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AIRTIGHTNESS TESTS ON COMPONENTS USED TO JOIN DIFFERENT OR SIMILAR MATERIALS OF THE BUILDING ENVELOPE

AIR TIGHTNESS TESTS ON COMPONENTS USED TO JOIN DIFFERENT OR SIMILAR MATERIALS OF THE BUILDING ENVELOPE

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Canada Mortgage and Housing Corporation, Canada Housing Agency, has, as its mandate to apply the National Housing Act.

The objective of this Act is to assist in improving housing and living conditions in Canada. That is why the Corporation is interested in everything that involves housing, urban expansion and development.

Under Part V of the Act, the government of Canada authorizes CMHC to spend funds on research on the socio-economic and technical aspects of housing and on related fields, and to publish and disseminate the results thereof. Thus CMHC has the legal obligation to see to the dissemination of any information which could improve housing and living conditions.

This publication is one of the numerous means of information which CMHC produces with the assistance of the Federal Government.

NOTE: Aussi disponible en français sous le titre: Essais d'étanchéité à l'air sur différents scellants, garnitures d'étanchéité et rubans gommes

DISCHARGE OF RESPONSIBILITY

This study was conducted by Air-Ins Inc. for Canada Mortgage and Housing Corporation under Part V of the National Housing Act. The analyses, interpretations and recommendations are those of the consultant and do not necessarily represent the opinions of Canada Mortgage and Housing Corporation nor of its divisions which assisted in the execution of the study.

TABLE OF CONTENTS

1. SUMMARY OF THE STUDY

1.1 GOAL

This project's goal is to verify the behavior of several connection techniques used between various air barrier elements, where the same connections are exposed simultaneously to extended pressure and temperature differentials reflecting those that may exist in the extreme conditions met in Canada.

The study deals with the 24 specimens listed in Table A. These specimens have been exposed to a pressure differential of 150 Pa during a continuous 5 month period (or until a system being studied lost its air tightness), whereas the test temperature is maintained at -20°C, 20°C or 65°C, depending on the nature of the elements of the system and on the position of the air barrier in the wall.

TABLE A: MATERIALS OR ASSEMBLIES TESTED

MATERIAL		MATERIAL		MATERIAL	
NO	DESCRIPTION	NO	DESCRIPTION	NO	DESCRIPTION
1	Closed cell backer rod (initial compression = 30%)	12	Adhesive tape on water resistant drywall joints (Spread = 1/4")	21	Exterior sealant joints (Acrylic) - width = 1/2" - wood-sealant-aluminium - backer rod
2	Closed cell backer rod (initial compression = 50%)	14	Adhesive tape on spun bonded olefin paper joints	22	Exterior sealant joint (Silicone) - width = 1/4" - wood-sealant-aluminium - backer rod
3	Open cell backer rod (initial compression = 50%)	15	Adhesive tape on perforated polyethylene air barrier	23	Exterior sealant joint (Acrylic) - width = 0 - wafer board-sealant on surface of waferboard
5	Mineral wool (width = 1/2") (low compaction density)	16	Interior sealant joints (Acrylic) - width = 1/2" - wood-sealant-alum. - backer rod	24	Exterior sealant joint (Acrylic) - width = 1/8" - wafer board-sealant-wafer board
6	Mineral wool (width = 1/2") (average compaction density)	17	Interior sealant joint (Acrylic) - width = 1/2" - wood-sealant-alum. - backer rod		
7	Mineral wool (width = 1/2") (high compaction density)	18	Interior sealant joints (Silicone) - width = 1/4" - wood-sealant-alum. - backer rod		
8	Polyethylene + mineral wool (1/2")	19	Interior sealant joints (Silicone) - width = 1/2" - wood-sealant-alum. - backer rod		
9	EPDM gap gasket (1/2")	20	Exterior sealant joints (Acrylic) - width = 1/4" - wood-sealant-alum. - backer rod		
10	Wood - urethane (1/2") - aluminium				
11	Adhesive tape on water resistant drywall joints (Spacing = 1/2")				

1.2 RESULTS

The measure of deterioration in each of the specimens tested is expressed by an increase in air infiltration between the initial state (new) and the final state. Table B provides air infiltration measurements at the initial and final state for each of the specimens under a pressure differential equal to 75 Pa.

It is observed that:

- At -20°C, no specimen had suffered damage causing a decrease in air tightness.
- At 20°C the specimens with opened cell gaskets, sheet type air barriers and mineral wool improved their air tightness due to an accumulation of dust on or within the joints. The specimens with closed cell backer joints and EPDM gap gaskets lost a portion of their air tightness due to greater losses at the joint ends.
- At 65°C, the spun bonded olefin paper tore away completely from its staples which caused total loss of air tightness by the specimen.

The acrylic sealant joints specimens were extensively damaged. All the joints cracked and one portion of the 1/2" joints (material no. 21) popped out completely over several centimeters (induced by pressure). It was not possible to take a final measurement of the air tightness on this latter specimen due to its deteriorated condition.

INITIAL FINAL AIR TIGHTNESS

TABLE B:

MATERIALS		Q (75 Pa) INITIAL	Q (75 Pa) FINAL	Q
NO	DESCRIPTION	m^3/h-m	m^3/h-m	%
1	Closed cell backer rod	0.0756 (20°C)	0.0777	+ 3 %
2	Closed cell backer rod	0.0437 (20°C)	0.0749	+71 %
3	Open cell gasket (comp. 20%)	23.90 (20°C)	21.86	- 8.5%
4	Open cell gasket (comp. 40%)	12.75 (20°C)	11.78	- 8 %
5	Mineral wool (low compaction)	14.11 (20°C)	14.11	0 %
6	Mineral wool (average compaction)	5.232 (20°C)	5.05	- 3.5%
7	Mineral wool (high compaction)	1.706 (20°C)	1.743	+ 2 %
8	Polyethelene and mineral wool	0.5888 (20°C)	0.5647	- 4 %
9	EPDM gap gasket	0.0638 (20°C)	0.0787	+23 %
10	Wood-urethane-aluminium	0.0602 (20°C)	0.0599	- 0.5%
11	Adhesive tape on water resistant drywall joints	(11-1) 0 (-20°C) (11-2) 0 (65°C)	(11-1) 0 (11-2) 0	--- ---
12	Adhesive tape on water resistant drywall joints	(12-1) 0 (-20°C) (12-2) 0 (65°C)	(12-1) 0 (12-1) 0	--- ---

TABLE B: (cont'd)

MATERIALS		Q (75 Pa) INITIAL 02 - 91	Q (75 Pa) FINAL 07 - 91	Q
NO	DESCRIPTION	m³/h-m	m³/h-m	%
14	Adhesive tape on spun bonded olefin paper joints	(14-1) 0.0276 (20°C) (14-2) 0.0315 (-20°C) (14-3) 0.0258 (65°C)	0.0252 0.0307 COMPLETE LOSS OF AIR TIGHTNESS	- 9 % - 2 % ---
15	Adhesive tape on perforated polyethelene air barrier joints	(15-1) 0.7740 (20°C) (15-2) 1.5452 (-20°C) (15-3) 3.1669 (65°C)	0.5276 0.5257 2.2351	-32 % -66 % -23 %
16	Interior sealant (Acrylic)	0 (20°C)	0	---
17	Interior sealant (Acrylic)	0 (20°C)	0	---
18	Interior sealant (Silicone)	0 (20°C)	0	---
19	Interior sealant (Silicone)	0 (20°C)	0	---
20	Exterior sealant (Acrylic)	(20-1) 0 (-20°C) (20-2) 0 (65°C)	0 0.9998	--- ---
21	Exterior sealant (Acrylic)	(21-1) 0 (-20°C) (21-2) 0 (65°C)	0 COMPLETE LOSS OF AIR TIGHTNESS	--- ---
22	Exterior sealant (Silicone)	(22-1) 0 (-20°C) (22-2) 0 (65°C)	0 0	--- ---
23	Exterior sealant (Acrylic)	(23-1) 0 (-20°C) (23-2) 0 (65°C)	0 0	--- ---
24	Exterior sealant (Acrylic)	(24-1) 0 (-20°C) (24-2) 0 (65°C)	0 0	--- ---

1.3 CONCLUSIONS

The spun bonded olefin paper as well as the acrylic base sealants should not be used at connections where the temperature may be hot. In the case of spun bonded olefin paper, attaching with staples is to be avoided.

Given their high permeability, open cell gaskets, mineral wool and perforated polyethelene membranes should not be used as air barriers.

Finally, silicone base sealant and the adhesive tape showed perfect adherence qualities regardless of the operating conditions.

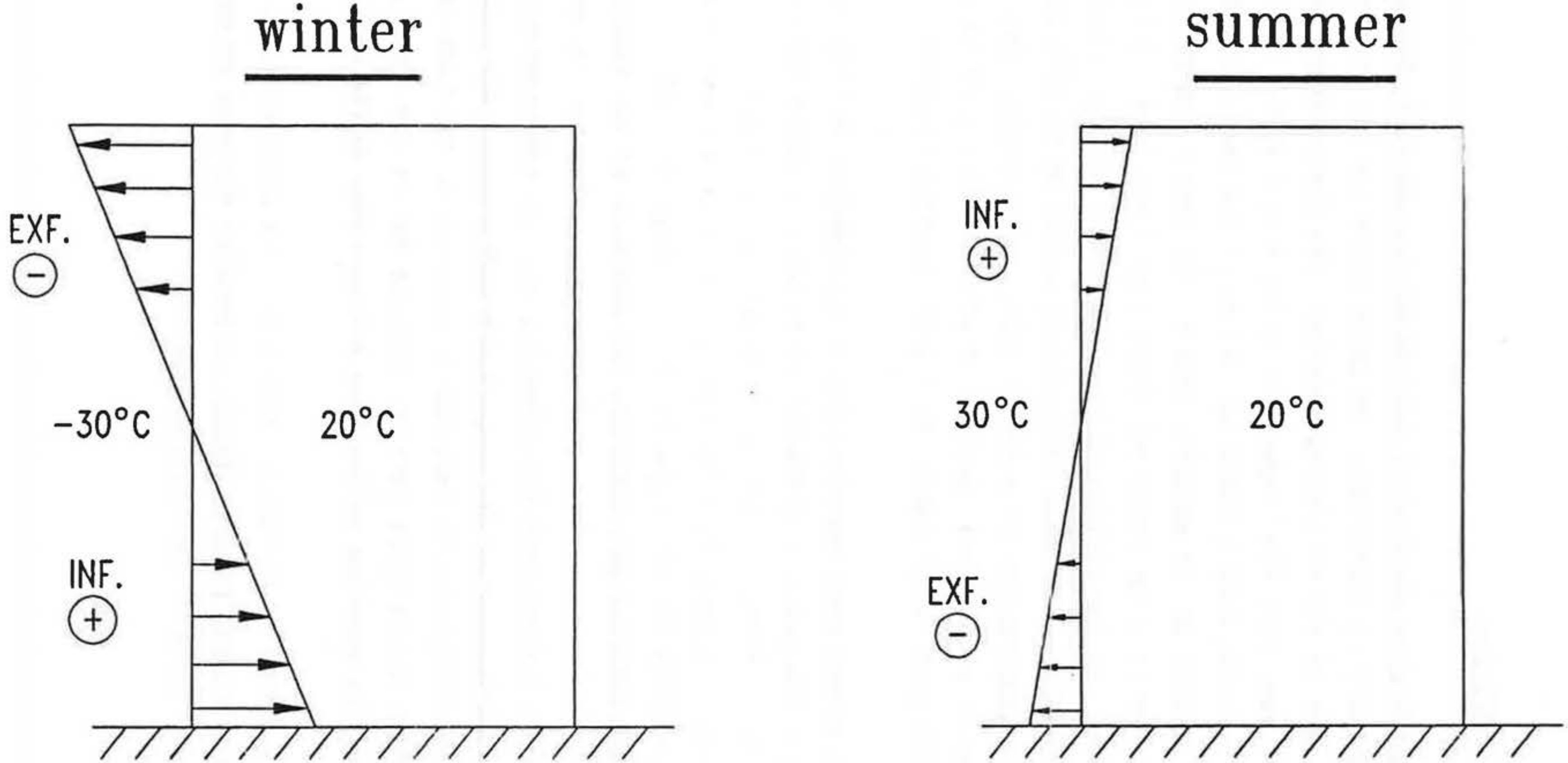
2. INTRODUCTION

Depending on where it is located within the wall, the air barrier is exposed to varying conditions. In cases where the air barrier is located on the room side of the insulating material, the fluctuations in temperature will be minimal with the temperature being around 20°C. On the other hand, in today's world, many residential buildings are designed and built with air barriers located on the exterior side of the insulating material (ex: adhesive tape on water resistant drywall or Tyvec type air barrier). In the latter case, the temperature of the air barrier may vary, depending on the exterior sheathing, between -20°C during winter up to 65°C during summer. Given that temperature has a direct effect on strength, adherence and connection creep (sealant, gasket and adhesive tape), it is essential to take this factor into consideration during the testing of certain materials.

The second most important factor to consider in this study to test air barriers is the pressure differential between interior and exterior produced by the stack effect, by wind and by mechanical ventilation in buildings. The total pressure differential between the interior and exterior of a heated building depends on the height of the building, the difference in temperature between the interior and exterior, the position of the element understudy in the vertical plane and the distribution of openings on the vertical plane. Illustration 1 shows that the intensity and the direction of the pressure differential depends on the temperature differential and seasons. During winter, the difference in pressure is positive at the base of the building and negative in the upper section, whereas during the summer, the difference in pressure is negative at the base and positive in the upper section.

Given that it is rare to have a uniform distribution of openings in a building envelope, it is difficult to predict the real pressure differential on the components of the building envelope.

FIGURE 1
stack effect



However, there is one limitation that practically everyone is aware of, i.e., the effort required for a person to open or close a door or window when the latter is exposed to a pressure differential. The upper limit ot the effort required to initiate motion of a sash is obtained when the pressure differential is around 150 Pa.

These various parameters indicated to us the conditions to be applied to test the numerous materials used in this study. To validate the results, we have measured the actual pressure differential across the envelope of two 20 storey buildings. The pressure measurements were taken at the tenth storey and the 20th storey. The results are reported in Table 1.

TABLE 1: PRESSURE DIFFERENTIAL ACROSS THE BUILDING ENVELOPE FOR TWO BUILDINGS (JANUARY 1991)

BUILDING	TOTAL PRESSURE DIFFERENTIAL (Pa)	
	10th storey (30 m)	20th storey (60 m)
1	67	139
2	72	146

2.1 DESCRIPTION OF THE SAMPLES

All samples were built so that the length of the joints is maximized within an area of 1 m^2. Illustration 2 demonstrates the technique for manufacturing a sample using a closed cell backer rod. The samples are built using 2" by 3" (pine) members. The ends of the specimens are attached with screws and sealed in order to avoid any leakage other than that coming from the joint itself. Illustration 3 illustrates how the samples simulating wood - aluminium joints were built. In this case, one end of the aluminium felt bar was left unattached allowing it to expand or contract depending on the temperature. An expansion joint was introduced to compensate for differential movements between the wood and aluminium. Table 1, lists all the specimens built, the various materials used, as well as the test temperature.

FIGURE 2

CONSTRUCTION OF A TYPICAL SPECIMEN

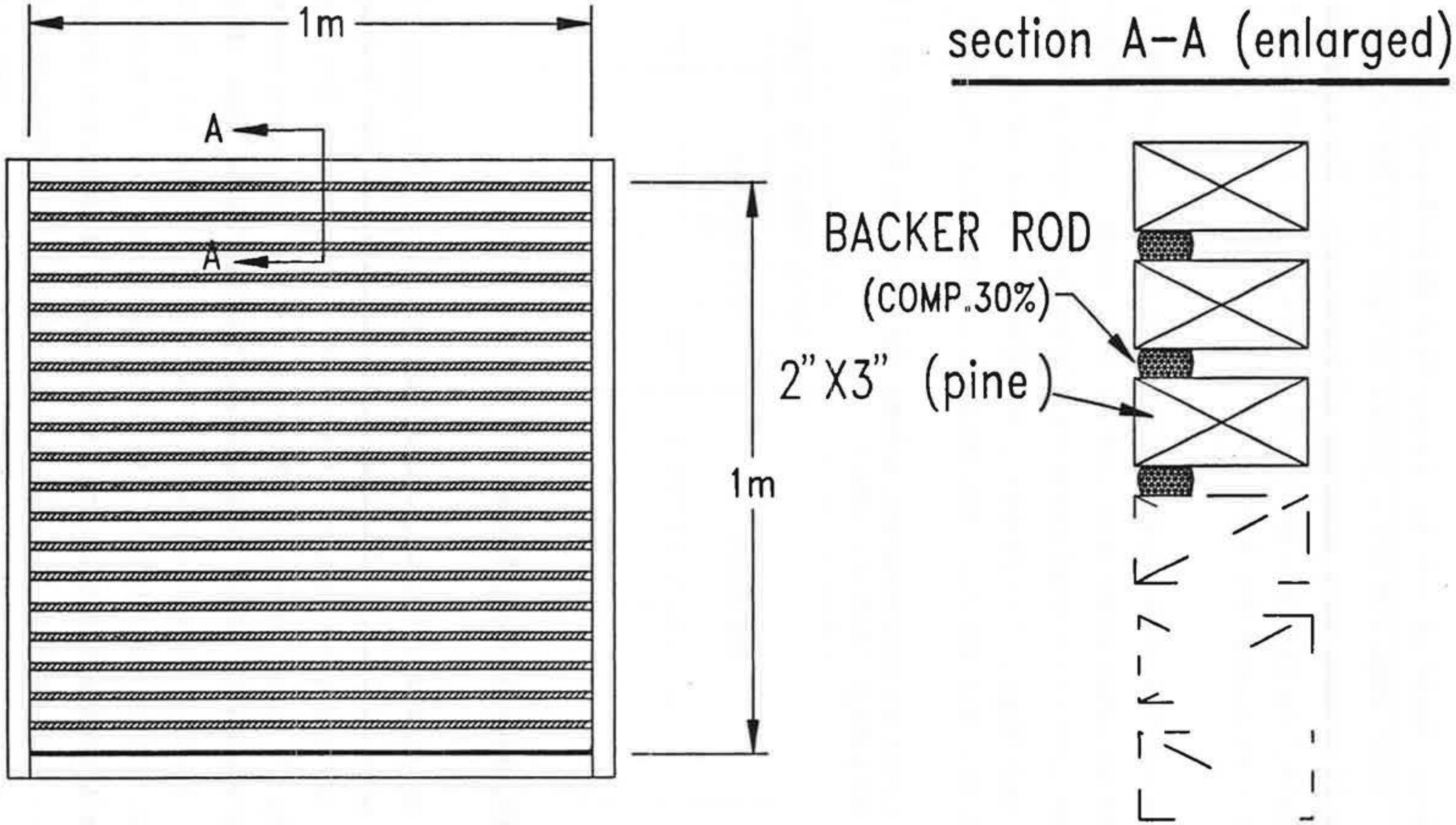


FIGURE 3

ASSEMBLY DRAWNING – SPECIMENS WITH ALUMINUM

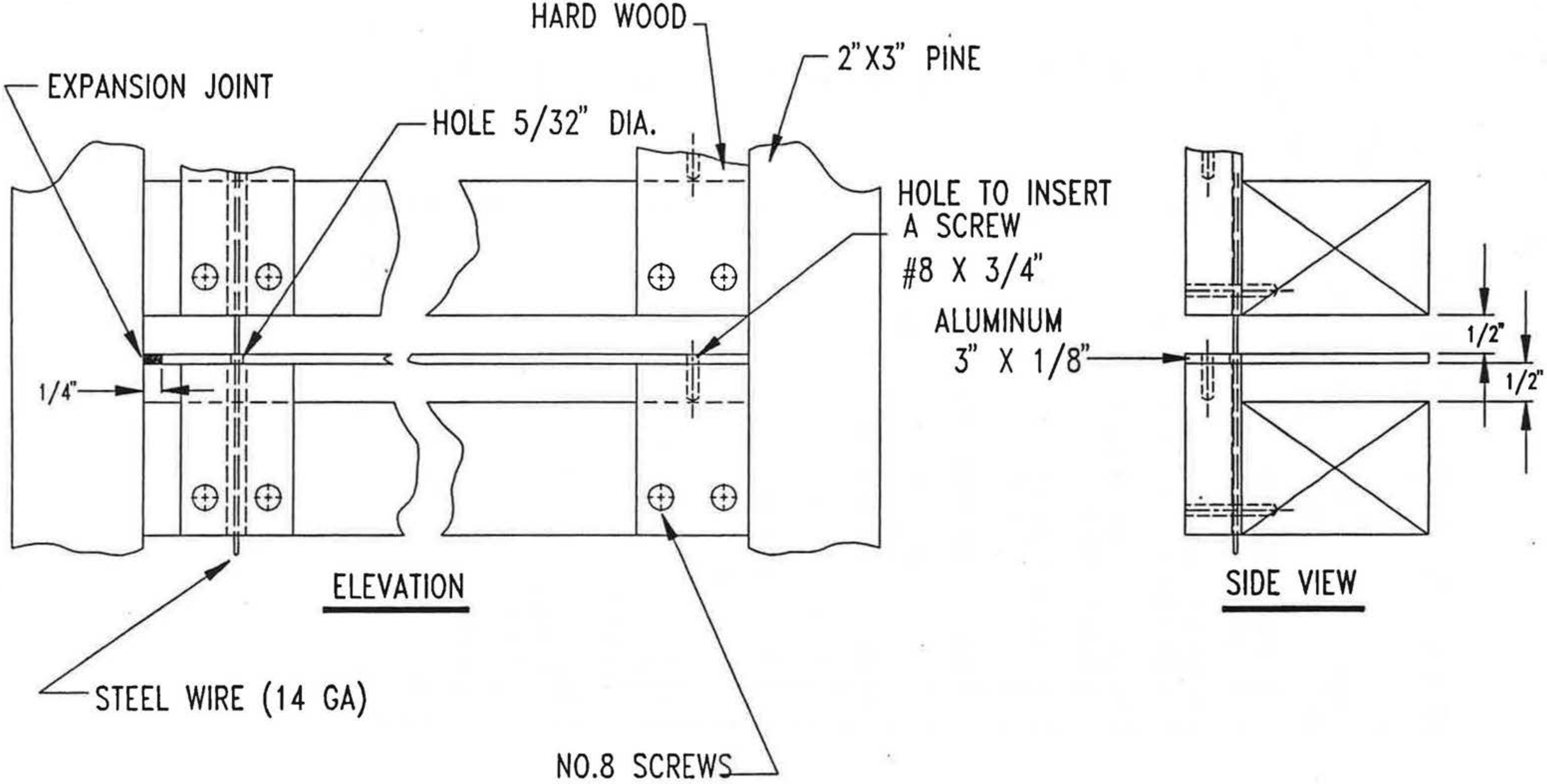


TABLE 1: MATERIALS OR ASSEMBLIES TESTED

MATERIALS		TEST TEMPERATURE (°C)	TOTAL NUMBER OF SPECIMENS
NO	DESCRIPTION		
1	Closed cell backer rod (initial compression = 30%)	20	1
2	Closed cell backer rod (initial compression = 50%)	20	1
3	Open cell gasket (initial compression = 20%)	20	1
4	Open cell gasket (initial compression = 40%)	20	1
5	Mineral wool (low compaction)	20	1
6	Mineral wool (average compaction)	20	1
7	Mineral wool (high compaction)	20	1
8	Polyethelene + mineral wool	20	1
9	EPDM gap gasket	20	1
10	Wood - urethane - aluminium	20	1
11	Adhesive tape on water resistant drywall joints (Spacing = 1/8")	-20 (11-1) 65 (11-2)	1
12	Adhesive tape on water resistant drywall joints (Spacing = 1/4")	-20 (12-1) 65 (12-2)	1 1
14	Adhesive tape on spun bonded olefin paper joints	20 (14-1) -20 (14-2) 65 (14-3)	1 1 1

TABLE 1: (cont'd)

MATERIALS		TEST TEMPERATURE (°C)	TOTAL NUMBER OF SPECIMENS
NO	DESCRIPTION		
15	Adhesive tape on perforated polyethelene air barrier joints	20 (15-1) -20 (15-2) 65 (15-3)	1 1 1
16	Interior sealant (Acrylic) - width = 1/4" - wood - sealant - aluminium - backer rod	20	1
17	Interior sealant (Acrylic) - width = 1/2" - wood - sealant - aluminium - backer rod	20	1
18	Interior sealant (Silicone) - width = 1/4" - wood - sealant - aluminium - backer rod	20	1
19	Interior sealant (Silicone) - width = 1/2" - wood - sealant - aluminium - backer rod	20	1
20	Exterior sealant (Acrylic) - width = 1/4" - wood - sealant - aluminium - backer rod	-20 (20-1) 65 (20-2)	1 1
21	Exterior sealant (Acrylic) - width = 1/2" - wood - sealant - aluminium - backer rod	-20 (21-1) 65 (21-2)	1 1
22	Exterior sealant (Silicone) - width = 1/4" - wood - sealant - aluminium - backer rod	-20 (22-1) 65 (22-2)	1 1

TABLE 1: (cont'd)

MATERIALS		TEST TEMPERATURE (°C)	TOTAL NUMBER OF SPECIMENS
NO	DESCRIPTION		
23	Exterior sealant (Acrylic) - width = 0 - wafer board - sealant applied over the surface - wafer board	-20 (23-1) 65 (23-2)	1 1
24	Exterior sealant (Acrylic) - width = 1/8" - wafer board - sealant - wafer board	-20 (24-1) 65 (24-2)	1 1
Total Number of Specimens		65 -20 20	9 9 16

2.2 DESCRIPTION OF THE TEST CHAMBERS

The experimental study required the construction of three test chambers. One test chamber operating at an ambient temperature of 20°C, the second at -20°C and the third at 65°C. Illustration 4 shows the principle involved in designing these chambers. The four walls, as well as the floor and the ceiling, are insulated to minimize heat flow to the surrounding area. In the center, the chamber is separated into two compartments by all the specimens to be tested. All the joints in the structure of this wall are sealed so that any air flow resulting from a pressure differential occurs only through the joints of the specimens.

The pressure differential of 150 Pa is insured by a fan which causes low pressure conditions on one side and high pressure conditions on the other. For the high and low temperature test chambers, the desired temperature is maintained by a cooling or heating coil. Propeller fans are located on the lower part of both sides of the central wall to insure uniformity of temperature. The interior temperature on both sides of the specimens is maintained at ± 1°C of the test temperature by using a bypass damper which allows air to move from one side to the other of the specimens, while maintaining a pressure differential between the specimens equal to 150 Pa.

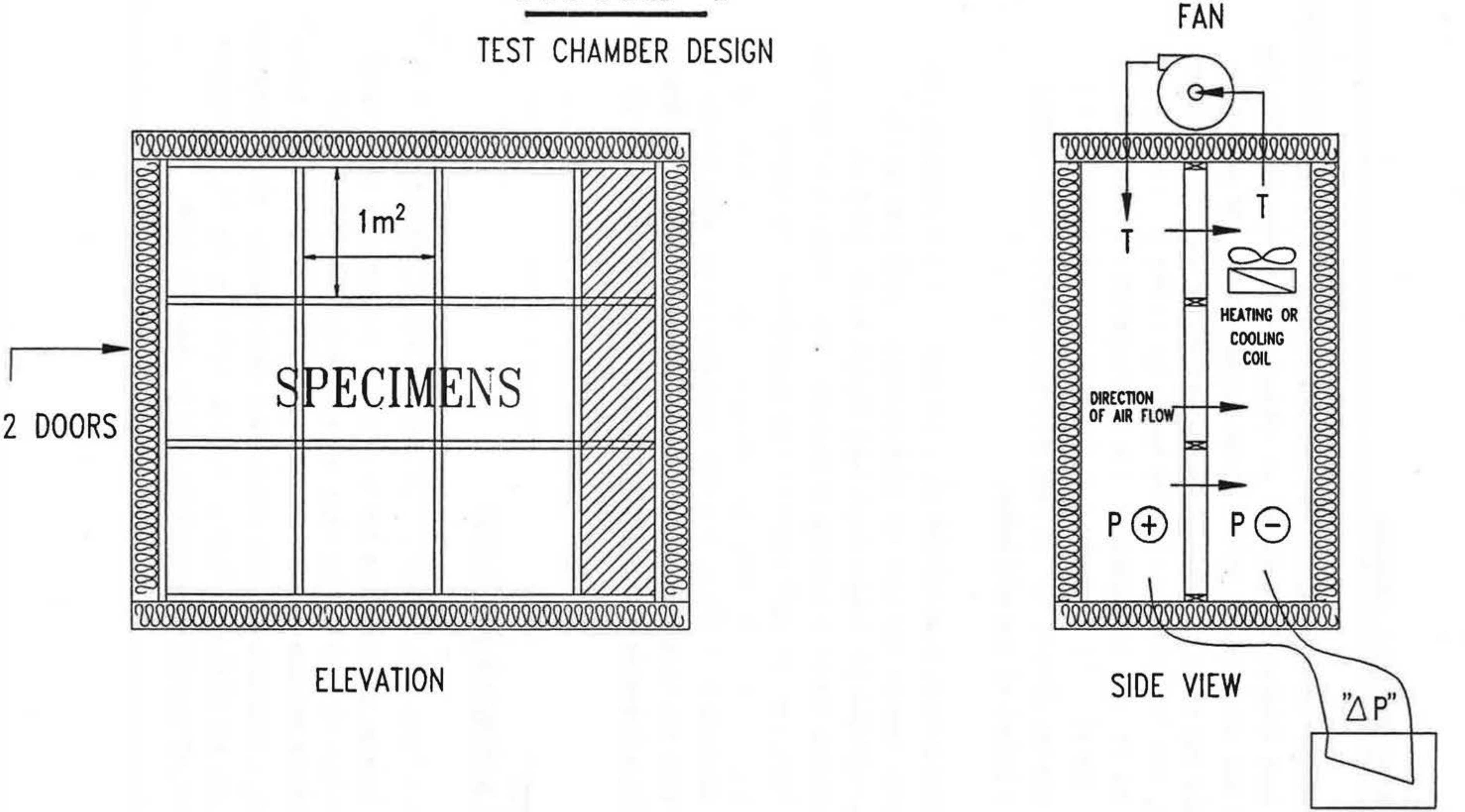
3. METHODOLOGY

3.1 INITIAL AIR TIGHTNESS MEASUREMENT

All the specimens were tested in compliance with the ASTM E283. This means that air leakage was measured for a pressure differential of 75 Pa at T=20°C. The results of this air leakage are provided in m^3/h-m of joint. Illustration 5 shows the set up used to take the initial measurements, i.e., the test chamber, a specimen and the measurement instruments. For a complete description of the air tightness test procedure, refer to the "Air permeance of building material" report presented to CMHC on June 17, 1988.

FIGURE 4

TEST CHAMBER DESIGN

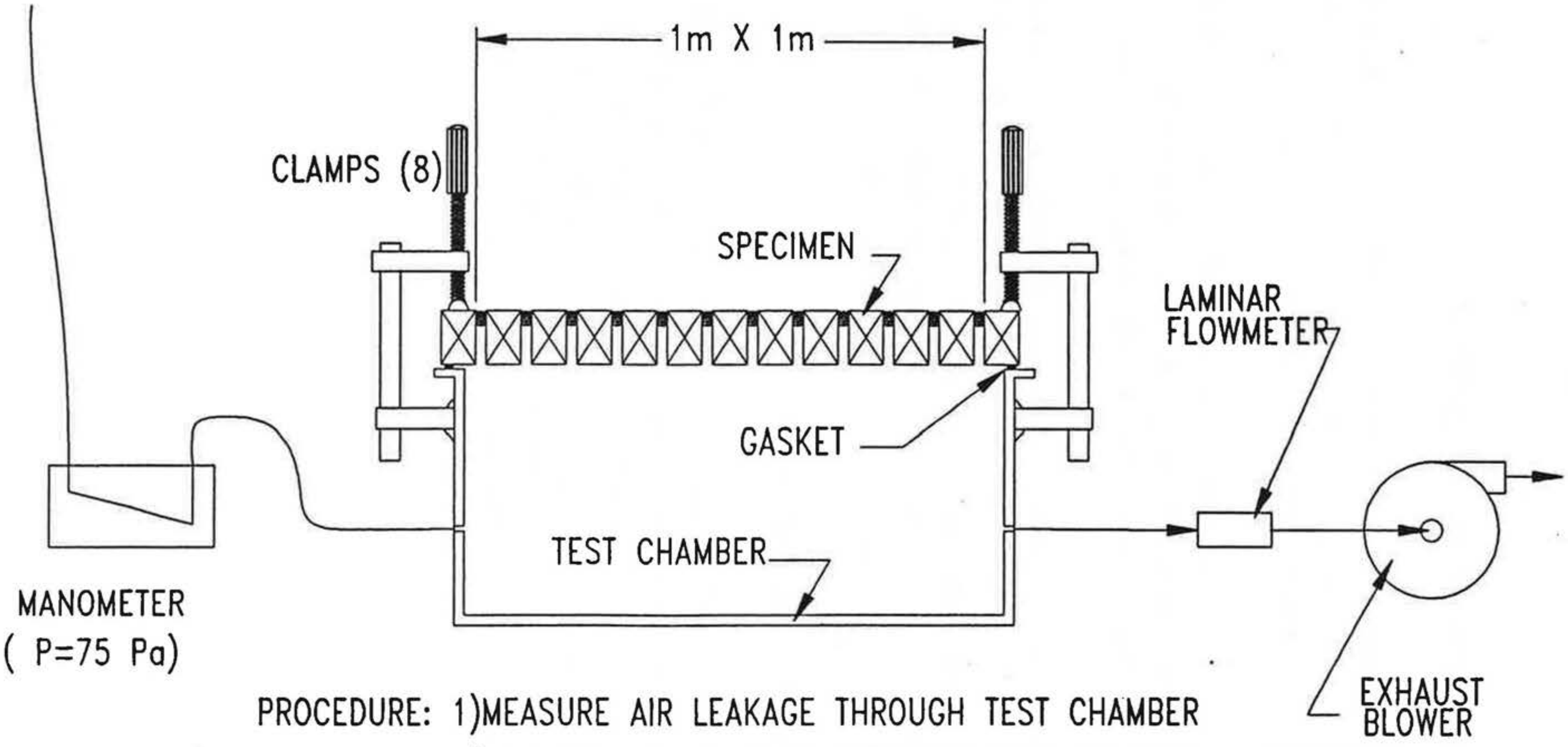


TEST CHAMBER #1: T=20°C,ΔP=150 Pa, NUMBER OF SPECIMENS:16
TEST CHAMBER #2: T=−20°C,ΔP=150 Pa,NUMBER OF SPECIMENS:9
TEST CHAMBER #3: T=65°C,ΔP=150 Pa, NUMBER OF SPECIMENS:9

MANOMETER
ΔP=150 Pa (.6" H_2O.)

FIGURE 5

AIR PERMEANCE MEASUREMENT



PROCEDURE: 1)MEASURE AIR LEAKAGE THROUGH TEST CHAMBER

2)MEASURE AIR LEAKAGE THROUGH TEST CHAMBER + SPECIMEN

3)SUBSTRACT (1) FROM (2)

3.2 TEST UNDER EXTENDED PRESSURE DIFFERENTIAL

To minimize bypass air flow at the perimeter of each specimen, the perimiter was sealed so that the only air flow possible is through the joints in the specimens or through the bypass damper.

Specimens were positioned so that the connections to be studied were put at the greatest possible disadvantage. Illustrations 6 to 10 show the direction of air flow resulting from the difference in pressure.

Each week, a visual inspection of the specimens was carried out to observe any deterioration. Should a specimen ever become deteriorated enough to prevent the maintenance of a pressure differential for all the specimens, it would be removed and replaced by a sealed wood panel. The total length of the test under extended pressure differential is 5 months.

3.3 MEASUREMENT OF FINAL AIR TIGHTNESS

After the extended pressure differential test, all the specimens were withdrawn from the chambers and were submitted to the air tightness test once again. The final air tightness test is also carried out in compliance with standard ASTM E283, the test is conducted with a pressure differential of 75 Pa with T = 20°C. The air leaks are reported in m^3/h-m of joint. The test chamber is the same as for the initial air tightness test.

FIGURE 6

SPECIMENS NO. 1,2,3,4,5,6,7 AND 9

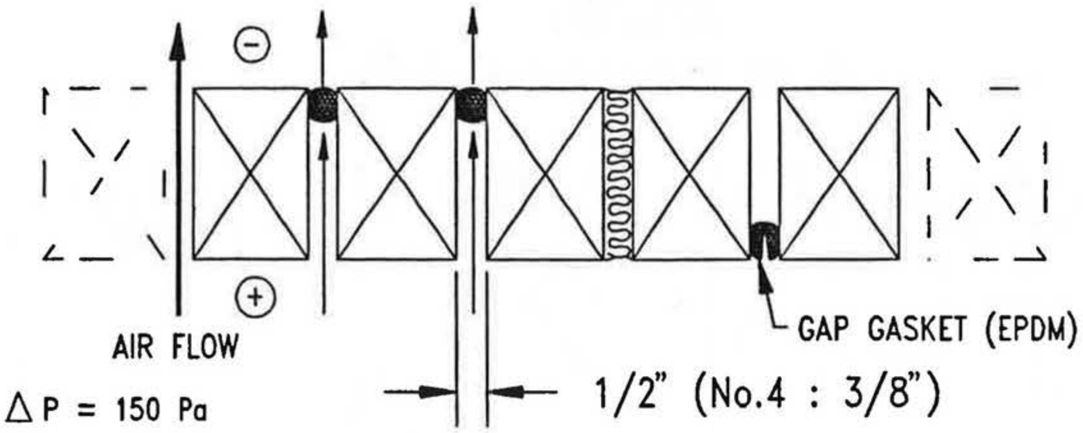


FIGURE 7

SPECIMEN NO.8

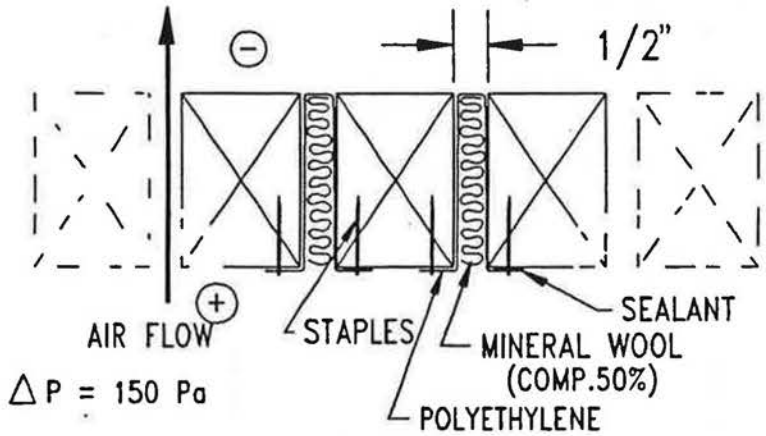


FIGURE 8

SPECIMEN NO.10

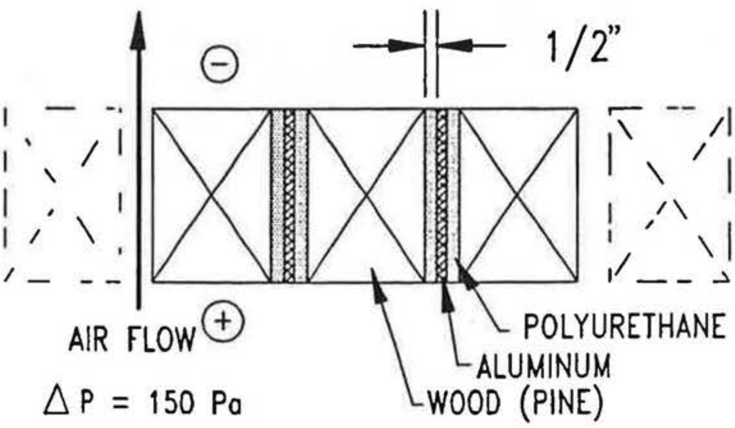


FIGURE 9

SPECIMENS NO.11,12,14,15,23 AND 24

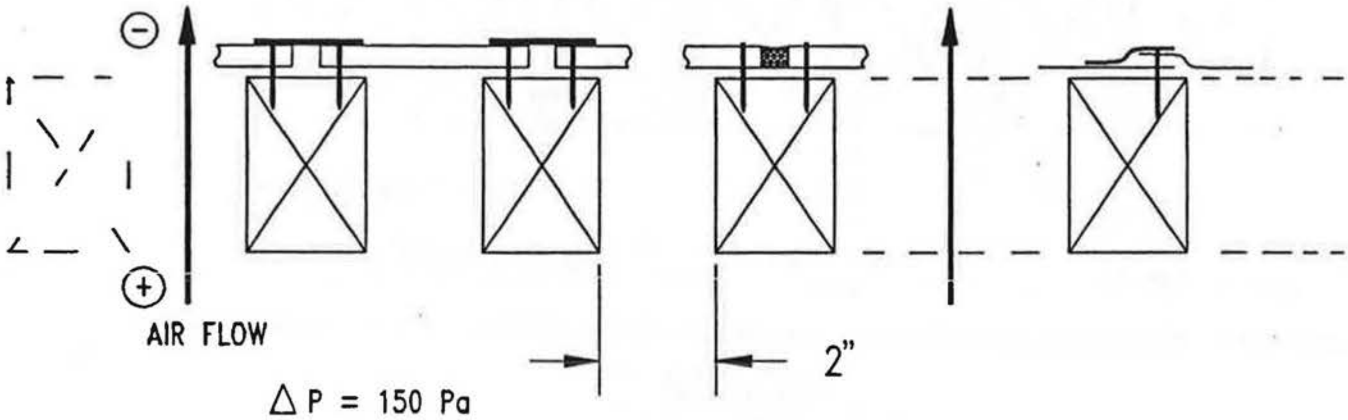
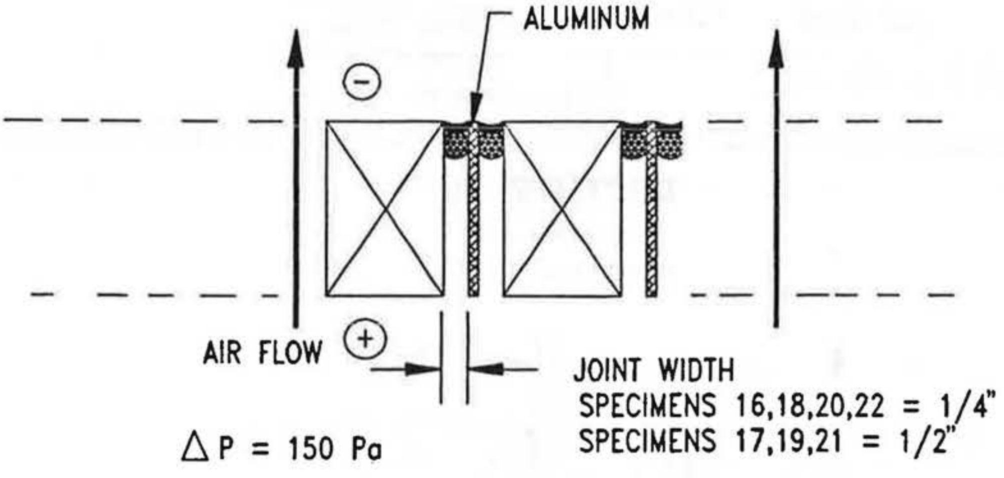


FIGURE 10

SPECIMEN NO.16,17,18,19,20,21 AND 22



4. RESULTS

Table 2 provides the results of initial and final air tightness measurements taken on the specimens. These results express the volume of air, in cubic meters, going through the specimens per hour and per one meter length of joint (m^3/h-m) under a pressure differential of 75 Pa. The third column shows the variation in air volume flow rate per unit of length of crack after the extended test in relation to the initial air volume flow rate. A positive variation indicates an increase in air leakage whereas a negative variation indicates a decrease in air leakage.

For certain assemblies, the value 0 indicates the air flow going through the specimen was too small to be measured. Two specimens, 14-3 and 21-2 were too deteriorated to allow for a final air tightness reading. This explains the entry "complete loss of air tightness".

INITIAL AND FINAL AIR TIGHTNESS

TABLE 2: MATERIALS OR ASSEMBLIES TESTED

MATERIALS		Q (75 Pa) INITIAL	Q (75 Pa) FINAL	Q
NO	DESCRIPTION	m³/h-m	m³/h-m	%
1	Closed cell backer rod (initial compression = 30%)	0.0756 (20°C)	0.0777	+ 3 %
2	Closed cell backer rod (initial compression = 50%	0.0437 (20°C)	0.0749	+71 %
3	Open cell gasket (initial compression = 20%)	23.90 (20°C)	21.86*(1)	- 8.5%
4	Open cell gasket (initial compression = 40%)	12.75 (20°C)	11.78	- 8 %
5	Mineral wool (low compaction)	14.11 (20°C)	14.11	0 %
6	Mineral wool (average compaction)	5.232 (20°C)	5.05	- 3.5%
7	Mineral wool (high compaction)	1.706 (20°C)	1.743	+ 2 %
8	Polyethelene and mineral wool	0.5888 (20°C)	0.5647	- 4 %
9	EPDM gap gasket	0.0638 (20°C)	0.0787	+23 %
10	Wood-urethane-aluminium	0.0602 (20°C)	0.0599	- 0.5%
11	Adhesive tape on water resistant drywall joints (Spacing = 1/8")	(11-1) 0 (-20°C) (11-2) 0 (65°C)	(11-1) 0 (11-2) 0	--- ---
12	Adhesive tape on water resistant drywall joints (Spacing = 1/4")	(12-1) 0 (-20°C) (12-2) 0 (65°C)	(12-1) 0 (12-1) 0	--- ---

TABLE 2: (cont'd)

MATERIALS		Q (75 Pa) INITIAL 02 - 91	Q (75 Pa) FINAL 07 - 91	Q
NO	DESCRIPTION	m³/h-m	m³/h-m	%
14	Adhesive tape on spun bonded olefin paper	(14-1) 0.0276 (20°C) (14-2) 0.0315 (-20°C) (14-3) 0.0258 (65°C)	0.0252 0.0307 COMPLETE LOSS OF AIR TIGHTNESS	- 9 % - 2 % ---
15	Adhesive tape on perforated polyethelene air barrier	(15-1) 0.7740 (20°C) (15-2) 1.5452 (-20°C) (15-3) 3.1669 (65°C)	0.5276 0.5257 2.2351	-32 % -66 % -23 %
16	Interior sealant (Acrylic) - width = 1/4" - wood - sealant - alu. - backer rod	0 (20°C)	0	---
17	Interior sealant (Acrylic) - width = 1/2" - wood - sealant - alu. - backer rod	0 (20°C)	0	---
18	Interior sealant (Silicone) - width = 1/4" - wood - sealant - alu. - backer rod	0 (20°C)	0	---
19	Interior sealant (Silicone) - width = 1/2" - wood - sealant - alu. - backer rod	0 (20°C)	0	---
20	Exterior sealant (Acrylic) - width = 1/4" - wood - sealant - alu. - backer rod	(20-1) 0 (-20°C) (20-2) 0 (65°C)	0 0.9998	--- ---

TABLE 2: (cont'd)

MATERIALS		Q (75 Pa) INITIAL 02 - 91	Q (75 Pa) FINAL 07 - 91	Q
NO	DESCRIPTION	m^3/h-m	m^3/h-m	%
21	Exterior sealant (Acrylic) - width = 1/2" - wood - sealant - alu. - backer rod	(21-1) 0 (-20°C) (21-2) 0 (65°C)	0 COMPLETE LOSS OF AIR TIGHTNESS	--- ---
22	Exterior sealant (Silicone) - width = 1/4" - wood - sealant - alu. - backer rod	(22-1) 0 (-20°C) (22-2) 0 (65°C)	0 0	--- ---
23	Exterior sealant (Acrylic) - width = 0 - wafer board - sealant over the surface wafer board	(23-1) 0 (-20°C) (23-2) 0 (65°C)	0 0	--- ---
24	Exterior sealant (Acrylic) - width = 1/8" - wafer board - sealant wafer board	(24-1) 0 (-20°C) (24-2) 0 (65°C)	0 0	--- ---

* (1) Two of the initial 17 joints in the specimen had to be filled in, since the gaskets had completely popped out of the joint. This value was obtained for the 15 remaining joints which resisted until the end of the test.

5. DISCUSSIONS AND OBSERVATIONS

Specimens: No. 1- Closed cell backer rod, 30% compression.
Photo 1 (3/4" backer rod in 1/2" joint).

No. 2- Closed cell backer rod, 50% compression.
Photo 2 (1" backer rod in 1/2" joint).

The closed cell backer rod is a stable material which is quite air tight depending on its compression rate. The main losses occur at the ends of the joints which must be made with care. The difference between the initial and final flow for specimen no. 2 is due to one joint which had shrunk over the 5 months leaving a small opening. This shrinkage was due to the fact that the backer rod had been stretched when it was originally inserted and over time it came back to its normal length.

Specimens: No. 3- Open cell gasket, compression 20%.
Photo 3 (Gasket = 5/8" in a joint = 1/2").

No. 4- Open cell gasket, compression 40%.
Photo 4 (Gasket = 5/8" in a joint = 3/8").

Due to the very nature of this gasket, it is a very poor air barrier, since the open cells present almost no resistance to the air. A low rate of compression generates problems relating to the positioning and stability of the backer rod. During the test under extended pressure differentials, two gaskets in specimen no. 3 popped out of the joint after 8 days (photo 3A). To complete the experiment, we had to patch up the cracks with adhesive tape. The results appearing in Table 2 for this specimen exclude these two latter joints. An open cell gasket acts as an air filter. This explains the improvement in air tightness of the specimens. Photos 3B and 3C shows the change in colour due to dust. This dust increases the air tightness of the gasket by partially blocking the cells.

Specimens: No. 5- Mineral wool, low compaction (0-20%) (0 to 3/4" wool in 1/2" joint) (Photo 5).

No. 6- Mineral wool, average compaction (50%) (1" wool in 1/2" joint) (Photo 6).

No. 7- Mineral wool, high compaction (75%) (2" wool in 1/2" joint) (Photo 7).

As expected, mineral wool is a poor air barrier. With low compaction, the inserted wool moved slightly under the influence of the pressure differential, but not enough to influence results (Photo 5A). As for the open cell gaskets, mineral wool acts as a filter for dust, especially for specimens no. 5 and 6 (Photo 5B). This had no influence whatsoever on the results for specimen no. 5, but increased very slightly the air tightness for specimenno. 6.

Specimen: No. 8- Polyethylene + mineral wool, average compaction (50%) (Ref: Illustration 7 and photo no. 8 and 8A).

This assembly was proposed in "The Journal of Light Construction (June 1990)", as a way to fill in the space between the window frame and the wall opening. This assembly proved to have no more than average air tightness, with large losses at the ends of the joints and in certain folds in the polyethelene (photo 8B and 8C). The most common sealant used in construction today are silicone and acrylic and neither of those adheres satisfactorily to polyethylene. This makes the sealant useless in this assembly.

Specimen: No. 9- EPDM Gap Gasket (Photo no. 9).

This joint proved to be rather air tight, but once again the problem of air tightness at the ends of the joints is critical. The small difference in air tightness between the beginning and the end of the test is undoubtedly due to the handling to set up and take down the assembly which accentuated the losses at the ends of the joints.

Specimen: No. 10- 1/2" urethane foam between a wood-aluminium joint. (Photo 10 and 10A).

Urethane foam is a very stable material which does not seem in any way to be affected by this test, either by time or pressure. The air tightness results could have been higher with a wider joint. Urethane foam is very effective in large joints (> ½"). In small joints such as the one in the test, small cracks or voids are formed leaving space for the air the circulate (Photo 10B).

Specimens: No. 11- Adhesive tape on water resistant drywall joint.
(11-1, -20°C) (Gap = 1/8")
(11-2, 65°C) (Photo no. 11)

No. 12- Adhesive tape on drywall.
(12-1, -20°C) (Gap = 1/4")
(12-2, 65°C) (Photo nos. 12 and 12A)

Assembly which is very air tight and did not suffer any modification due to cold or heat. At no time did the adhesive tape threaten to peel off even when an attempt was made to scratch it slightly to remove it.

Specimen: No. 14- Adhesive tape on spun bonded ofelin paper joint.
(14-1, 20°C) Photo nos. 14 and 14A)
(14-2, -20°C)
(14-3, 65°C)

The air tightness test on this paper provided very good results, but very rapidly, the specimen at 65°C presented certain problem.

After 7 days the paper has torn away from certain staples (Photo 14B). After three weeks the paper had completely torn away from the staples and the specimen blow up like a balloon (Photo 14C, 14D). Finally, with the load being focused solely on the perimeter, one of the sides gave away presenting a large opening (Photo 14E). Subsequent to this opening being produced, pressure could not be maintained within the test chamber and as such the specimen had to be removed and replaced by a panel (Photo 14F).

For the specimens at 20°C and -20°C, creasing was all that was observed, the paper did not tear at these temperatures. None of the taped joints peeled away, this connection seemed to be very solid. The tear resistance of paper at high temperatures seems much more critical. The staples were installed 6" apart (15 cm) and the joints were spaced at 4" (10 cm) o.c. Thus, the force exerted against each staple was 2.25 N (0.52 lb). This fastening technique in high temperature application should be avoided.

<u>Specimen</u>: No. 15- Adhesive tape on perforated polyethelene air barrier.
(15-1, 20°C) (Photo nos. 15 and 15A)
(15-2, -20°C)
(15-3, 65°C)

This air barrier is a plastic membrane perforated with many thousands of small holes (4.3 holes/cm^2). It is supposed to act as an air barrier by preventing air infiltration while allowing water vapour diffusion.

This membrane proved itself to be permeable to air since its perforated surface held back very little air. Specimen 15-1 was manufactured with one paper section where the holes were smaller whereas the section that was used to build specimen 15-3 had bigger holes. This explains their large variance in air tightness (Photos 15B and 15C). Once again, the improvement in the final air tightness is due to the dust which, this time, partially blocked the perforations in the paper (Photo 15A).

Under pressure, the creases were noticed in the paper fiber, but the paper was not torn or ripped. Similarly, the adhesive tape showed perfect adherence to the surface and no problem was observed in this regard.

<u>Specimens</u>: No.16- Interior sealant, 20°C
<u>Acrylic</u>, joint: Wood-sealant-aluminium with backer rod.
<u>Width of the joint</u>: 1/4" (Photo nos. 16 and 16A)

No. 17- Connection identical with specimen no. 16
<u>Width of the joint</u>: 1/2" (Photo no. 17)

No. 20- Exterior sealant
<u>Acrylic</u> joint: Wood-sealant-aluminium with backer rod.
<u>Width of the joint</u>: 1/4" (Photo no. 20)
(20-1, -20°C) (20-2, 65°C)

No. 21- Connection identical for specimen no. 20
<u>Width of the joint</u>: 1/2" (Photo no. 21)
(21-1, -20°C) (21-2, 65°C)

The use of acrylic base sealant is quite widespread in construction due to its low price. The initial and final air tightness tests for these assemblies were very good except for those exposed to high temperatures (65°C). After only one week, the two specimens at 65°C showed rips along the joints (Photo 20A, 20B, 21A). After two weeks, one part of the joints in specimen 21-2, due to pressure, popped completely out along a distance of several centimeters (Photo 21B). Moreover, the cracks observed previously got longer. The cracks became slightly longer over the next two weeks and then they stopped.

The other specimens at 20°C and -20°C showed no visible change which would alter their air tightness.

Specimens: No. 18- Interior sealant, 20°C
Silicone joint: Wood-sealant-aluminium with backer rod.
Width of the joint: 1/4" (Photo no. 18)

No. 19- Connection identical with specimen no. 18
Width of the joint: 1/2" (Photo no. 19)

No. 22- Exterior sealant
Silicone, joint: Wood-sealant-aluminium with backer rod.
Width of the joint: 1/4" (Photo no. 22)
(21-1, -20°C) (22-2, 65°C)

Regardless of the temperature or the width of the joint, none of these specimens showed any damage (Photo 22A). Only a change in colour occurred, with the sealant taking on a yellow colour.

Specimens: No. 23- Exterior sealant
Acrylic
(23-1, -20°C) Wafer board with sealant on surface (Photos 23, 23A)
(23-2, 65°C)

No. 24- Exterior sealant
Acrylic
(24-1, -20°C) Wafer board, spacing 1/8", with sealant.
(24-2, 65°C) (Photo 24)

As is the case with the other acrylic joints at 65°C, these also split, and this is true for both the surface joints as well as to the 1/8" wide joints (Photos 23B, 24A). But, perhaps due to their low exposure to pressure, this did not have any measurable change on air tightness. The specimens at -20°C do not show any cracks. Once again, it is the affect of heat which causes acrylic base sealant joints to tear.

6. COMPARISON OF AIR TIGHTNESS OF CONNECTIONS IN RELATION TO THE REQUIREMENTS FOR A FIXED WINDOW

Since these connections are fixed joints between air barrier elements, their air tightness must be equivalent to that for a fixed window which is also made up of fixed joints.

According to CAN/CSA-A440-M90 the maximum infiltration rate allowed at 75 Pa for a fixed window is 0.25 (m^3/h-m). Table 3 gives the connections which satisfy the air tightness criteria for this reference standard.

Material no. 14, spun bonded ofelin paper, initially had sufficient air tightness, but due to the deterioration of the specimen at 65°C, it does not appear on the table. The same thing applies to assembly no. 21 (exterior 1/2" acrylic sealant joint).

TABLE 3: COMPARISON OF CONNECTIONS WITH A FIX WINDOW

SPECIMENS MEETING THE STANDARD		SPECIMENS NOT MEETING THE STANDARD	
SPECIMEN NO.	AIR INFILTRATION $m^3/h\text{-}m$	SPECIMEN NO.	AIR INFILTRATION $m^3/h\text{-}m$
Fixed window Standard A440-M90	0.25	Fixed window	0.25
1- Closed cell backer rod	0.078	3- Open cell gasket	23.90
		4- Open cell gasket	12.75
2- Closed cell backer rod	0.075	5- Mineral wool	14.11
		6- Mineral wool	5.232
9- EPDM gap gasket	0.079	7- Mineral wool	1.743
10- Urethane	0.060	8- Wool + polyethelene	0.589
11- Tape + drywall	0		
12- Tape + drywall	0	15- Polyethelene membrane	3.1669
16- Interior acrylic 1/4"	0	20- Exterior acrylic	0.999
17- Interior acrylic 1/2"	0		
18- 1/4" Silicone	0		
19- 1/2" Silicone	0		
22- Exterior silicone	0		
23- Acrylic on wood	0		
24- Acrylic on wood	0		

Note: Complete deterioration of samples no. 14-3 and no. 21-2.

7. CONCLUSIONS

In spite of satisfactory air tightness, the closed cell backer rod should not be used as an air barrier element. Most of the leaks occur at the end of the joints and they tend to increase over time due to a contraction and/or loss of compression at the end of the joint.

The open cell gaskets are very poor air barriers even at high compression. If they are not compressed enough, they pop out of the joint or quite simply collapse. Thus, they should never be used simply in view of stopping up a crack.

Mineral wool remains a good insulation material, but of course it is a poor air barrier. Even if the idea of using it in conjunction with a polyethelene membrane is interesting, the construction principle for this is still difficult to execute properly.

The rubber EDPM gap gasket has shown good air tightness and stability properties. On the other hand, the efficiency of the EDPM joint depends to a great extent on its installation which must be executed very carefully.

Urethane foam is rather widespread and its insulating properties are well known. However, it's used as an air barrier at junctions or connections is not recommendable. Given that it is a very rigid material, it cannot accommodate large differential movements.

Adhesive tape used in this study showed great adherence on the surfaces where we used it under all the conditions tested. Whether this be water resistant drywall, olefin paper or perforated polyethelene, the joints all remained intact.

The problems with the spun bonded ofelin paper appeared very rapidly in the 65°C test chamber. At such a high temperature, the paper seem to loose its property to stretch and under pressure, it broke away from the staples holding it in place. In practice then if this was to happen, the exterior sheathing would hold the paper back and expose itself to the force generated by the pressure. Since exterior sheathing is not designed to do this, this could lead to deformation and ripping problems.

The silicone base sealant used did not show any weakness after the five months of testing, whether this being under cold or hot conditions. On the other hand, the acrylic base sealant used deteriorated very rapidly under high temperature conditions. However, it did not experience problems in the other two chambers. Ideally, its usage should be limited to the interior side of the building envelope.

One important thing is that in this accelerated aging process all the major deterioration occurred during the first two months. Beyond this first two months no visible change was observed except for the gradual yellowing of the sealants.

APPENDIX "A" - PHOTOGRAPHS

FOND DE JOINT ET GARNITURE D'ETANCHEITE UTILISE

FOND DE JOINT A CELLULE FERME: No. 1 = 1"

No. 2 = 3/4"

No. 3 = 5/8"

No. 4 OPEN CELL GASKET 5/8"

No. 5 EPDM GAP GASKET

BACKER ROD AND AIR TIGHT GASKET USED

CLOSED CELL BACKER ROD: No. 1 = 1"

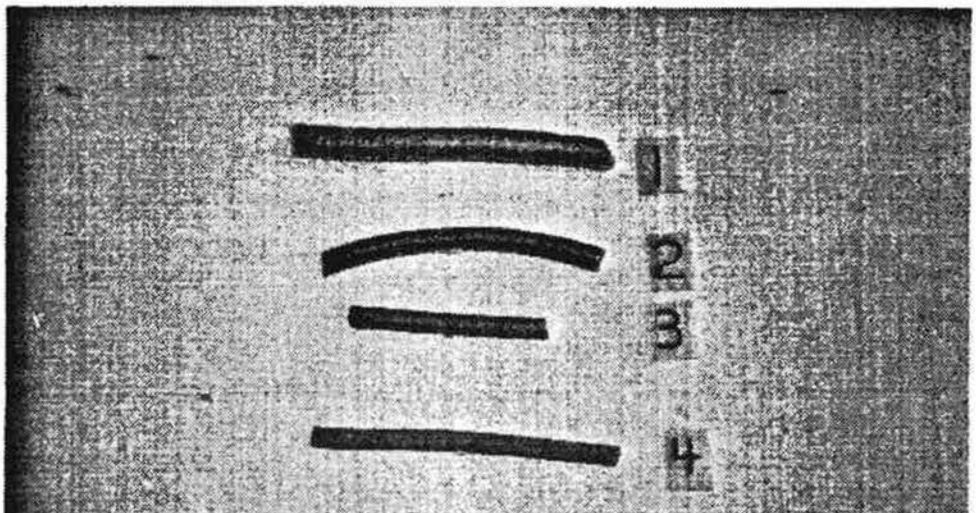


Photo No. 0

SPECIMEN NO. 1: Closed cell backer rod (compression = 30%).

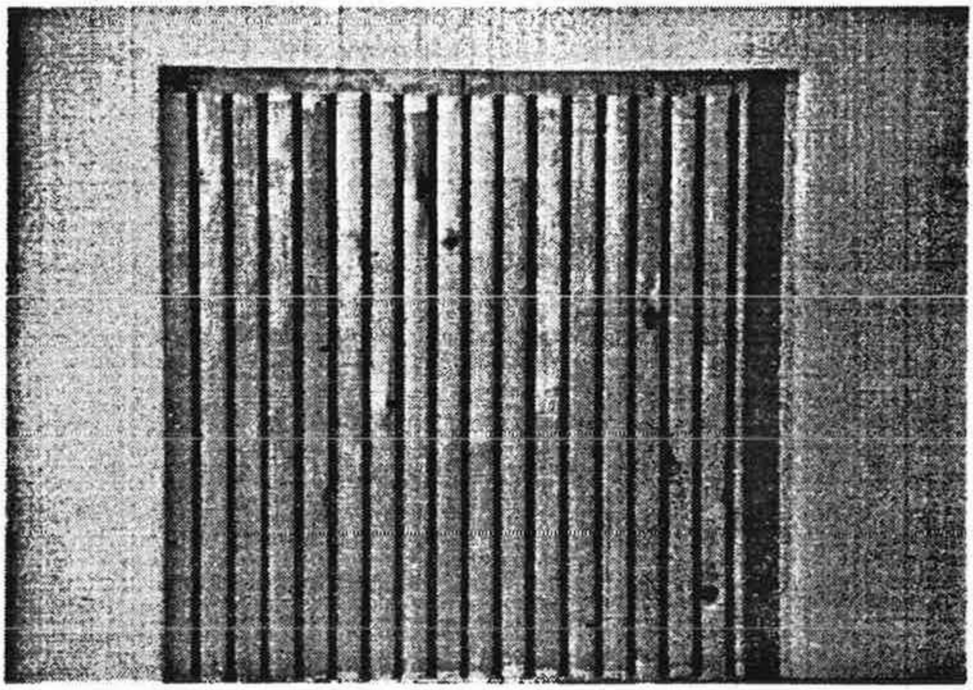


Photo No. 1

SPECIMEN NO. 2: Closed cell backer rod (compression = 50%).

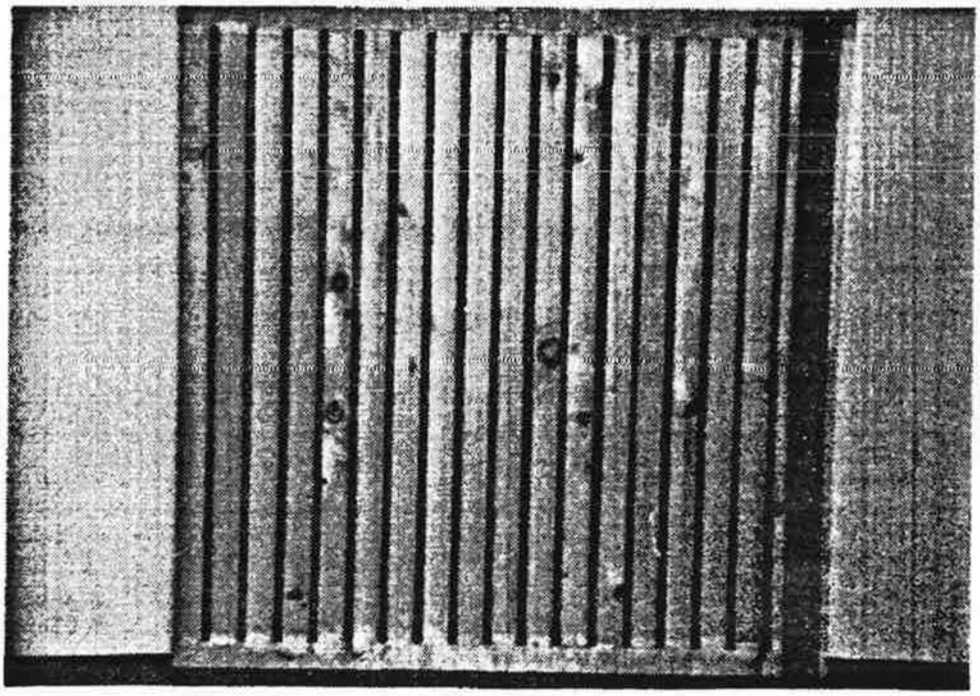


Photo No. 2

<u>SPECIMEN NO. 3</u>: Open cell gaskets (compression 20%).

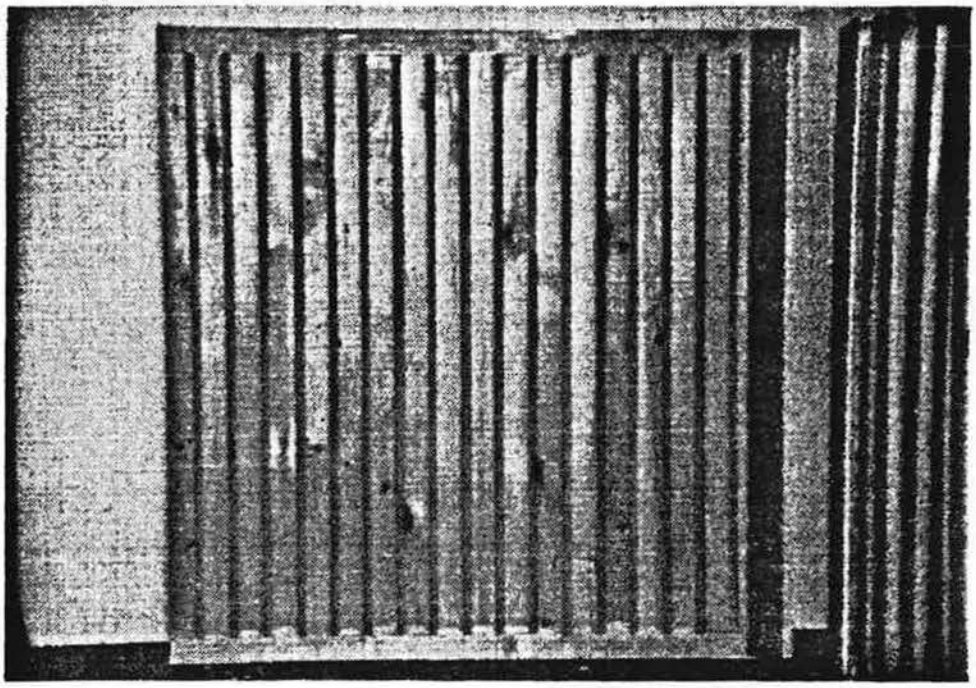


Photo No. 3

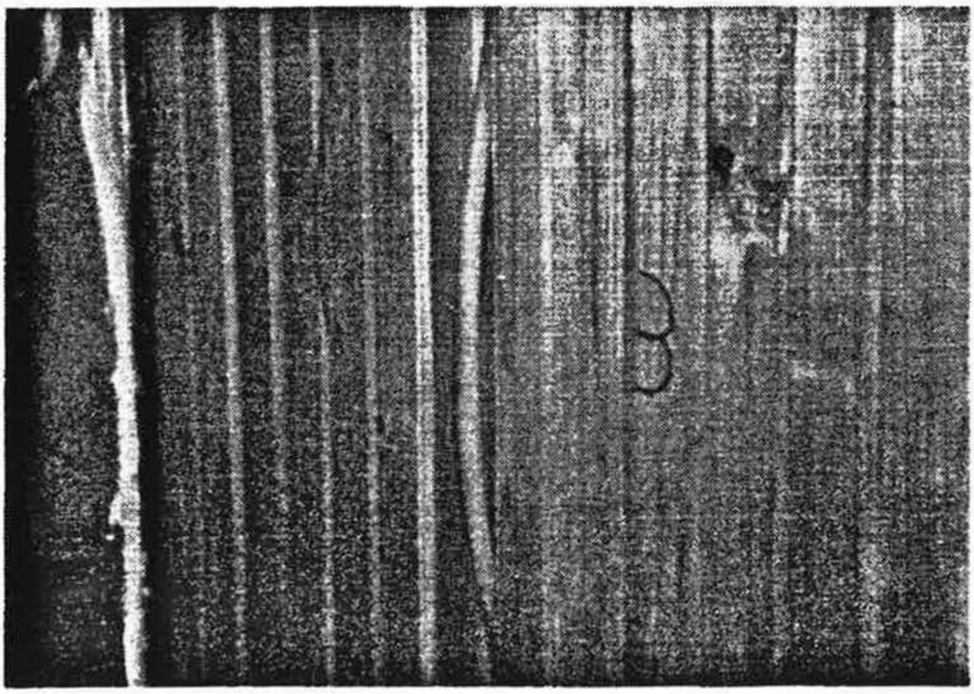


Photo No. 3A

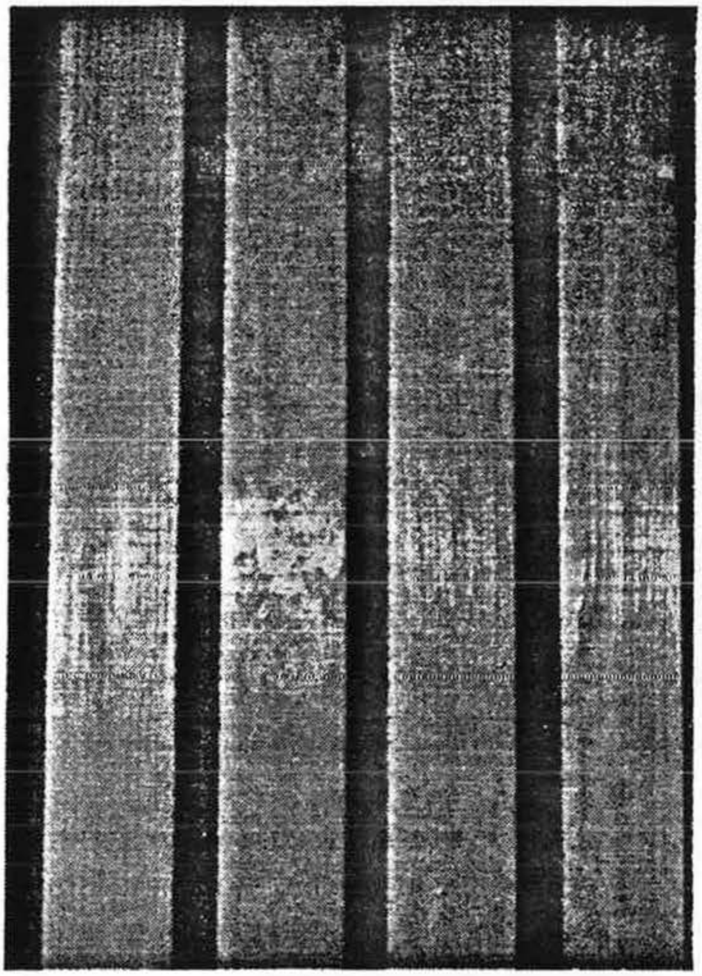


Photo No. 3B

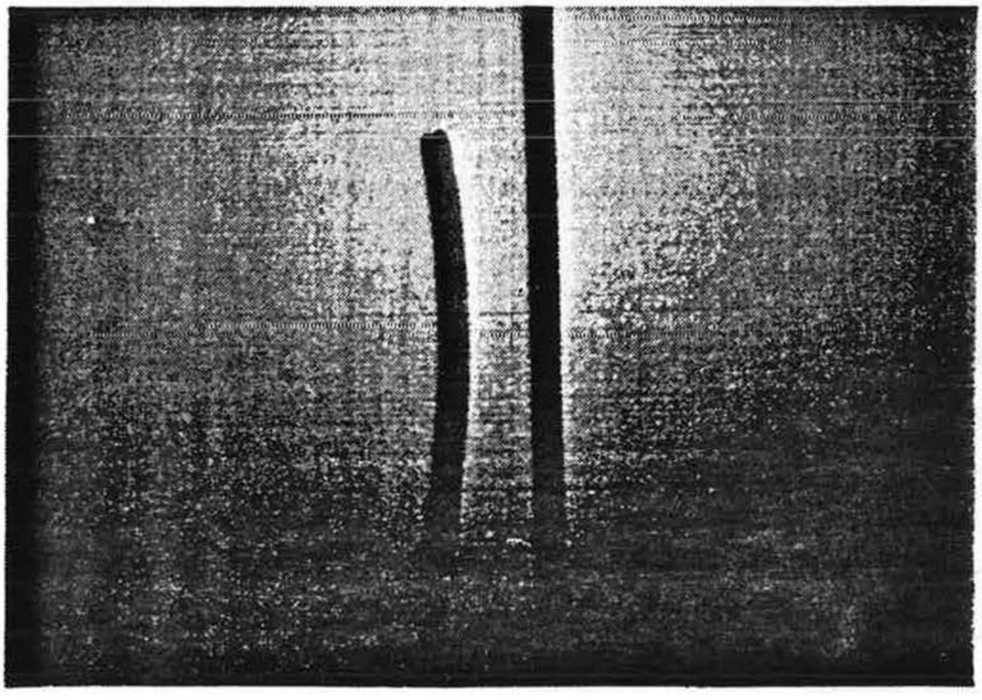


Photo no. 3C

<u>SPECIMEN NO. 4</u>: Open cell gaskets (compression 40%).

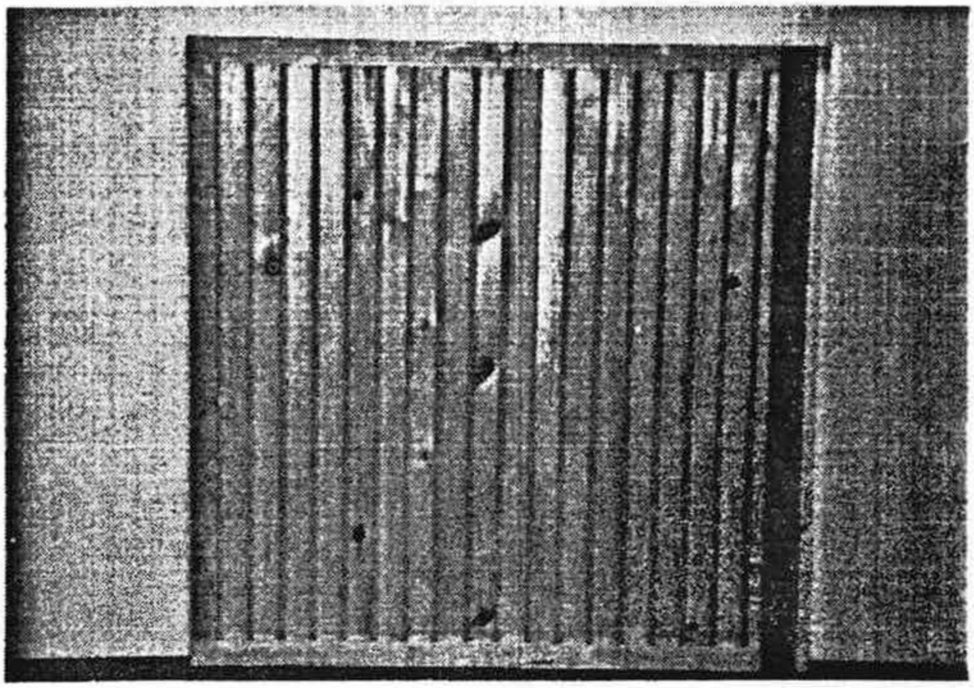


Photo No. 4

<u>SPECIMEN NO. 5</u>: Mineral wool, low compaction.

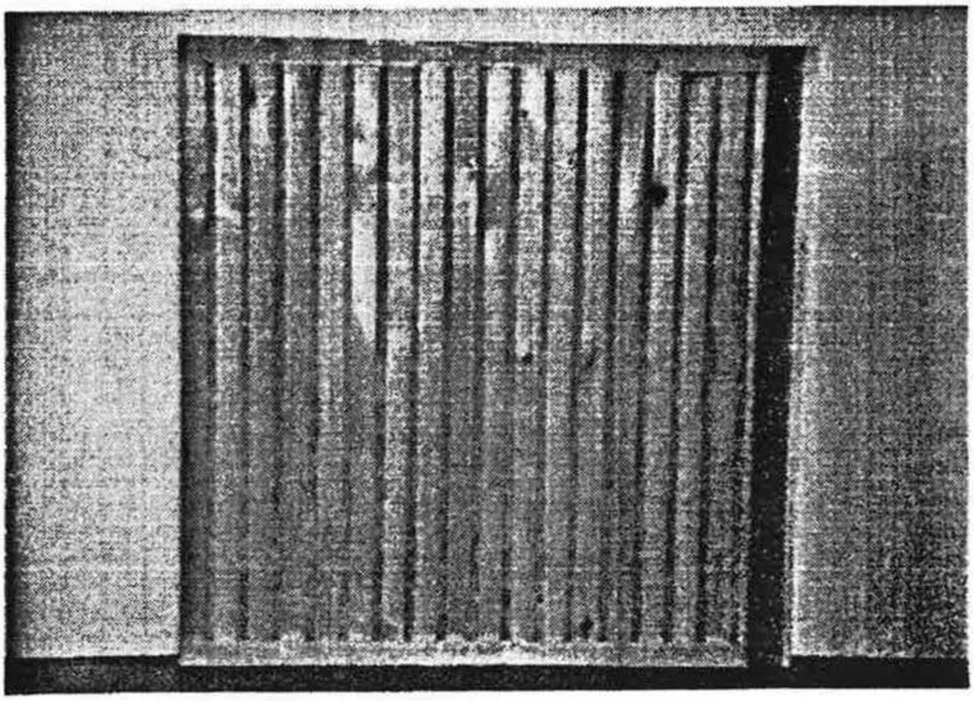


Photo No. 5

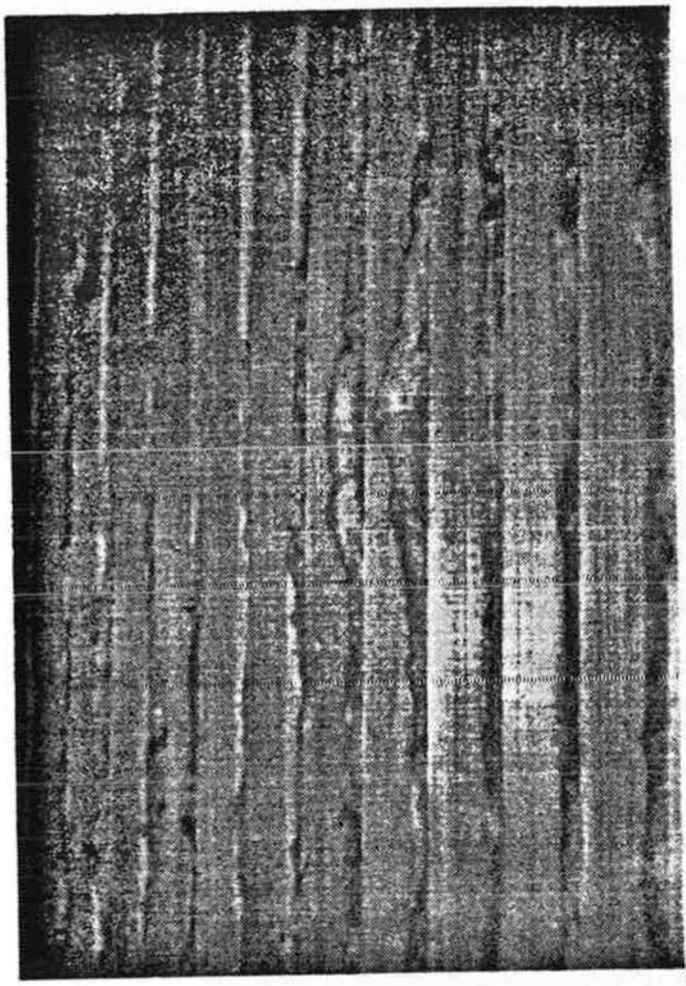


Photo no. 5A

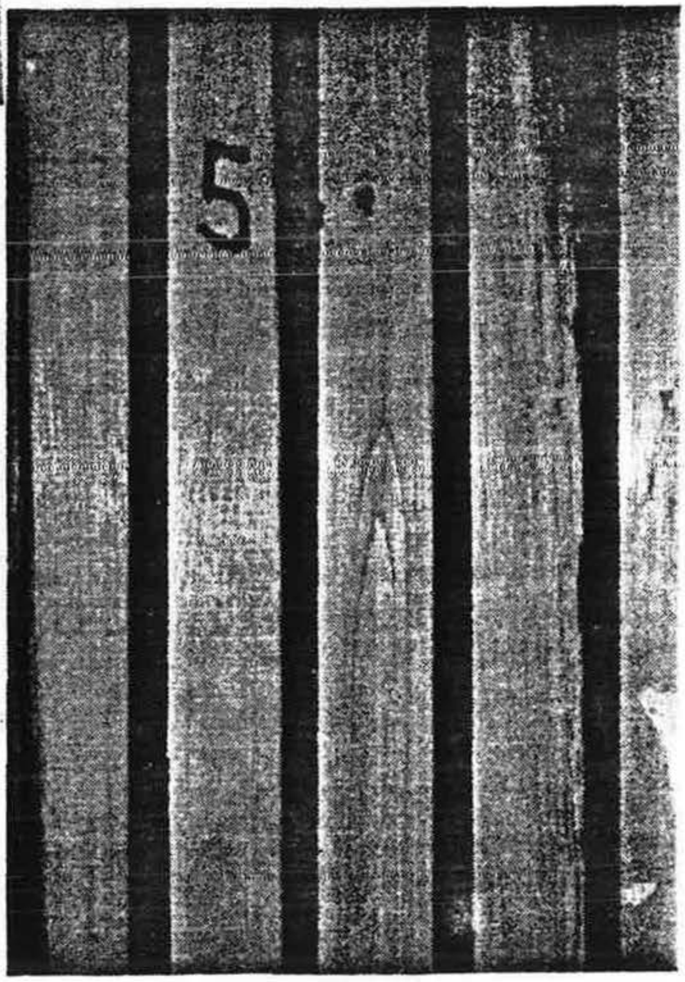


Photo no. 5B

SPECIMEN NO. 6: **Mineral wool, average compaction.**

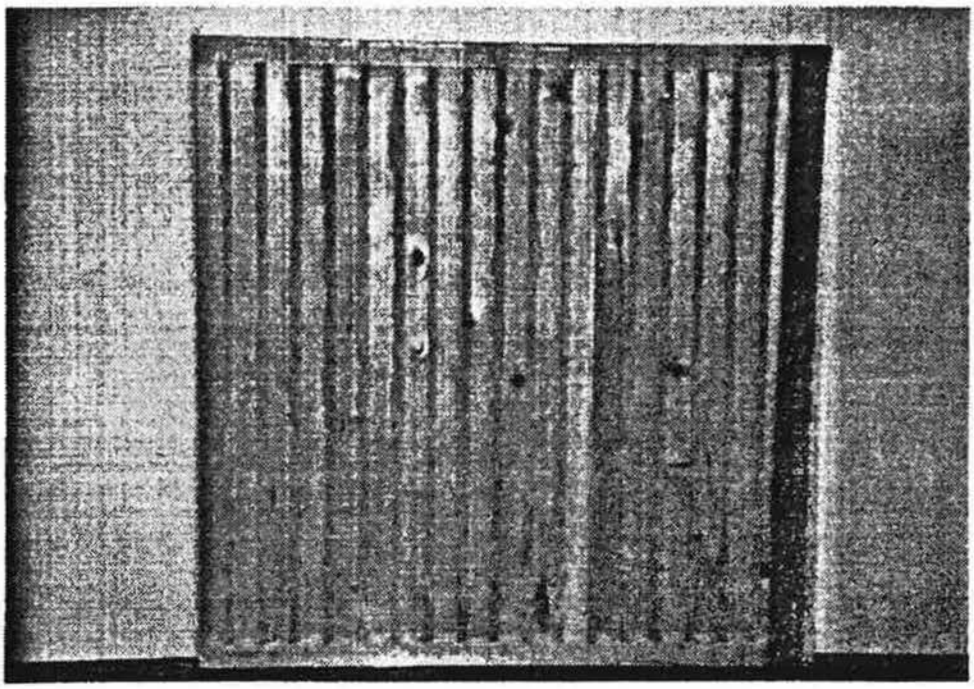


Photo No. 6

SPECIMEN NO. 7: **Mineral wool, high compaction.**

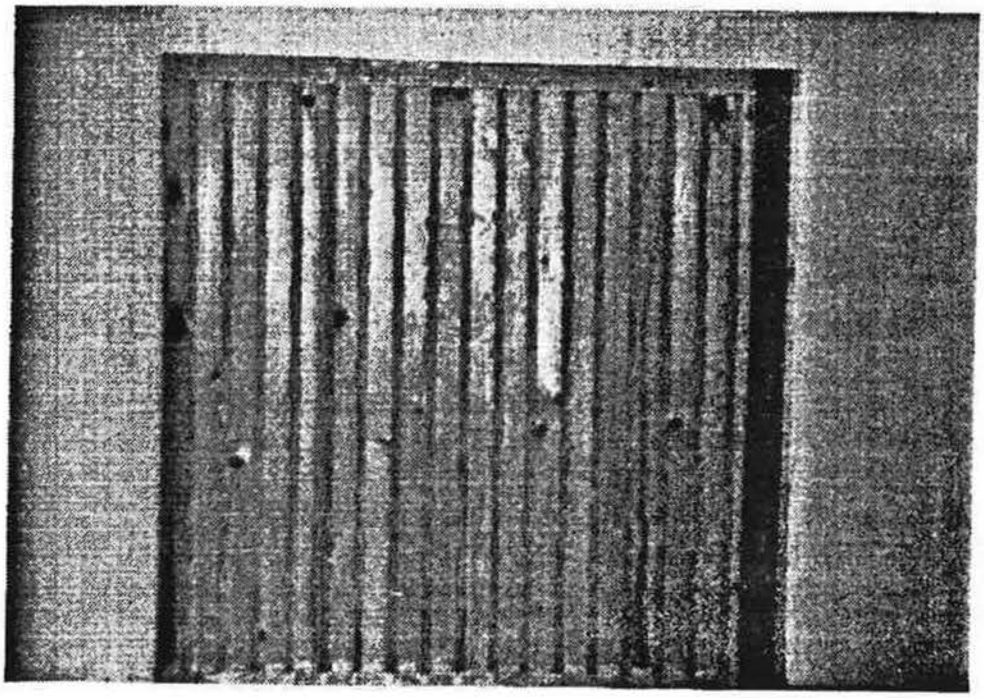


Photo No. 7

SPECIMEN NO. 8: Polyethylene + mineral wool.

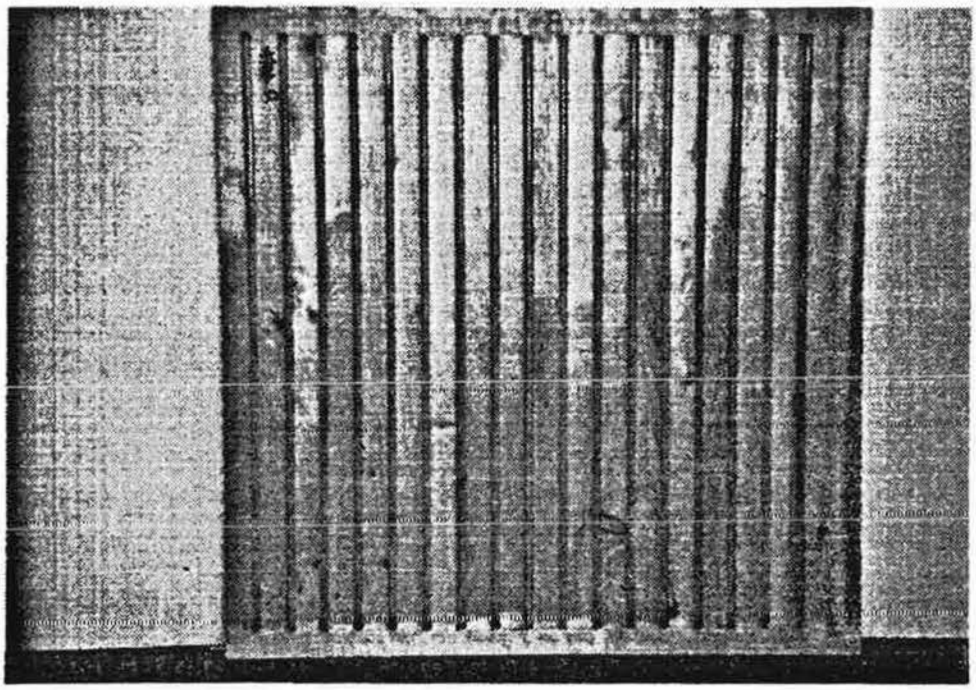


Photo No. 8

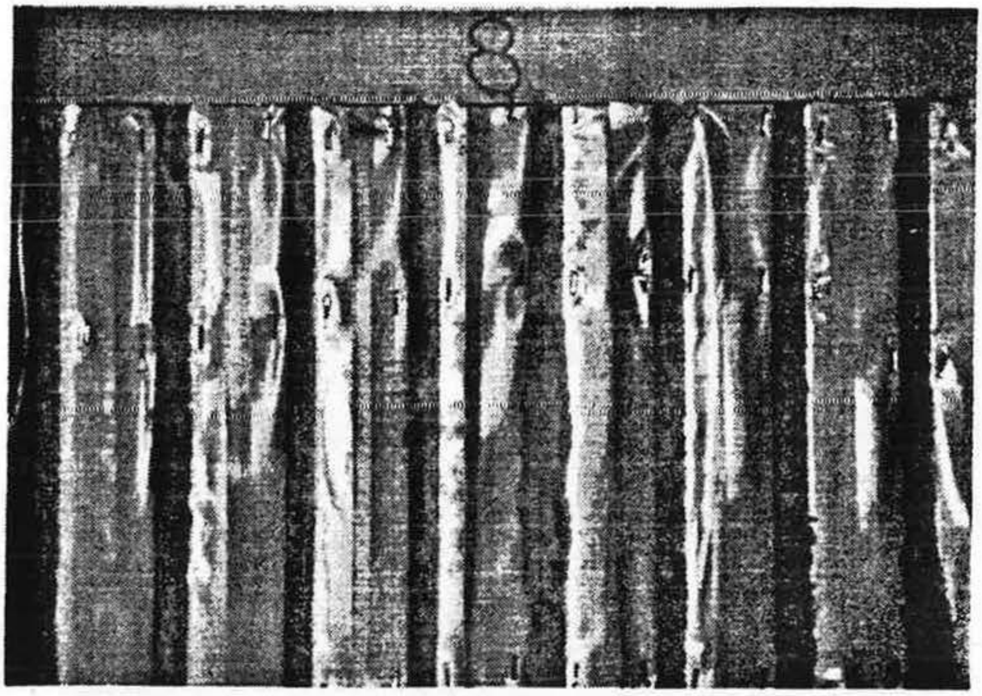


Photo No. 8A

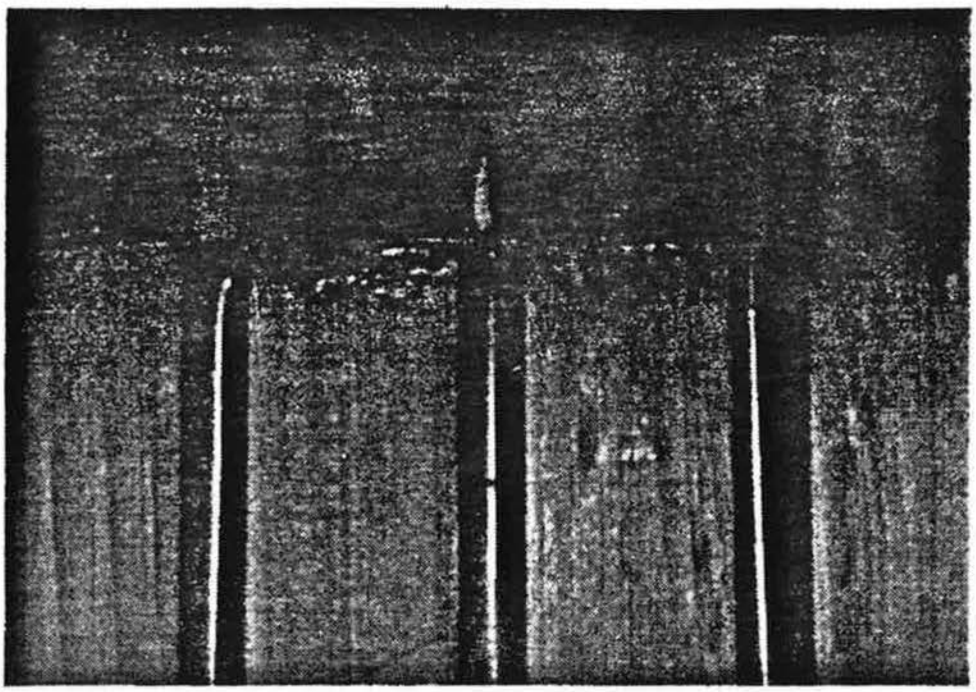


Photo No. 8B

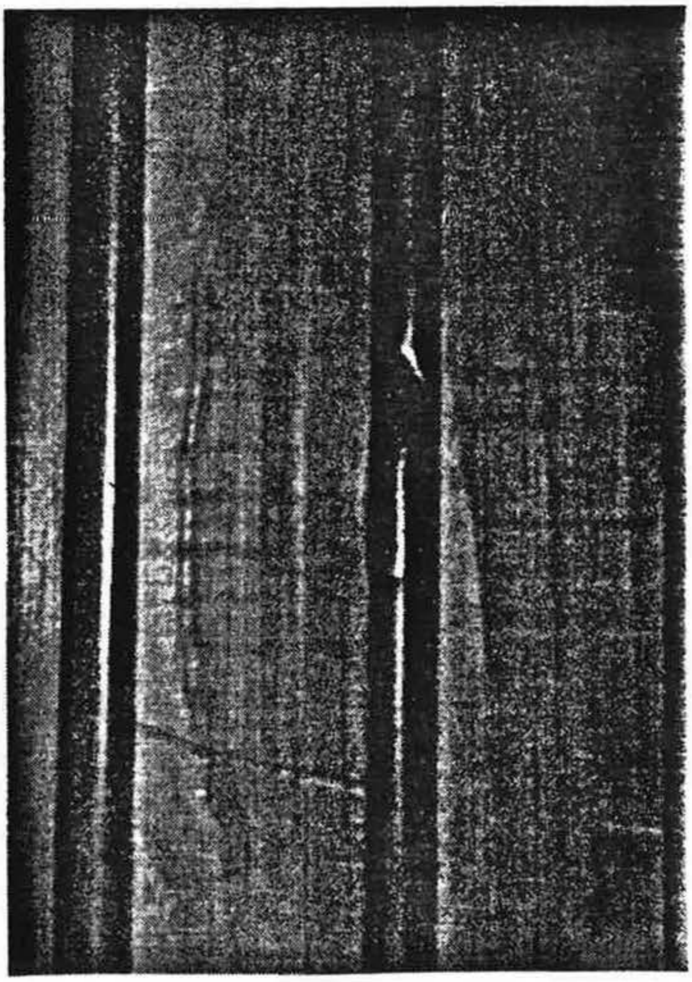


Photo No. 8C

SPECIMEN NO. 9: EPDM Gap Gasket

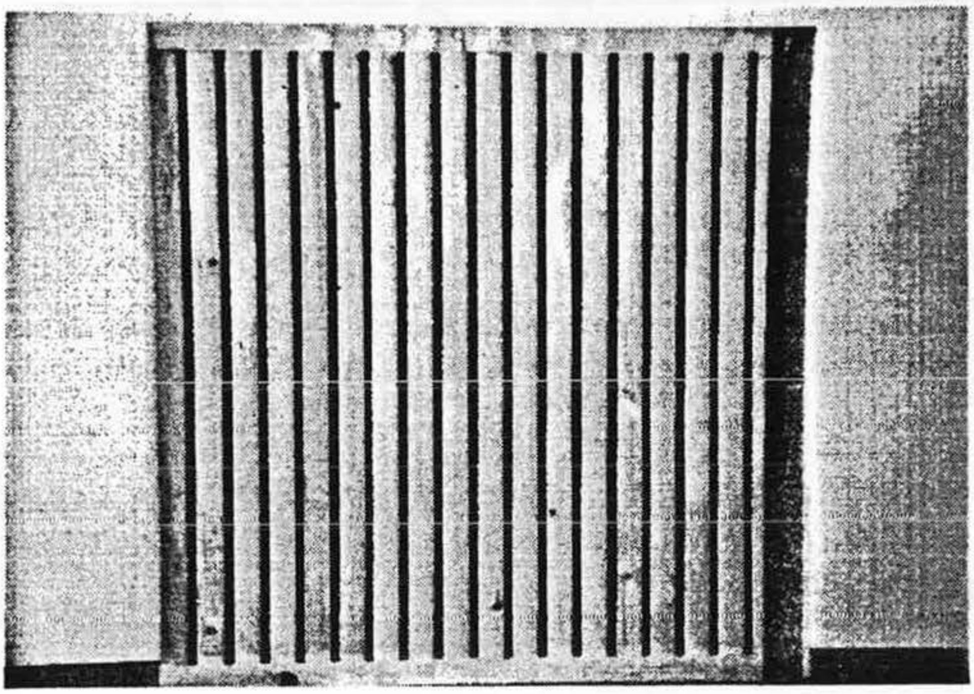


Photo No. 9

SPECIMEN NO. 10: Wood-urethane-aluminium joint.

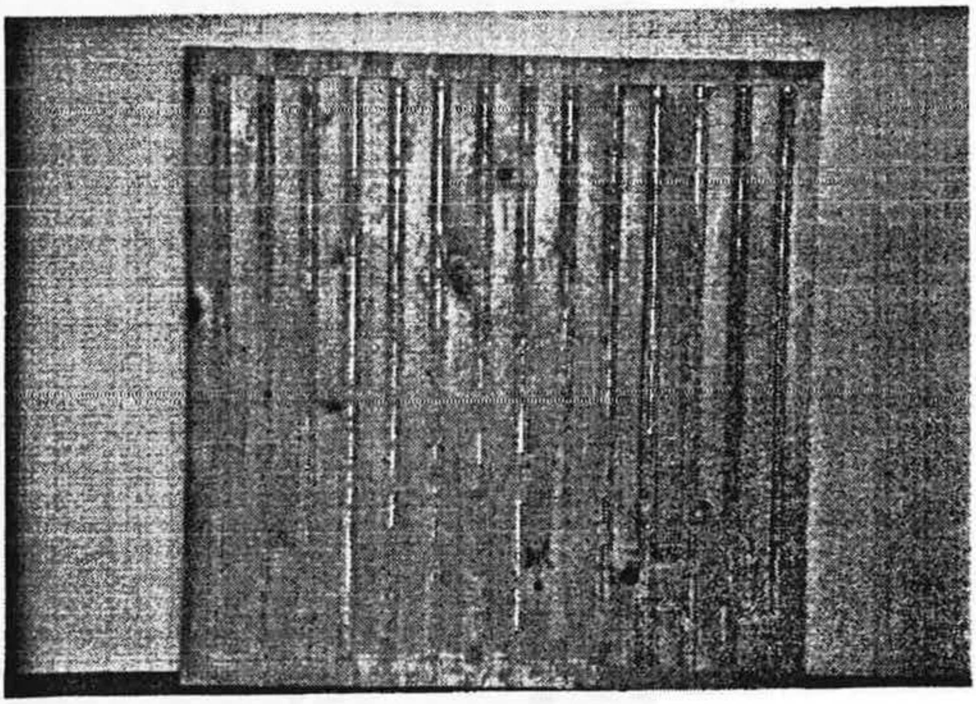


Photo No. 10

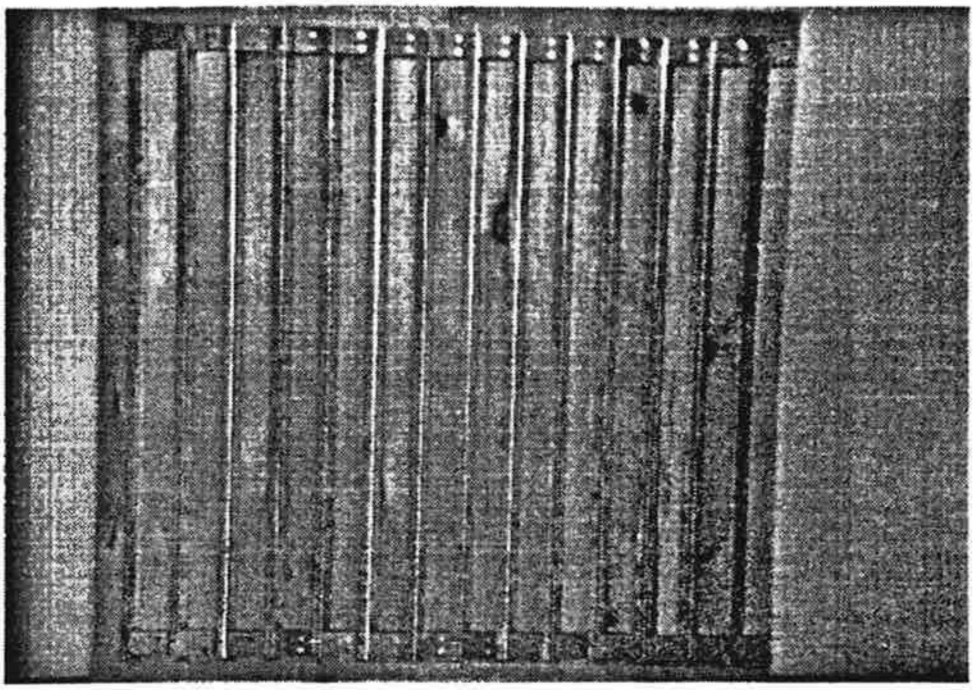
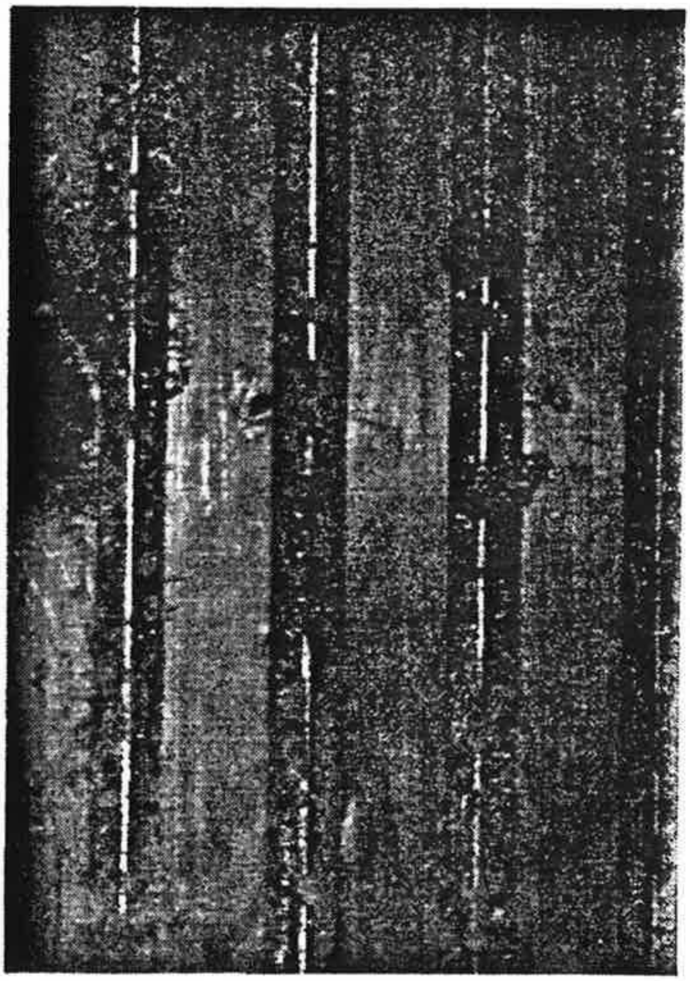


Photo No. 10A

Photo No. 10 B



SPECIMEN NO. 11: Adhesive tape on water resistant drywall joint (spacing = 1/8").

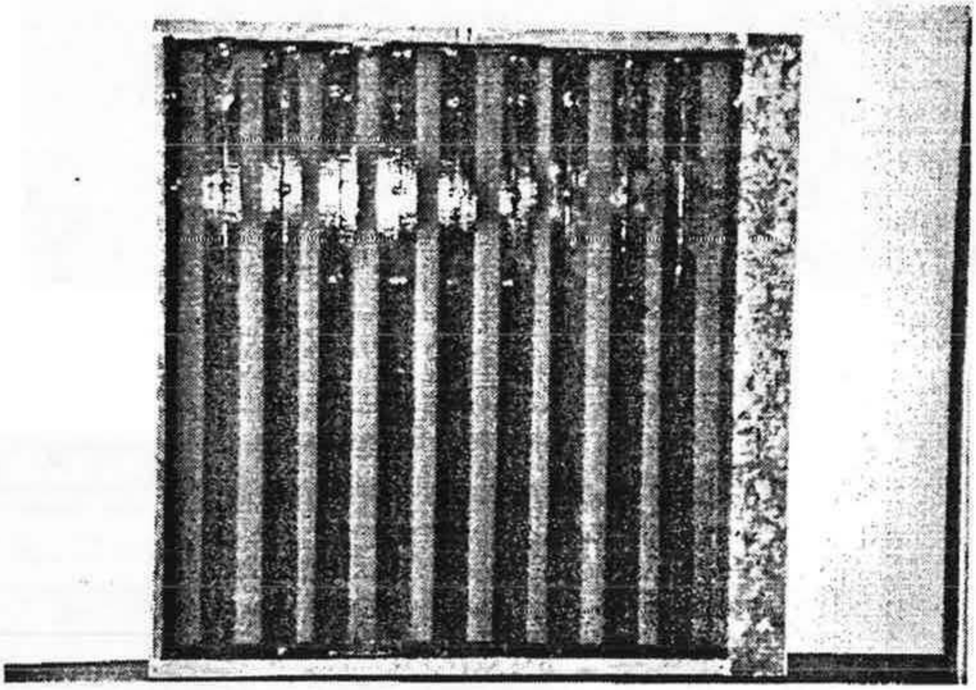


Photo No. 11

SPECIMEN NO. 12: Adhesive tape on drywall (spacing = 1/4").

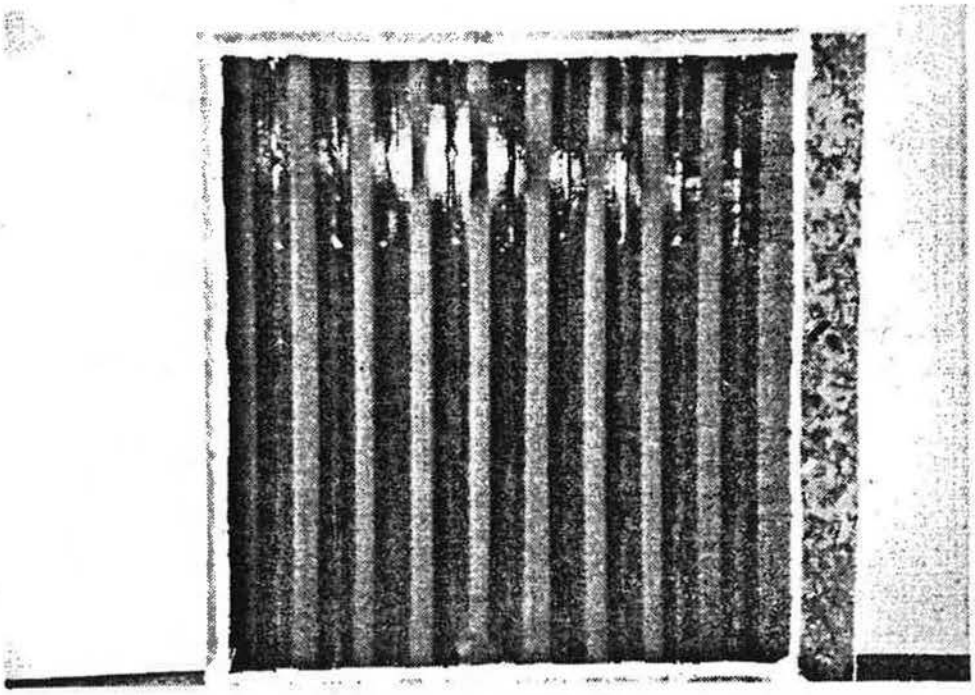


Photo No. 12

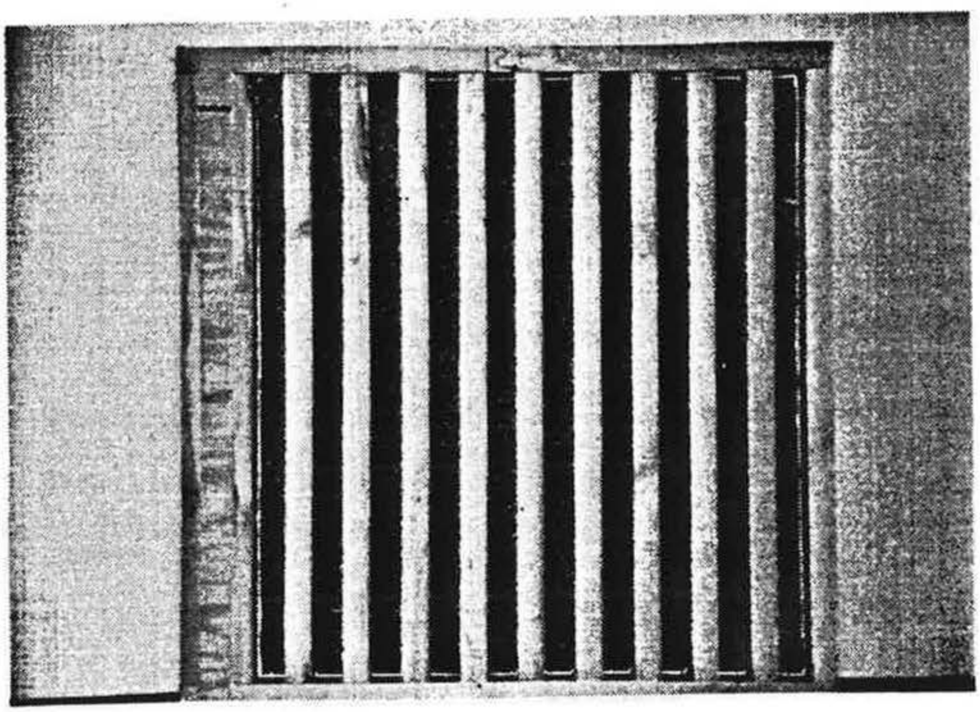


Photo No. 12A

SPECIMEN NO. 14: Adhesive tape on spun bonded ofelin paper joint.

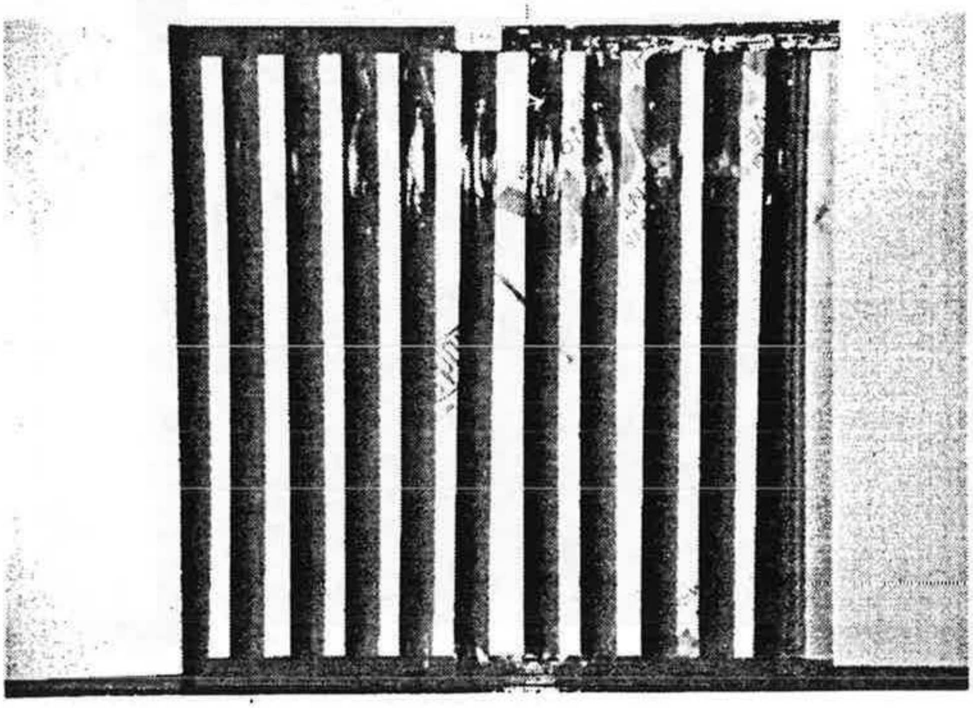


Photo No. 14

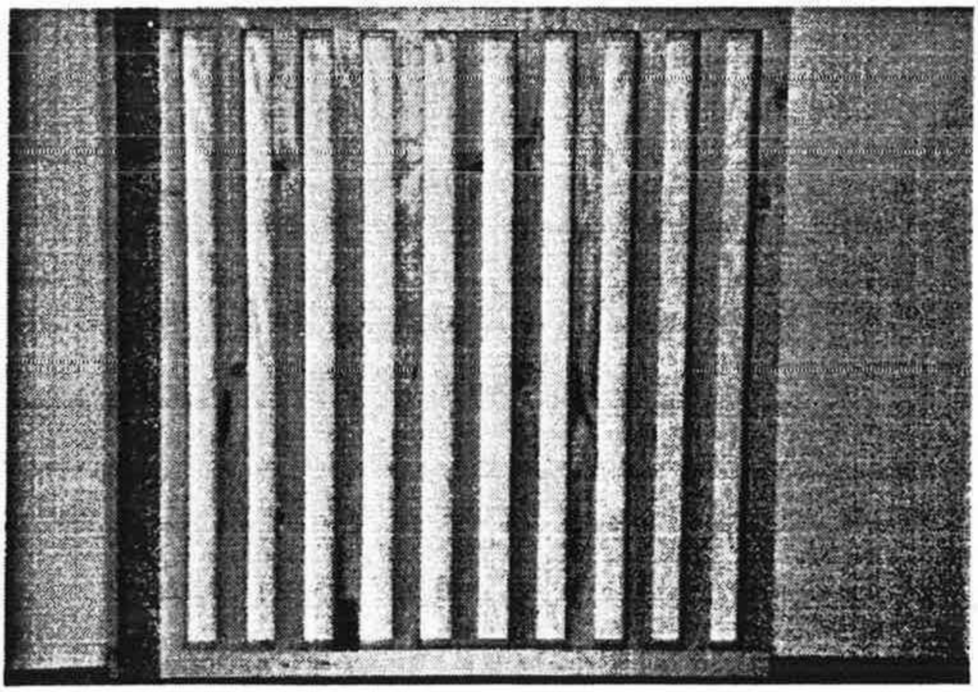


Photo No. 14A

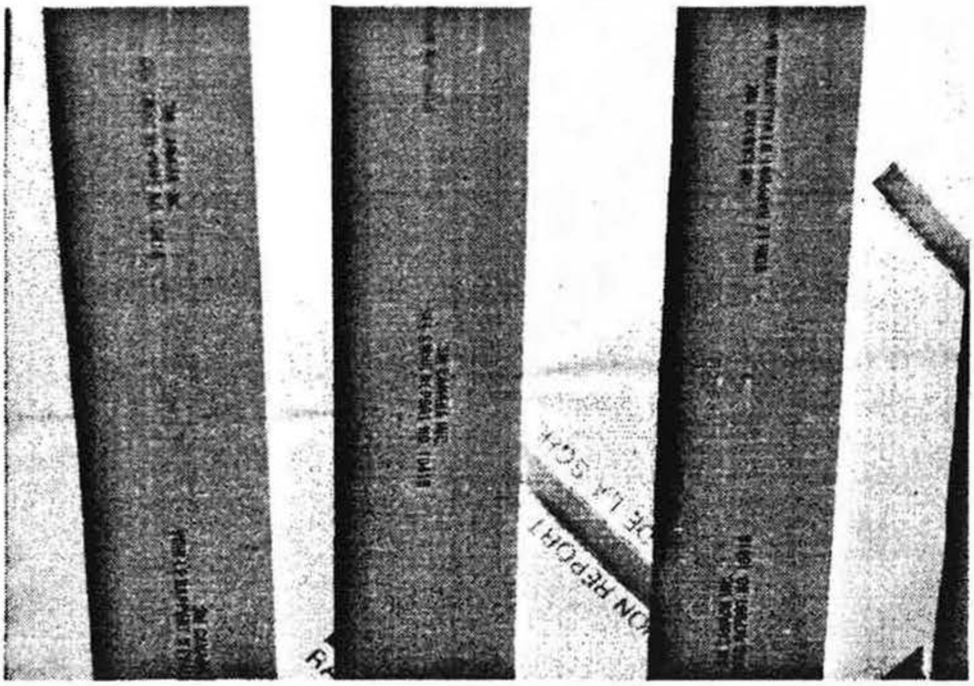


Photo No. 14B

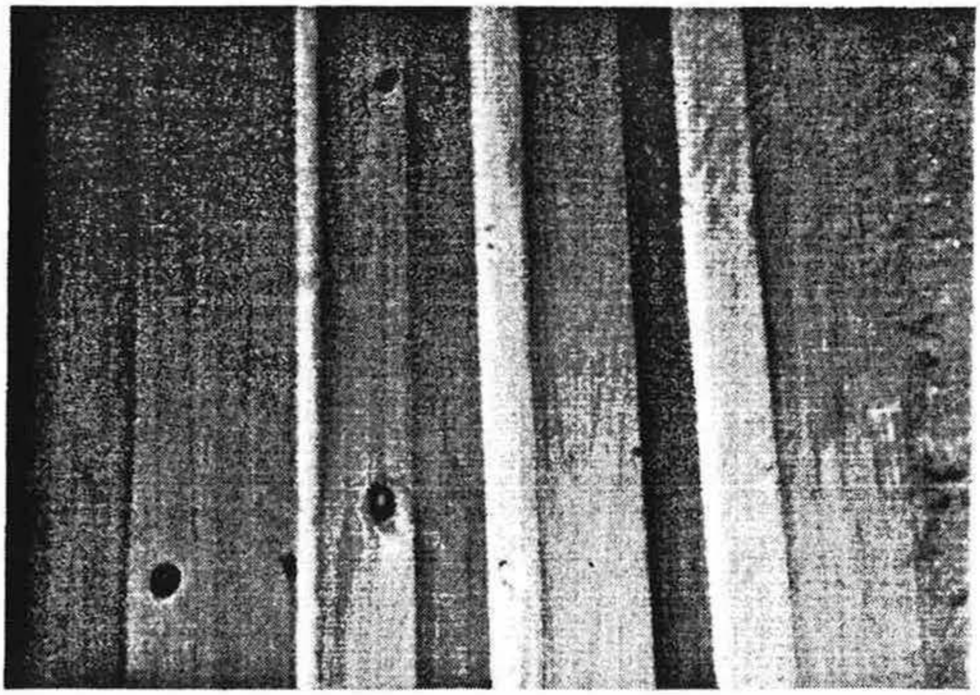


Photo No. 14C

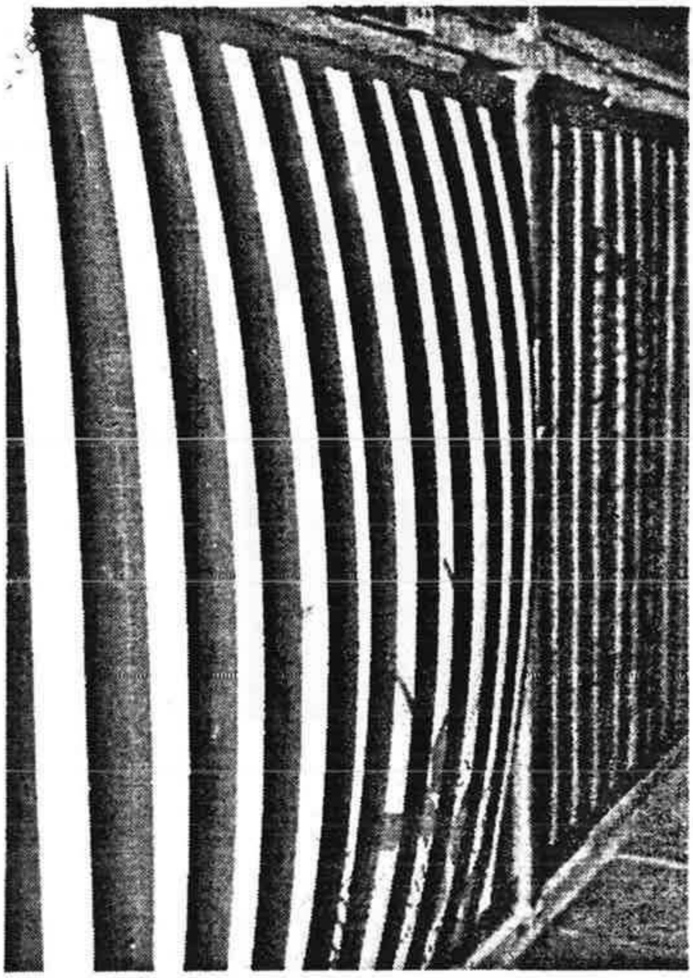


Photo No. 14D

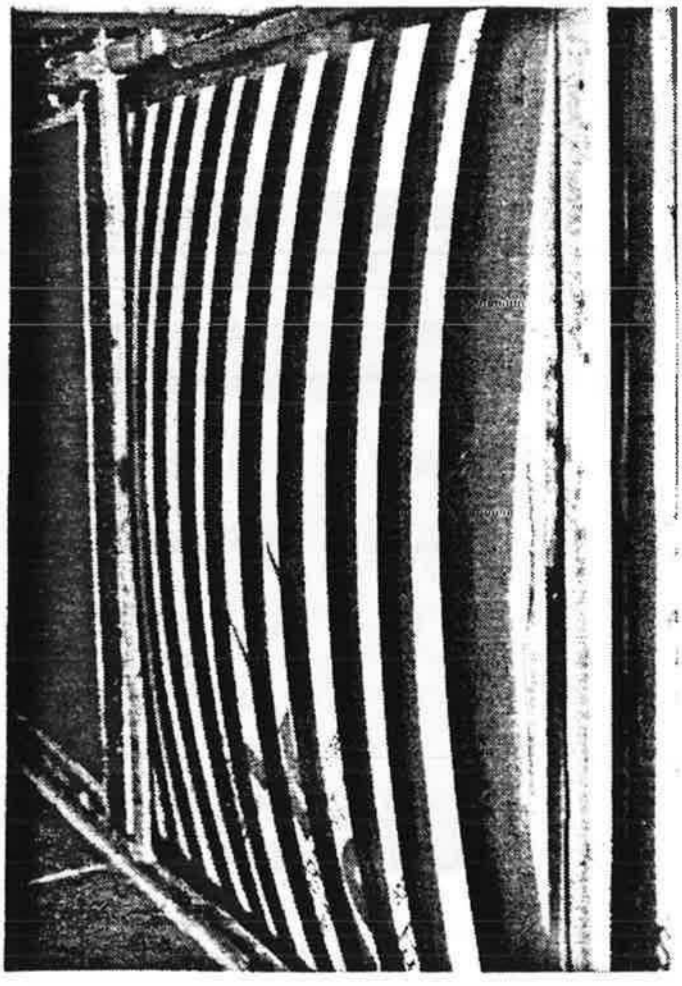


Photo No. 14E

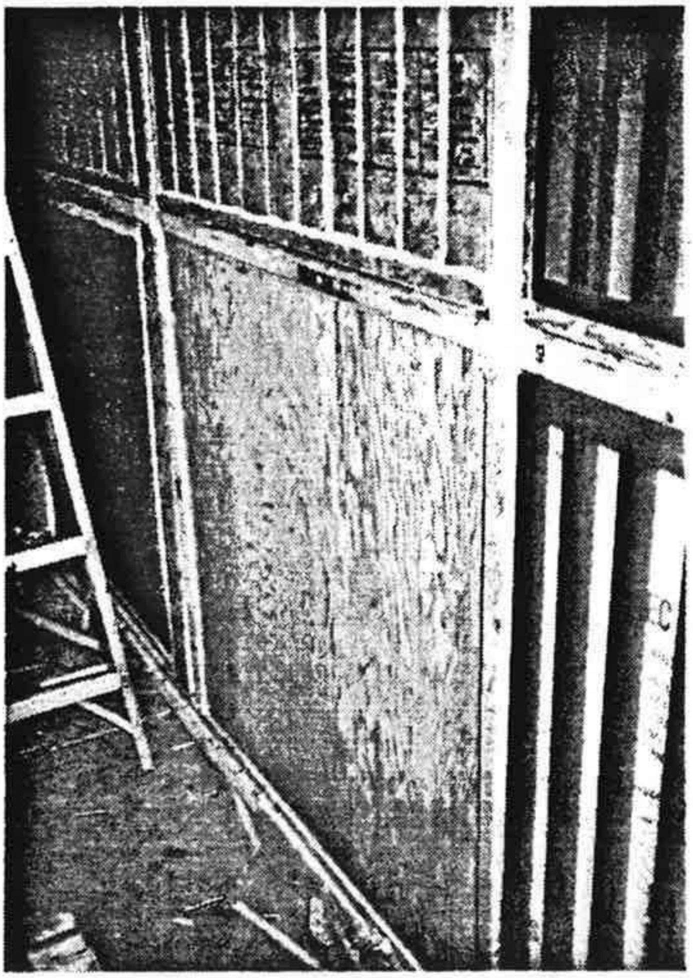


Photo no. 14F

SPECIMEN NO. 15: Adhesive tape on perforated polyethelene air barrier joint.

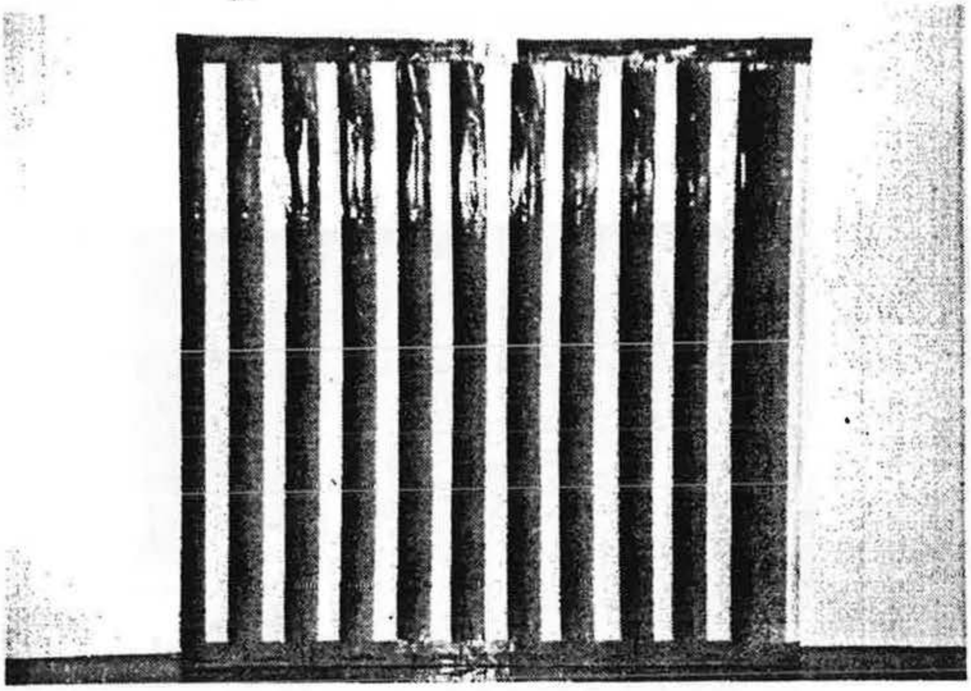


Photo No. 15

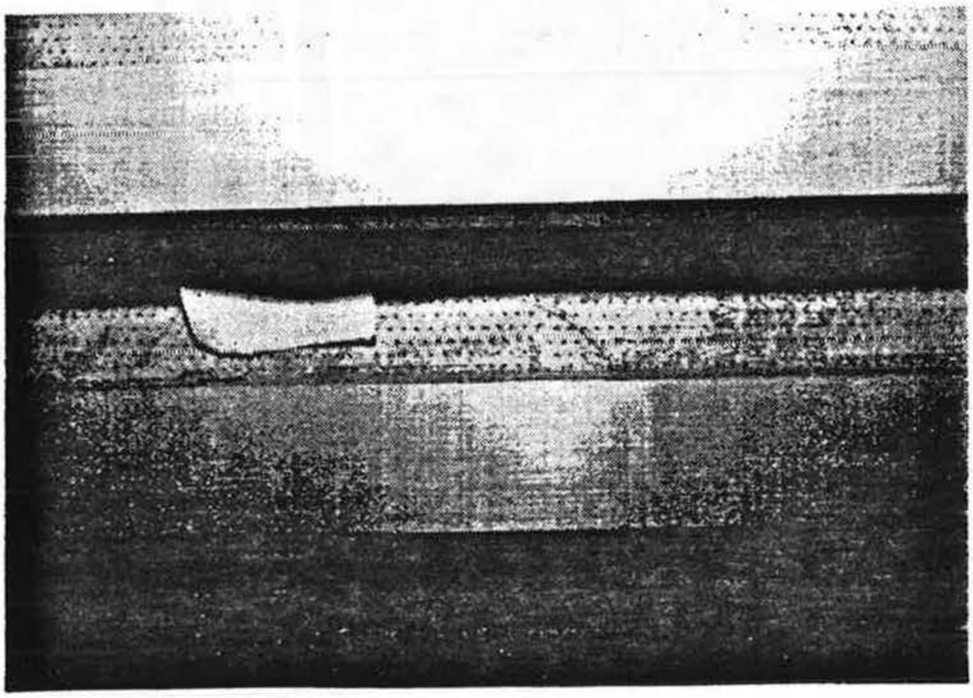


Photo No. 15A

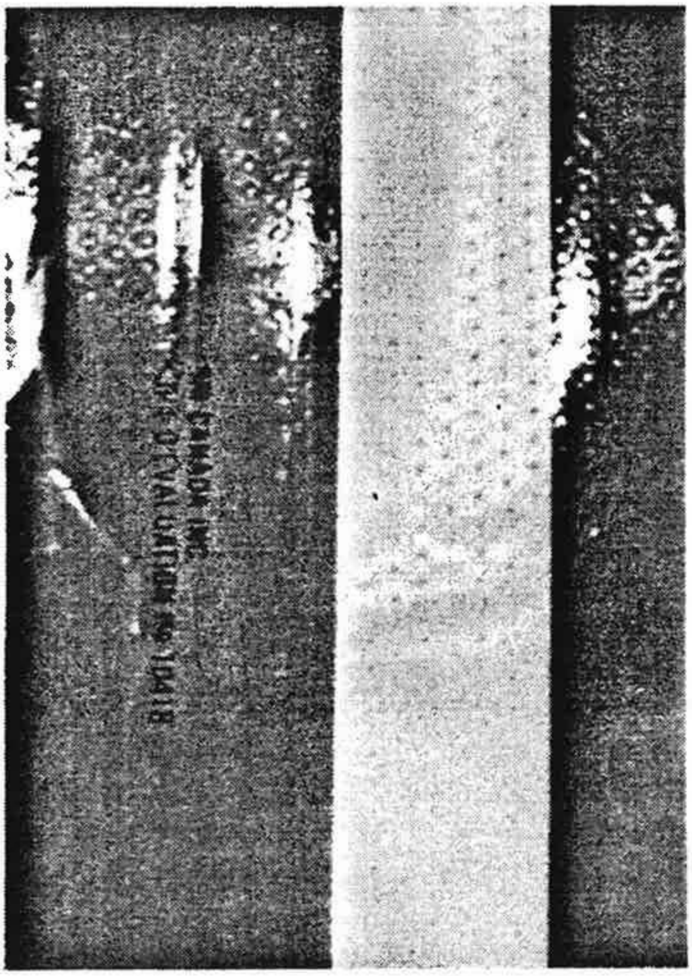


Photo no. 15B

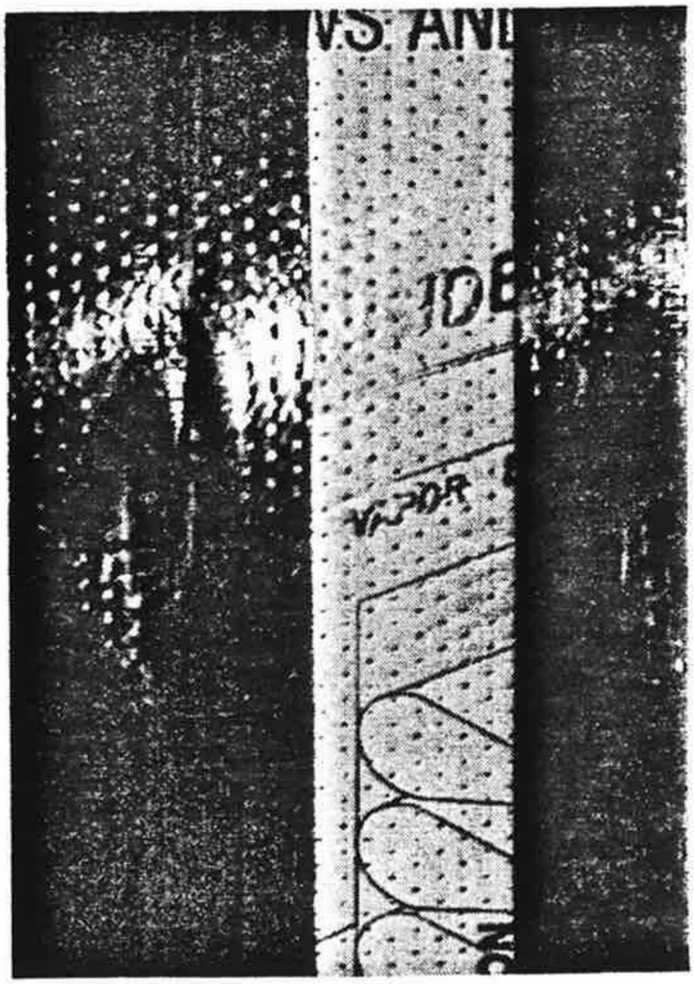


Photo No. 15C

SPECIMEN NO. 16: Interior acrylic sealant, width 1/4".

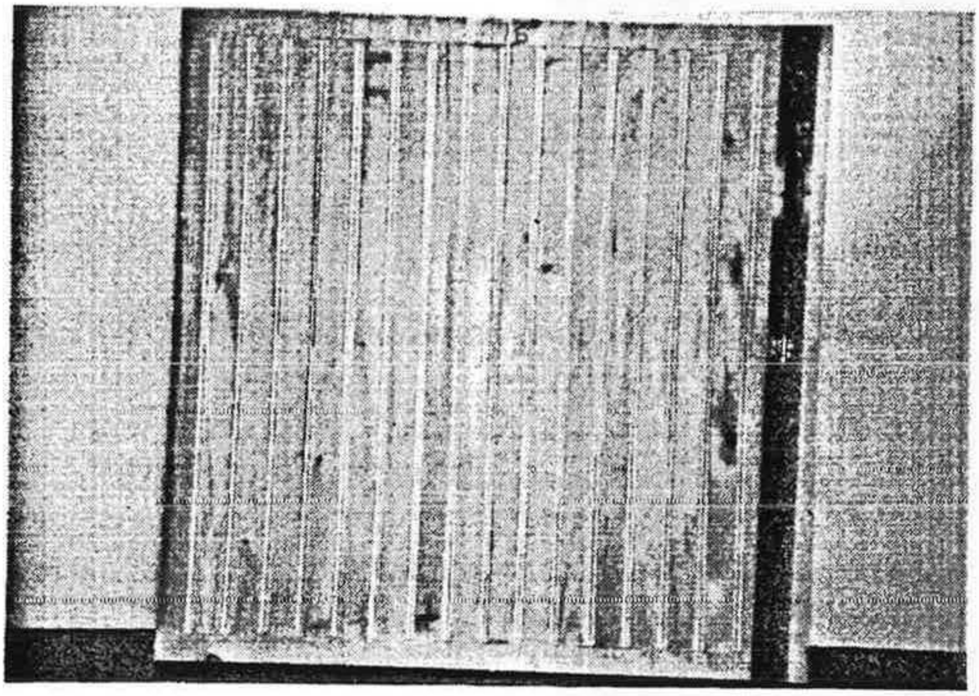


Photo No. 16

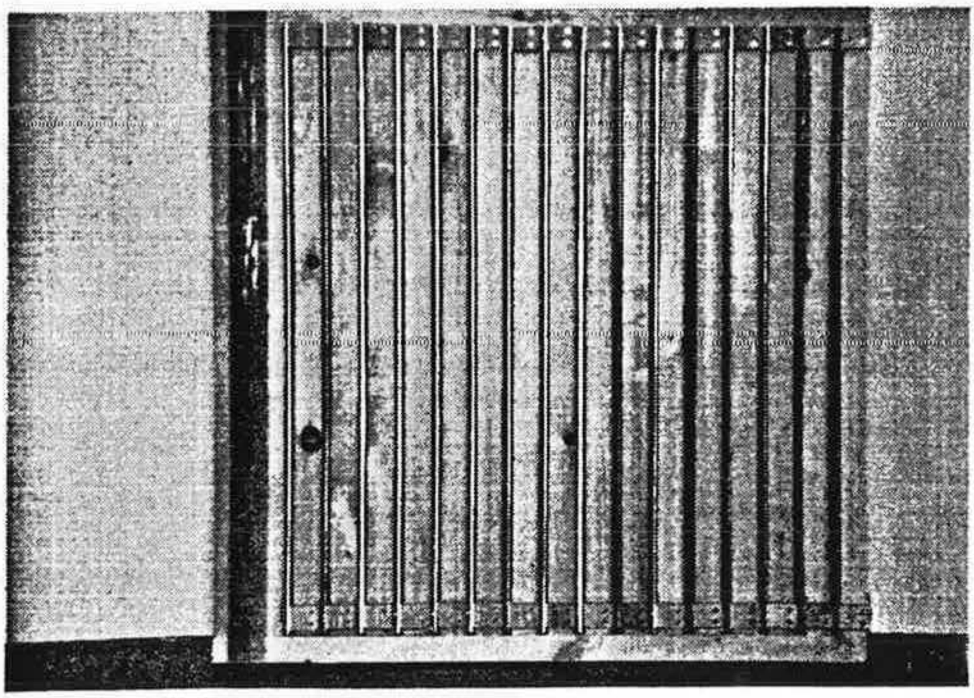


Photo No. 16A

SPECIMEN NO. 17: **Interior acrylic sealant joint, width 1/2".**

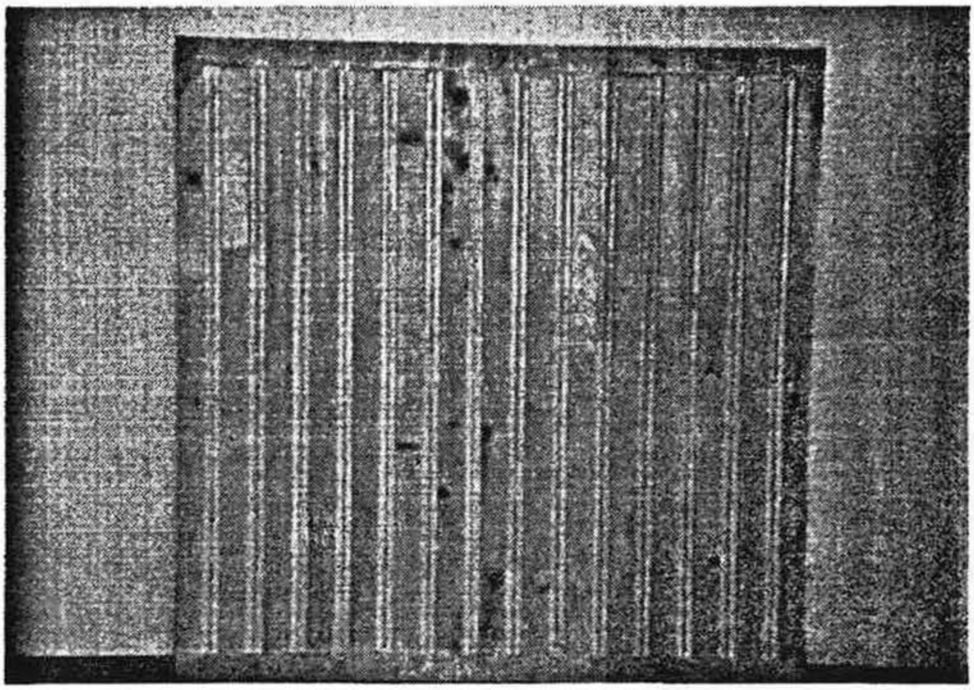


Photo No. 17

SPECIMEN NO. 18: **Interior silicone sealant joint, width 1/2".**

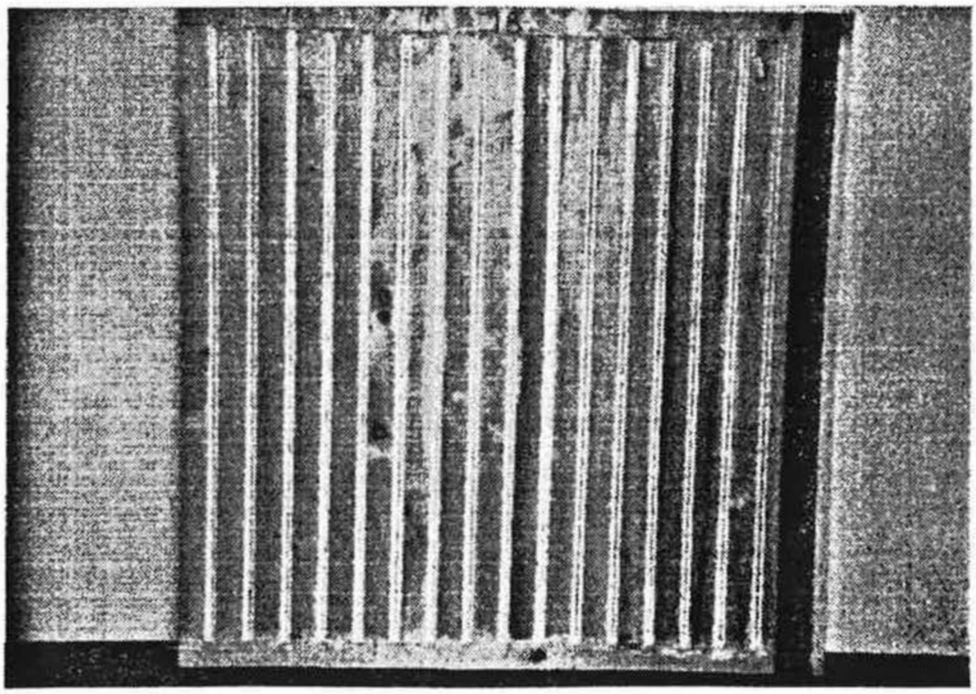


Photo No. 18

SPECIMEN NO. 19: **Interior silicone sealant joint, width 1/2".**

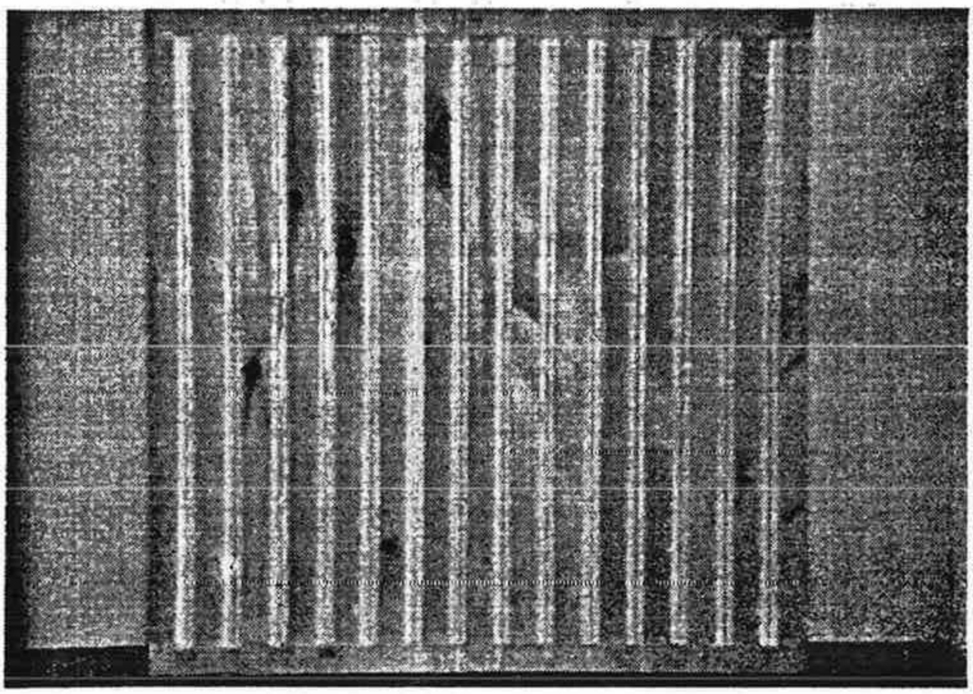


Photo No. 19

SPECIMEN NO. 20: **Exterior acrylic sealant joint, width 1/4".**

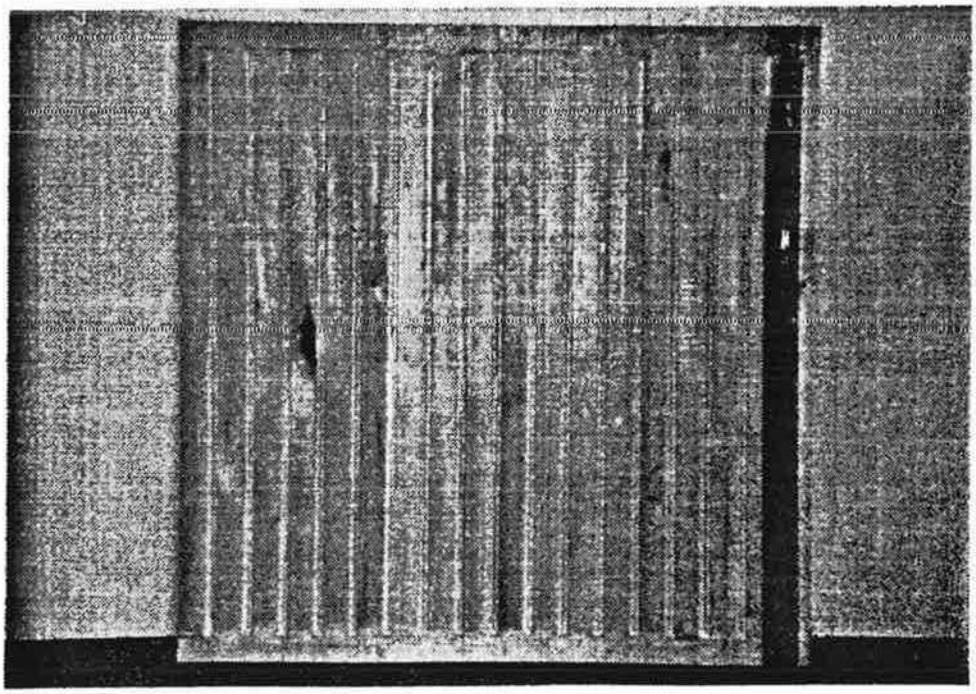


Photo No. 20

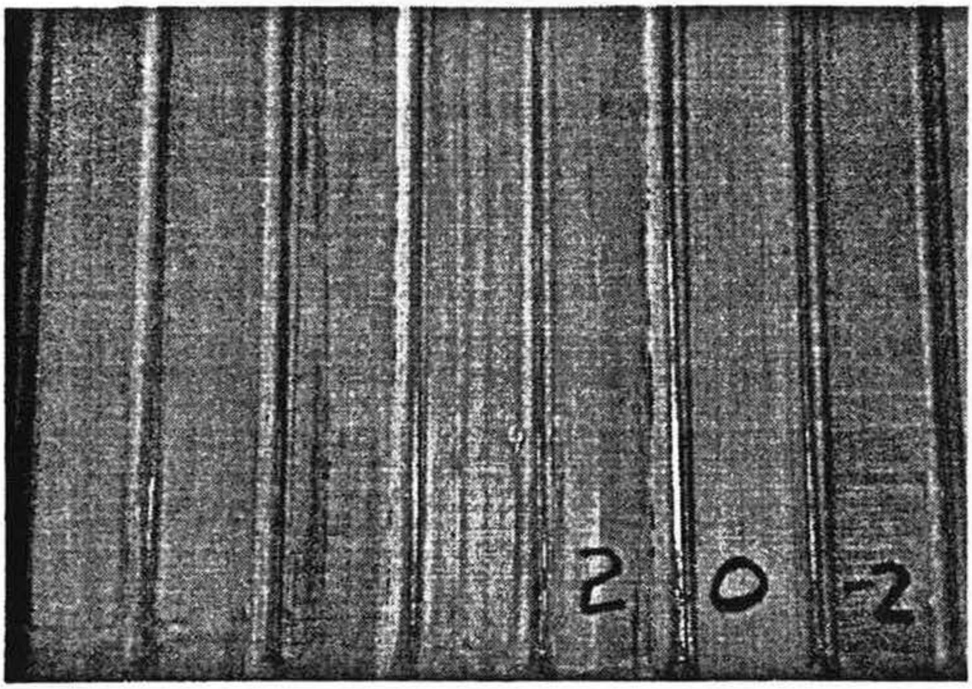


Photo No. 20A

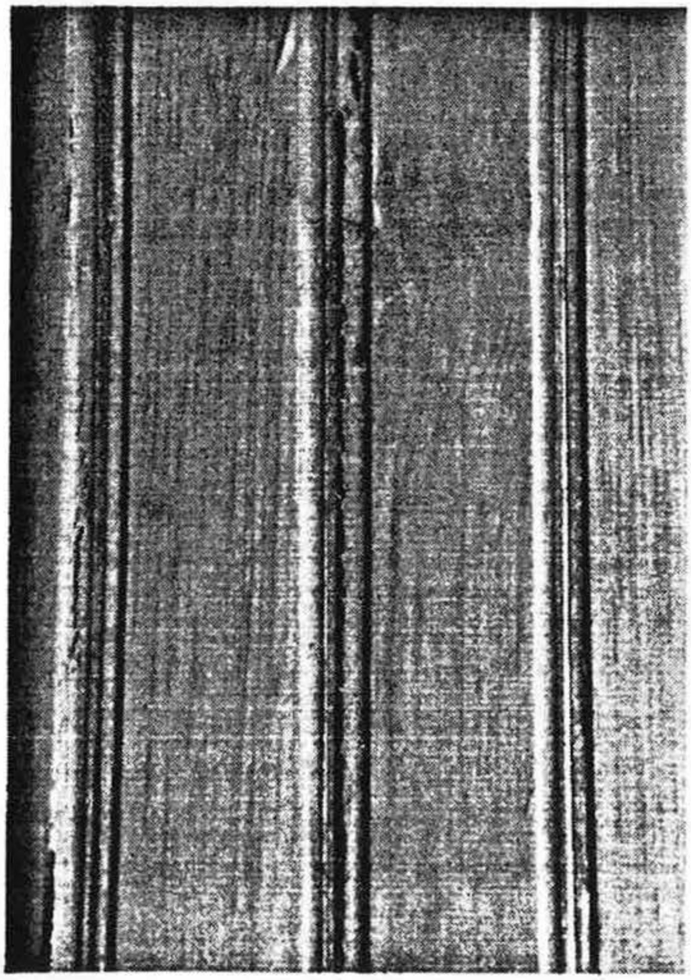


Photo No. 20B

SPECIMEN NO. 21: Exterior acrylic sealant joint, width 1/2".

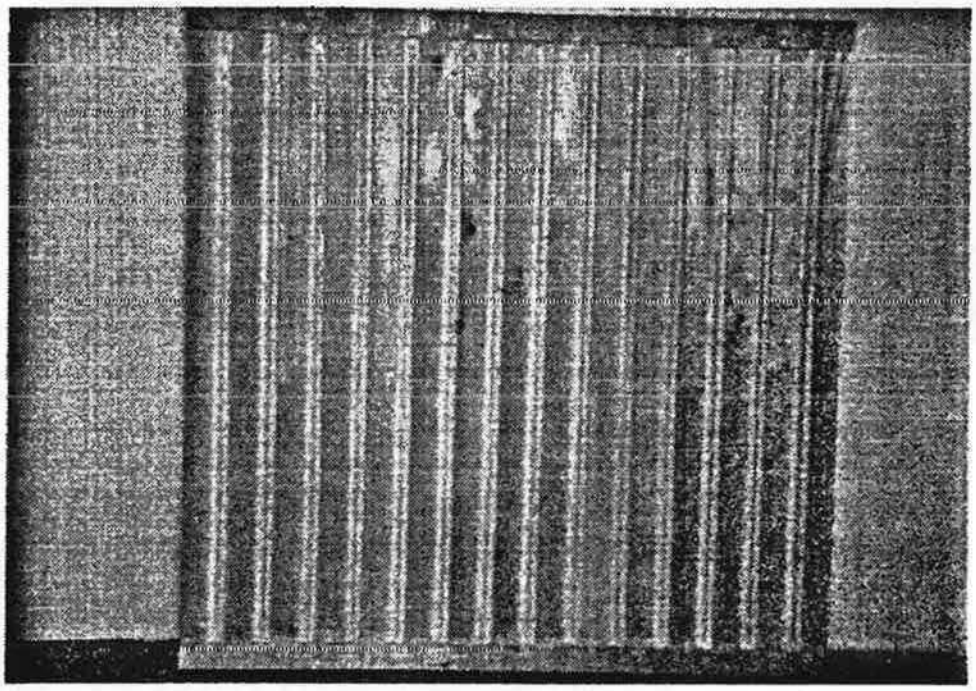


Photo No. 21

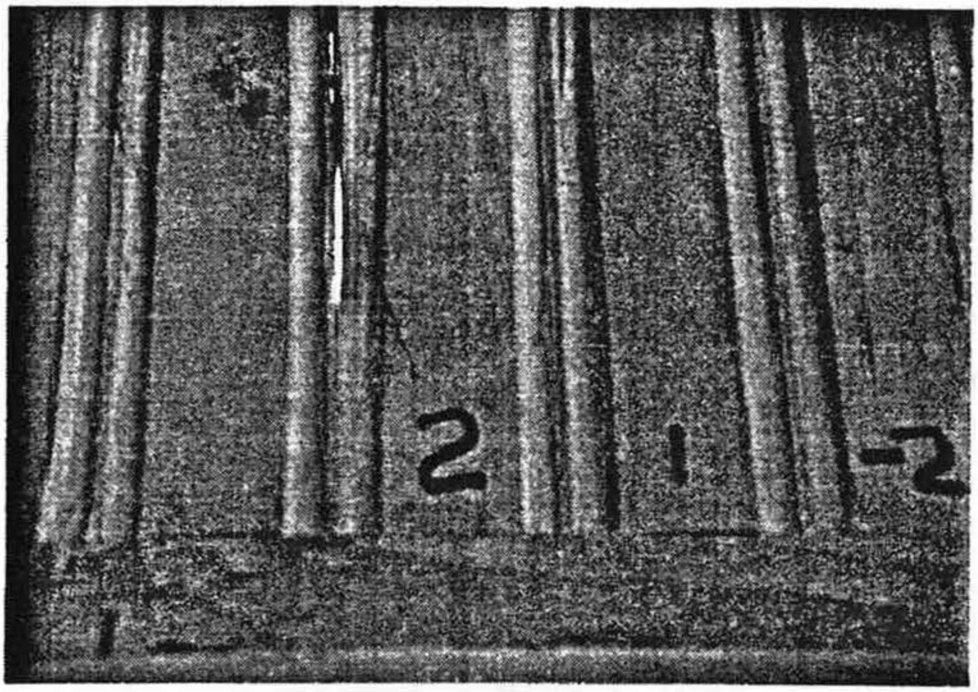


Photo No. 21A

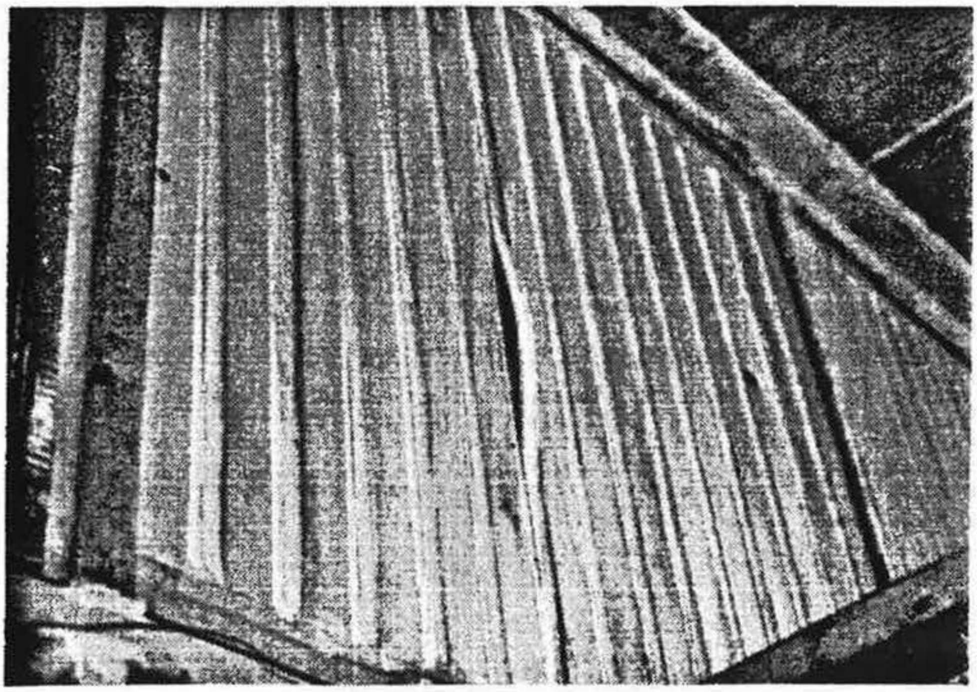


Photo No. 21B

<u>SPECIMEN NO. 22</u>: **Exterior silicone sealant joint, width 1/4".**

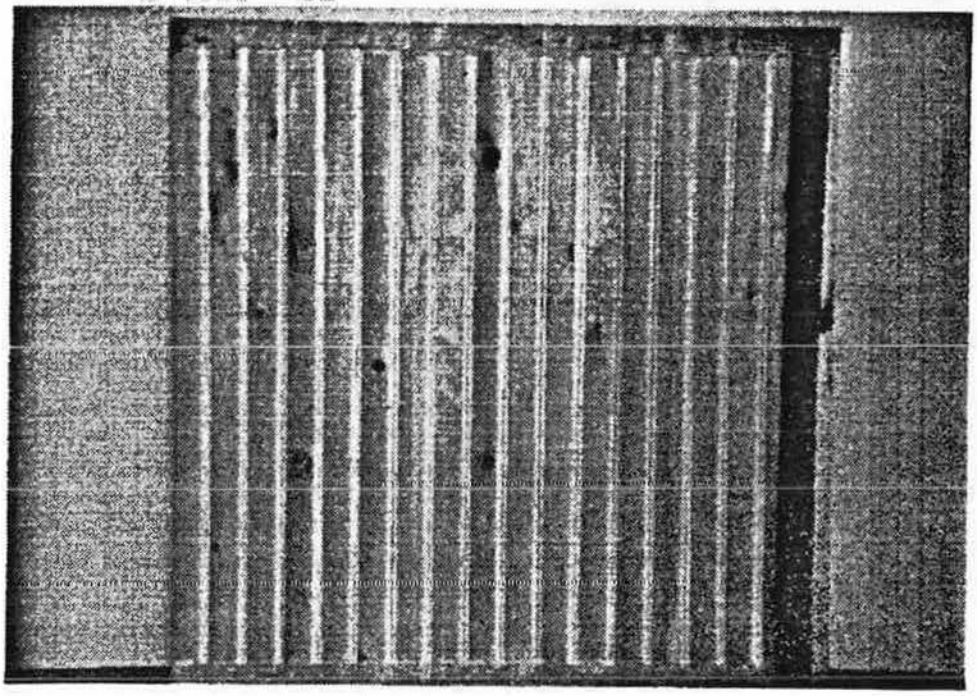


Photo No. 22

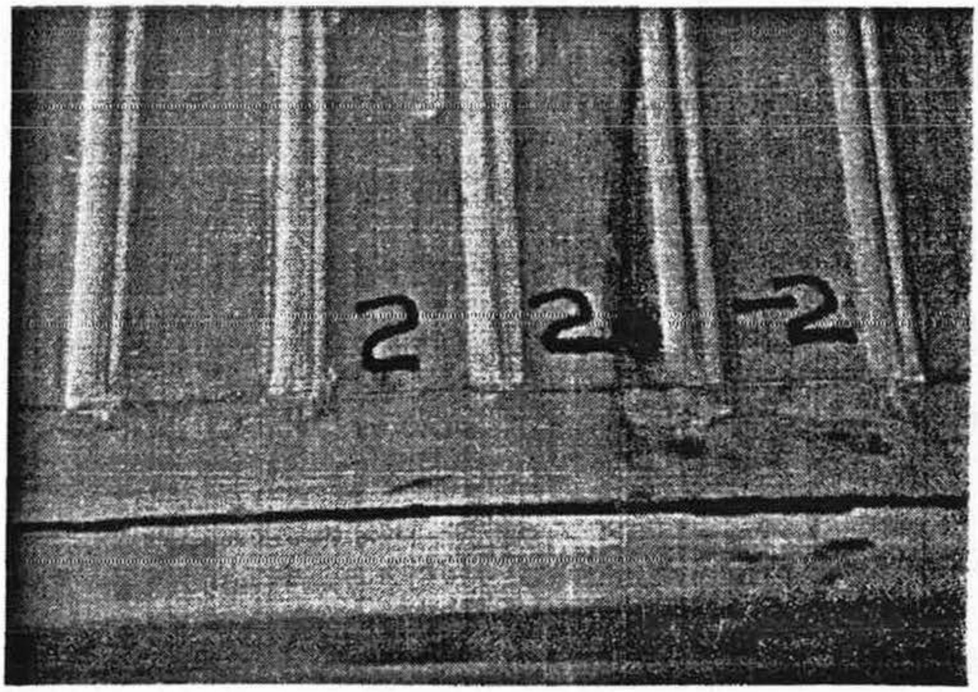


Photo No. 22A

SPECIMEN NO. 23: Exterior acrylic sealant joint on wafer board (spacing nil).

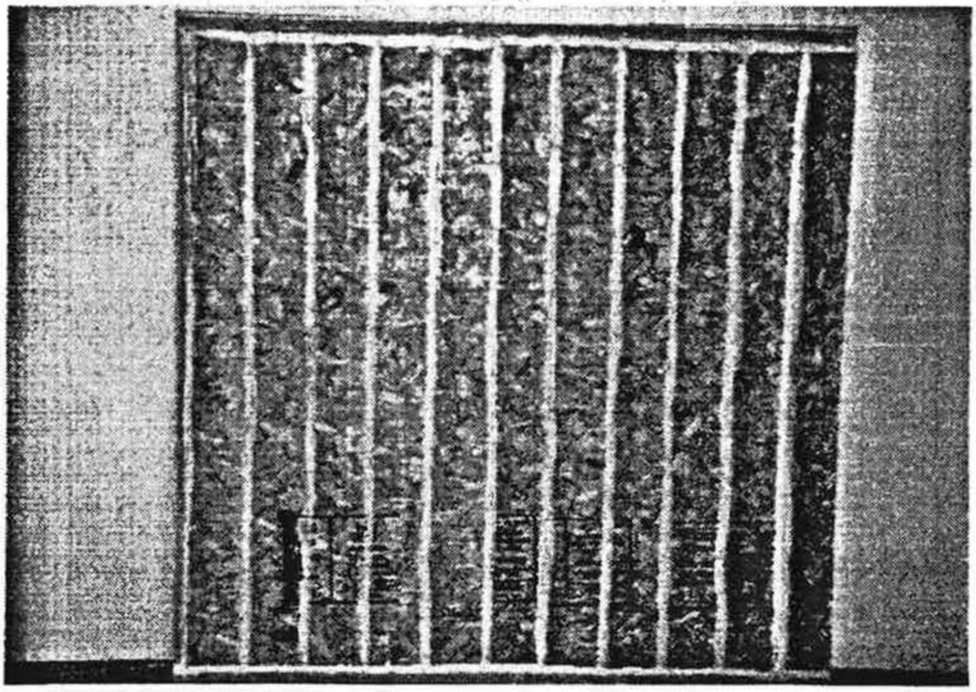


Photo No. 23

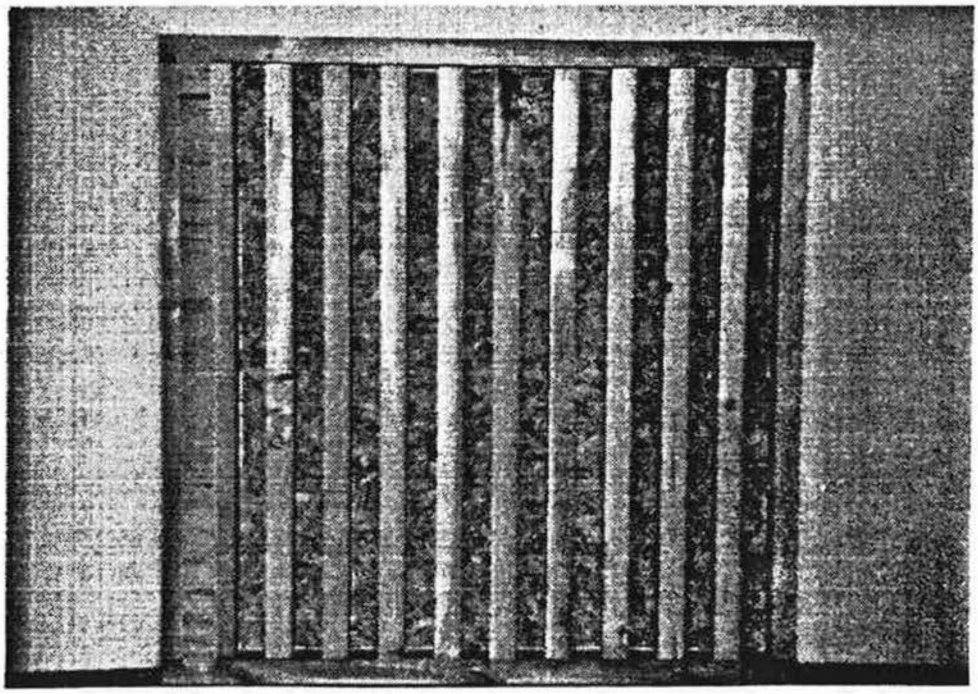


Photo No. 23A

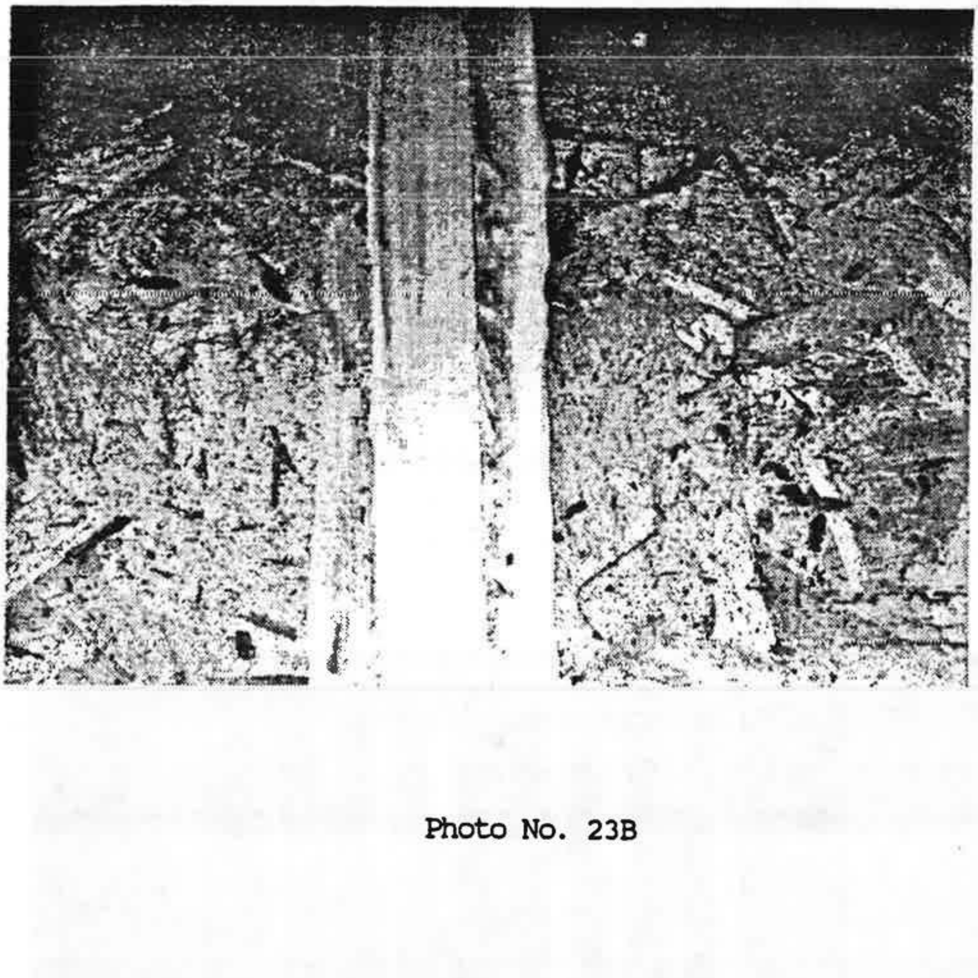


Photo No. 23B

SPECIMEN NO. 24: **Exterior acrylic sealant joint between wafer board sheets (spacing 1/8").**

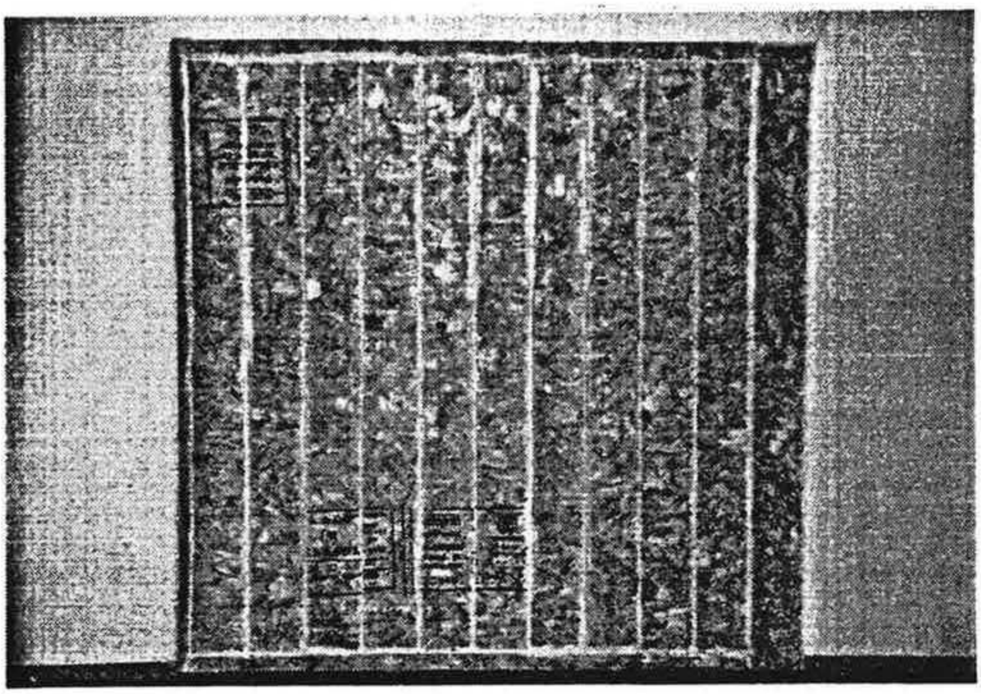


Photo No. 24

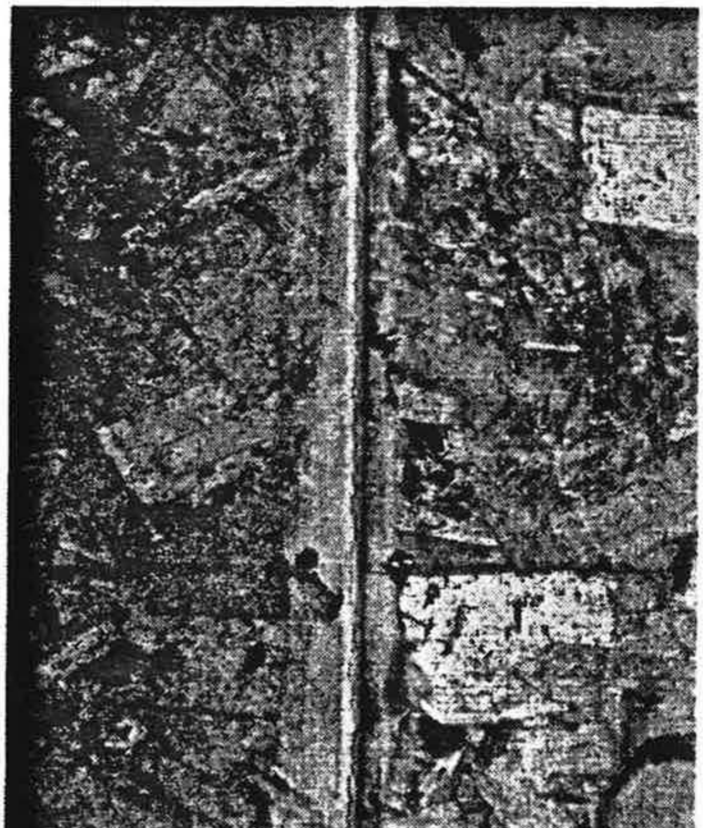


Photo No. 24A