems, Canadian Construction Materials Centre, National Research Council Canada, Ottawa Canada.

Figure 2: *Air flow measured for Base Leakage, Specimen Perimeter Leakage and Specimen Leakage*

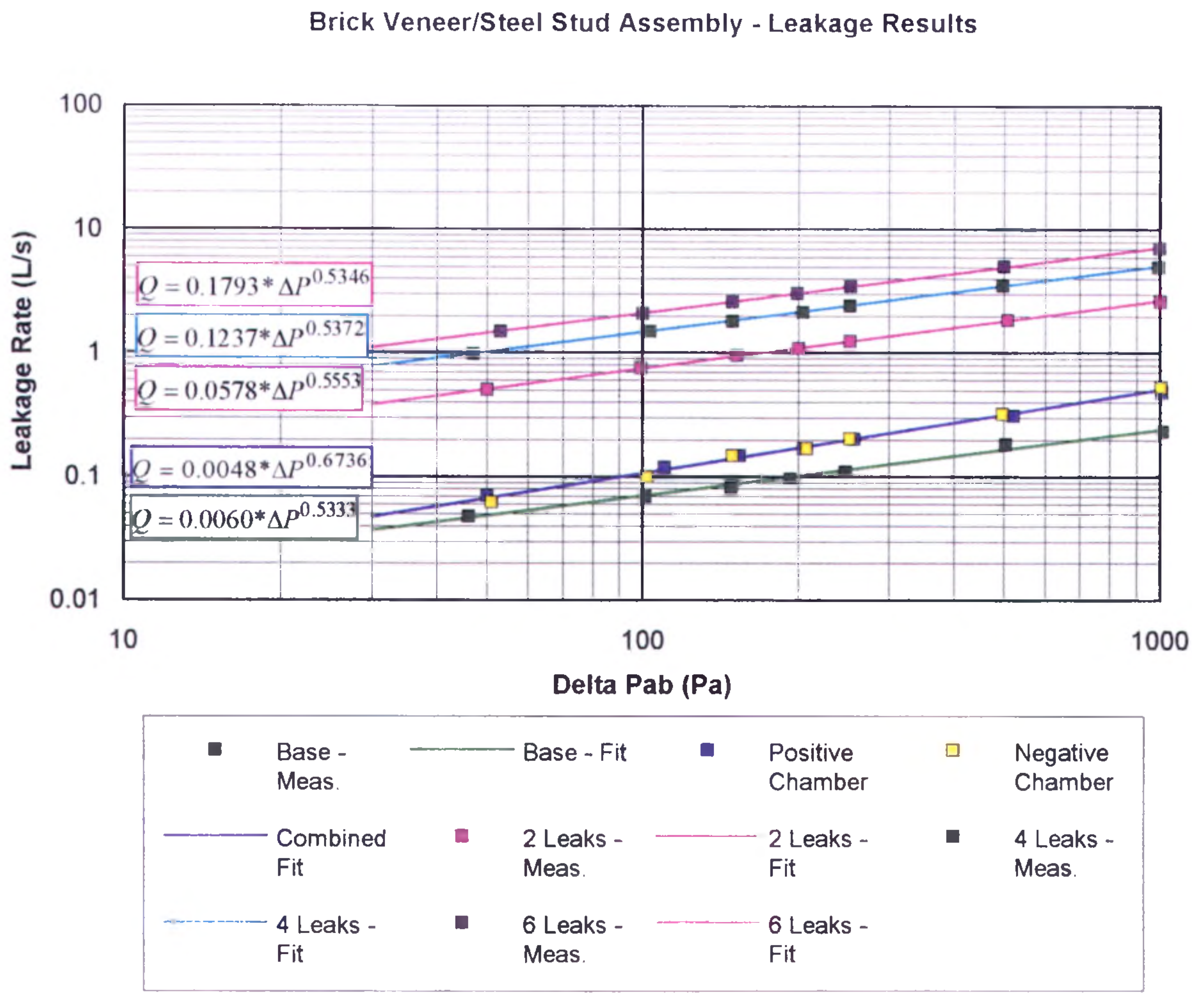
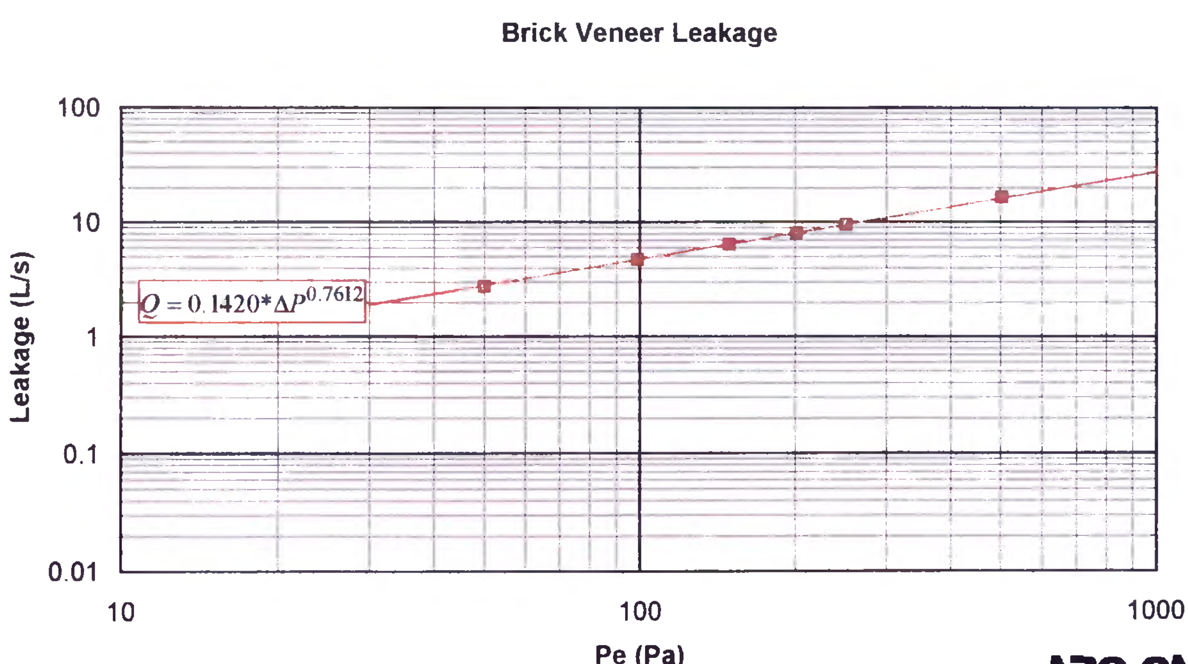


Figure 3: *Air flow measured for Rainscreen Leakage.*



Pressure difference across the air barrier was measured along the height of the specimen (Figure 4) with Setra differential pressure transducers, all with similar frequency response characteristics. These were installed using the same length of vinyl tubing and attached to the same length of copper pressure taps. The pressure taps extended to the space between the brick veneer and the gypsum sheathing and were epoxied in place to ensure a high strength, airtight seal.

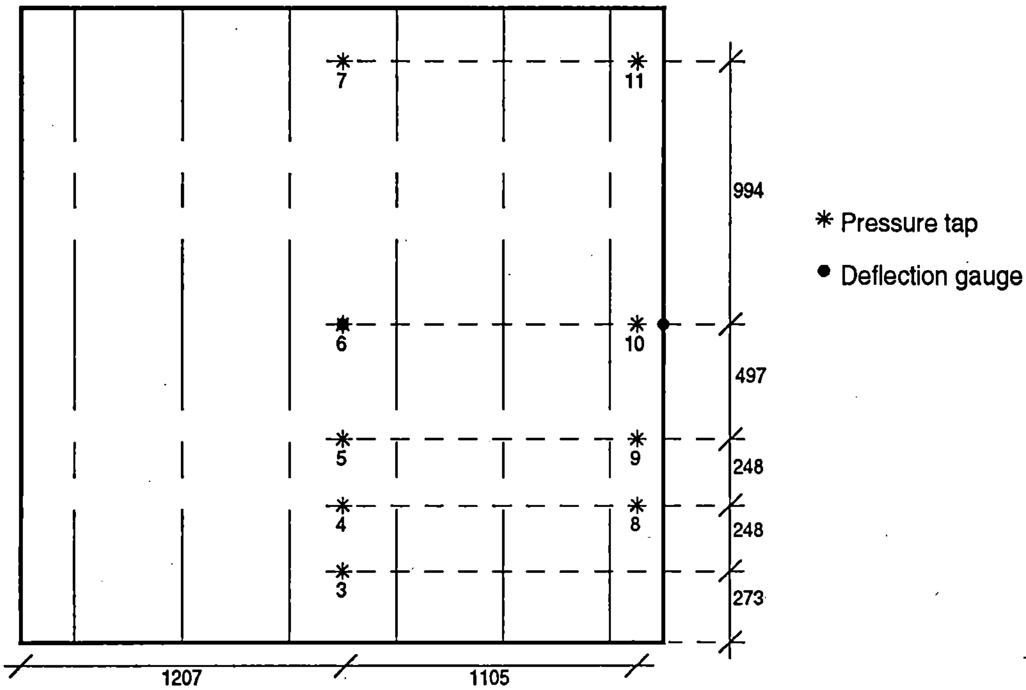


Figure 4. *Location of pressure taps and deflection gauges.*

Figure 5 provides a graphical representation of data obtained from a typical pressure equalization test. The top half of the figure presents data collected with a loading scenario of $500+500 \cdot \sin(2\pi f t)$ Pa with f equal to 1.0 Hz. The bottom half presents the pressure difference calculated across the rainscreen by subtracting the air barrier pressure difference from the excitation pressure difference. Figure 5 also demonstrates that degradation of the response of the specimen leads to a reduction in amplitude ratio and an increase in phase lag for cavity pressure. It is important to note that the maximum pressure difference across the rainscreen is a consequence of both factors, and that a substantial pressure difference can result even though the amplitude of the pressure difference across the air barrier may be close to that across the specimen.

All of the pressure data measured for each test condition were fitted to sine/cosine functions using a least squares fit. From this analysis, an amplitude and phase angle were determined and the pressure equalization response of the specimen was calculated. Figure 6 provides a summary of the results obtained from the specimen. Plotted are the percentage load across the rainscreen versus the number of leakage holes, the number of vent holes, and the loading condition for both 0.5 Hz and 5.0 Hz. The pressure equalization response measured for all test conditions are presented in Appendix A.

Observations: The following observations on the pressure equalization response of the specimen derive from the summary of results given in Figure 6.

- The pressure equalization response was unaffected by the airtightness of the air barrier system. However, the governing criteria for air leakage with respect to rain penetration control may be that required for static pressure equalization rather than that required for dynamic pressure equalization. For example, an effective vent resistance to leakage resistance ratio of 20:1 will produce a rainscreen pressure difference of 25 Pa if the design pressure is 500 Pa.
- The pressure equalization response improved as the venting in the rainscreen increased. It can be shown that dynamic pressure equalization response is directly related to the volume to vent ratio - for this specimen the volume to vent ratio is approximately 100 m with 8 vent holes. This ratio produced

less than adequate response at 5 Hz, and therefore a maximum volume to vent ratio of about 50 m might have to be considered for adequate dynamic response of brick veneer/steel stud walls.

- The pressure equalization response became worse as the frequency increased. Comparison of the response at 0.5 Hz to that at 5.0 Hz demonstrates that, without adequate dynamic pressure equalization response, a significant pressure difference can be imposed on the rainscreen as the frequency increases.

Deflection

Deflections of the air barrier system and rainscreen were measured using Lucas Schaevitz DC-operated Linear Voltage Differential Transformer (LVDT) gauges. Two LVDTs located at mid-height of the air barrier system measured deflections at the centre and the outer edge. A similar setup measured deflections at the centre of the brick veneer. Deflections were measured with 0 and 6 leakage holes, 4 vent holes and for a specimen pressure difference of $0+1000 \cdot \sin(2\pi f t)$ Pa with f equal to 0.5 Hz and 1.0 Hz. The measurements indicated that the air barrier system is more flexible than the rainscreen in spite of their composite action.

Observations: Deflections of the air barrier system can adversely affect the pressure equalization response and deflections of the rainscreen can have the opposite effect. Distinguishing between the flexibility of the rainscreen and that of the air barrier system is difficult, given that they are connected by steel brick ties. However, it is concluded from these test results that the relative flexibility of the air barrier system to the rainscreen will have a negative effect on the response of brick veneer/steel stud walls.

Water penetration

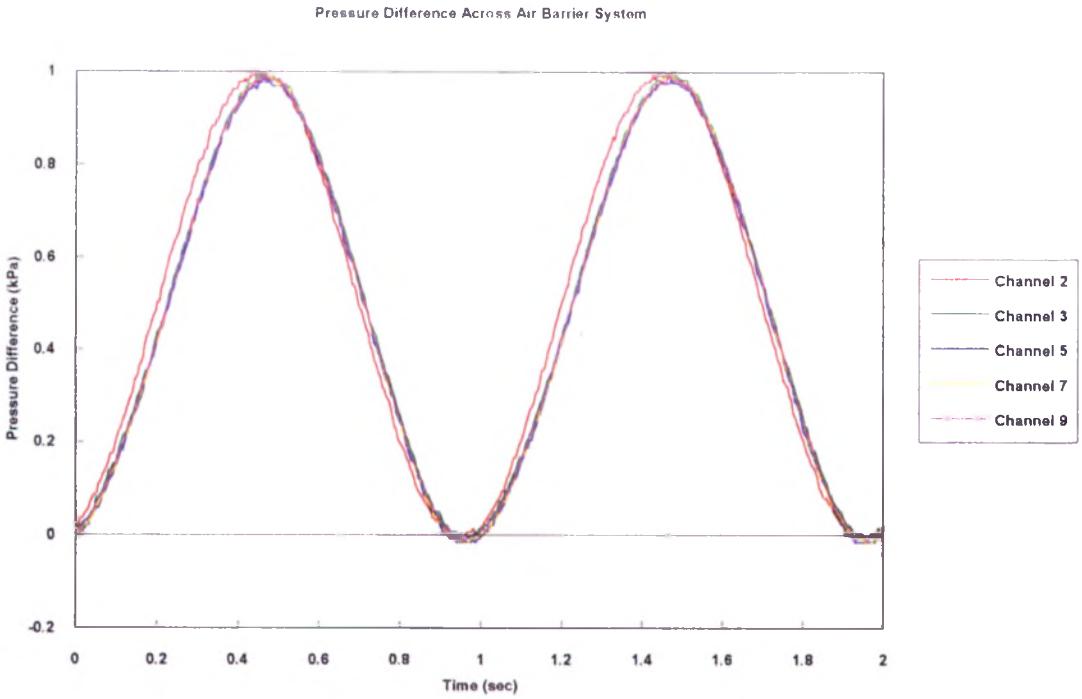
Water was sprayed on the test specimens at a rate of 3.42 L/min/m^2 using the spray rack in the DWTF. The rate of water entering the specimen cavity was measured gravimetrically using a water collection system which was installed at the bottom of the cavity.

The relationship between static pressure difference across the rainscreen and water flow through the rainscreen, i.e., the 'face seal' value of the rainscreen, was determined with all leakage holes opened, all vent holes closed, and for pressure differences across the rainscreen from 0 Pa to 500 Pa. The results are presented graphically in Figure 7. At 0 Pa, 0.09 L/min/m^2 passed through the rainscreen due to capillary action and gravity. A maximum of 0.44 L/min/m^2 passed through the rainscreen with a pressure difference of about 500 Pa.

Observations: The effect of dynamic pressure conditions was determined with a pressure difference across the specimen of $0+1000 \cdot \sin(2\pi f t)$ Pa with f equal to 0.5 Hz. The water flow rate measured through the rainscreen under these conditions was as follows (Figure 8):

- With a leaky air barrier, i.e., 6 leakage holes open, and no venting, 0.14 L/min/m^2 passed through the rainscreen. Note that these conditions are the equivalent of a 'face seal' system with a defect.
- With an airtight air barrier and no venting, 0.15 L/min/m^2 passed through the rainscreen. Note that these conditions are the equivalent of a drained cavity wall, i.e., one with an airtight air barrier to achieve static pressure equalization but insufficient venting to achieve dynamic pressure equalization.
- With an airtight air barrier and 8 vent holes open, 0.08 L/min/m^2 passed through the rainscreen. Note that these conditions are the equivalent of a PER wall i.e., one with an airtight air barrier to achieve static pressure equalization and sufficient venting to achieve dynamic pressure equalization. In this case the amount of water passing through the defect was about the same as with no pressure difference across the rainscreen (0.09 L/min/m^2).

Figure 5 *Typical test data. Measured for BV SS Specimen with 4 head joints and 4 leakage holes under a loading condition of* $500 + 500*\sin(2\pi f)$ *with* f *equal to 1.0 Hz (See Figure 4 for location of channels).*



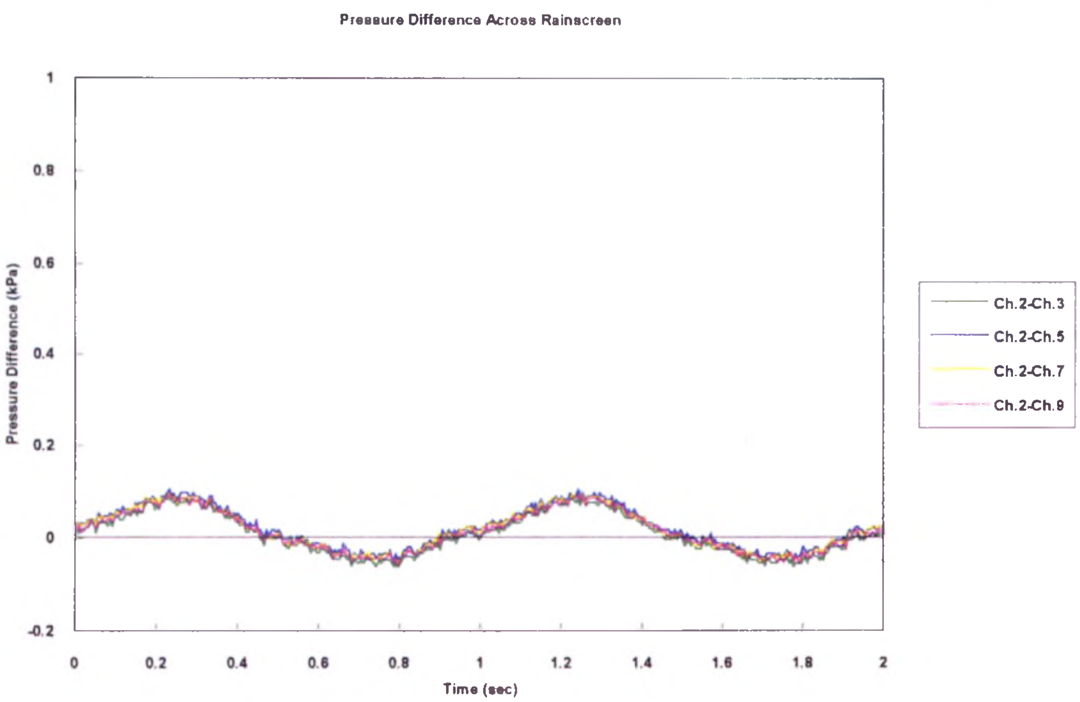
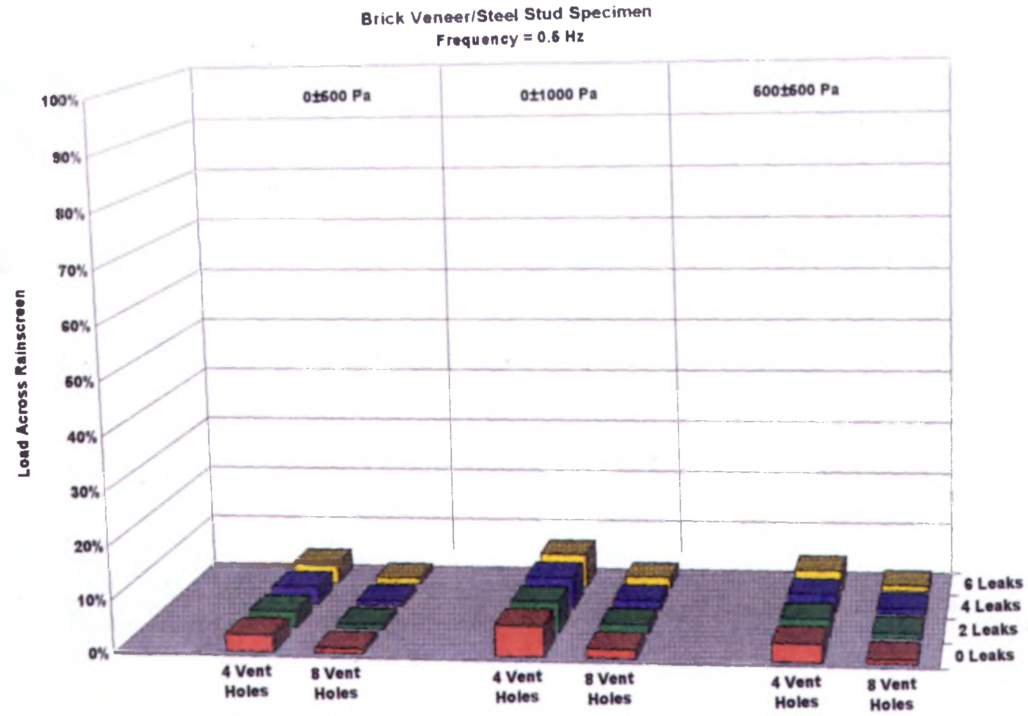


Figure 6 *Percentage load measured across the rainscreen of the BV/SS Specimen for 0.5 Hz and 5.0 Hz.*



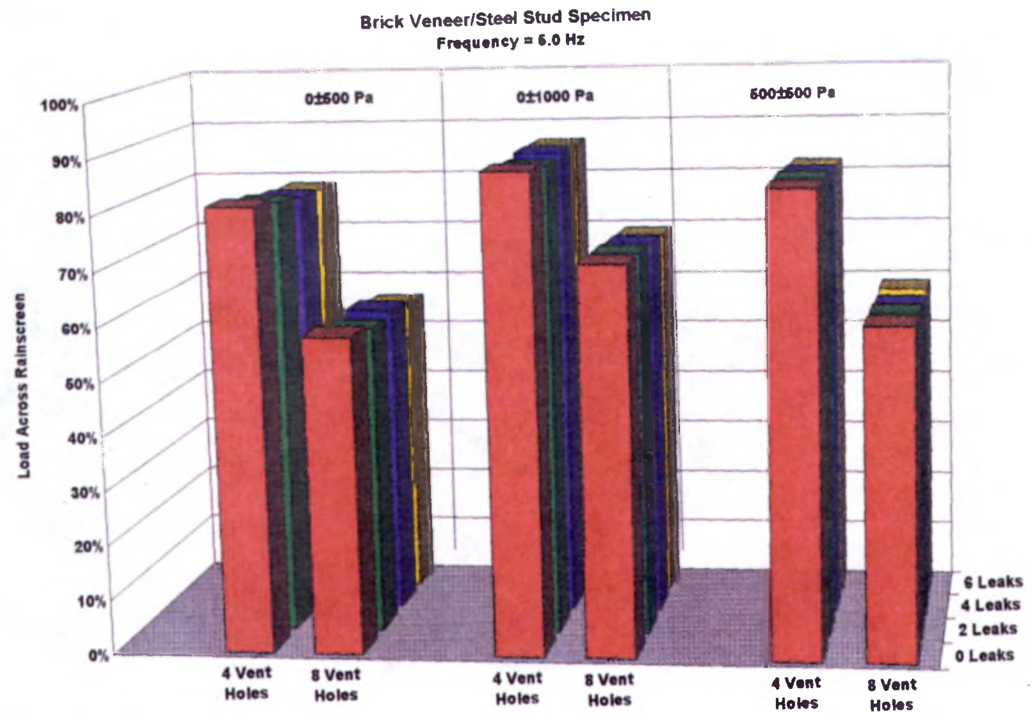


Figure 7 *Static water penetration into cavity.*

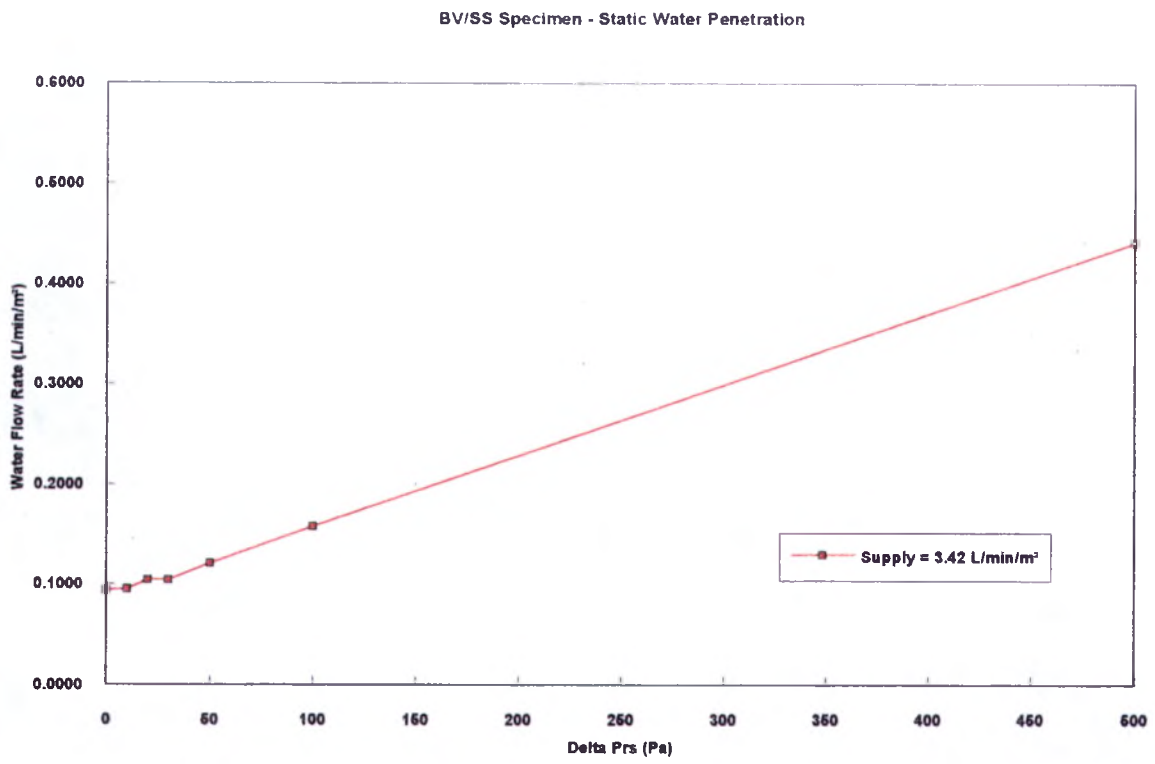


Figure 8 *Water penetration into cavity under dynamic conditions.*

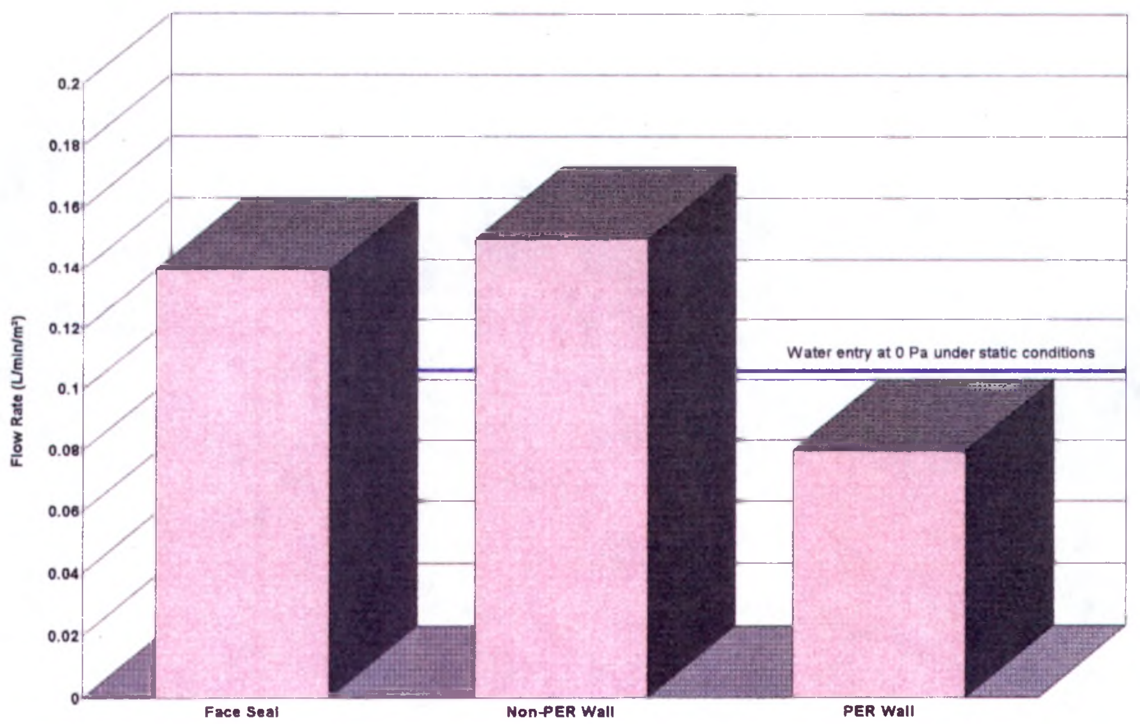


Figure A1 *Measured dynamic response across the air barrier system (ABS) and across the rainscreen(RS) for BV/SS Specimen with 8 head joints and 0 leakage holes under a loading condition of 0 Pa Mean and 500 Pa Amplitude*

		Test Frequency						
		0.05	0.10	0.20	0.50	1.00	2.00	5.00
Channel 3	Amp. ABS	1.00	1.00	1.00	1.00	1.00	1.01	0.90
	Phase ABS	0.0	0.0	-0.1	-0.7	-2.2	-7.7	-35.6
	Amp RS	0.00	0.00	0.00	0.01	0.04	0.14	0.59
Channel 5	Amp. ABS	1.00	1.00	1.00	1.00	1.01	1.01	0.92
	Phase ABS	0.0	0.0	-0.1	-0.7	-2.2	-7.6	-35.5
	Amp RS	0.00	0.00	0.00	0.01	0.04	0.13	0.59
Channel 7	Amp. ABS	1.01	1.01	1.00	1.01	1.01	1.02	0.94
	Phase ABS	0.0	0.0	-0.1	-0.6	-2.1	-7.5	-35.0
	Amp RS	0.01	0.01	0.01	0.01	0.04	0.13	0.59
Channel 9	Amp. ABS	1.00	1.00	1.00	1.00	1.00	1.01	0.91
	Phase ABS	0.0	0.0	-0.1	-0.6	-2.0	-7.3	-35.0
	Amp RS	0.00	0.00	0.00	0.01	0.04	0.13	0.58
Channel 11	Amp. ABS	1.00	1.00	1.00	1.00	1.00	1.01	0.93
	Phase ABS	0.0	0.0	-0.1	-0.6	-2.0	-7.2	-34.6
	Amp RS	0.00	0.00	0.00	0.01	0.03	0.13	0.58

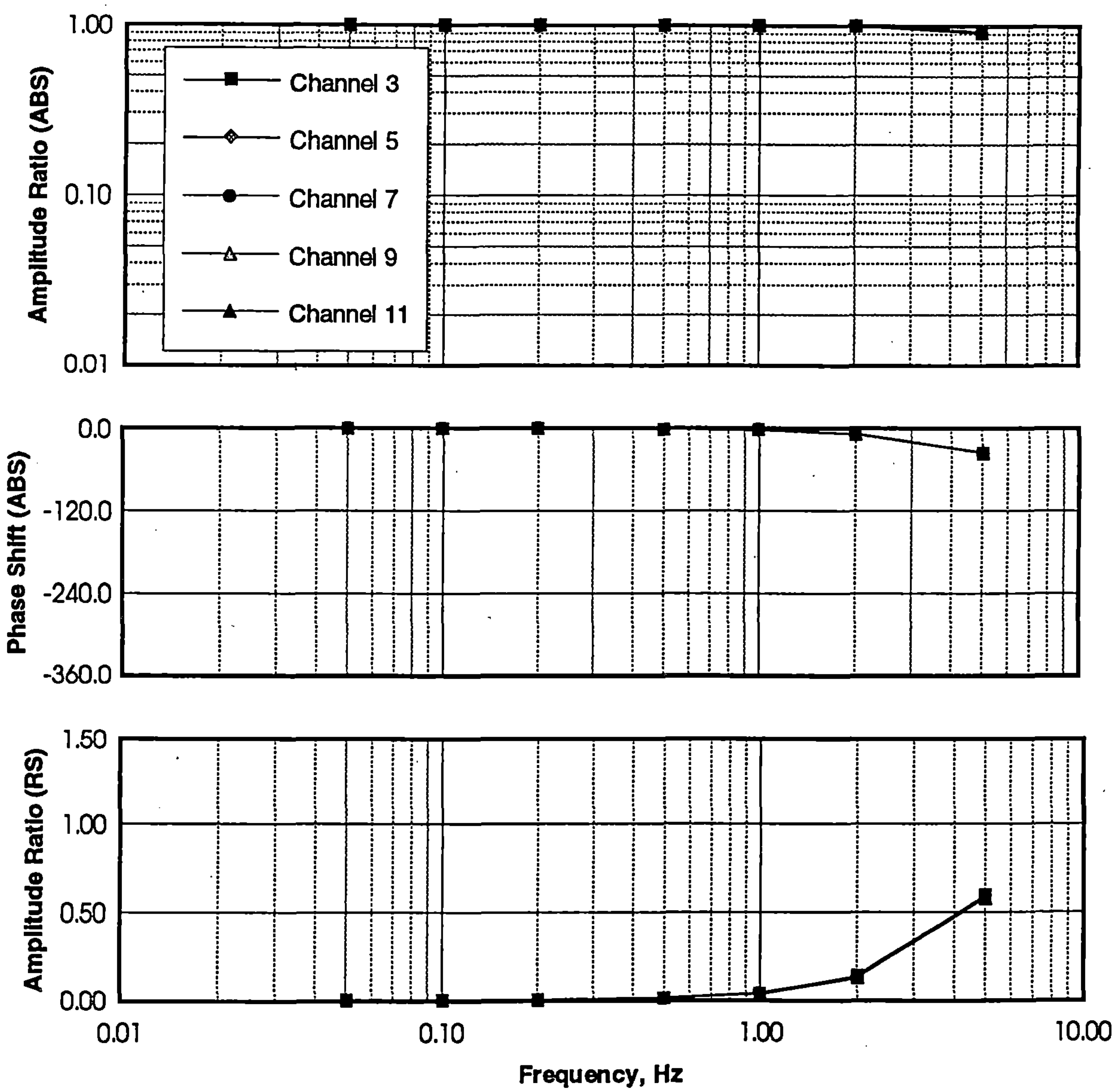


Figure A2 *Measured dynamic response across the air barrier system (ABS) and across the rainscreen(RS) for BV/SS Specimen with 8 head joints and 2 leakage holes under a loading condition of 0 Pa Mean and 500 Pa Amplitude*

		Test Frequency						
		0.05	0.10	0.20	0.50	1.00	2.00	5.00
Channel 3	Amp. ABS	1.00	1.00	1.00	1.00	1.00	1.00	0.91
	Phase ABS	0.0	-0.1	-0.1	-0.7	-2.3	-7.7	-35.0
	Amp RS	0.00	0.00	0.00	0.01	0.04	0.13	0.58
Channel 5	Amp. ABS	1.00	1.00	1.00	1.00	1.00	1.00	0.92
	Phase ABS	0.0	-0.1	-0.2	-0.7	-2.3	-7.5	-35.0
	Amp RS	0.00	0.00	0.00	0.01	0.04	0.13	0.58
Channel 7	Amp. ABS	1.01	1.00	1.01	1.01	1.01	1.01	0.94
	Phase ABS	0.0	0.0	-0.1	-0.7	-2.3	-7.4	-34.9
	Amp RS	0.01	0.00	0.01	0.01	0.04	0.13	0.59
Channel 9	Amp. ABS	1.00	1.00	1.00	1.00	1.00	1.00	0.92
	Phase ABS	-0.1	0.0	-0.1	-0.6	-2.1	-7.3	-34.3
	Amp RS	0.00	0.00	0.00	0.01	0.04	0.13	0.57
Channel 11	Amp. ABS	1.00	1.00	1.00	1.00	1.00	1.00	0.92
	Phase ABS	0.0	0.0	-0.1	-0.6	-2.1	-7.1	-34.0
	Amp RS	0.00	0.00	0.00	0.01	0.04	0.12	0.57

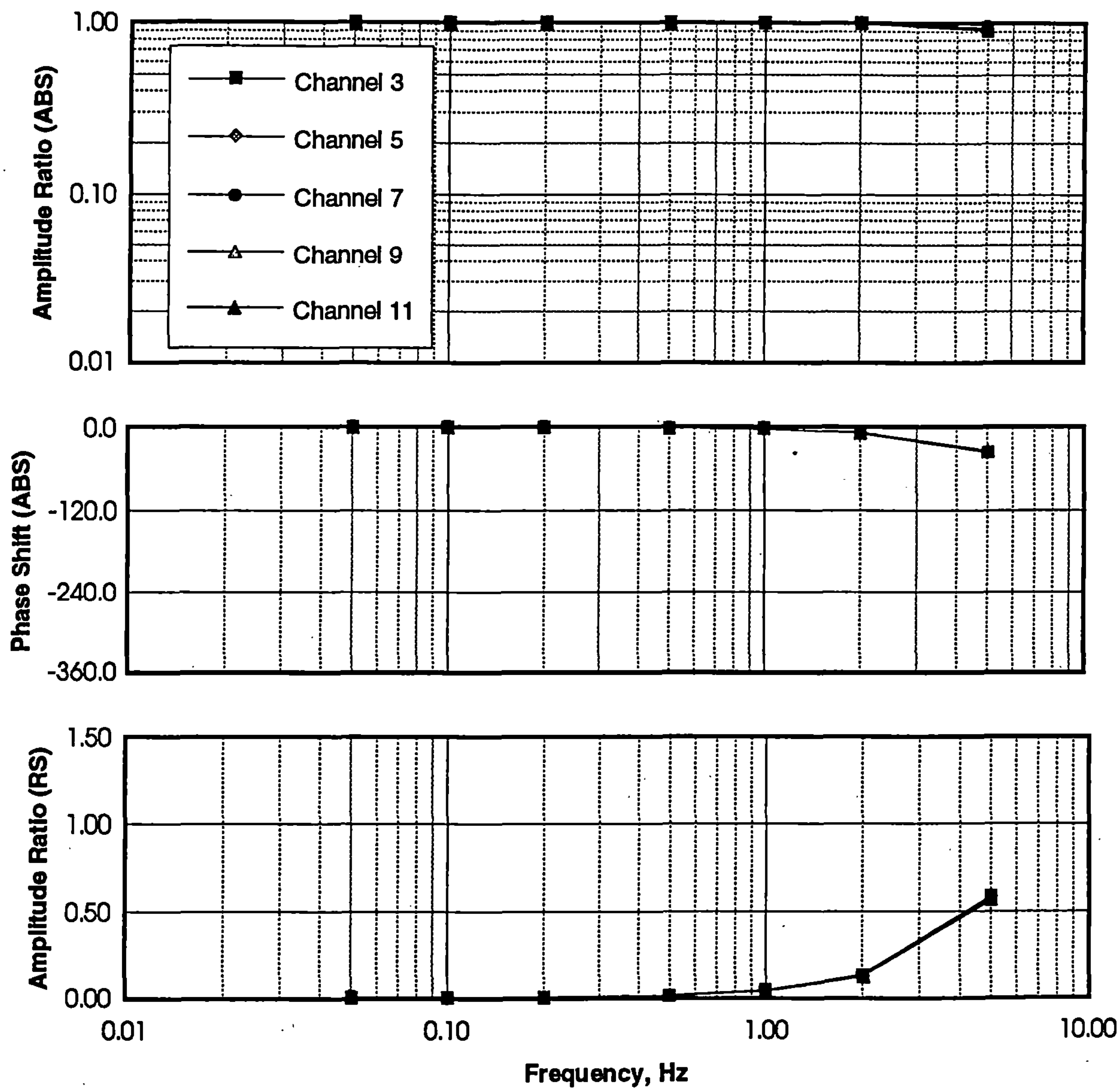


Figure A3 *Measured dynamic response across the air barrier system (ABS) and across the rainscreen(RS) for BV/SS Specimen with 8 head joints and 4 leakage holes under a loading condition of 0 Pa Mean and 500 Pa Amplitude*

		Test Frequency						
		0.05	0.10	0.20	0.50	1.00	2.00	5.00
Channel 3	Amp. ABS	1.00	1.00	1.00	1.00	1.00	1.00	0.90
	Phase ABS	0.0	-0.1	-0.2	-0.7	-2.4	-7.6	-35.2
	Amp RS	0.00	0.00	0.00	0.01	0.04	0.13	0.58
Channel 5	Amp. ABS	1.00	1.00	1.00	1.00	1.00	1.00	0.91
	Phase ABS	-0.1	-0.1	-0.1	-0.7	-2.3	-7.5	-35.0
	Amp RS	0.00	0.00	0.00	0.01	0.04	0.13	0.58
Channel 7	Amp. ABS	1.00	1.00	1.00	1.00	1.00	1.01	0.93
	Phase ABS	0.0	-0.1	-0.2	-0.7	-2.3	-7.5	-34.6
	Amp RS	0.00	0.00	0.00	0.01	0.04	0.13	0.58
Channel 9	Amp. ABS	1.00	1.00	1.00	1.00	0.99	1.00	0.91
	Phase ABS	0.0	-0.1	-0.1	-0.6	-2.2	-7.2	-34.4
	Amp RS	0.00	0.00	0.00	0.01	0.04	0.13	0.57
Channel 11	Amp. ABS	1.00	1.00	1.00	1.00	1.00	1.00	0.93
	Phase ABS	0.0	-0.1	-0.1	-0.6	-2.1	-7.2	-34.4
	Amp RS	0.00	0.00	0.00	0.01	0.04	0.12	0.57

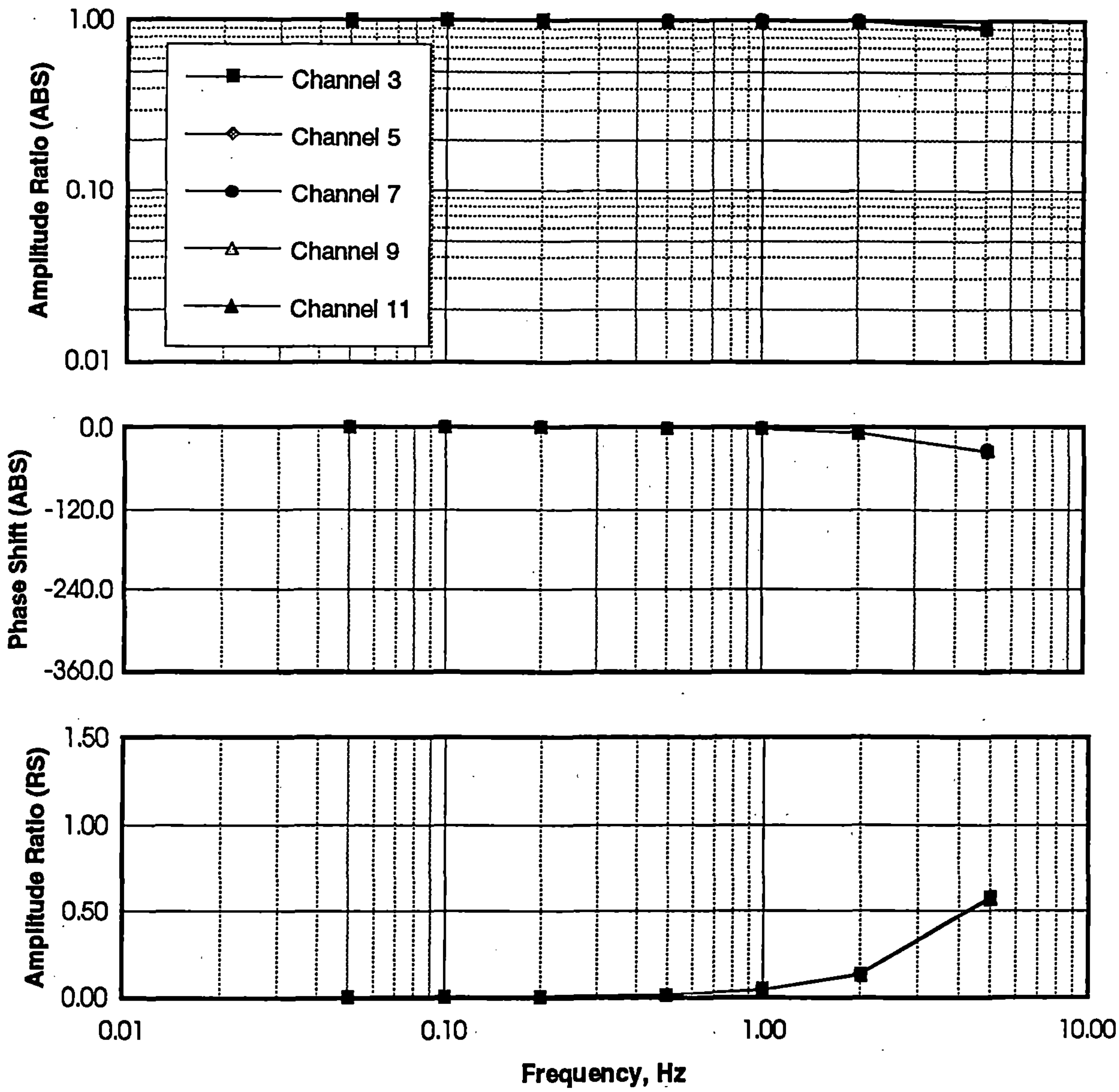


Figure A4 *Measured dynamic response across the air barrier system (ABS) and across the rainscreen(RS) for BV/SS Specimen with 8 head joints and 6 leakage holes under a loading condition of 0 Pa Mean and 500 Pa Amplitude*

		Test Frequency						
		0.05	0.10	0.20	0.50	1.00	2.00	5.00
Channel 3	Amp. ABS	1.00	1.00	1.00	1.00	0.99	0.99	0.89
	Phase ABS	0.0	-0.1	-0.2	-0.8	-2.4	-7.7	-34.1
	Amp RS	0.00	0.00	0.01	0.01	0.04	0.13	0.56
Channel 5	Amp. ABS	1.00	1.00	1.00	1.00	1.00	0.99	0.90
	Phase ABS	-0.1	-0.1	-0.2	-0.7	-2.4	-7.7	-34.1
	Amp RS	0.00	0.00	0.00	0.01	0.04	0.13	0.57
Channel 7	Amp. ABS	1.00	1.00	1.00	1.00	1.00	1.00	0.93
	Phase ABS	0.0	-0.1	-0.2	-0.7	-2.3	-7.6	-34.2
	Amp RS	0.00	0.00	0.00	0.01	0.04	0.13	0.57
Channel 9	Amp. ABS	1.00	0.99	1.00	0.99	1.00	0.99	0.90
	Phase ABS	0.0	-0.1	-0.1	-0.7	-2.2	-7.4	-33.3
	Amp RS	0.00	0.01	0.00	0.01	0.04	0.13	0.55
Channel 11	Amp. ABS	1.00	1.00	1.00	0.99	1.00	0.99	0.92
	Phase ABS	0.0	-0.1	-0.2	-0.6	-2.1	-7.3	-33.5
	Amp RS	0.00	0.00	0.00	0.01	0.04	0.13	0.56

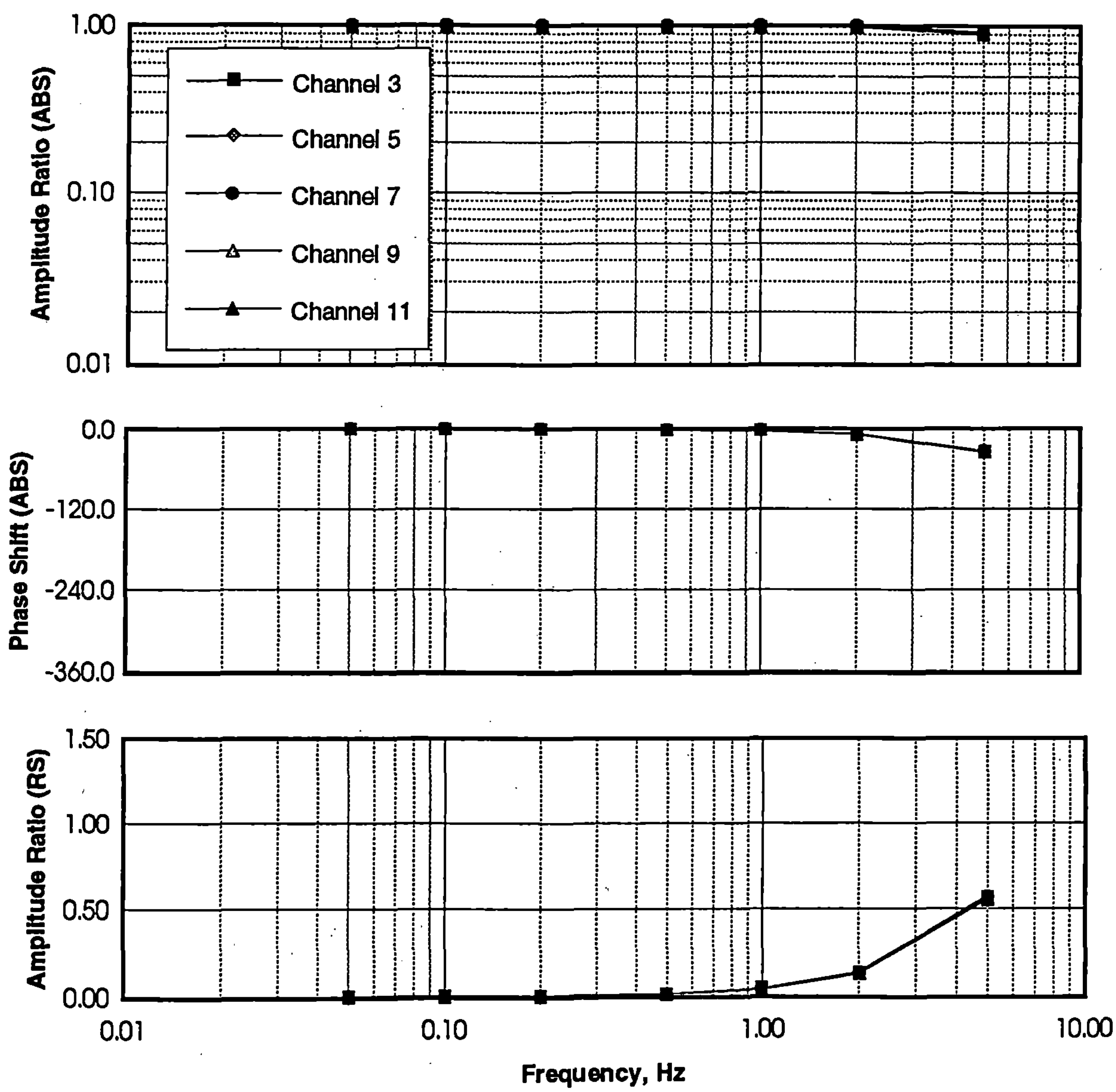


Figure A5 *Measured dynamic response across the air barrier system (ABS) and across the rainscreen(RS) for BV/SS Specimen with 4 head joints and 0 leakage holes under a loading condition of 0 Pa Mean and 500 Pa Amplitude*

		Test Frequency						
		0.05	0.10	0.20	0.50	1.00	2.00	5.00
Channel 3	Amp. ABS	1.00	1.00	1.00	1.00	0.99	0.95	0.64
	Phase ABS	0.0	-0.1	-0.4	-2.1	-6.2	-18.6	-54.9
	Amp RS	0.00	0.00	0.01	0.04	0.11	0.32	0.82
Channel 5	Amp. ABS	1.00	1.00	1.00	1.00	0.99	0.95	0.65
	Phase ABS	0.0	-0.1	-0.4	-2.0	-6.2	-18.4	-54.8
	Amp RS	0.00	0.00	0.01	0.04	0.11	0.32	0.82
Channel 7	Amp. ABS	1.01	1.01	1.01	1.01	1.00	0.96	0.67
	Phase ABS	0.0	-0.1	-0.4	-2.0	-6.1	-18.3	-54.4
	Amp RS	0.01	0.01	0.01	0.03	0.11	0.31	0.82
Channel 9	Amp. ABS	1.00	1.00	1.00	1.00	0.99	0.95	0.66
	Phase ABS	0.0	-0.1	-0.3	-1.9	-6.1	-18.2	-54.3
	Amp RS	0.00	0.00	0.01	0.03	0.11	0.31	0.81
Channel 11	Amp. ABS	1.00	1.00	1.00	1.00	0.99	0.95	0.67
	Phase ABS	0.0	-0.1	-0.3	-1.9	-6.0	-18.1	-54.0
	Amp RS	0.00	0.00	0.01	0.03	0.10	0.31	0.81

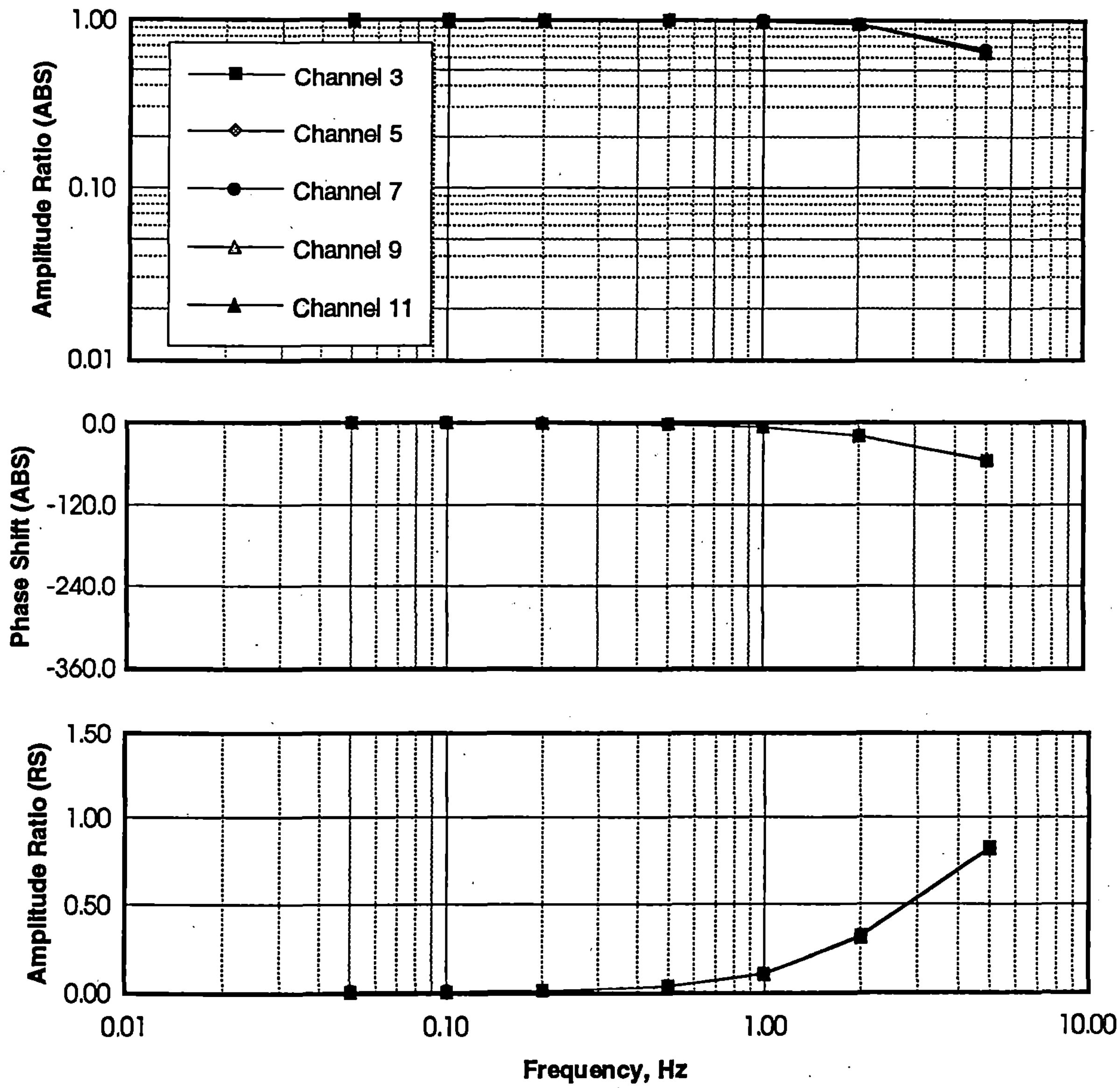


Figure A6 *Measured dynamic response across the air barrier system (ABS) and across the rainscreen(RS) for BV/SS Specimen with 4 head joints and 2 leakage holes under a loading condition of 0 Pa Mean and 500 Pa Amplitude*

		Test Frequency						
		0.05	0.10	0.20	0.50	1.00	2.00	5.00
Channel 3	Amp. ABS	1.00	1.00	1.00	0.99	0.99	0.94	0.64
	Phase ABS	-0.1	-0.2	-0.4	-2.0	-6.2	-18.3	-53.9
	Amp RS	0.00	0.00	0.01	0.04	0.11	0.31	0.81
Channel 5	Amp. ABS	1.00	1.00	1.00	1.00	0.99	0.94	0.65
	Phase ABS	-0.1	-0.2	-0.4	-2.0	-6.1	-18.2	-53.9
	Amp RS	0.00	0.00	0.01	0.04	0.11	0.31	0.81
Channel 7	Amp. ABS	1.00	1.00	1.00	1.00	0.99	0.95	0.66
	Phase ABS	0.0	-0.1	-0.4	-2.0	-6.1	-18.1	-53.6
	Amp RS	0.00	0.00	0.01	0.03	0.11	0.31	0.81
Channel 9	Amp. ABS	1.00	1.00	0.99	0.99	0.99	0.94	0.65
	Phase ABS	-0.1	-0.1	-0.4	-1.9	-6.0	-18.0	-53.3
	Amp RS	0.00	0.00	0.01	0.03	0.10	0.31	0.80
Channel 11	Amp. ABS	1.00	1.00	1.00	0.99	0.99	0.94	0.66
	Phase ABS	0.0	-0.1	-0.3	-1.9	-6.0	-17.8	-52.9
	Amp RS	0.00	0.00	0.01	0.03	0.10	0.31	0.80

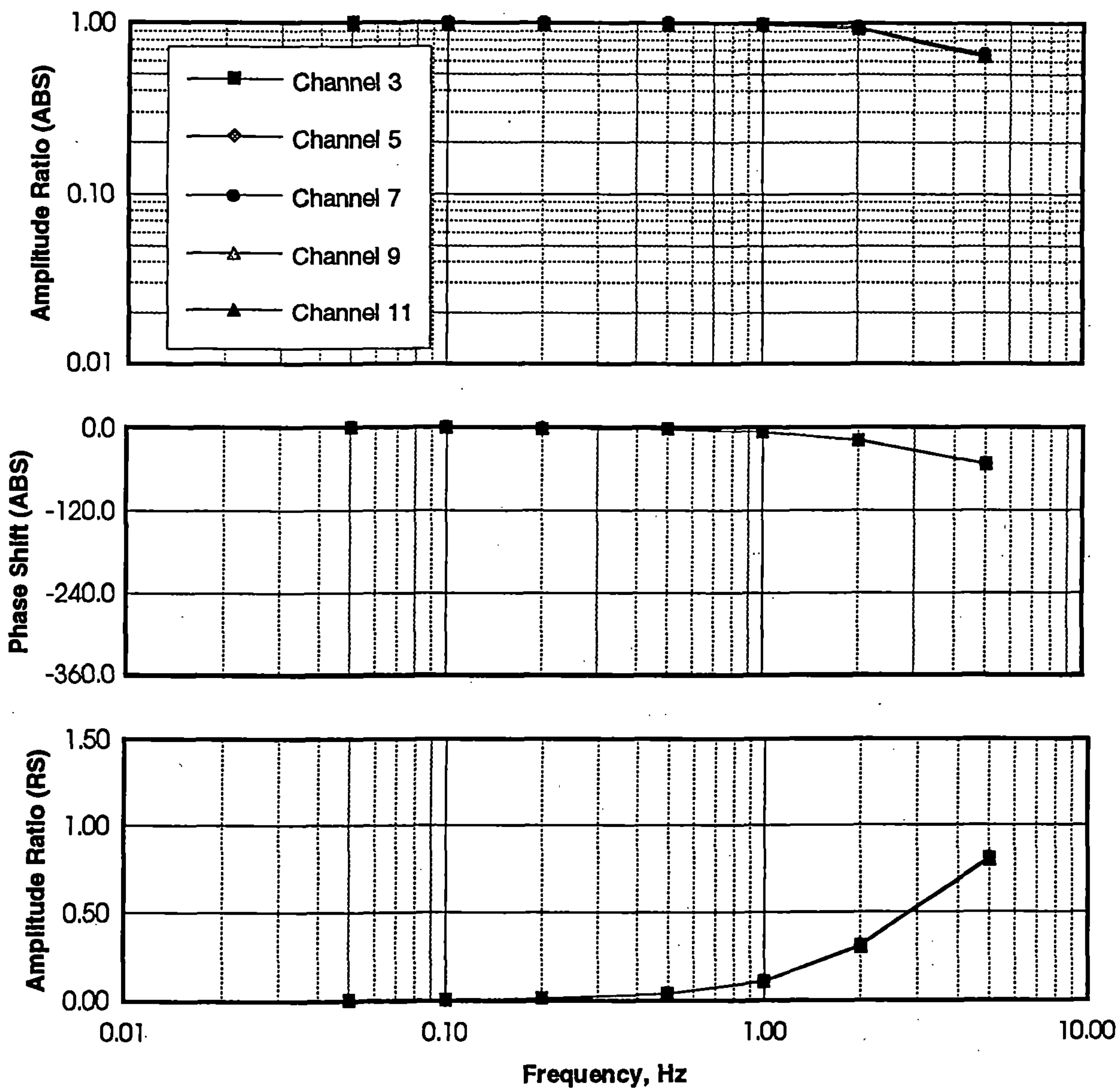


Figure A7 Measured dynamic response across the air barrier system (ABS) and across the rainscreen(RS) for BV/SS Specimen with 4 head joints and 4 leakage holes under a loading condition of 0 Pa Mean and 500 Pa Amplitude

		Test Frequency						
		0.05	0.10	0.20	0.50	1.00	2.00	5.00
Channel 3	Amp. ABS	1.00	1.00	0.99	0.99	0.98	0.92	0.63
	Phase ABS	-0.1	-0.2	-0.5	-2.1	-6.2	-18.3	-53.1
	Amp RS	0.00	0.01	0.01	0.04	0.11	0.31	0.80
Channel 5	Amp. ABS	1.00	1.00	1.00	0.99	0.98	0.93	0.64
	Phase ABS	-0.1	-0.2	-0.5	-2.1	-6.2	-18.1	-53.0
	Amp RS	0.00	0.00	0.01	0.04	0.11	0.31	0.80
Channel 7	Amp. ABS	1.00	1.00	1.00	1.00	0.98	0.94	0.66
	Phase ABS	-0.1	-0.2	-0.5	-2.0	-6.1	-18.1	-52.9
	Amp RS	0.00	0.00	0.01	0.04	0.11	0.31	0.80
Channel 9	Amp. ABS	0.99	0.99	0.99	0.99	0.98	0.93	0.65
	Phase ABS	-0.1	-0.2	-0.5	-2.0	-6.1	-17.9	-52.5
	Amp RS	0.01	0.01	0.01	0.04	0.11	0.31	0.79
Channel 11	Amp. ABS	0.99	0.99	0.99	0.99	0.98	0.93	0.65
	Phase ABS	-0.1	-0.2	-0.5	-2.0	-6.0	-17.8	-52.0
	Amp RS	0.01	0.01	0.01	0.04	0.10	0.31	0.79

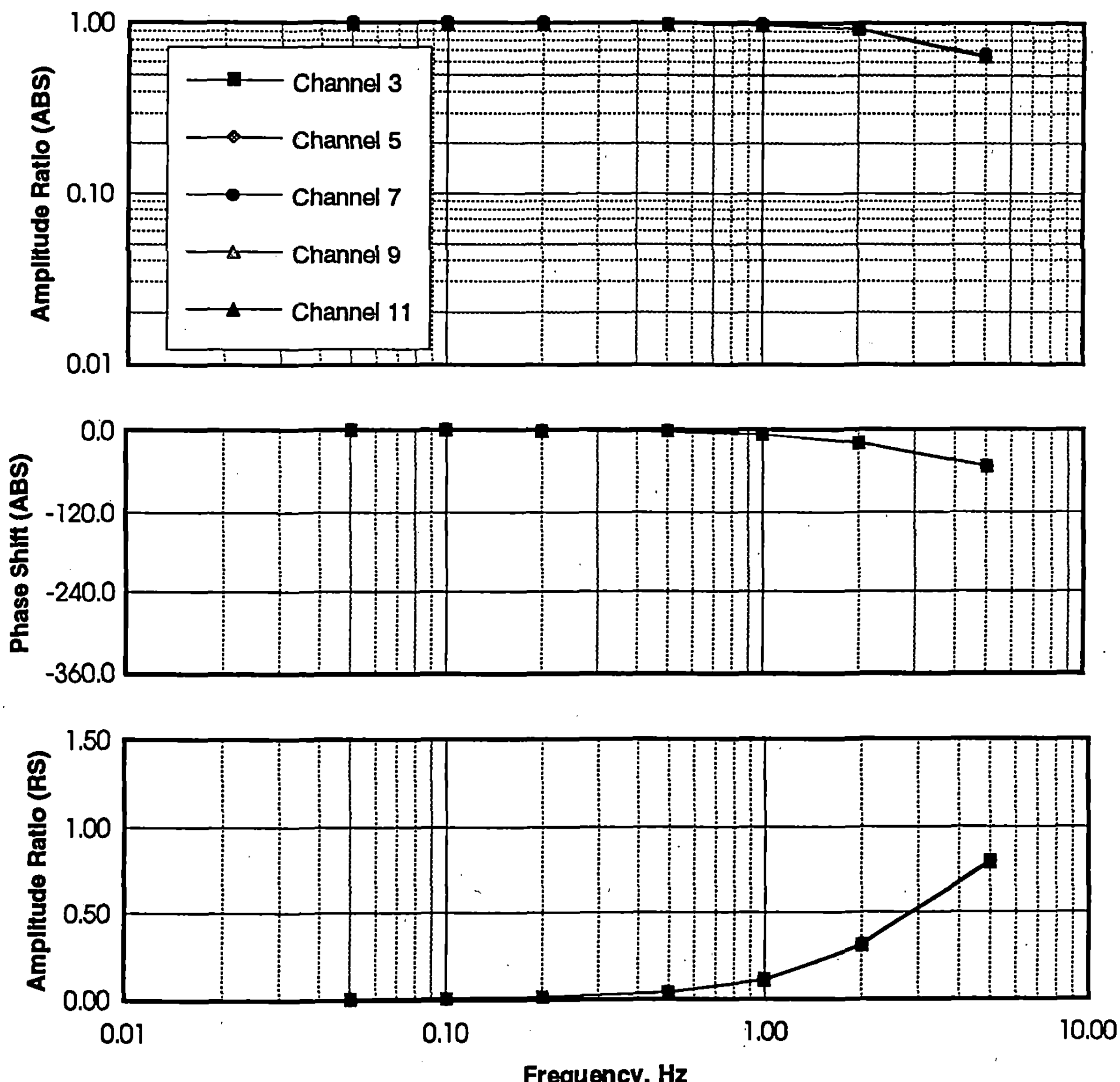


Figure A8 *Measured dynamic response across the air barrier system (ABS) and across the rainscreen(RS) for BV/SS Specimen with 4 head joints and 6 leakage holes under a loading condition of 0 Pa Mean and 500 Pa Amplitude*

		Test Frequency						
		0.05	0.10	0.20	0.50	1.00	2.00	5.00
Channel 3	Amp. ABS	0.99	0.99	0.99	0.98	0.97	0.91	0.62
	Phase ABS	-0.1	-0.3	-0.7	-2.1	-6.2	-18.0	-51.9
	Amp RS	0.01	0.01	0.02	0.04	0.11	0.31	0.79
Channel 5	Amp. ABS	0.99	0.99	0.99	0.99	0.97	0.92	0.64
	Phase ABS	-0.1	-0.3	-0.6	-2.1	-6.1	-17.9	-52.1
	Amp RS	0.01	0.01	0.01	0.04	0.11	0.31	0.79
Channel 7	Amp. ABS	1.00	1.00	1.00	0.99	0.98	0.92	0.65
	Phase ABS	-0.1	-0.3	-0.6	-2.1	-6.1	-17.9	-52.3
	Amp RS	0.00	0.01	0.01	0.04	0.11	0.31	0.79
Channel 9	Amp. ABS	0.99	0.99	0.99	0.98	0.97	0.92	0.64
	Phase ABS	-0.1	-0.2	-0.6	-2.1	-5.9	-17.7	-51.6
	Amp RS	0.01	0.01	0.02	0.04	0.11	0.31	0.78
Channel 11	Amp. ABS	0.99	0.99	0.99	0.98	0.97	0.92	0.65
	Phase ABS	-0.1	-0.3	-0.6	-2.1	-5.9	-17.6	-51.5
	Amp RS	0.01	0.01	0.02	0.04	0.11	0.30	0.78

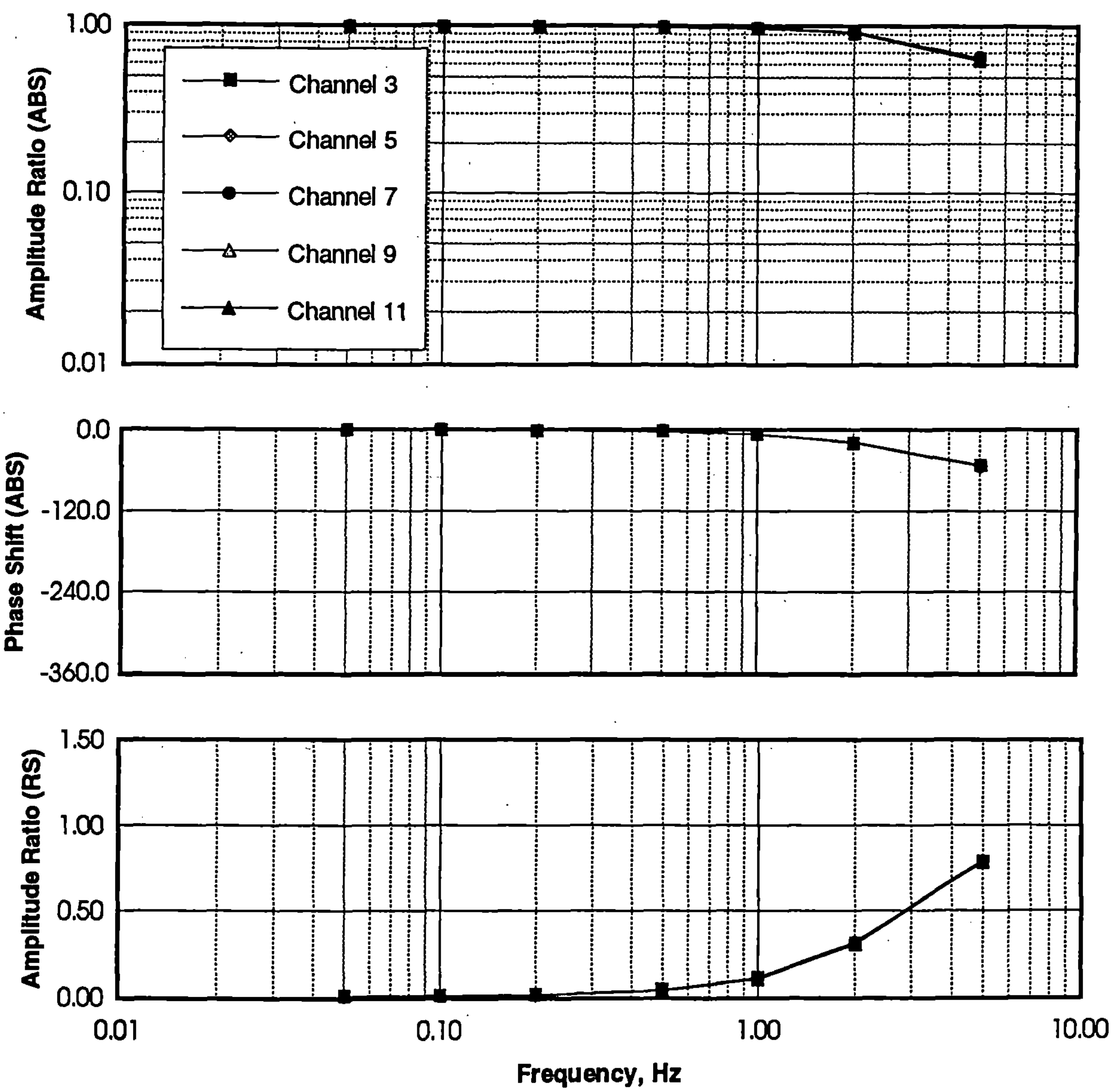


Figure A9 *Measured dynamic response across the air barrier system (ABS) and across the rainscreen(RS) for BV/SS Specimen with 8 head joints and 0 leakage holes under a loading condition of 0 Pa Mean and 1000 Pa Amplitude*

		Test Frequency						
		0.05	0.10	0.20	0.50	1.00	2.00	5.00
Channel 3	Amp. ABS	1.00	1.00	1.00	1.00	1.00	0.97	0.74
	Phase ABS	0.0	-0.1	-0.3	-1.2	-4.1	-13.4	-46.0
	Amp RS	0.00	0.00	0.00	0.02	0.07	0.23	0.72
Channel 5	Amp. ABS	1.00	1.00	1.00	1.00	1.00	0.97	0.75
	Phase ABS	0.0	-0.1	-0.3	-1.2	-4.0	-13.3	-45.8
	Amp RS	0.00	0.00	0.00	0.02	0.07	0.23	0.72
Channel 7	Amp. ABS	1.01	1.01	1.01	1.01	1.01	0.98	0.77
	Phase ABS	0.0	0.0	-0.2	-1.1	-3.9	-13.1	-46.0
	Amp RS	0.01	0.01	0.01	0.02	0.07	0.23	0.72
Channel 9	Amp. ABS	1.00	1.00	1.00	1.00	1.00	0.97	0.74
	Phase ABS	0.0	0.0	-0.2	-1.1	-3.9	-13.0	-45.1
	Amp RS	0.00	0.00	0.00	0.02	0.07	0.22	0.71
Channel 11	Amp. ABS	1.00	1.00	1.00	1.00	1.00	0.98	0.75
	Phase ABS	0.0	0.0	-0.2	-1.0	-3.8	-12.8	-45.0
	Amp RS	0.00	0.00	0.00	0.02	0.07	0.22	0.71

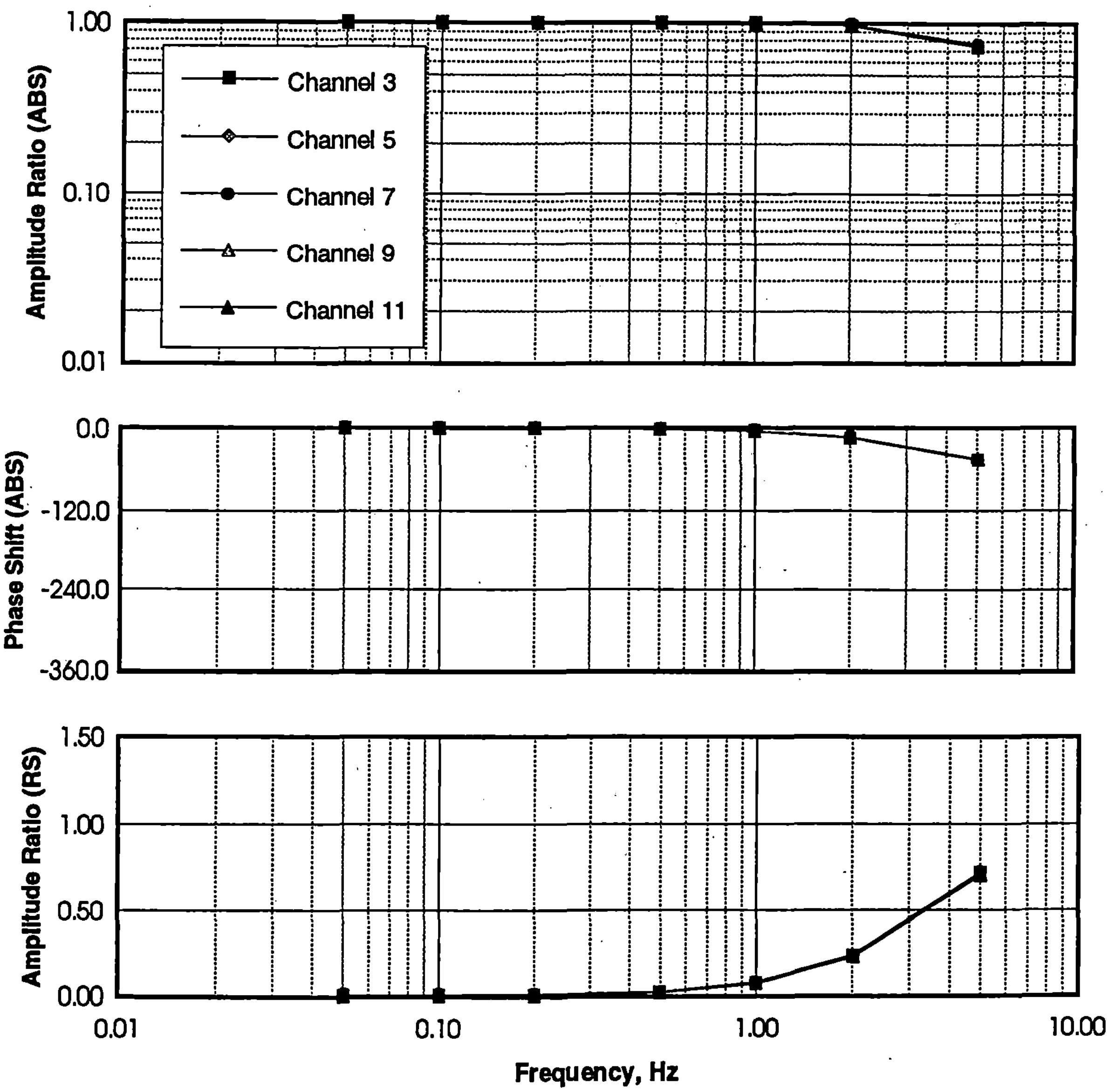


***Figure A10** Measured dynamic response across the air barrier system (ABS) and across the rainscreen(RS) for BV/SS Specimen with 8 head joints and 2 leakage holes under a loading condition of 0 Pa Mean and 1000 Pa Amplitude*

		Test Frequency						
		0.05	0.10	0.20	0.50	1.00	2.00	5.00
Channel 3	Amp. ABS	1.00	1.00	1.00	1.00	0.99	0.97	0.73
	Phase ABS	0.0	-0.1	-0.3	-1.2	-4.0	-13.2	-45.5
	Amp RS	0.00	0.00	0.00	0.02	0.07	0.23	0.71
Channel 5	Amp. ABS	1.00	1.00	1.00	1.00	1.00	0.97	0.75
	Phase ABS	0.0	-0.1	-0.3	-1.2	-4.0	-13.1	-45.3
	Amp RS	0.00	0.00	0.00	0.02	0.07	0.23	0.71
Channel 7	Amp. ABS	1.01	1.01	1.01	1.00	1.00	0.98	0.76
	Phase ABS	0.0	-0.1	-0.2	-1.1	-3.9	-12.9	-45.4
	Amp RS	0.01	0.01	0.01	0.02	0.07	0.22	0.71
Channel 9	Amp. ABS	1.00	1.00	1.00	1.00	0.99	0.97	0.74
	Phase ABS	0.0	-0.1	-0.2	-1.1	-3.8	-12.8	-44.8
	Amp RS	0.00	0.00	0.00	0.02	0.07	0.22	0.70
Channel 11	Amp. ABS	1.00	1.00	1.00	1.00	0.99	0.97	0.76
	Phase ABS	0.0	0.0	-0.2	-1.1	-3.8	-12.6	-44.6
	Amp RS	0.00	0.00	0.00	0.02	0.07	0.22	0.70

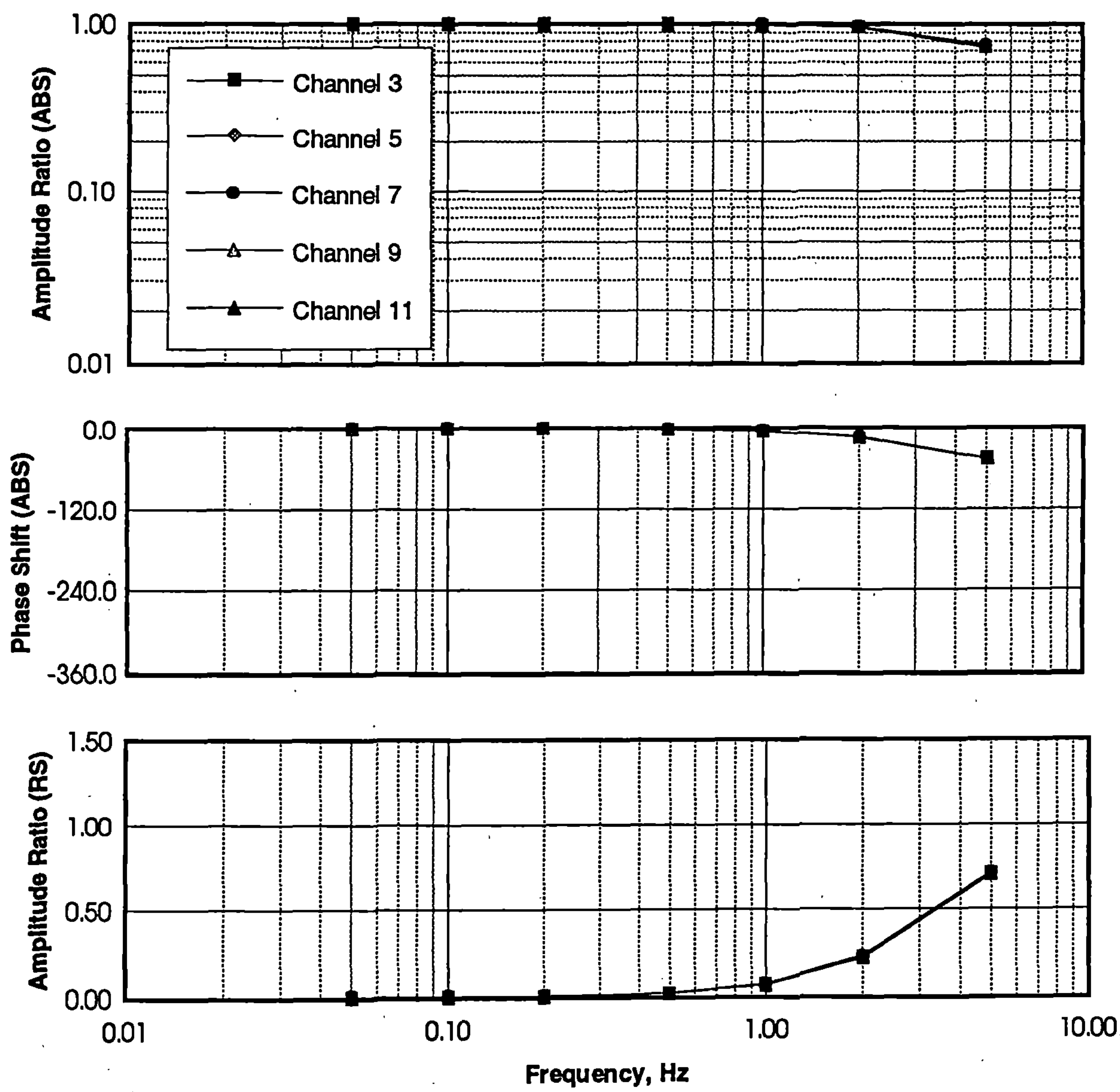


Figure A11 *Measured dynamic response across the air barrier system (ABS) and across the rainscreen(RS) for BV/SS Specimen with 8 head joints and 4 leakage holes under a loading condition of 0 Pa Mean and 1000 Pa Amplitude*

		Test Frequency						
		0.05	0.10	0.20	0.50	1.00	2.00	5.00
Channel 3	Amp. ABS	1.00	1.00	1.00	1.00	0.99	0.96	0.73
	Phase ABS	-0.1	-0.1	-0.3	-1.2	-4.0	-13.1	-45.4
	Amp RS	0.00	0.00	0.01	0.02	0.07	0.23	0.71
Channel 5	Amp. ABS	1.00	1.00	1.00	1.00	0.99	0.96	0.74
	Phase ABS	-0.1	-0.1	-0.3	-1.2	-4.0	-13.0	-45.2
	Amp RS	0.00	0.00	0.00	0.02	0.07	0.23	0.71
Channel 7	Amp. ABS	1.01	1.00	1.00	1.00	1.00	0.97	0.76
	Phase ABS	-0.1	-0.1	-0.2	-1.2	-4.0	-13.0	-45.0
	Amp RS	0.01	0.00	0.01	0.02	0.07	0.22	0.71
Channel 9	Amp. ABS	1.00	1.00	1.00	0.99	0.99	0.96	0.74
	Phase ABS	0.0	-0.1	-0.2	-1.1	-3.9	-12.7	-44.5
	Amp RS	0.00	0.00	0.00	0.02	0.07	0.22	0.70
Channel 11	Amp. ABS	1.00	1.00	1.00	1.00	0.99	0.96	0.75
	Phase ABS	0.0	-0.1	-0.2	-1.1	-3.7	-12.8	-44.1
	Amp RS	0.00	0.00	0.00	0.02	0.07	0.22	0.70

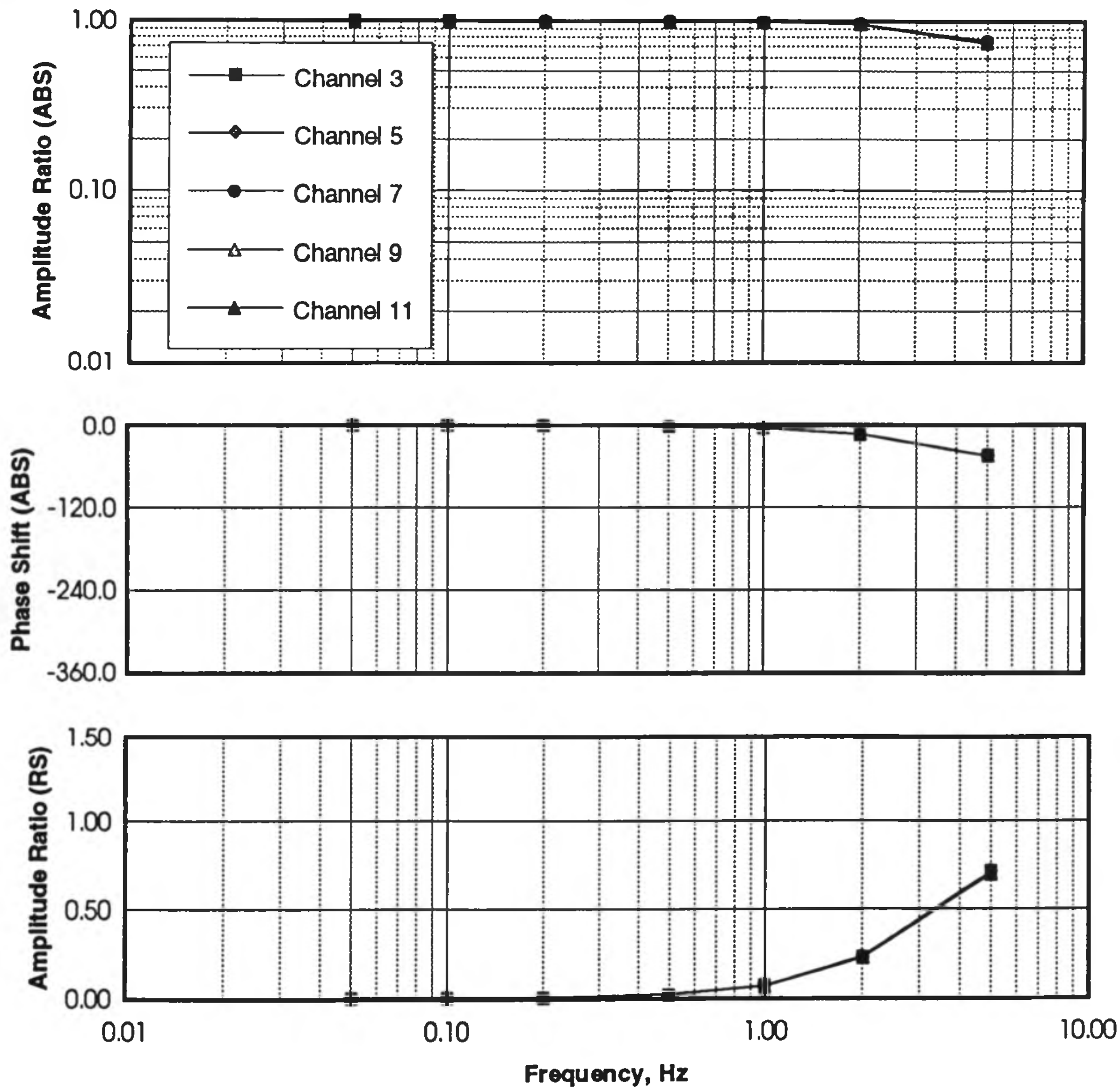


Figure A12 *Measured dynamic response across the air barrier system (ABS) and across the rainscreen(RS) for BV/SS Specimen with 8 head joints and 6 leakage holes under a loading condition of 0 Pa Mean and 1000 Pa Amplitude*

		Test Frequency						
		0.05	0.10	0.20	0.50	1.00	2.00	5.00
Channel 3	Amp. ABS	1.00	1.00	1.00	0.99	0.99	0.95	0.73
	Phase ABS	-0.1	-0.1	-0.3	-1.3	-4.0	-13.1	-44.3
	Amp RS	0.00	0.00	0.01	0.02	0.07	0.23	0.70
Channel 5	Amp. ABS	1.00	1.00	1.00	0.99	0.99	0.96	0.74
	Phase ABS	-0.1	-0.1	-0.3	-1.2	-4.0	-12.9	-44.3
	Amp RS	0.00	0.00	0.01	0.02	0.07	0.22	0.70
Channel 7	Amp. ABS	1.00	1.00	1.00	1.00	0.99	0.96	0.76
	Phase ABS	-0.1	-0.1	-0.3	-1.2	-4.0	-12.9	-44.3
	Amp RS	0.00	0.00	0.01	0.02	0.07	0.22	0.70
Channel 9	Amp. ABS	1.00	1.00	0.99	0.99	0.99	0.95	0.74
	Phase ABS	0.0	-0.1	-0.3	-1.2	-3.9	-12.7	-43.7
	Amp RS	0.00	0.00	0.01	0.02	0.07	0.22	0.69
Channel 11	Amp. ABS	1.00	1.00	1.00	0.99	0.99	0.96	0.76
	Phase ABS	-0.1	-0.1	-0.3	-1.2	-3.8	-12.7	-43.7
	Amp RS	0.00	0.00	0.01	0.02	0.07	0.22	0.69

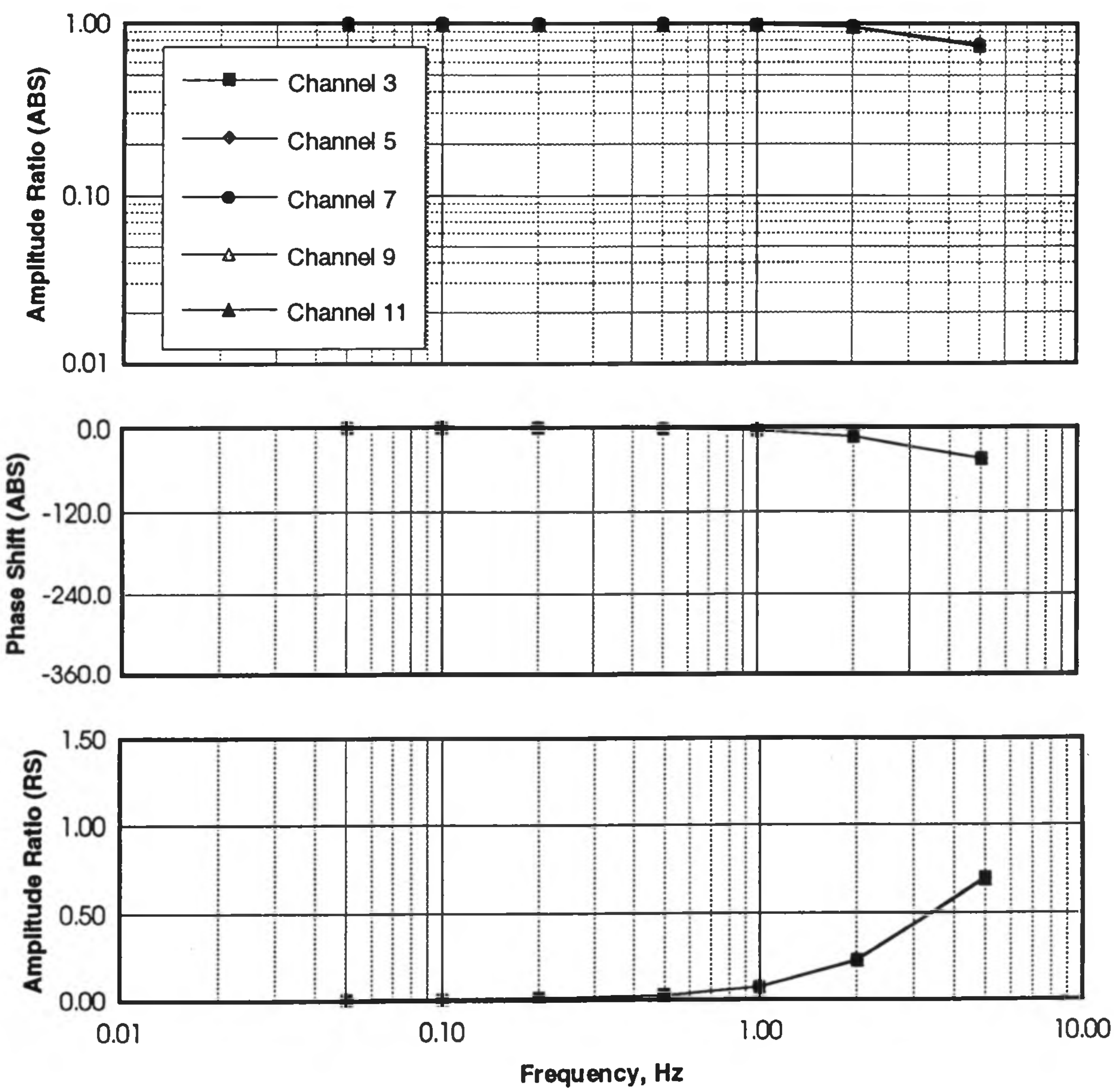


Figure A13 *Measured dynamic response across the air barrier system (ABS) and across the rainscreen(RS) for BV/SS Specimen with 4 head joints and 0 leakage holes under a loading condition of 0 Pa Mean and 1000 Pa Amplitude*

		Test Frequency						
		0.05	0.10	0.20	0.50	1.00	2.00	5.00
Channel 3	Amp. ABS	1.00	1.00	1.00	1.00	0.97	0.85	0.48
	Phase ABS	-0.1	-0.2	-0.7	-3.5	-10.9	-29.3	-61.7
	Amp RS	0.00	0.00	0.01	0.06	0.19	0.49	0.88
Channel 5	Amp. ABS	1.00	1.00	1.00	1.00	0.97	0.85	0.49
	Phase ABS	-0.1	-0.2	-0.7	-3.5	-10.8	-29.1	-61.4
	Amp RS	0.00	0.00	0.01	0.06	0.19	0.49	0.88
Channel 7	Amp. ABS	1.01	1.01	1.01	1.00	0.98	0.86	0.50
	Phase ABS	-0.1	-0.2	-0.7	-3.4	-10.7	-29.0	-61.3
	Amp RS	0.01	0.01	0.01	0.06	0.19	0.48	0.88
Channel 9	Amp. ABS	1.00	1.00	1.00	0.99	0.97	0.85	0.49
	Phase ABS	-0.1	-0.2	-0.7	-3.4	-10.7	-28.9	-61.0
	Amp RS	0.00	0.00	0.01	0.06	0.19	0.48	0.87
Channel 11	Amp. ABS	1.00	1.00	1.00	1.00	0.97	0.85	0.50
	Phase ABS	-0.1	-0.2	-0.7	-3.3	-10.6	-28.7	-60.7
	Amp RS	0.00	0.00	0.01	0.06	0.18	0.48	0.87

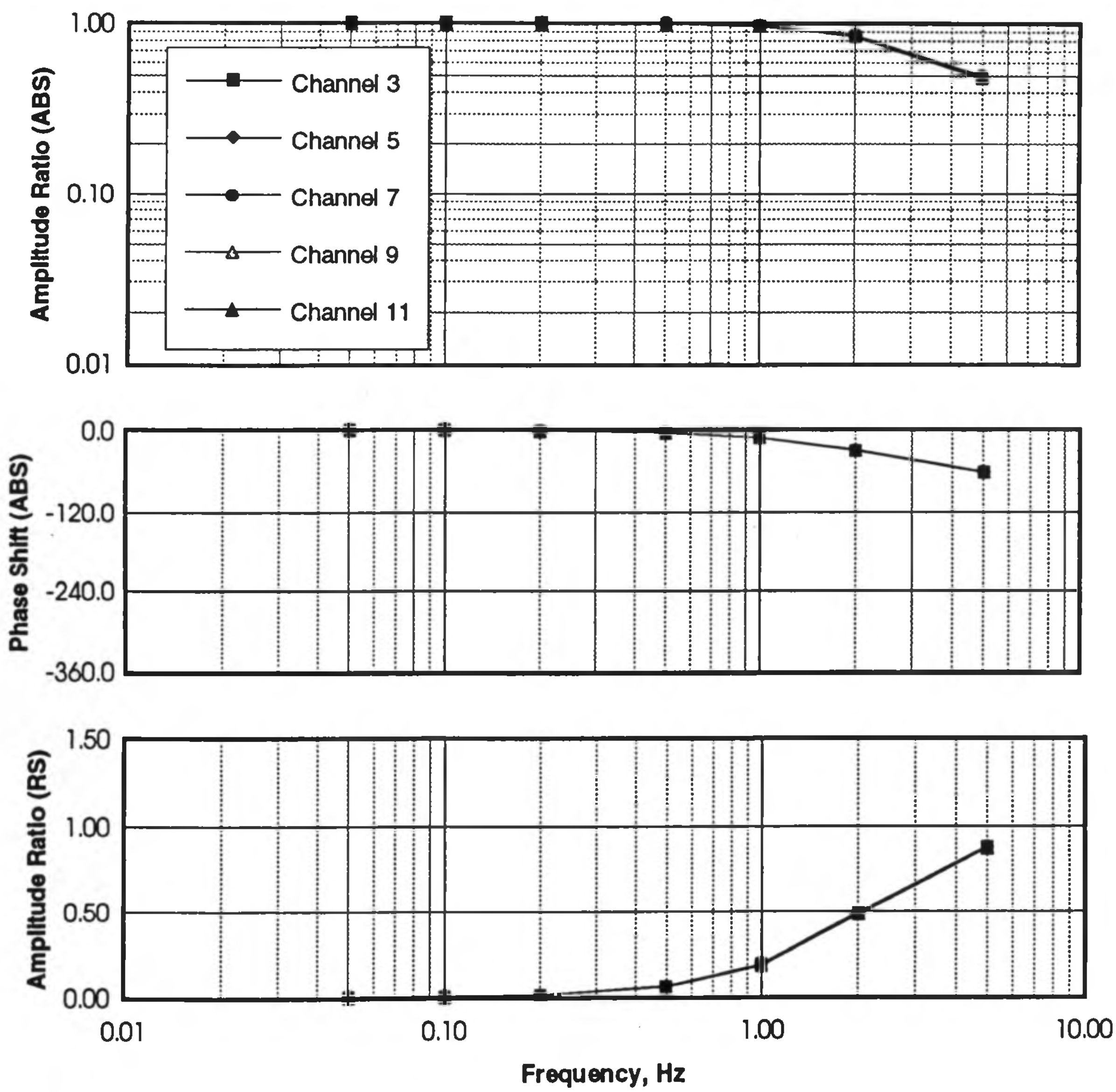


Figure A14 *Measured dynamic response across the air barrier system (ABS) and across the rainscreen(RS) for BV/SS Specimen with 4 head joints and 2 leakage holes under a loading condition of 0 Pa Mean and 1000 Pa Amplitude*

		Test Frequency						
		0.05	0.10	0.20	0.50	1.00	2.00	5.00
Channel 3	Amp. ABS	1.00	1.00	1.00	0.99	0.96	0.84	0.48
	Phase ABS	-0.1	-0.2	-0.7	-3.5	-10.7	-28.7	-60.4
	Amp RS	0.00	0.00	0.01	0.06	0.19	0.48	0.87
Channel 5	Amp. ABS	1.00	1.00	1.00	0.99	0.96	0.84	0.49
	Phase ABS	-0.1	-0.3	-0.7	-3.4	-10.7	-28.6	-60.3
	Amp RS	0.00	0.00	0.01	0.06	0.19	0.48	0.87
Channel 7	Amp. ABS	1.00	1.00	1.00	1.00	0.97	0.85	0.50
	Phase ABS	-0.1	-0.2	-0.7	-3.4	-10.6	-28.4	-60.4
	Amp RS	0.01	0.01	0.01	0.06	0.18	0.48	0.87
Channel 9	Amp. ABS	1.00	1.00	0.99	0.99	0.96	0.84	0.49
	Phase ABS	-0.1	-0.2	-0.7	-3.4	-10.5	-28.3	-59.7
	Amp RS	0.00	0.01	0.01	0.06	0.18	0.48	0.86
Channel 11	Amp. ABS	1.00	1.00	1.00	0.99	0.96	0.85	0.49
	Phase ABS	-0.1	-0.2	-0.7	-3.3	-10.4	-28.2	-59.5
	Amp RS	0.00	0.00	0.01	0.06	0.18	0.47	0.86

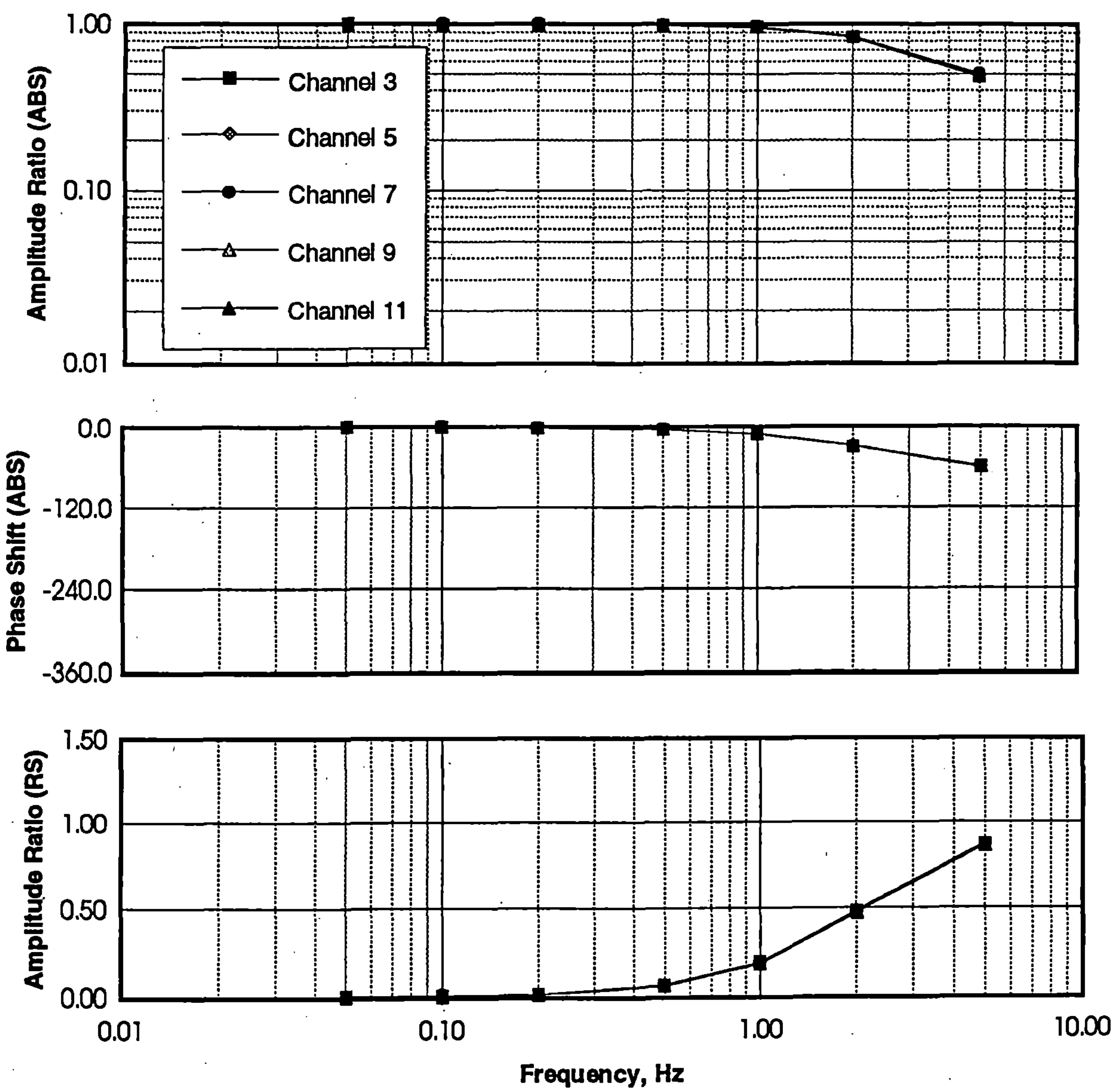


Figure A15 *Measured dynamic response across the air barrier system (ABS) and across the rainscreen(RS) for BV/SS Specimen with 4 head joints and 4 leakage holes under a loading condition of 0 Pa Mean and 1000 Pa Amplitude*

		Test Frequency						
		0.05	0.10	0.20	0.50	1.00	2.00	5.00
Channel 3	Amp. ABS	1.00	1.00	0.99	0.98	0.95	0.83	0.46
	Phase ABS	-0.1	-0.3	-0.8	-3.5	-10.6	-28.0	-60.7
	Amp RS	0.00	0.01	0.02	0.06	0.19	0.47	0.87
Channel 5	Amp. ABS	1.00	1.00	0.99	0.98	0.95	0.84	0.47
	Phase ABS	-0.1	-0.3	-0.8	-3.5	-10.6	-27.9	-60.7
	Amp RS	0.00	0.01	0.02	0.06	0.19	0.47	0.87
Channel 7	Amp. ABS	1.00	1.00	1.00	0.99	0.96	0.84	0.48
	Phase ABS	-0.1	-0.3	-0.8	-3.4	-10.5	-27.9	-60.7
	Amp RS	0.00	0.01	0.01	0.06	0.18	0.47	0.87
Channel 9	Amp. ABS	0.99	0.99	0.99	0.98	0.95	0.83	0.47
	Phase ABS	-0.1	-0.3	-0.8	-3.4	-10.4	-27.7	-60.2
	Amp RS	0.01	0.01	0.02	0.06	0.18	0.47	0.87
Channel 11	Amp. ABS	1.00	0.99	0.99	0.98	0.95	0.84	0.48
	Phase ABS	-0.1	-0.3	-0.8	-3.4	-10.3	-27.6	-60.1
	Amp RS	0.01	0.01	0.02	0.06	0.18	0.47	0.87

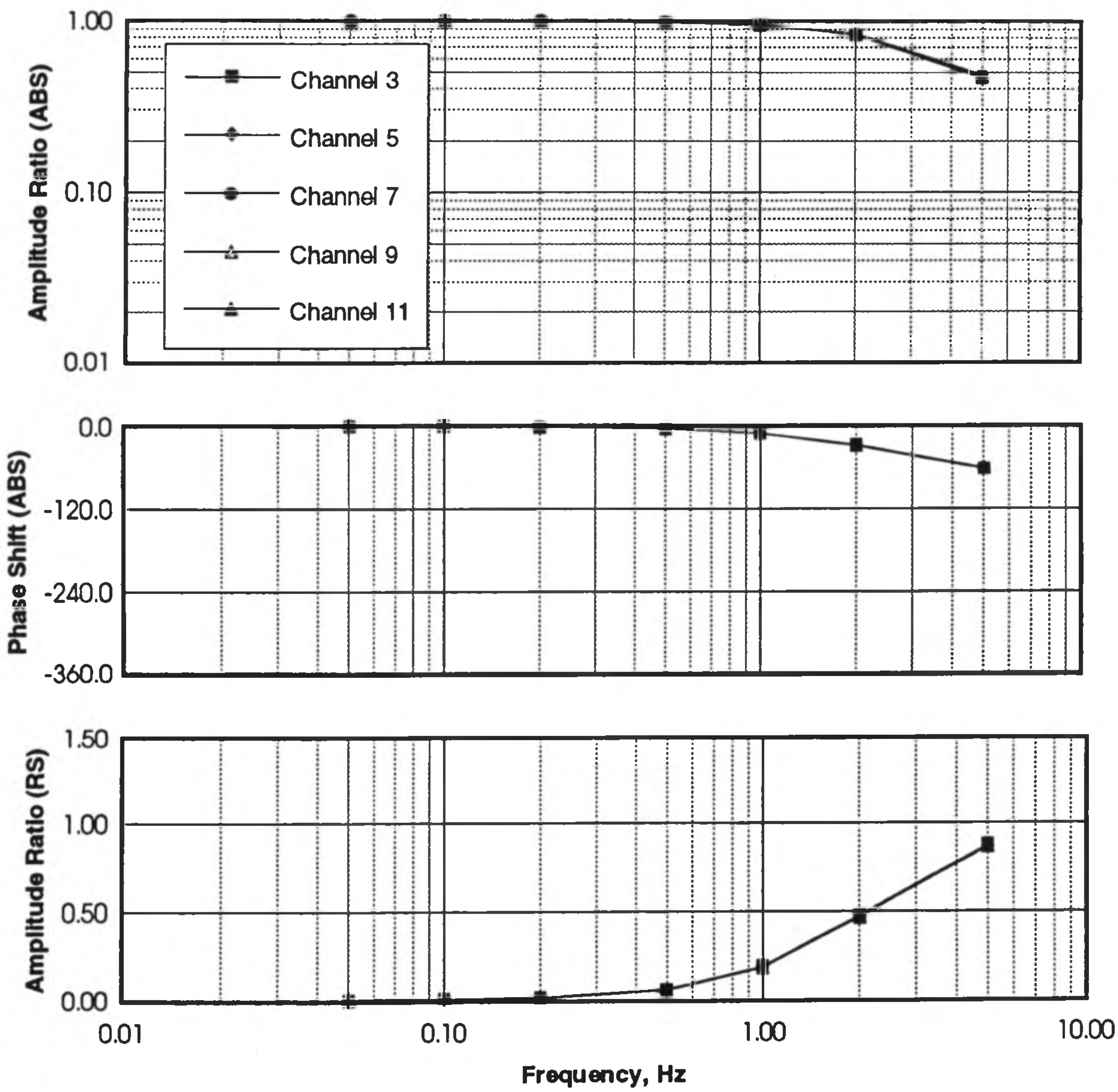


Figure A16 *Measured dynamic response across the air barrier system (ABS) and across the rainscreen(RS) for BV/SS Specimen with 4 head joints and 6 leakage holes under a loading condition of 0 Pa Mean and 1000 Pa Amplitude*

		Test Frequency						
		0.05	0.10	0.20	0.50	1.00	2.00	5.00
Channel 3	Amp. ABS	0.99	0.99	0.99	0.98	0.94	0.82	0.45
	Phase ABS	-0.2	-0.4	-0.9	-3.6	-10.5	-27.5	-60.7
	Amp RS	0.01	0.01	0.02	0.07	0.19	0.47	0.87
Channel 5	Amp. ABS	0.99	0.99	0.99	0.98	0.94	0.83	0.46
	Phase ABS	-0.2	-0.4	-0.9	-3.6	-10.4	-27.4	-60.4
	Amp RS	0.01	0.01	0.02	0.07	0.18	0.46	0.87
Channel 7	Amp. ABS	1.00	1.00	0.99	0.98	0.95	0.83	0.47
	Phase ABS	-0.2	-0.4	-0.9	-3.5	-10.4	-27.3	-60.2
	Amp RS	0.00	0.01	0.02	0.06	0.18	0.46	0.87
Channel 9	Amp. ABS	0.99	0.99	0.99	0.97	0.94	0.83	0.46
	Phase ABS	-0.2	-0.4	-0.9	-3.5	-10.3	-27.1	-59.8
	Amp RS	0.01	0.01	0.02	0.07	0.18	0.46	0.87
Channel 11	Amp. ABS	0.99	0.99	0.99	0.98	0.94	0.83	0.47
	Phase ABS	-0.2	-0.4	-0.8	-3.4	-10.2	-27.1	-59.6
	Amp RS	0.01	0.01	0.02	0.06	0.18	0.46	0.86

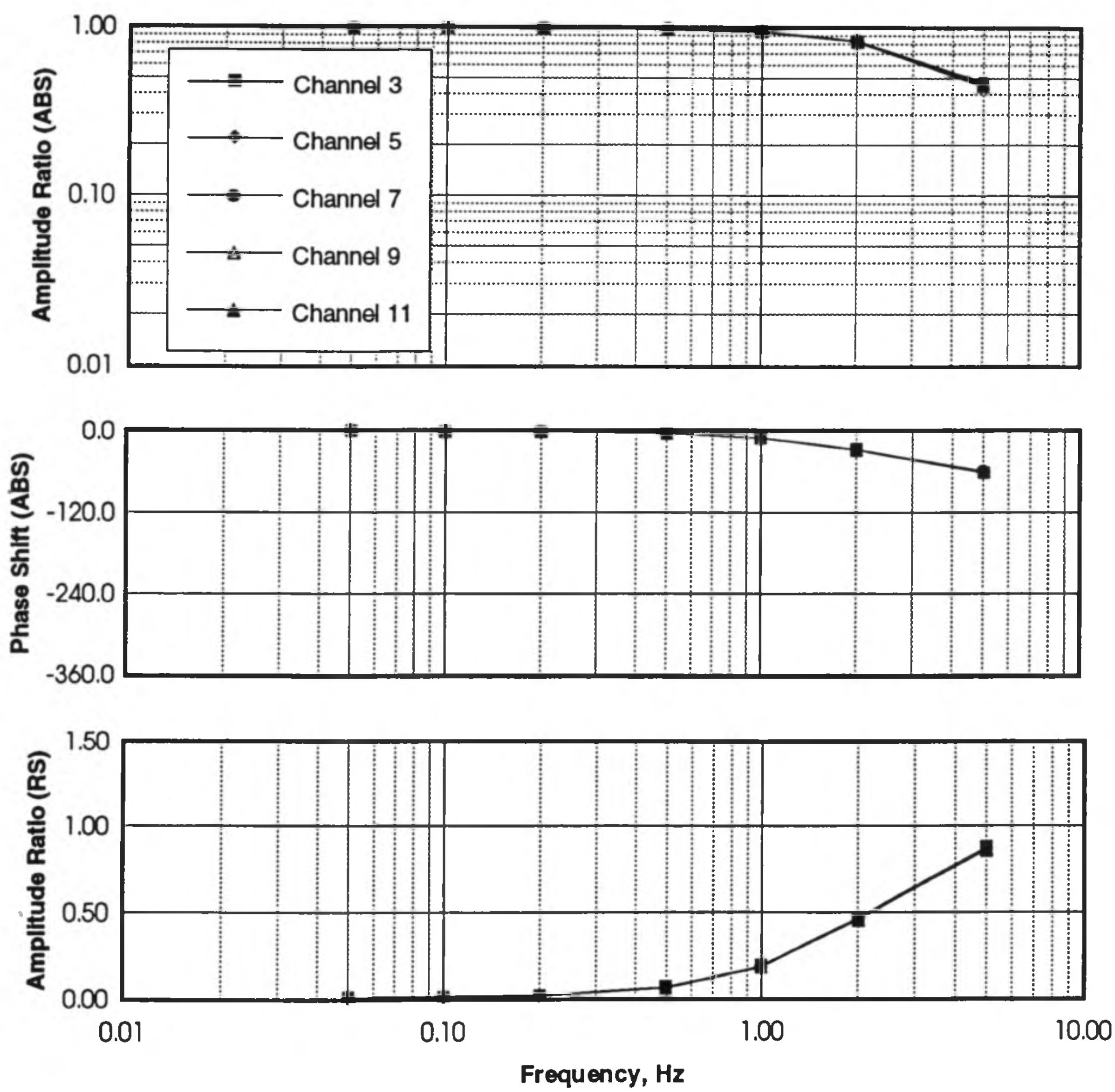


***Figure A17** Measured dynamic response across the air barrier system (ABS) and across the rainscreen(RS) for BV/SS Specimen with 8 head joints and 0 leakage holes under a loading condition of 500 Pa Mean and 500 Pa Amplitude*

		Test Frequency						
		0.05	0.10	0.20	0.50	1.00	2.00	5.00
Channel 3	Amp. ABS	1.00	1.00	1.00	1.00	1.00	1.01	0.90
	Phase ABS	0.0	-0.1	-0.2	-0.7	-2.4	-7.9	-36.7
	Amp RS	0.00	0.00	0.00	0.01	0.04	0.14	0.61
Channel 5	Amp. ABS	1.00	1.00	1.00	1.00	1.01	1.01	0.91
	Phase ABS	0.0	0.0	-0.2	-0.7	-2.3	-7.8	-36.6
	Amp RS	0.00	0.00	0.00	0.01	0.04	0.14	0.61
Channel 7	Amp. ABS	1.01	1.01	1.01	1.01	1.01	1.02	0.93
	Phase ABS	0.0	0.0	-0.1	-0.6	-2.3	-7.7	-36.5
	Amp RS	0.01	0.01	0.01	0.01	0.04	0.14	0.61
Channel 9	Amp. ABS	1.00	1.00	1.00	1.00	1.00	1.01	0.91
	Phase ABS	0.0	0.0	-0.1	-0.6	-2.2	-7.5	-36.0
	Amp RS	0.00	0.00	0.00	0.01	0.04	0.13	0.60
Channel 11	Amp. ABS	1.00	1.00	1.00	1.00	1.01	1.01	0.93
	Phase ABS	0.0	0.0	-0.1	-0.5	-2.1	-7.3	-35.7
	Amp RS	0.00	0.00	0.00	0.01	0.04	0.13	0.60

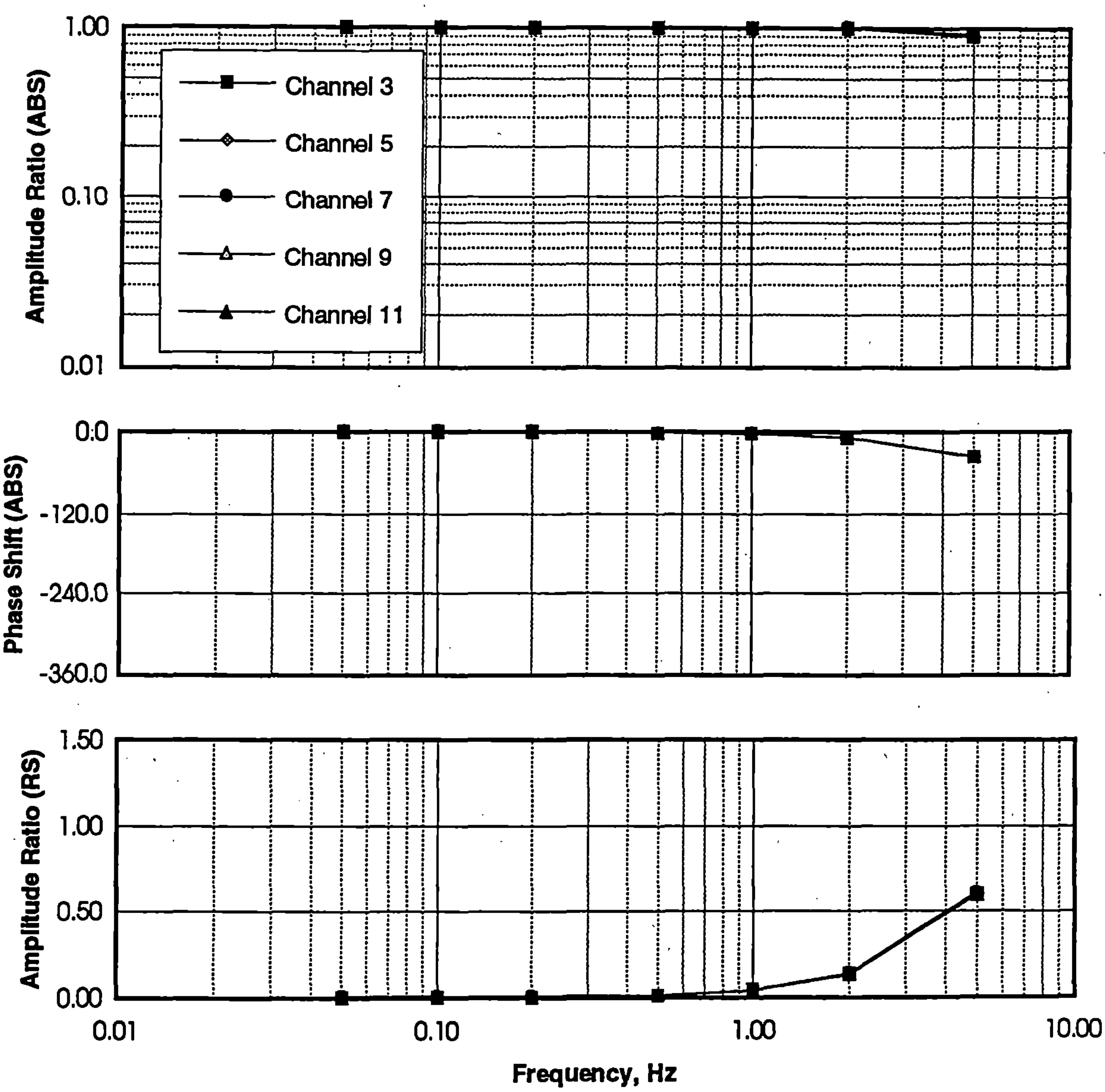


***Figure A18** Measured dynamic response across the air barrier system (ABS) and across the rainscreen(RS) for BV/SS Specimen with 8 head joints and 2 leakage holes under a loading condition of 500 Pa Mean and 500 Pa Amplitude*

		Test Frequency						
		0.05	0.10	0.20	0.50	1.00	2.00	5.00
Channel 3	Amp. ABS	1.00	1.00	1.00	1.00	1.00	1.00	0.89
	Phase ABS	0.0	-0.1	-0.2	-0.7	-2.4	-7.9	-36.3
	Amp RS	0.00	0.00	0.00	0.01	0.04	0.14	0.60
Channel 5	Amp. ABS	1.00	1.00	1.00	1.00	1.00	1.01	0.91
	Phase ABS	0.0	0.0	-0.1	-0.7	-2.3	-7.8	-36.2
	Amp RS	0.00	0.00	0.00	0.01	0.04	0.14	0.60
Channel 7	Amp. ABS	1.01	1.01	1.01	1.01	1.01	1.02	0.93
	Phase ABS	0.0	-0.1	-0.2	-0.6	-2.3	-7.7	-36.2
	Amp RS	0.01	0.01	0.01	0.01	0.04	0.14	0.60
Channel 9	Amp. ABS	1.00	1.00	1.00	1.00	1.00	1.00	0.90
	Phase ABS	0.0	0.0	-0.1	-0.7	-2.2	-7.5	-35.7
	Amp RS	0.00	0.00	0.00	0.01	0.04	0.13	0.59
Channel 11	Amp. ABS	1.00	1.00	1.00	1.00	1.00	1.01	0.92
	Phase ABS	0.0	0.0	-0.1	-0.6	-2.1	-7.4	-35.6
	Amp RS	0.00	0.00	0.00	0.01	0.04	0.13	0.59

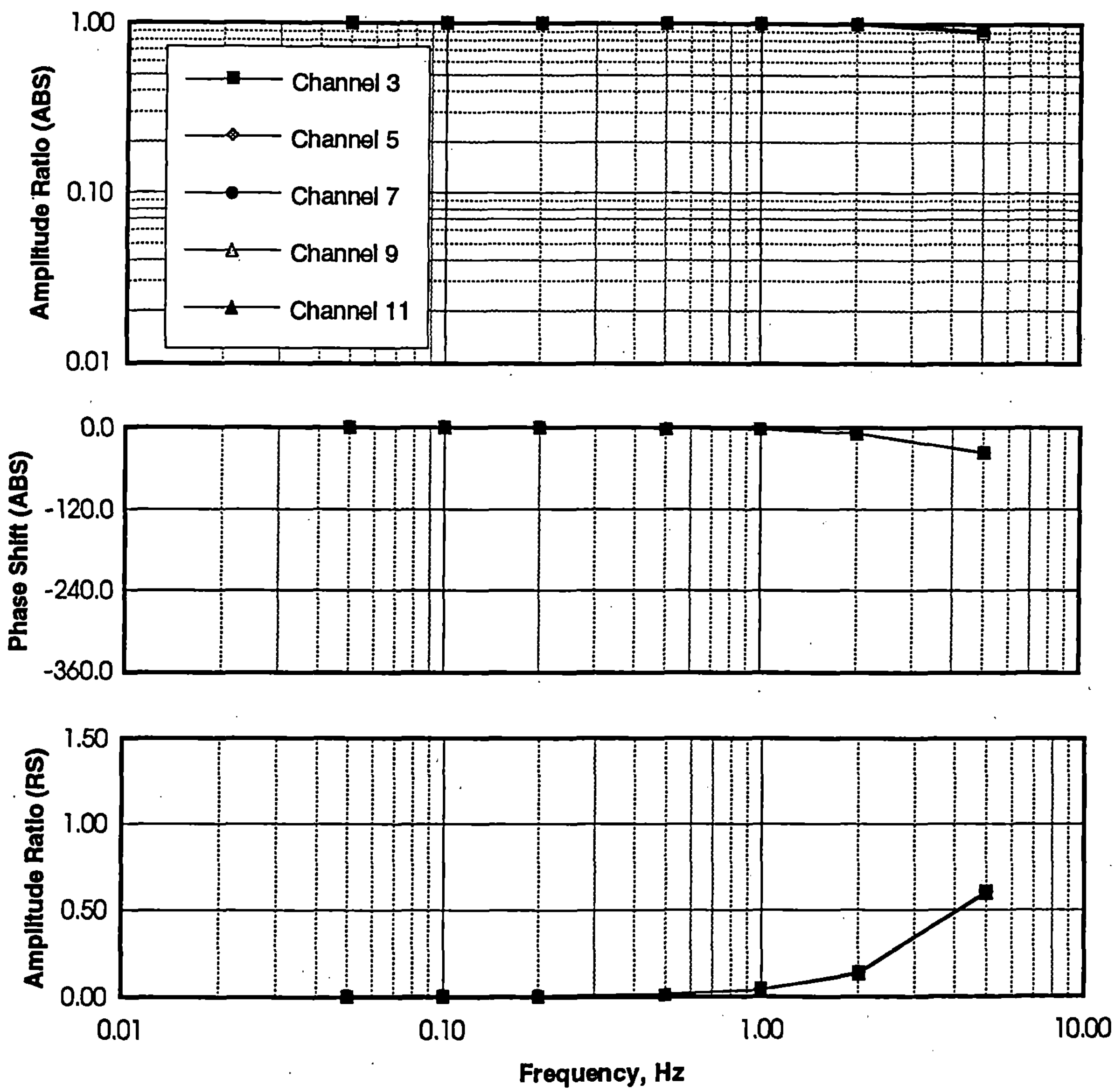


***Figure A19**. Measured dynamic response across the air barrier system (ABS) and across the rainscreen(RS) for BV/SS Specimen with 8 head joints and 4 leakage holes under a loading condition of 500 Pa Mean and 500 Pa Amplitude*

		Test Frequency						
		0.05	0.10	0.20	0.50	1.00	2.00	5.00
Channel 3	Amp. ABS	1.00	1.00	1.00	1.00	1.00	1.00	0.89
	Phase ABS	-0.1	-0.1	-0.2	-0.8	-2.4	-7.8	-36.3
	Amp RS	0.00	0.00	0.00	0.01	0.04	0.14	0.60
Channel 5	Amp. ABS	1.00	1.00	1.00	1.00	1.00	1.00	0.91
	Phase ABS	-0.1	-0.1	-0.2	-0.7	-2.4	-7.8	-36.1
	Amp RS	0.00	0.00	0.00	0.01	0.04	0.14	0.60
Channel 7	Amp. ABS	1.01	1.01	1.01	1.01	1.01	1.01	0.93
	Phase ABS	-0.1	-0.1	-0.2	-0.7	-2.3	-7.7	-35.9
	Amp RS	0.01	0.01	0.01	0.01	0.04	0.14	0.60
Channel 9	Amp. ABS	1.00	1.00	1.00	1.00	1.00	1.00	0.89
	Phase ABS	0.0	0.0	-0.2	-0.7	-2.2	-7.5	-35.5
	Amp RS	0.00	0.00	0.00	0.01	0.04	0.13	0.59
Channel 11	Amp. ABS	1.00	1.00	1.00	1.00	1.00	1.01	0.91
	Phase ABS	0.0	-0.1	-0.2	-0.6	-2.1	-7.5	-35.1
	Amp RS	0.00	0.00	0.00	0.01	0.04	0.13	0.58

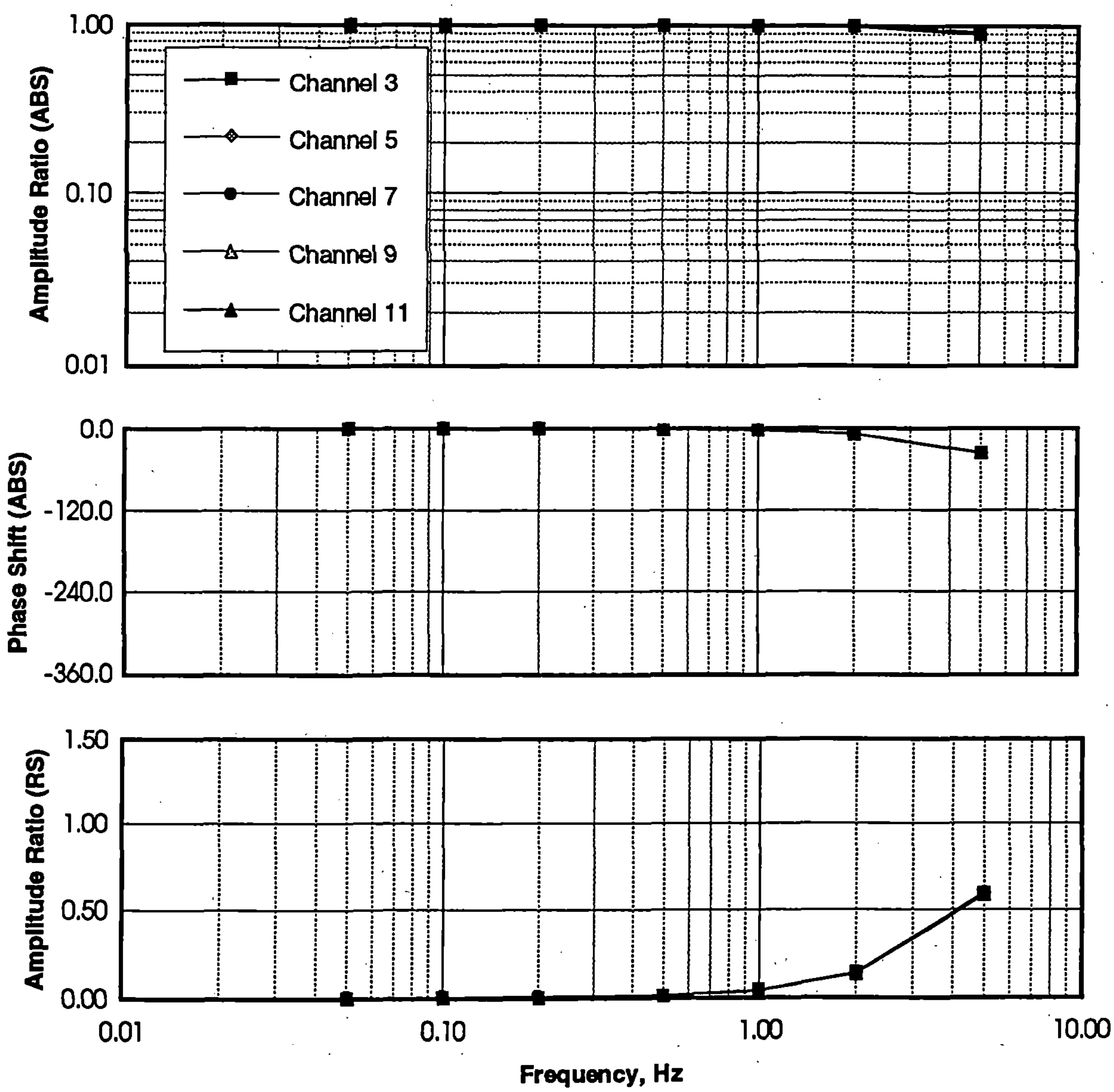


Figure A20 Measured dynamic response across the air barrier system (ABS) and across the rainscreen(RS) for BV/SS Specimen with 8 head joints and 6 leakage holes under a loading condition of 500 Pa Mean and 500 Pa Amplitude

		Test Frequency						
		0.05	0.10	0.20	0.50	1.00	2.00	5.00
Channel 3	Amp. ABS	1.00	1.00	1.00	1.00	1.00	1.00	0.88
	Phase ABS	-0.1	-0.1	-0.3	-0.8	-2.5	-8.0	-36.0
	Amp RS	0.00	0.00	0.01	0.01	0.04	0.14	0.59
Channel 5	Amp. ABS	1.00	1.00	1.00	1.00	1.00	1.00	0.90
	Phase ABS	-0.1	-0.2	-0.3	-0.8	-2.5	-7.9	-35.9
	Amp RS	0.00	0.00	0.00	0.01	0.04	0.14	0.59
Channel 7	Amp. ABS	1.01	1.00	1.01	1.01	1.01	1.01	0.92
	Phase ABS	-0.1	-0.1	-0.2	-0.8	-2.4	-7.8	-35.8
	Amp RS	0.01	0.01	0.01	0.01	0.04	0.14	0.59
Channel 9	Amp. ABS	1.00	1.00	1.00	1.00	1.00	1.00	0.89
	Phase ABS	-0.1	-0.1	-0.3	-0.7	-2.4	-7.6	-35.2
	Amp RS	0.00	0.00	0.00	0.01	0.04	0.13	0.58
Channel 11	Amp. ABS	1.00	1.00	1.00	1.00	1.00	1.00	0.92
	Phase ABS	0.0	-0.1	-0.2	-0.7	-2.3	-7.4	-35.2
	Amp RS	0.00	0.00	0.00	0.01	0.04	0.13	0.59

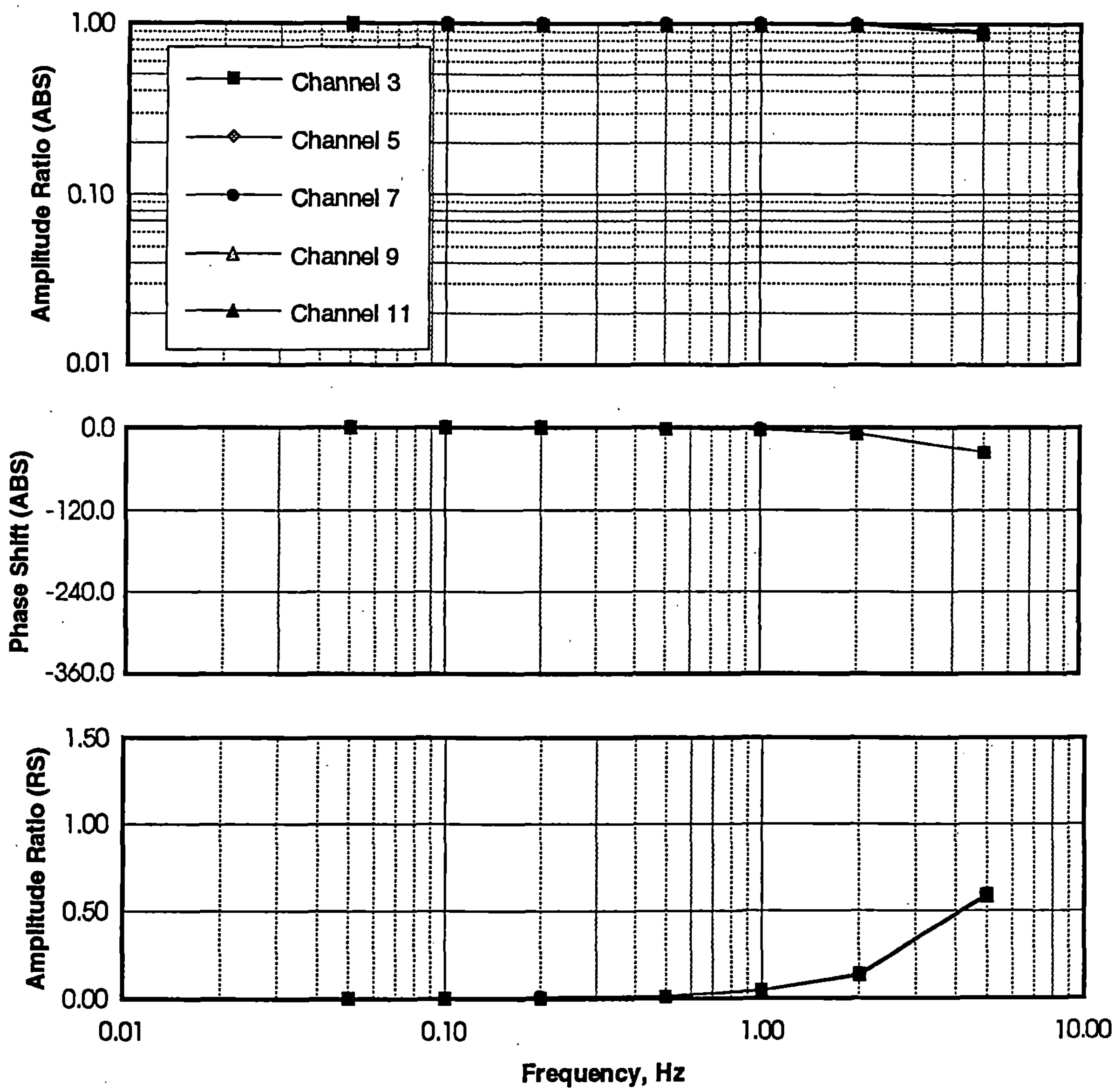


Figure A21 *Measured dynamic response across the air barrier system (ABS) and across the rainscreen(RS) for BV/SS Specimen with 4 head joints and 0 leakage holes under a loading condition of 500 Pa Mean and 500 Pa Amplitude*

		Test Frequency						
		0.05	0.10	0.20	0.50	1.00	2.00	5.00
Channel 3	Amp. ABS	1.00	1.00	1.00	1.00	0.99	0.93	0.60
	Phase ABS	0.0	-0.1	-0.4	-2.1	-7.1	-21.1	-57.2
	Amp RS	0.00	0.00	0.01	0.04	0.12	0.36	0.84
Channel 5	Amp. ABS	1.00	1.00	1.00	1.00	0.99	0.94	0.61
	Phase ABS	0.0	-0.1	-0.4	-2.1	-7.0	-21.0	-57.3
	Amp RS	0.00	0.00	0.01	0.04	0.12	0.36	0.84
Channel 7	Amp. ABS	1.01	1.01	1.01	1.01	1.00	0.94	0.63
	Phase ABS	0.0	-0.1	-0.4	-2.0	-6.9	-20.9	-57.2
	Amp RS	0.01	0.01	0.01	0.04	0.12	0.36	0.85
Channel 9	Amp. ABS	1.00	1.00	1.00	1.00	0.99	0.93	0.61
	Phase ABS	0.0	-0.1	-0.4	-2.0	-6.9	-20.7	-56.8
	Amp RS	0.00	0.00	0.01	0.04	0.12	0.35	0.84
Channel 11	Amp. ABS	1.00	1.00	1.00	1.00	0.99	0.94	0.62
	Phase ABS	0.0	-0.1	-0.4	-2.0	-6.8	-20.6	-56.6
	Amp RS	0.00	0.00	0.01	0.03	0.12	0.35	0.84

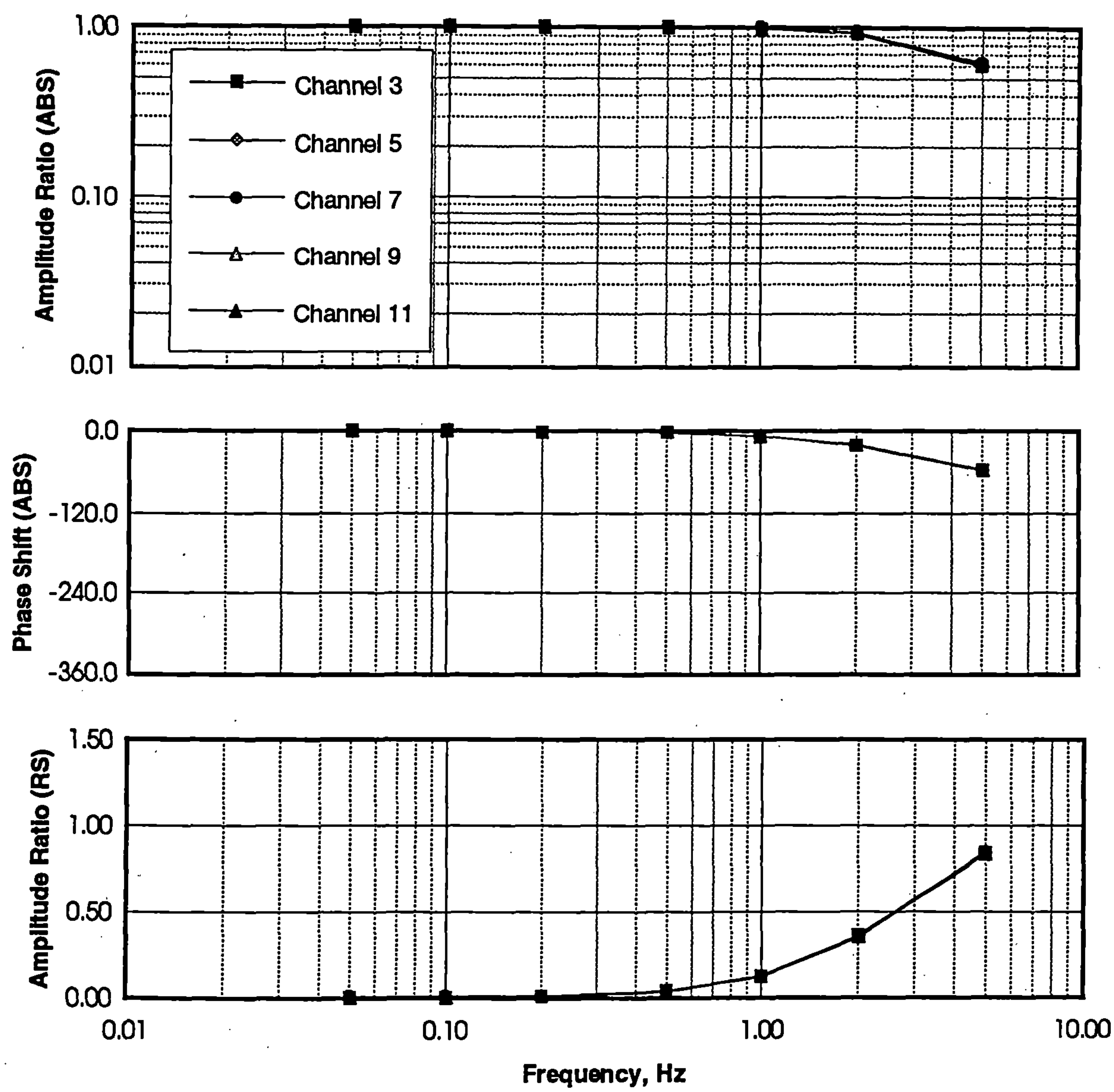


Figure A22 Measured dynamic response across the air barrier system (ABS) and across the rainscreen(RS) for BV/SS Specimen with 4 head joints and 2 leakage holes under a loading condition of 500 Pa Mean and 500 Pa Amplitude

		Test Frequency						
		0.05	0.10	0.20	0.50	1.00	2.00	5.00
Channel 3	Amp. ABS	1.00	1.00	1.00	1.00	0.99	0.93	0.59
	Phase ABS	-0.1	-0.2	-0.5	-2.2	-7.0	-21.0	-57.3
	Amp RS	0.00	0.00	0.01	0.04	0.12	0.36	0.84
Channel 5	Amp. ABS	1.00	1.00	1.00	1.00	0.99	0.93	0.60
	Phase ABS	-0.1	-0.2	-0.5	-2.1	-7.0	-20.8	-57.1
	Amp RS	0.00	0.00	0.01	0.04	0.12	0.36	0.84
Channel 7	Amp. ABS	1.01	1.01	1.01	1.00	0.99	0.94	0.62
	Phase ABS	-0.1	-0.2	-0.4	-2.1	-6.9	-20.7	-56.9
	Amp RS	0.01	0.01	0.01	0.04	0.12	0.35	0.84
Channel 9	Amp. ABS	1.00	1.00	1.00	1.00	0.99	0.93	0.61
	Phase ABS	-0.1	-0.1	-0.4	-2.0	-6.8	-20.6	-56.6
	Amp RS	0.00	0.00	0.01	0.04	0.12	0.35	0.84
Channel 11	Amp. ABS	1.00	1.00	1.00	1.00	0.99	0.93	0.61
	Phase ABS	-0.1	-0.1	-0.4	-2.0	-6.8	-20.5	-56.5
	Amp RS	0.00	0.00	0.01	0.03	0.12	0.35	0.84

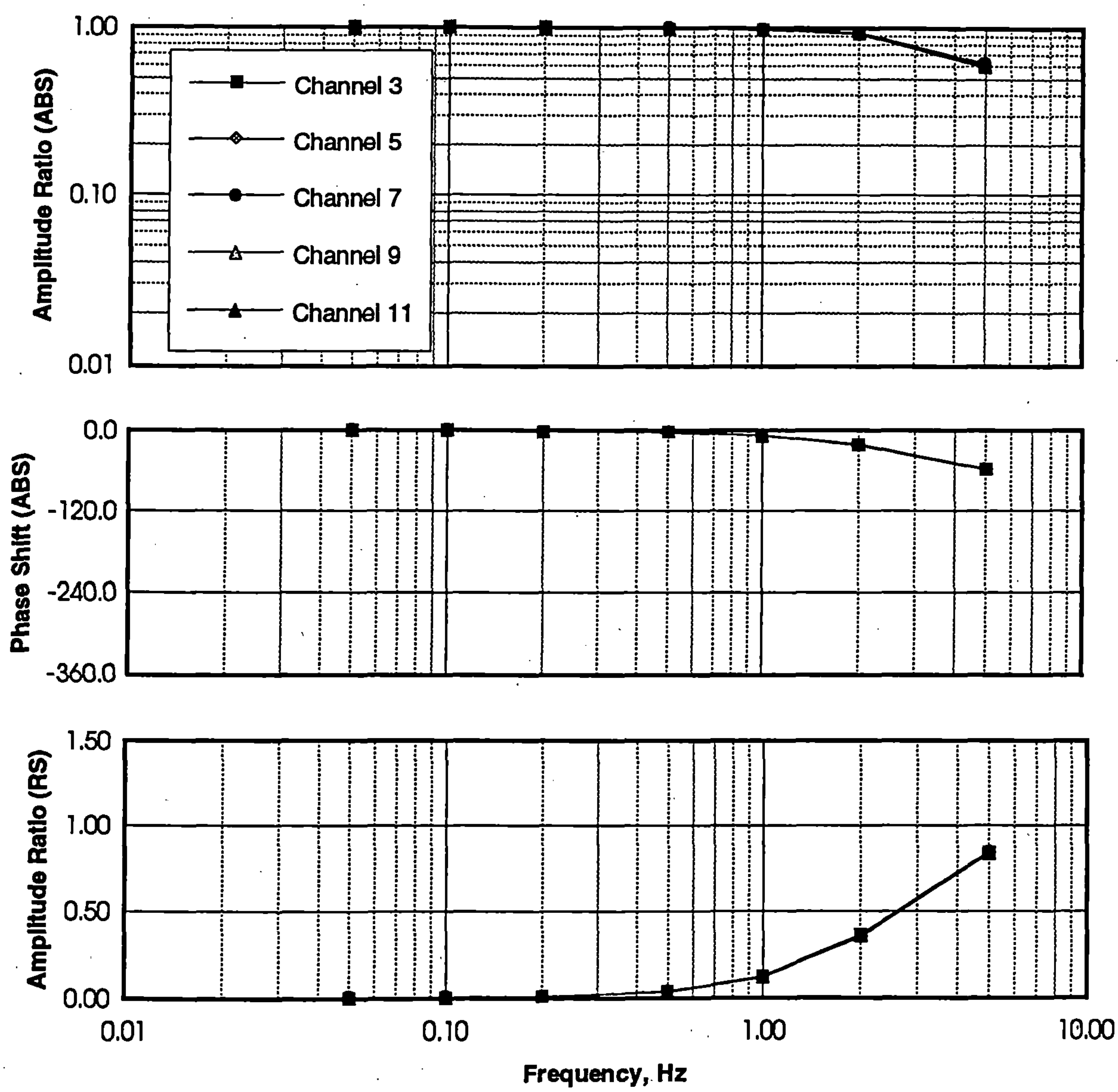


***Figure A23** Measured dynamic response across the air barrier system (ABS) and across the rainscreen(RS) for BV/SS Specimen with 4 head joints and 4 leakage holes under a loading condition of 500 Pa Mean and 500 Pa Amplitude*

		Test Frequency						
		0.05	0.10	0.20	0.50	1.00	2.00	5.00
Channel 3	Amp. ABS	1.00	1.00	1.00	0.99	0.98	0.92	0.60
	Phase ABS	-0.2	-0.3	-0.6	-2.2	-7.0	-20.9	-56.5
	Amp RS	0.00	0.01	0.01	0.04	0.12	0.36	0.84
Channel 5	Amp. ABS	1.00	1.00	1.00	1.00	0.98	0.92	0.61
	Phase ABS	-0.2	-0.3	-0.6	-2.2	-6.9	-20.8	-56.6
	Amp RS	0.00	0.01	0.01	0.04	0.12	0.35	0.84
Channel 7	Amp. ABS	1.00	1.00	1.00	1.00	0.99	0.93	0.63
	Phase ABS	-0.2	-0.3	-0.5	-2.2	-6.9	-20.7	-56.5
	Amp RS	0.00	0.01	0.01	0.04	0.12	0.35	0.84
Channel 9	Amp. ABS	1.00	1.00	1.00	0.99	0.98	0.92	0.61
	Phase ABS	-0.2	-0.3	-0.6	-2.1	-6.8	-20.5	-55.9
	Amp RS	0.01	0.01	0.01	0.04	0.12	0.35	0.83
Channel 11	Amp. ABS	1.00	1.00	1.00	0.99	0.98	0.92	0.62
	Phase ABS	-0.2	-0.2	-0.5	-2.1	-6.7	-20.3	-55.6
	Amp RS	0.00	0.01	0.01	0.04	0.12	0.35	0.83

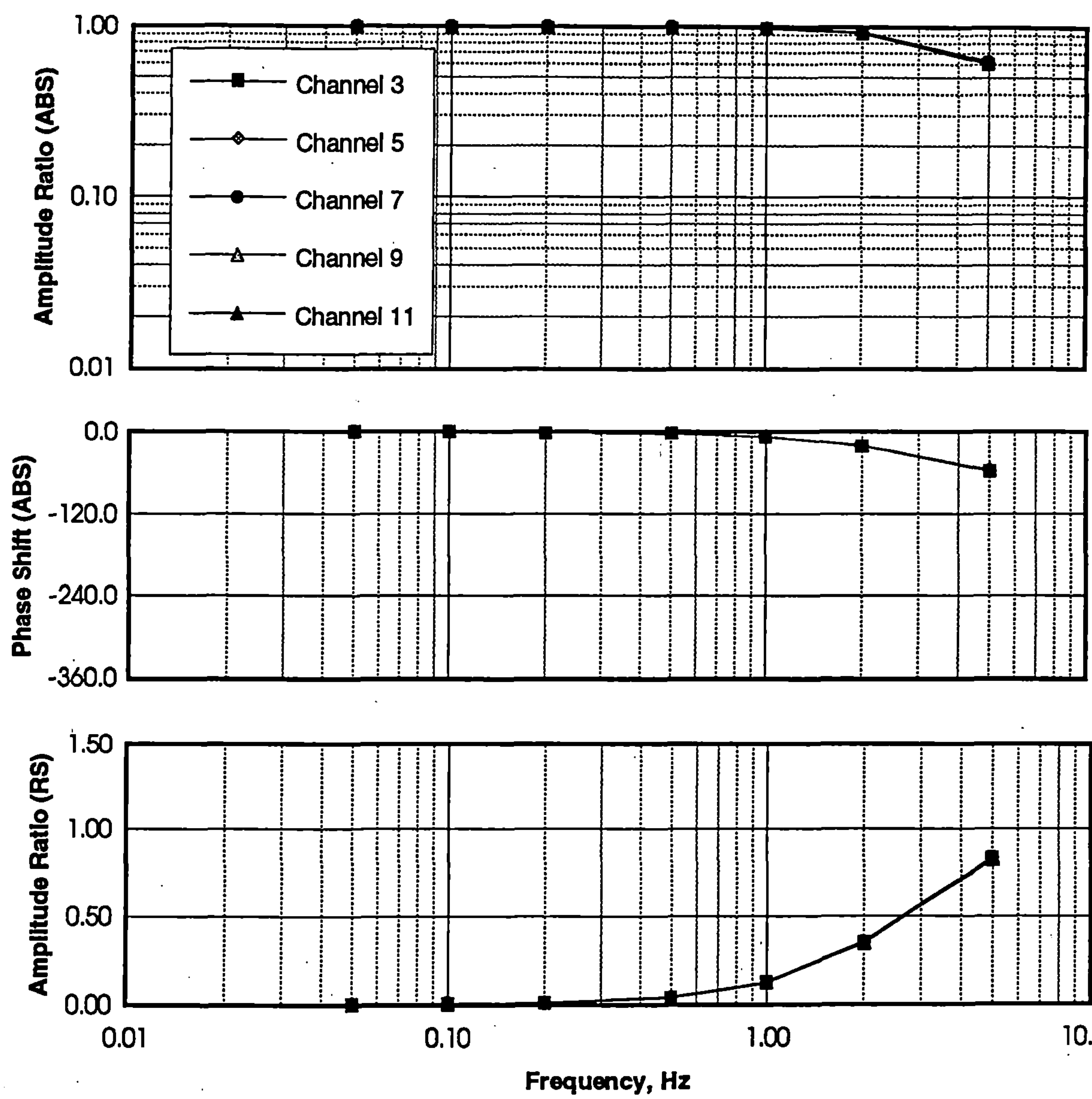
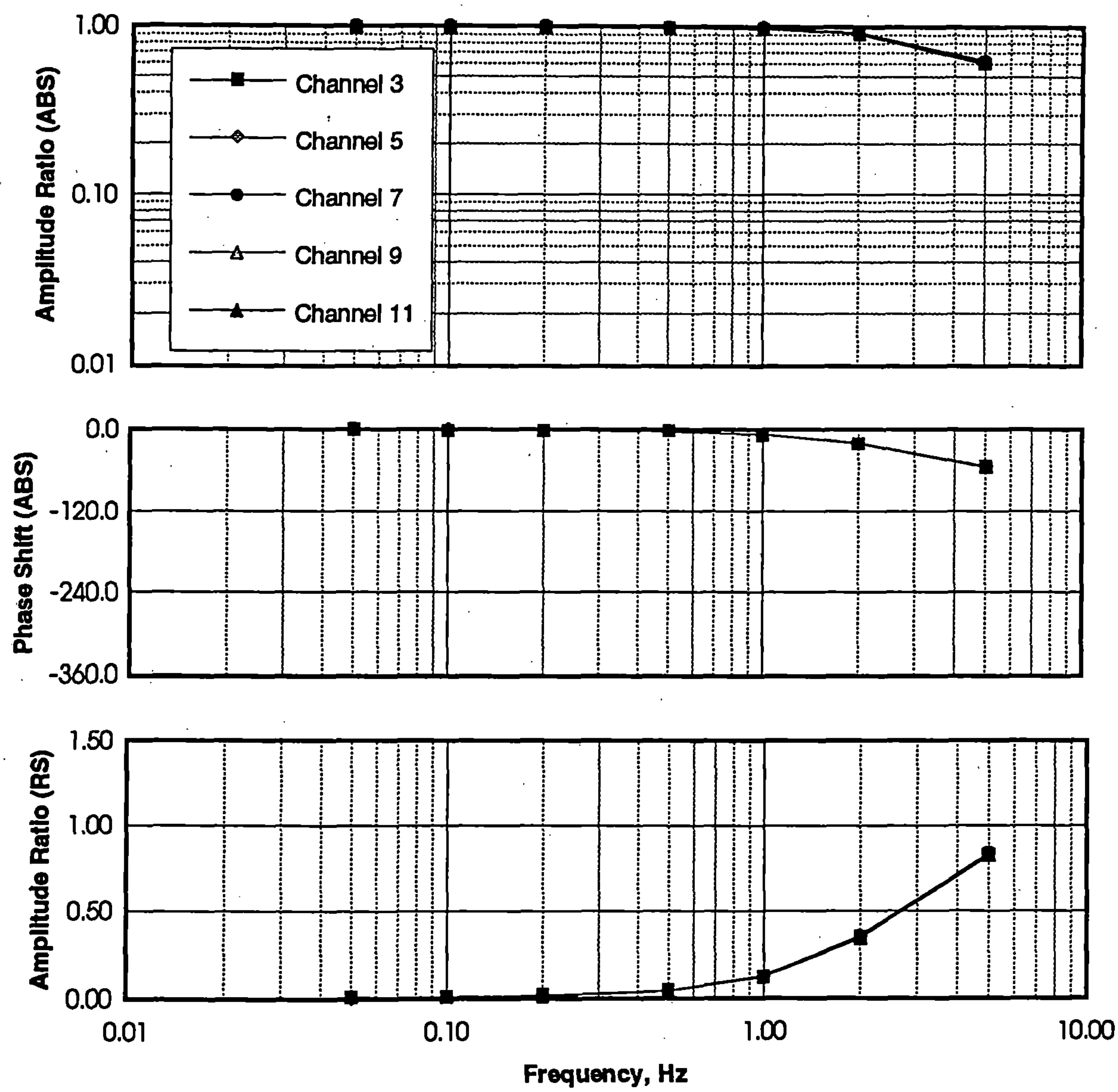


Figure A24 *Measured dynamic response across the air barrier system (ABS) and across the rainscreen(RS) for BV/SS Specimen with 4 head joints and 6 leakage holes under a loading condition of 500 Pa Mean and 500 Pa Amplitude*

		Test Frequency						
		0.05	0.10	0.20	0.50	1.00	2.00	5.00
Channel 3	Amp. ABS	0.99	0.99	0.99	0.99	0.98	0.91	0.60
	Phase ABS	-0.2	-0.4	-0.8	-2.3	-7.1	-20.7	-55.7
	Amp RS	0.01	0.01	0.01	0.04	0.12	0.35	0.83
Channel 5	Amp. ABS	1.00	1.00	0.99	0.99	0.98	0.92	0.61
	Phase ABS	-0.2	-0.4	-0.8	-2.3	-7.0	-20.6	-55.9
	Amp RS	0.01	0.01	0.01	0.04	0.12	0.35	0.83
Channel 7	Amp. ABS	1.00	1.00	1.00	1.00	0.98	0.93	0.62
	Phase ABS	-0.2	-0.4	-0.7	-2.3	-7.0	-20.5	-56.0
	Amp RS	0.00	0.01	0.01	0.04	0.12	0.35	0.83
Channel 9	Amp. ABS	0.99	0.99	0.99	0.99	0.98	0.92	0.61
	Phase ABS	-0.2	-0.4	-0.7	-2.2	-6.9	-20.3	-55.4
	Amp RS	0.01	0.01	0.01	0.04	0.12	0.35	0.82
Channel 11	Amp. ABS	0.99	1.00	0.99	0.99	0.98	0.92	0.61
	Phase ABS	-0.2	-0.4	-0.7	-2.2	-6.8	-20.2	-55.1
	Amp RS	0.01	0.01	0.01	0.04	0.12	0.35	0.82



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Client Report

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for

Canada Mortgage and Housing Corporation
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