THE LONG TERM PERFORMANCE OF OPERATING WINDOWS SUBJECTED TO MOTION CYCLING

PREPARED FOR:

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NOTE

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FOREWORD

This project determines the influence of motion cycling on nine (9) operating windows for the following performance criteria: ease of operation, air leakage, resistance to water penetration and condensation resistance.

The motion cycling test showed that after 2000 cycles (typical of 10 years use) for all specimens there was a decrease in one or several of the performance criterion covered by the CAN/CSA-A440-M90 Standard. The variation of operating forces from initial to final testing ranged from -50% to +207%. Except for one specimen with no change, the remaining eight (8) specimens showed after 2000 cycles an increase in the air leakage rate ranging from 4% to 136%. With respect to resistance to water penetration, 6 specimens kept their initial rating, whereas the remaining 3 specimens suffered a decrease of 1 or 2 levels of performance after 2000 open-close cycles. For the condensation resistance criterion 8 specimens out of 9 showed a decrease of the temperature index ranging from 4 to 24 points. This is likely due to increased air infiltration or cold air movement within the cavity formed between sash and frame. Among all the critera, condensation resistance is the criterion which suffered the largest decrease in performance from initial to final testing (one specimen did not even the minimum initial level requirement of the A440 Standard).

As expected, pressure and motion cycling result in some deteriation of window performance, primarily due to reduction of seal effectiveness. Greatest changes are for air leakages which can also have substantial influence on condensation resistance. Except for some windows, that fail initial tests, it may be expected that over a resonable lifetime performance may be reduced by one level. Further work is recommended in the area of condensation resistance and air infiltration at low temperatures.

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PREAMBULE

La présente étude détermine l'influence d'un essai d'endurance (cyclage ouverture - fermeture) sur 9 fenêtres ouvrantes. Les critères d'évaluation utilisés pour caractériser l'influence de l'essai d'endurance sont: la facilité de fonctionnement, l'infiltration d'air, la résistance à la pénétration d'eau et la résistance à la condensation.

L'essai d'endurance a démontré qu'après 2000 cycles (utilisation typique de 10 ans) toutes les fenêtres ont subi une diminution d'un ou plusieurs niveaux de performance dans la classification d'un produit selon la norme CAN/CSA-A440-M90. L'effort requis pour opérer les ouvrants a varié de -50% à +207% entre le début et la fin de l'essai d'endurance. En ce qui concerne l'infiltration d'air, 8 des 9 échantillons ont subi une augmentation du taux d'infiltration d'air variant de +4% à +136% entre le début et la fin de l'essai d'endurance. Pour le critère résistance à la pénétration d'eau, 6 échantillons ont conservé leur classification de base, alors que 3 échantillons ont subi une diminution de classe de 1 ou 2 niveaux après 2000 cycles. Pour le critère de résistance à la condensation, 8 échantillons sur 9 ont subi une baisse de l'indice de température variant de 4 à 24 points. Ceci est probablement causé par une infiltration d'air froid ou par un mouvement accru de l'air froid entre le châssis et le dormant de la fenêtre. Parmi tous les critères évalués, la résistance à la condensation est certainement le critère qui est le plus influencé par l'essai d'endurance.

Tel que prévu, l'essai d'endurance a démontré qu'il y a abaissement des performances globales en fonction du temps. La chute de performance est intimement liée au comportement des garnitures d'étanchéité. Les plus grands changements sont associés à l'infiltration d'air, laquelle influence à son tour la résistance à la condensation. A l'exception des quelques fenêtres qui ne rencontrent pas les exigences de base de la norme A440, l'étude démontre que l'on doit s'attendre à une chute de 1 niveau de classification durant la vie utile du produit. D'autres travaux de recherches sont recommandés sur les sujets de résistance à la condensation et de la mesure du taux d'infiltration à basse température.

1. EXECUTIVE SUMMARY

1.1 OBJECTIVES

The intent of the project is to determine the influence of motion cycling on operating windows for the following criteria of performance: ease of operation, air leakage, resistance to water penetration and condensation resistance. Even though ease of operation and resistance to water penetration are not related to energy conservation, their respective levels of performance have to be maintained throughout the life of the product since they have an important impact on the durability of the window system. As such, they were evaluated.

1.2 SAMPLING

Motion cycling tests were conducted on nine windows. Sampling included the following window types: casement, vertical sliding and horizontal sliding. Table A gives a brief description of each window with respect to the frame material.

TABLE A: WINDOW TYPES AND IDENTIFICATION

TYPE OF WINDOW	IDENTIFICATION NUMBER OF THE SPECIMENS (FRAME)				
CASEMENT (700 mm x 1600 mm)	MC-1 (AL)*	MC-2 (FG)**	MC-8 (PVC)***	MC-13 (WOOD)	MC-14 (WOOD)
VERTICAL SLIDER (1000 mm x 1600 mm)	MC-3 (AL)	MC-15 (WOOD)			
HORIZONTAL SLIDER (1600 mm x 1000 mm)	MC-7 (PVC)	MC-9 (PVC)			

* AL : Aluminum
** FG : Fibreglass
*** PVC: Polyvinyl chloride

1.3 METHODOLOGY

All specimens were subjected to the following test sequence:

a) Determine the initial ratings (R_o) with respect to the following criteria; ease of operation, air leakage, resistance to water penetration and condensation resistance;

b) Conduct 500 opening and closing cycles of the operating sash(es);

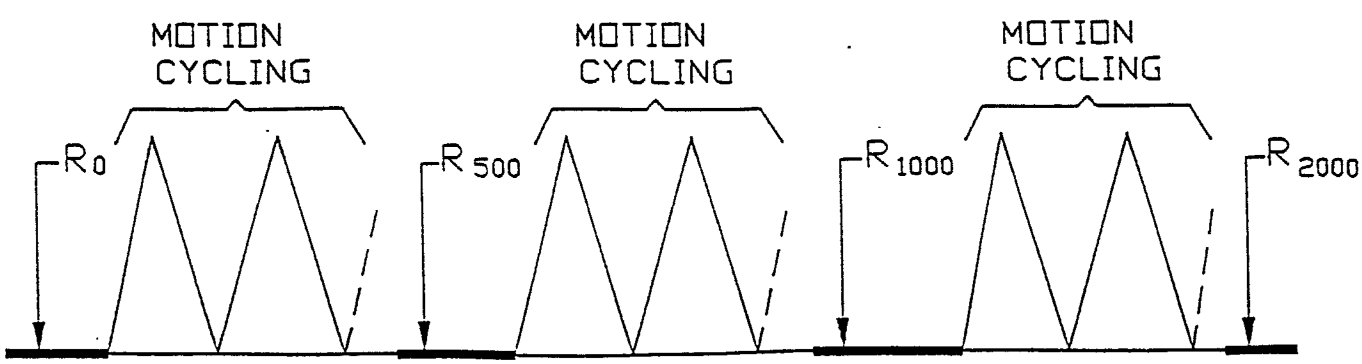
c) Determine new rating (R_{500}) with respect to ease of operation and air leakage;

d) Conduct an additional 500 opening and closing cycles as defined in (b);

e) Determine new rating (R_{1000}) with respect to ease of operation, air leakage and resistance to water penetration;

f) Conduct an additional 1000 opening and closing cycles as defined in (b);

g) Determine new rating (R_{2000}) with respect to ease of operation, air leakage resistance to water penetration and condensation resistance.



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1.4 RESULTS

Tables B, C, D and E summarize the changes in performance which occured on each specimen throughout the complete test sequence.

TABLE B: EASE OF OPERATION

TYPE AND SPECIMEN NUMBER	INITIAL STATIC N (lb) OPEN	INITIAL STATIC N (lb) CLOSE	INITIAL DYNAMIC N (lb) OPEN	INITIAL DYNAMIC N (lb) CLOSE	2000 CYCLES STATIC N (lb) OPEN	2000 CYCLES STATIC N (lb) CLOSE	2000 CYCLES DYNAMIC N (lb) OPEN	2000 CYCLES DYNAMIC N (lb) CLOSE	% VARIATION IN FORCE (%) STATIC	% VARIATION IN FORCE (%) DYN.
CASEMENT MC-1 (AL)	13 (3)	7 (1.5)	13 (3)	13 (3)	13 (3)	9 (2)	4 (1)	9 (2)	0	-50
MC-2 (FIBRE GLASS)	31 (7)	33 (7.5)	20 (4.5)	22 (5)	33 (7.5)	44.5 (10)	15.5 (3.5)	18 (4)	-	-25
MC-8 (PVC)	40 (9)	49 (11)	11 (2.5)	11 (2.5)	44.5 (10)	60 (13.5)	11 (2.5)	11 (2.5)	+ 5	0
MC-13 (WOOD)	29 (6.5)	27 (6)	7 (1.5)	16 (3.5)	120 (27)	53 (12)	31 (7)	22 (5)	+207	+130
MC-14 (WOOD)	31 (7)	18 (4)	13 (3)	9 (2)	62 (14)	18 (4)	7 (1.5)	7 (1.5)	+100	-33
VERTICAL SLIDER MC-3 (AL)	122 (27.5)	127 (29)	98 (22)	89 (20)	178 (40)	178 (40)	147 (33)	107 (24)	+40	+25
MC-15 (WOOD)	173.5 (39)	116 (26)	120 (27)	120 (27)	151 (34)	76 (17)	107 (24)	98 (22)	-25	-17
HORIZONTAL SLIDER MC-7 (PVC)	76 (17)	40 (9)	22 (5)	22 (5)	67 (15)	89 (20)	58 (13)	58 (13)	+30	+163
MC9 SASH (PVC) #1	42 (9.5)	38 (8.5)	31 (7)	33 (7.5)	49 (11)	67 (15)	33 (7.5)	38 (8.5)	+45	+12
SASH #2	49	58	31	36	53	53	42	42	0	+30

* Exceeds the maximum allowable force specified by the A440 Standard.

TABLE C: AIR LEAKAGE

TYPE AND SPECIMEN	INITIAL $m^3/h-m$ (SCFM/ft)	500 CYCLES $m^3/h-m$ (SCFM/ft)	1000 CYCLES $m^3/h-m$ (SCFM/ft)	2000 CYCLES $m^3/h-m$ (SCFM/ft)	δQ	
					ABSOLUTE $m^3/h-m$ (SCFM/ft)	%
CASEMENT						
MC-1 (AL)	0.758-A2 (0.136)	0.869-A2 (0.156)	0.880-A2 (0.158)	0.903-A2 (0.162)	0.145 (0.026)	+19
MC-2 (FIBERGLASS)	0.412-A3 (0.074)	0.451-A3 (0.081)	0.479-A3 (0.086)	0.52-A3 (0.093)	0.118 (0.019)	+28.6
MC-8 (PVC)	0.443-A3 (0.0795)	0.751-A2 (0.133)	0.777-A2 (0.139)	1.047-A2 (0.188)	0.604 (0.109)	+136
MC-13 (WOOD)	0.273-A3 (0.049)	0.366-A3 (0.066)	0.389-A3 (0.070)	0.505-A3 (0.091)	0.232 (0.042)	+85
MC-14 (WOOD)	0.279-A3 (0.050)	0.390-A3 (0.070)	0.524-A3 (0.094)	0.507-A2 (0.102)	0.291 (0.052)	+104
VERTICAL SLIDER						
MC-3 (AL)	1.198-A2 (0.215)	1.315-A2 (0.236)	1.320-A2 (0.237)	1.35-A2 (0.242)	0.152 (0.027)	+12
MC-15 (WOOD)	0.892-A2 (0.160)	0.925-A2 (0.166)	0.930-A2 (0.166)	0.930-A2 (0.166)	0.038 (0.006)	+4
HORIZONTAL SLIDER						
MC-7 (PVC)	2.558-A1 (0.459)	2.72-A1 (0.488)	2.84* (0.51)	2.89* (0.52)	0.332 (0.061)	+13
MC-9 (PVC)	2.301-A1 (0.413)	2.286-A1 (0.41)	2.294-A1 (0.411)	2.30-A1 (0.412)	0	0

* Exceeds the maximum allowable air leakage specified by the A440 Standard.

To meet level A1, the air leakage rate must be equal or lower than 2.79 $m^3/h-m$ and higher than 1.65 $m^3/h-m$.

To meet level A2, the air leakage rate must be equal or lower than 1.65 $m^3/h-m$ and higher than 0.55 $m^3/h-m$.

To meet level A3, the air leakage rate must be equal or lower than 0.55 $m^3/h-m$.

TABLE D: RESISTANCE TO WATER PENETRATION

TYPE AND SPECIMEN NUMBER	INITIAL	1000 CYCLES	2000 CYCLES
CASEMENT			
MC-1 (AL)	B3	B2	B2
MC-2 (FIBREGLASS)	B3	B1	Nil*
MC-8 (PVC)	B3	B3	B3
MC-13 (WOOD)	B3	B3	B3
MC-14 (WOOD)	B3	B3	B3
VERTICAL SLIDER			
MC-3 (AL)	B1	B1	B1
MC-15 (WOOD)	B5	B5	B3
HORIZONTAL SLIDER			
MC-7 (PVC)	Nil*	Nil*	Nil*
MC-9 (PVC)	B1	B1	B1

* : Does not meet the minimum level of performance defined by the A440 Standard.

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TABLE E: TEMPERATURE INDEX (CONDENSATION RESISTANCE)

TYPE AND SPECIMEN NUMBER	INITIAL		2000 CYCLES	
	TI_G	TI_F	TI_G	TI_F
CASEMENT				
MC-1 (AL)	54	38*	54	32*
MC-2 (FIBREGLASS)	62	52	62	52
MC-8 (PVC)	60	34*	58	26*
MC-13 (WOOD)	58	48	58	40
MC-14 (WOOD)	62	48	58	24*
VERTICAL SLIDER				
MC-3 (AL)	60	46	60	44
MC-15 (WOOD)	60	50	56	42
HORIZONTAL SLIDER				
MC-7 (PVC)	60	48	56	24*
MC-9 (PVC)	60	18*	60	18*

* TI lower than minimum acceptable value specified by A440

TI_G(MIN.) - A440 = 40
TI_F(MIN.) - A440 = 40

1.5 CONCLUSIONS

- EASE OF OPERATION

  The variation of operating forces from initial to final testing ranged between -50% to + 207%.

- AIR LEAKAGE

  Except for specimen MC-9 which showed no change, all other specimens showed an increase in the air leakage rate from initial to final testing ranging from 4 to 136 % (MC-8).

- RESISTANCE TO WATER PENETRATION

  Except for one specimen that never met the minimum and two specimens that dropped in performance, the resistance to water penetration of all other five specimens remained unchanged between initial and final testing.

- CONDENSATION RESISTANCE

  The performance level of one specimen (MC-2) remained unchanged, while all other specimens (8) showed a decrease in performance level. The reduction of the temperature index for glass (TI_G) is always less than 4 points (MC-7, MC-15), whereas the reduction of the temperature index for the frame and sash components can be as large as 24 points (MC-7, MC-14). The latter indicates that reduction was primarily due to air infiltration and/or cold air movement within cavity between the sash and frame as a result of cracks developing between sash and frame members.

- GENERAL

  Among all the tested criteria, condensation resistance is certainly the criteria which suffered the largest decrease in performance from initial to final testing for some windows. Visual inspection revealed that unreinforced PVC profiles are subjected to distortion. Such distortion is caused by the lack of rigidity and the high coefficient of linear expansion of sash members.

1.6 RECOMMENDATIONS

- The condensation resistance tests conducted on non-metallic windows (wood and PVC) showed that some of these new products did not meet the minimum performance level specified by the A440 Standard. Therefore, in order to make it fair and acceptable to the consumer, the evaluation of this criteria should be made mandatory for all materials.
- In view of the fact that 2 out of 9 specimens did not meet the minimum performance level of the A440 Standard, a certification program or spot reevaluations should be put in place. Such a program will improve the certainty of the performance levels recorded by CCMC.
- The motion cycling test showed that in all cases there was a decrease in one or several of the performance criterion covered by the existing A440 Standard. To ensure that windows will maintain their performance level over their life span, this new criteria should be incorporated into the main body of the A440 Standard.
- This subject matter although not previously discussed shall now be brought forward to the A440 Committee given the conclusions of this report.
- In addition to the above, a higher number of motion cycles could also be used to provide information on the durability of components such as weatherstripping, friction hinges, sash balances, roller assemblies, rotory-operators.

2. INTRODUCTION

Windows are evaluated by the A440 Standard as new products. Except for sealed unit manufacturing, this Standard does not ensure that the established performance level with respect to a given criteria will be maintained with respect to time throughout the life expectancy of the product.

With respect to energy conservation a change in performance may translate into higher energy consumption which may be caused by an increase in the air infiltration rate, which may in turn be due to premature deterioration of weatherstripping, hardware, etc. In addition, higher air infiltration rates will also reduce the condensation resistance of windows and accelerate the deterioration of the assembly and surrounding components. In fact, the durability and the long term performance of the entire window system may be affected.

To alleviate the durability problems and improve the long term performance of operating windows, the behavior of existing products needs to be determined and the criteria of acceptance for incoming new products need to be established.

The intent of this project is to determine the influence of motion cycling on the following criteria of performance: ease of operation, air leakage, resistance to water penetration and condensation resistance. Even though ease of operation and resistance to water penetration are not related to energy conservation, their respective levels of performance have to be maintained throughout the life of the product since they have an important impact on the durability of the window system. As such, they were to be evaluated.

2.1 DESCRIPTION OF SPECIMENS

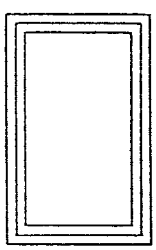
Table 1 below indicates the window types tested.

Table 1: Window Types and Identification

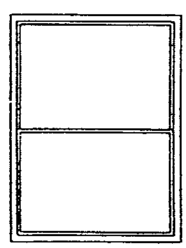
TYPE OF WINDOW	IDENTIFICATION NUMBER OF THE SPECIMENS (FRAME)				
CASEMENT (700 mm x 1600 mm)	MC-1 (AL)*	MC-2 (FG)**	MC-8 (PVC)***	MC-13 (Wood)	MC-14 (Wood)
VERTICAL SLIDER (1000 mm x 1600 mm)	MC-3 (Al)	MC-15 (Wood)			
HORIZONTAL SLIDER (1600 mm x 1000 mm)	MC-7 (PVC)	MC-9 (PVC)			

* AL = Aluminum
** FG = Fibreglass
*** PVC= Polyvinyl chloride

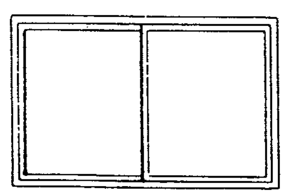
Total number of specimens: 9



Casement



Vertical Slider



Horizontal Slider

A detailed description of each specimen (weatherstripping, dimensions, etc...) is given in Appendix A.

2.2 DESCRIPTION OF TEST APPARATUS

To undertake the study, two robots were designed. The first robot handles the motion cycling of horizontal and vertical sliding windows (linear displacement), whereas the second robot handles the motion cycling of casement and awning windows (rotation movement).

2.2.1 MOTION CYCLING OF HORIZONTAL AND VERTICAL SLIDING WINDOWS

The test apparatus includes:

- a test bench allowing solid retention of the window system (see Figure 1);
- a linear actuator to provide controled linear displacement of a given sash with respect to the frame of the window (see Figure 2).
- a control system to allow proper sequencing.

The linear actuator is designed to allow offset between the translation plane of the sash and the translation axis of the actuator. This is accomplished by a linear bearing which is free to move in the plane perpendicular to the translation axis of the actuator.

The point(s) of attachment between the end member of the linear bearing to the sash pull rail is designed to simulate the application of the hand(s) of the person operating a sash, i.e. allows rotation of pull rail during translation of sash (see Figure 3).

The linear actuator is designed to maintain a translation lineal speed of 5 m/min (± 10%) with a deceleration (acceleration) at the end (beginning) of each stroke. Deceleration and acceleration were introduced to prevent abrupt stop or start of the sash. In the case of windows comprising of two or more sashes, the motion cycling is performed on each sash from the fully closed to the fully opened position.

The linear actuator system includes a stroke counter which after a predetermined number of cycles will stop the system.

Figure 4 shows the basic principle of operation for the translation cycling test

FIGURE 1: WINDOW RETAINING SYSTEM

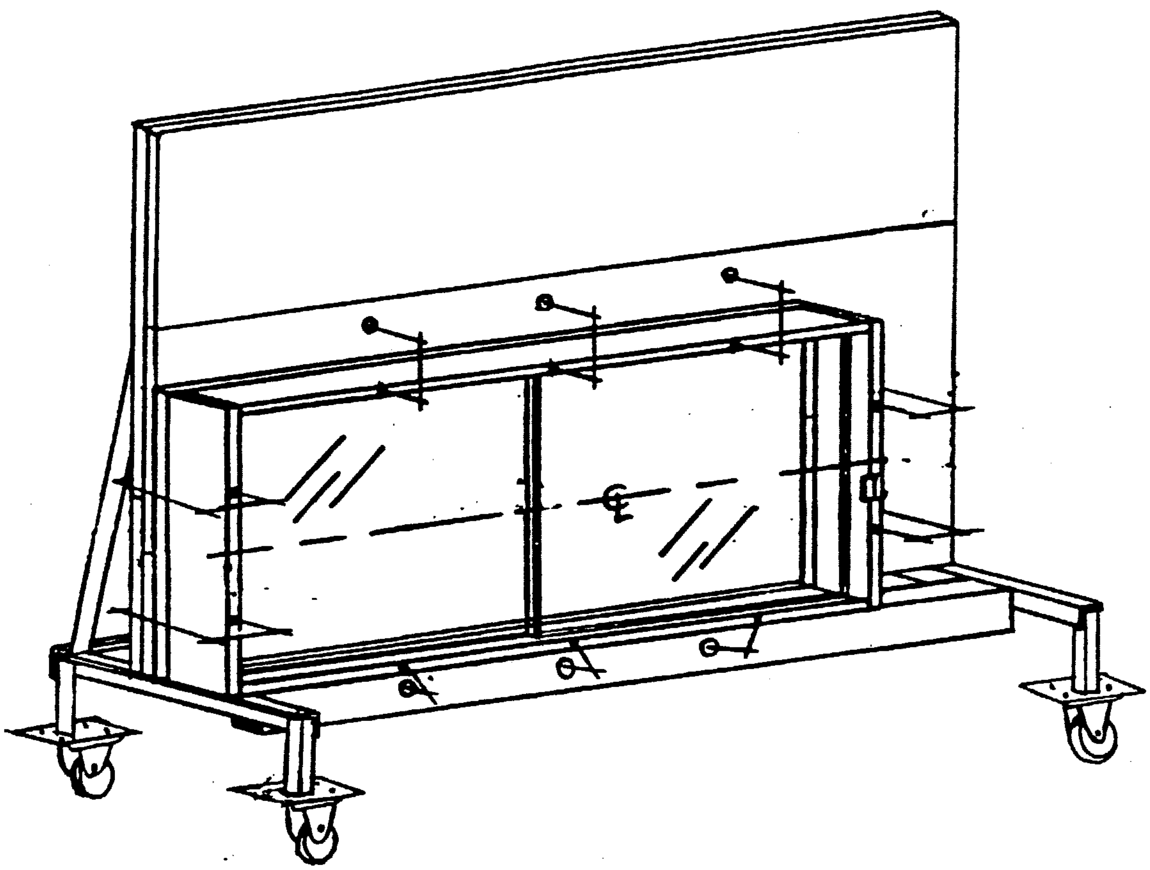


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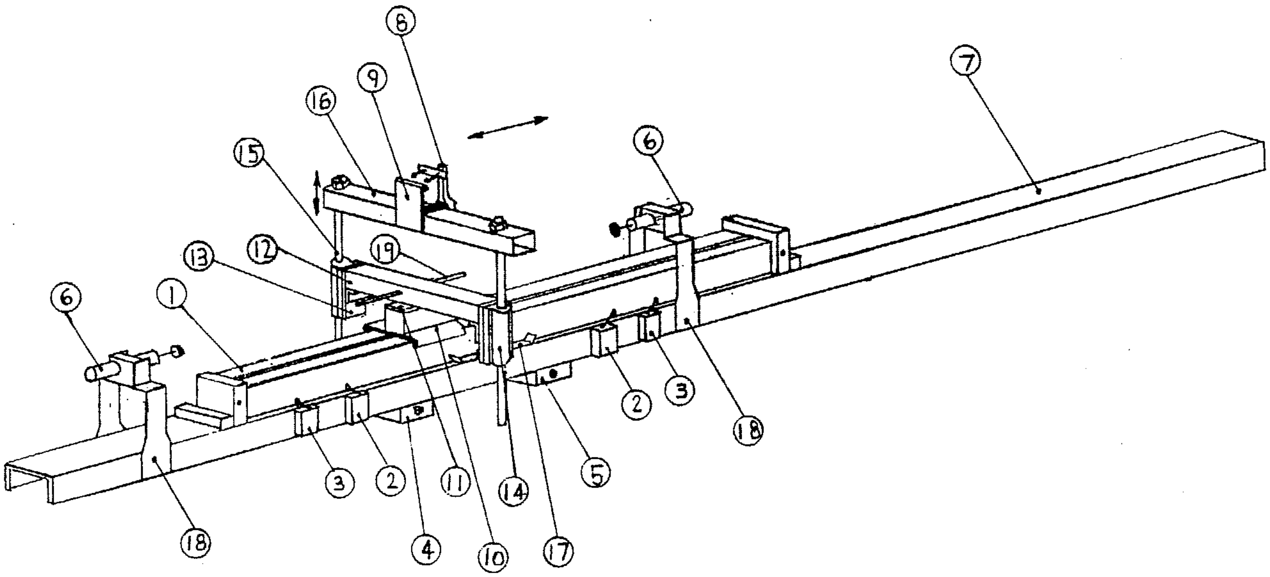
FIGURE 2: LINEAR ACTUATOR



NO.	DESCRIPTION
1	Pneumatic cylinder
2	Limit switch (speed)
3	Limit switch (motion)
4	Control valve (speed)
5	Control valve (motion)
6	Shock absorber
7	"C" Beam (aluminum)
8	Clamp
9	Holding device
10	Chariot
11	Transfer plate
12	Linear bearing holder
13	Linear bearing holder
14	Linear bearing
15	Steel rod
16	Transfer arm
17	Cam
18	Shock absorber holder
19	Ajustment screw

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FIGURE 1 + 2: <u>TEST BENCH + LINEAR ACTUATOR</u>

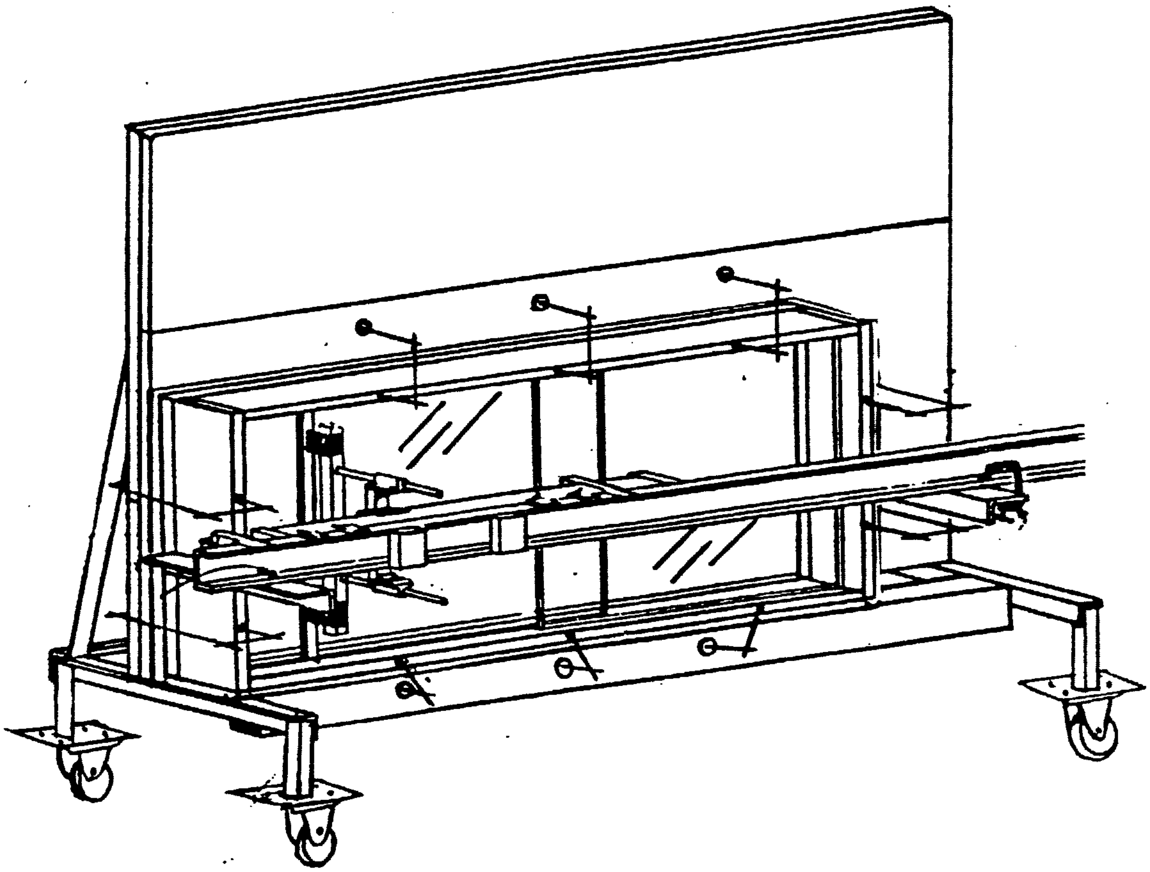

FIGURE 3: <u>HOLDING DEVICE</u>

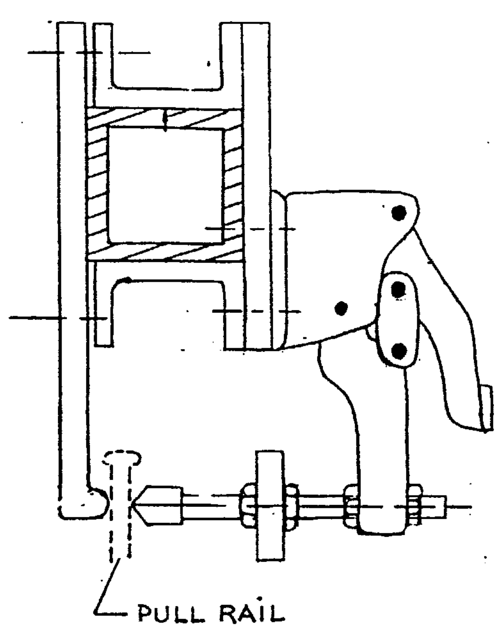

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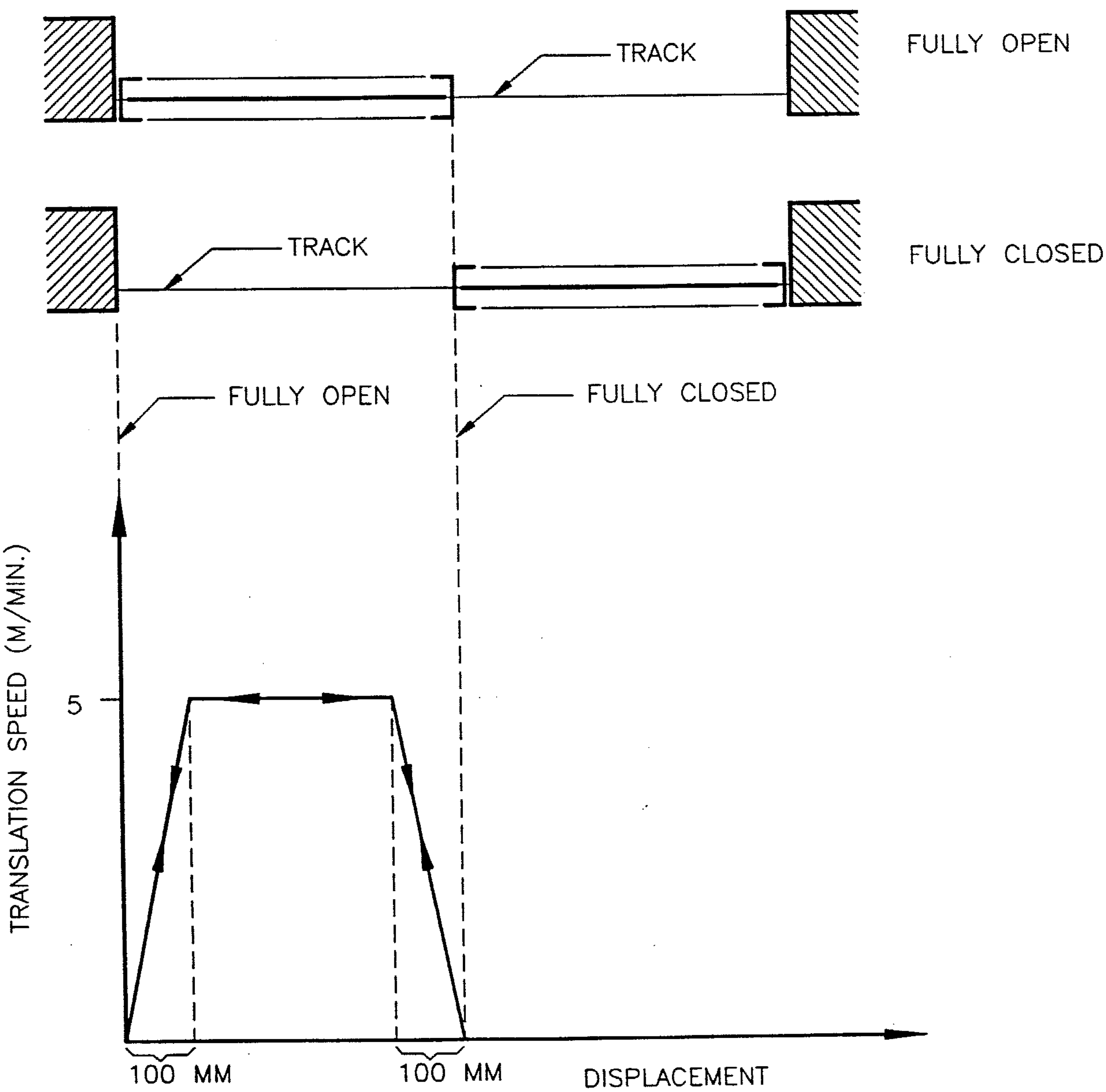
FIGURE 4: <u>PRINCIPLE OF OPERATION</u>

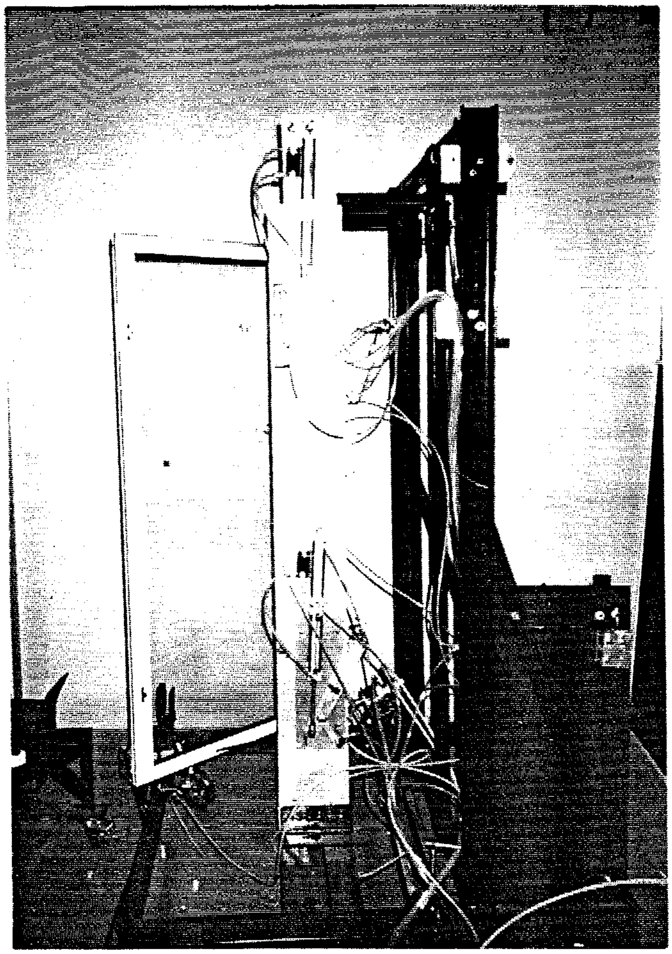


2.2.2 MOTION CYCLING OF CASEMENT AND AWNING WINDOWS

The test apparatus includes:

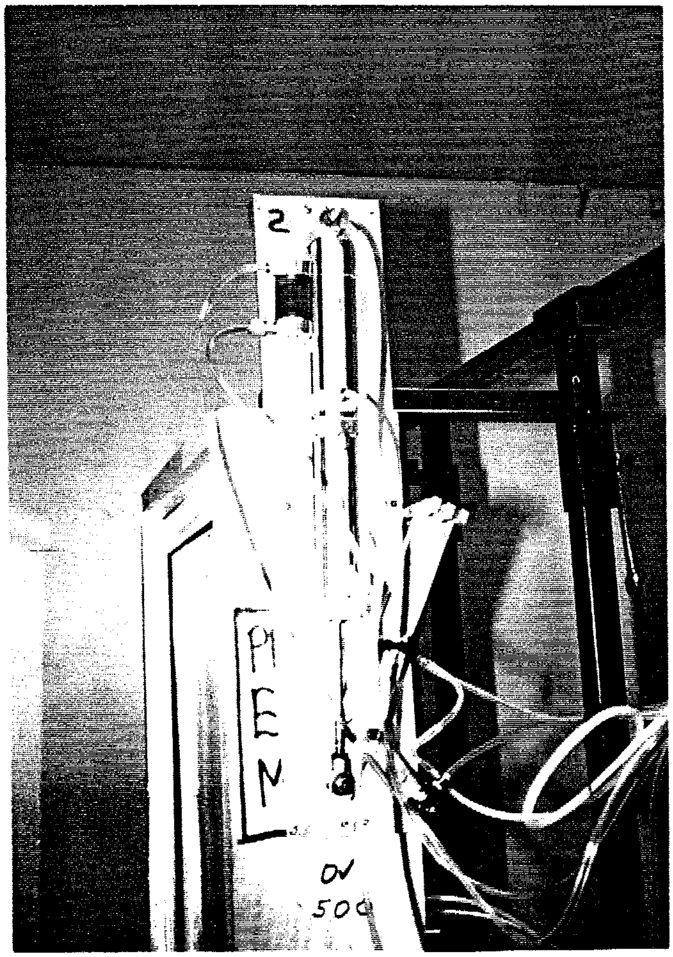
- a test bench allowing solid retention of the window system (see photograph no. 1);
- two piston actuators allowing to open and close the locking devices (see Photograph no. 2);
- a pneumatic motor connected to the shaft of the rotary operator. The pneumatic motor provide controled angular displacement of the sash with respect to the window frame;
- a control system to allow the following operating sequence (see Figure 5)
    - open lock no.1;
    - open lock no.2;
    - open sash to maximum opening -5°;
    - close sash to original position;
    - close lock no.2;
    - close lock no.1;

The system is designed to open and close the sash at various frequencies. Testing was conducted with a cycling time of 6 seconds. The sash angular rotation was adjusted to obtain the maximum opening angle with a tolerance of + 0° and -5°. At the end of each open - close cycle, a four second delay (minimum) was allowed to open and close locks.



PHOTOGRAPH NO. 1:

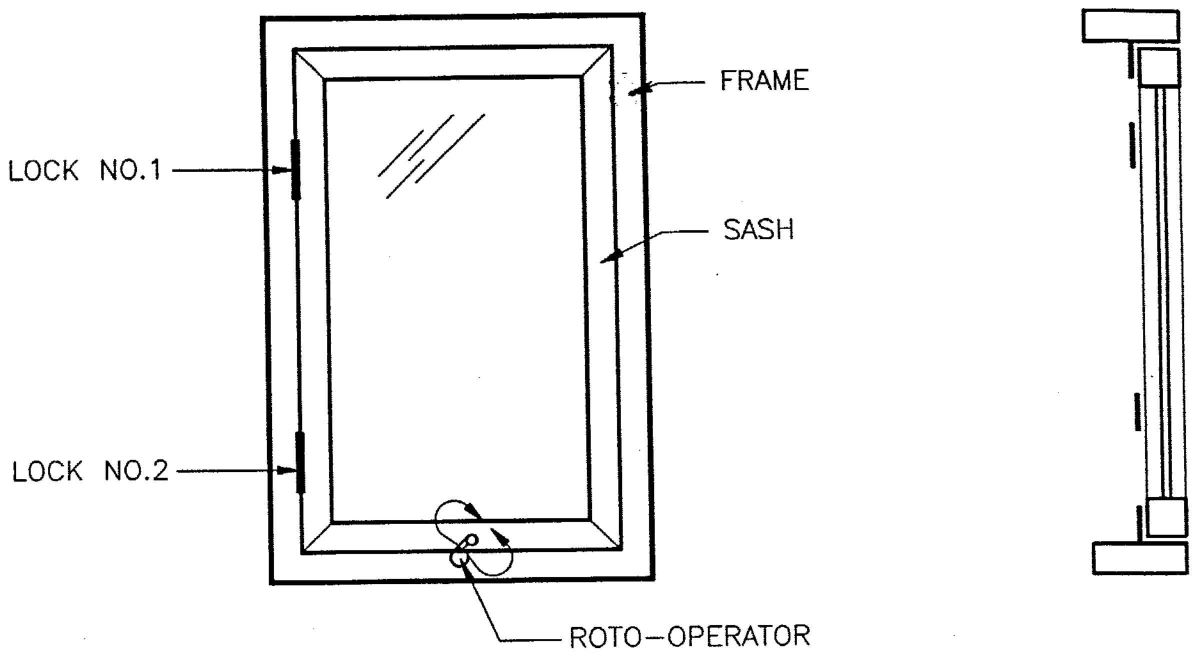
WINDOW RETAINING SYSTEM



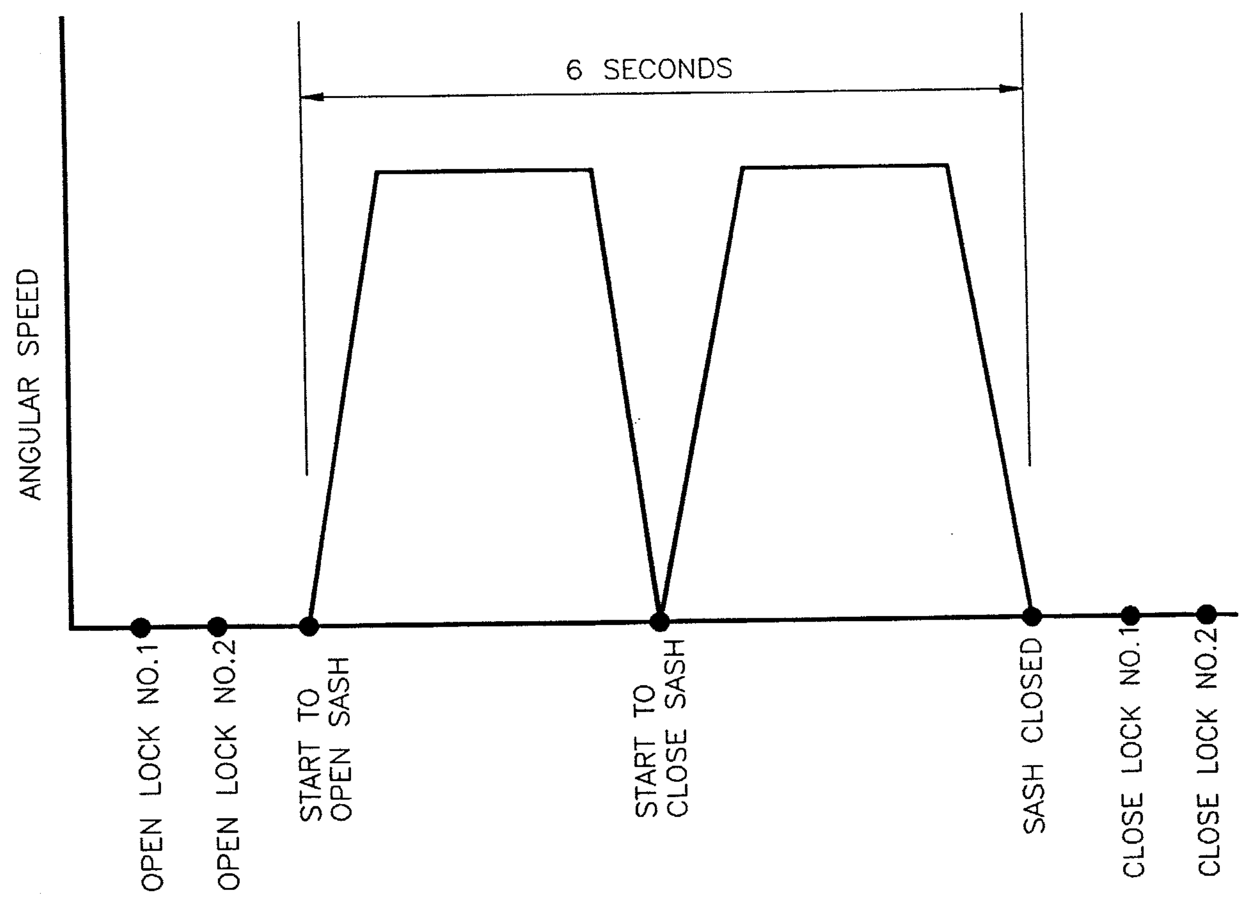
PHOTOGRAPH NO. 2:

PISTON ACTUATOR

FIGURE 5: OPERATING SEQUENCE



DESCRIPTION OF A TYPICAL CYCLE



3. METHODOLOGY

For all specimens, the test consisted of the initial evaluation of the four basic performance criteria: ease of operation, air leakage, resistance to water penetration and condensation. Upon completion of these tests, all specimens where subjected to a predetermined number of motion cycles (see Table 2). After completing a given number of cycles, some performance criterion were checked.

All performance criterion were checked using the testing procedures and methods outlined in the CAN/CSA-A440-M90 window Standard.

TABLE 2: PERFORMANCE CHECK

NUMBER OF CYCLES	EVALUATION OF PERFORMANCE LEVEL			
	EASE OF OPERATION	AIR LEAKAGE (INF. & EXF)	WATER PENETRATION	CONDENSATION RESISTANCE
0	X	X	X	X
500	X	X		
1000	X	X	X	
2000*	X	X	X	X

* Typical of 10 years of use.

3.1 DESCRIPTION OF TEST PROCEDURE

The test performed on the specimens are described in the following sections, in accordance with the CAN/CSA-A440-M90 standard.

3.1.2 EASE OF OPERATION

With the window mounted on a suitable test frame, the operable light(s) shall be moved from the fully closed to the fully open position and back at least three times, to ensure that the light is operating freely. Such adjustments as might easily be performed in the field during normal installation may be made.

Using a spring balance or other suitable device* calibrated in units no larger than 5 N, the force required to initiate motion of the operable light(s) from both the fully closed and fully open positions shall be measured, as well as the force required to maintain motion to the opposite limits of travel. The point of application, direction, and maximum acceptable value of such force shall be as indicated in Table 3.

TABLE 3: EASE OF OPERATION

TYPE OF WINDOW	POINT OF APPLICATION OF FORCE	DIRECTION OF FORCE	MAXIMUM FORCE TO INITIATE MOTION, N (lb)	MAXIMUM FORCE TO MAINTAIN MOTION, N (lb)
Vertically sliding	Midpoint of operating handle(s) or of meeting rail	Vertical, parallel to plane of glass	200 (45)	100 (22.5)
Horizontally sliding	Midpoint of operating handle(s) or of meeting rail	Horizontal parallel to plane of glass	90 (20.5)	45 (10.1)
Casement and projecting with roto-operators	End of crank handle	Perpendi-cular to crank handle and screw	60 (13.5)	30 (6.75)

* When testing windows with roto-operators, it is recommended that the torque, T, necessary to initiate and maintain motion be measured. This may then be converted to force (F) values using the centre-to-centre length of the lever, L, in the equation $F = T/L$.

3.1.3 AIR INFILTRATION

Windows are rated with respect to the rate of air infiltration per unit length of crack of the specimen when the window is subjected to a static pressure differential of 75 Pa (1.56 lb/ft.^{2}). Such a pressure differential is equivalent to the pressure exerted by a wind having a velocity of 40 km/h (25 mi/h). The test is performed in accordance with A.S.T.M. E-283-84 specification. The window rating or classification is given in Table 4 below.

TABLE 4: WINDOW CLASSIFICATION FOR AIR LEAKAGE

WINDOW RATING	MAXIMUM AIR LEAKAGE RATE PER UNIT LENGTH OF CRACK AT ΔP=75 Pa (1.56 lb/ft^2)	
	m^3/h-m	(ft^3/min-ft)
A1	2.79	0.5
A2	1.65	0.3
A3	0.55	0.1
FIXED	0.25	0.045

3.1.4 WATER PENETRATION RESISTANCE

Windows are rated with respect to the highest static pressure differential sustained with success by the specimen during a given test period. The window classification is given in Table 5 below.

TABLE 5: WATER TIGHTNESS

WINDOW RATING		
FOR USE IN SMALL BUILDINGS	FOR USE IN OTHER BUILDINGS	TEST PRESSURE DIFFERENTIAL, Pa
Storm	—	0
B1	B1	150
B2	B2	200
B3	B3	250
—	B4	400
—	B5	500
—	B6	600
—	B7	700

The tests are performed in accordance with the A.S.T.M. E-547-86 specification, i.e. with a static pressure differential (see above table) across the window (including screen) and a water rate of flow rate equal to 3.,4 li/m^2-min.(5 U.S.gal./ft^2-h). At each test pressure, four cycles are completed.

Each cycle consists of five minutes with the pressure applied and one minute with the pressure released. Throughout the test, water is sprayed continuously.

3.1.5 CONDENSATION RESISTANCE TEST

Testing procedure

The test consists of sealing the specimen in a test unit between hot and cold chambers. The specimen is mounted in a wall separating the hot and cold chambers, with the exterior side of the window facing into the cold chamber.

Requirements of CAN/CSA-A440-M90 Standard

The room-side temperature (Th) shall be maintained at 20 ± 1°C and the weather-side temperature (Tc) shall maintained at -30 ± 1°C.

The pressure difference across the specimen shall be adjusted to be near zero ± 5 Pa when measured at mid-height of the specimen.

Once a steady state condition has been reached, maintain the specimen for five hours at test temperatures and then take five consecutive observations at 10 minute intervals. The temperature variation shall be within 1°C for the five observations at each location.

A temperature index (I) is then calculated using the noted measurements. The temperature index is calculated as follows:

Determination of the "Temperature index" (I)

For the glass

$$Ig = \frac{Tg - Tc}{TH - Tc} \times 100$$

For the frame

$$If = \frac{Tf - Tc}{Th - Tc} \times 100$$

EXAMPLE

-	Average surface temperature of glass (Tg)	= -2.0 °C
-	Coldest frame temperature (Tf)	= 0.0 °C
-	Difference between the temperature (Tg) and the weather side temperature (Tc)	= 28.0 °C
-	Difference between the temperature (Tf) and the weather side temperature (Tc)	= 30.0 °C
-	Difference between the room-side temperature (Th) and the weather-side temperature (Tc)	= 50.0 °C
-	Temperature index for the glass $Ig = \frac{28}{50} \times 100$	= 56.0
-	Temperature index for the frame $If = \frac{30}{50} \times 100$	= 60.0

The minimum acceptable value of I is 40 to pass the condensation resistance test.

4. RESULTS

Tables 6, 7, 8 and 9 record the intermediate and final results applicable to each performance criteria.

4.1 EASE OF OPERATION

This test was performed initially and after 500, 1000 and 2000 cycles on all operating windows.

Table 6 gives the initial and final (2000 cycles) operating force. Intermediate results at 500 and 1000 cycles were removed since the magnitude of the forces measured were approximately equal to forces indicated at 2000 cycles.

4.2 AIR LEAKAGE

Table 7 gives the measured air leakage rate per unit length of crack upon completion of each interval of motion cycling. The equivalent A440 rating is also shown adjacent to the measured value.

4.3 RESISTANCE TO WATER PENETRATION

Table 8 shows the equivalent A440 rating obtained on each window upon completion of the predetermined number of cycles.

4.4 CONDENSATION RESISTANCE

For each product, Table 9 shows the calculated temperature index of glass and frame upon completion of the preditermined number of cycles. Surface temperature distribution and detailed calculations are given in Appendix "C".

TABLE 6: EASE OF OPERATION

TYPE AND SPECIMEN NUMBER	INITIAL				2000 CYCLES				% VARIATION IN FORCE (%)	
	STATIC N (lb)		DYNAMIC N (lb)		STATIC N (lb)		DYNAMIC N (lb)			
	OPEN	CLOSE	OPEN	CLOSE	OPEN	CLOSE	OPEN	CLOSE	STATIC	DYN.
CASEMENT										
MC-1 (AL)	13 (3)	7 (1.5)	13 (3)	13 (3)	13 (3)	9 (2)	4 (1)	9 (2)	0	-50
MC-2 (PVC)	31 (7)	33 (7.5)	20 (4.5)	22 (5)	33 (7.5)	44.5 (10)	15.5 (3.5)	18 (4)	-	-25
MC-8 (PVC)	40 (9)	49 (11)	11 (2.5)	11 (2.5)	44.5 (10)	60 (13.5)	11 (2.5)	11 (2.5)	+ 5	0
MC-13 (WOOD)	29 (6.5)	27 (6)	7 (1.5)	16 (3.5)	120 (27)	53 (12)	31 (7)	22 (5)	+207	+130
MC-14 (WOOD)	31 (7)	18 (4)	13 (3)	9 (2)	62 (14)	18 (4)	7 (1.5)	7 (1.5)	+100	-33
VERTICAL SLIDER										
MC-3 (AL)	122 (27.5)	127 (29)	98 (22)	89 (20)	178 (40)	178 (40)	147 (33)	107 (24)	+40	+25
MC-15 (WOOD)	173.5 (39)	116 (26)	120 (27)	120 (27)	151 (34)	76 (17)	107 (24)	98 (22)	-25	-17
HORIZONTAL SLIDER										
MC-7 (PVC)	76 (17)	40 (9)	22 (5)	22 (5)	67 (15)	89 (20)	58 (13)	58 (13)	+30	+163
MC9 SASH (PVC) #1	42 (9.5)	38 (8.5)	31 (7)	33 (7.5)	49 (11)	67 (15)	33 (7.5)	38 (8.5)	+45	+12
SASH #2	49	58	31	36	53	53	42	42	0	+30

* Exceeds the maximum allowable force specified by the A440 Standard.

TABLE 7: AIR LEAKAGE

TYPE AND SPECIMEN	INITIAL $m^3/h-m$ (SCFM/ft)	500 CYCLES $m^3/h-m$ (SCFM/ft)	1000 CYCLES $m^3/h-m$ (SCFM/ft)	2000 CYCLES $m^3/h-m$ (SCFM/ft)	δQ	
					ABSOLUTE $m^3/h-m$ (SCFM/ft)	%
CASEMENT						
MC-1 (AL)	0.758-A2 (0.136)	0.869-A2 (0.156)	0.880-A2 (0.158)	0.903-A2 (0.162)	0.145 (0.026)	+19
MC-2 (FIBERGLASS)	0.412-A3 (0.074)	0.451-A3 (0.081)	0.479-A3 (0.086)	0.52-A3 (0.093)	0.118 (0.019)	+28.6
MC-8 (PVC)	0.443-A3 (0.0795)	0.751-A2 (0.133)	0.777-A2 (0.139)	1.047-A2 (0.188)	0.604 (0.109)	+136
MC-13 (WOOD)	0.273-A3 (0.049)	0.366-A3 (0.066)	0.389-A3 (0.070)	0.505-A3 (0.091)	0.232 (0.042)	+85
MC-14 (WOOD)	0.279-A3 (0.050)	0.390-A3 (0.070)	0.524-A3 (0.094)	0.507-A2 (0.102)	0.291 (0.052)	+104
VERTICAL SLIDER						
MC-3 (AL)	1.198-A2 (0.215)	1.315-A2 (0.236)	1.320-A2 (0.237)	1.35-A2 (0.242)	0.152 (0.027)	+12
MC-15 (WOOD)	0.892-A2 (0.160)	0.925-A2 (0.166)	0.930-A2 (0.166)	0.930-A2 (0.166)	0.038 (0.006)	+4
HORIZONTAL SLIDER						
MC-7 (PVC)	2.558-A1 (0.459)	2.72-A1 (0.488)	2.84* (0.51)	2.89* (0.52)	0.332 (0.061)	+13
MC-9 (PVC)	2.301-A1 (0.413)	2.286-A1 (0.41)	2.294-A1 (0.411)	2.30-A1 (0.412)	0	0

* Exceeds the maximum allowable air leakage specified by the A440 Standard.

To meet level A1, the air leakage rate must be equal or lower than 2.79 $m^3/h-m$ and higher than 1.65 $m^3/h-m$.

To meet level A2, the air leakage rate must be equal or lower than 1.65 $m^3/h-m$ and higher than 0.55 $m^3/h-m$.

To meet level A3, the air leakage rate must be equal or lower than 0.55 $m^3/h-m$.

TABLE 8: RESISTANCE TO WATER PENETRATION

TYPE AND SPECIMEN NUMBER	INITIAL	1000 CYCLES	2000 CYCLES
CASEMENT			
MC-1 (AL)	B3	B2	B2
MC-2 (FIBREGLASS)	B3	B1	Nil*
MC-8 (PVC)	B3	B3	B3
MC-13 (WOOD)	B3	B3	B3
MC-14 (WOOD)	B3	B3	B3
VERTICAL SLIDER			
MC-3 (AL)	B1	B1	B1
MC-15 (WOOD)	B5	B5	B3
HORIZONTAL SLIDER			
MC-7 (PVC)	Nil*	Nil*	Nil*
MC-9 (PVC)	B1	B1	B1

* : Does not meet the minimum level of performance defined by the A440 Standard.

TABLE 9: TEMPERATURE INDEX (CONDENSATION RESISTANCE)

TYPE AND SPECIMEN NUMBER	INITIAL		2000 CYCLES	
	TI_G	TI_F	TI_G	TI_F
CASEMENT				
MC-1 (AL)	54	38*	54	32*
MC-2 (FIBREGLASS)	62	52	62	52
MC-8 (PVC)	60	34*	58	26*
MC-13 (WOOD)	58	48	58	40
MC-14 (WOOD)	62	48	58	24*
VERTICAL SLIDER				
MC-3 (AL)	60	46	60	44
MC-15 (WOOD)	60	50	56	42
HORIZONTAL SLIDER				
MC-7 (PVC)	60	48	56	24*
MC-9 (PVC)	60	18*	60	18*

* TI lower than minimum acceptable value specified by A440

TI_G(MIN.) - A440 = 40
TI_F(MIN.) - A440 = 40

5. OBSERVATIONS

During the motion cycling tests several observations were made. These observations are mostly related to wear of weatherstripping, locking devices and sash or frame components. Other deficiencies are related to the basic window design and fabrication.

This part of the report gives some typical observations on specific specimens. Nevertheless, some of these observations could also apply to the remaining specimens.

5.1 WEATHERSTRIP WEAR

Photographs no. 3 to 8 show what happened after 500 cycles on some typical casement windows. These observations can be summarized as:

- pile type weatherstrip being cut by the alternating sash movements (see photograph no. 3 to 7);
- the center weatherstrip fin being torn apart (see photograph no. 5);
- bulb type weatherstrip being cut by the open-close cycling of locks (see photograph no. 7);
- loss of glue adhesion at weatherstrip corner junction (see photograph no. 8).

5.2 LOCKING DEVICES WEAR

Photograph no. 7 shows that in addition to the undercutting of the weatherstrip, there is friction between the locking handle versus the keeper. Such friction creates metal dust accumulation at the window sill (see P-8).

5.3 SASH AND FRAME WEAR

Photograph no. 9 shows that friction of a PVC sash versus a PVC frame may create undercutting of one component. Such undercutting will increase the force required to initiate and maintain the movement of the sash with respect to the frame.

5.4 INTERFACE GASKET BETWEEN ROTO-OPERATOR AND PVC FRAME

Photograph no. 10 shows that the gasket between the roto-operator and the retaining sill member became loose after 2000 motion cycles. This may be explained by compression set of the interface gasket and/or the creeping of PVC around the roto-operator retaining screws. In addition to the screws loosening, we also observed that such a gap did increase the rate of air leakage at that particular location (refer to MC-8 - Table 7).

5.5 RIGIDITY OF FRAME MEMBERS

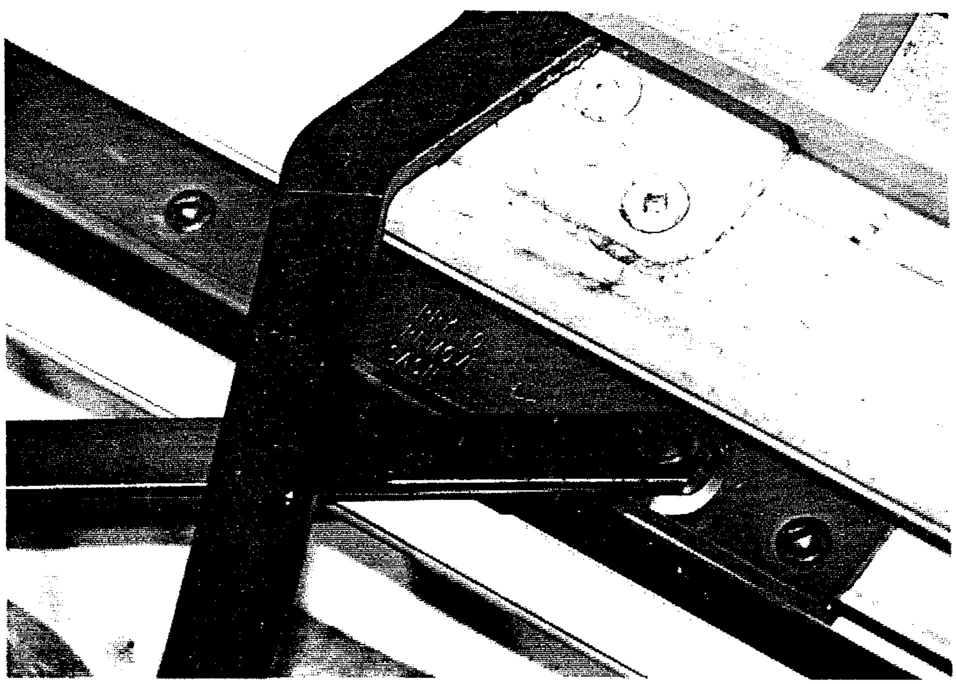
Photograph no. 11 shows that a lack of rigidity of the sill member introduced a deflection of such member when subjected to the cycling test. In turn, the deflection of the sill member created a stress on the glue line connecting the screen retaining member to the window sill. This fatigue stress brought a loss of adhesion of the screen retaining member versus window sill.

5.6 DISTORTION OF PVC SASH MEMBERS SUBJECTED TO A TEMPERATURE DIFFERENTIAL

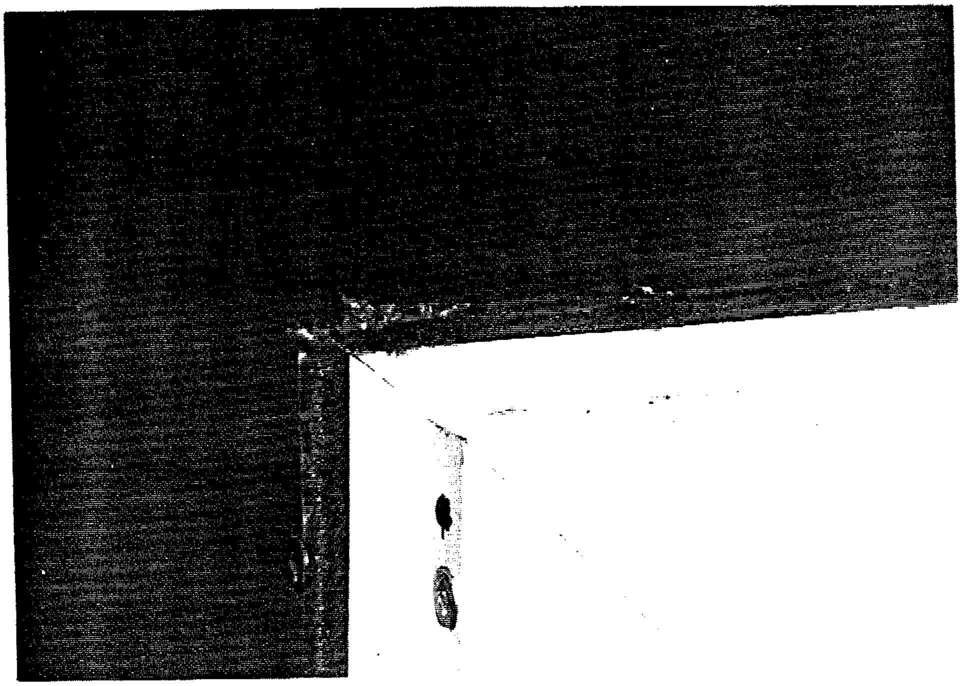
Photographs no. 12 and 13 show that the PVC sash stile located on the lock side of unreinforced PVC casement windows distort when subjected to a differential temperature of 50°C (-30°C outdoor and +20°C indoor). This can only be explained by a combination of two factors: the high coefficient of linear expansion of PVC and the lack of rigidity of the "glass-PVC" assembly. Such distortion implies that a loss of contact between sash and frame may occur at such locations and that cold air may enter the building during winter. Table 9 shows that this particular window failed to pass the minimum acceptable condensation resistance requirement of the A440-M90 Standard.

AIR-INS inc.

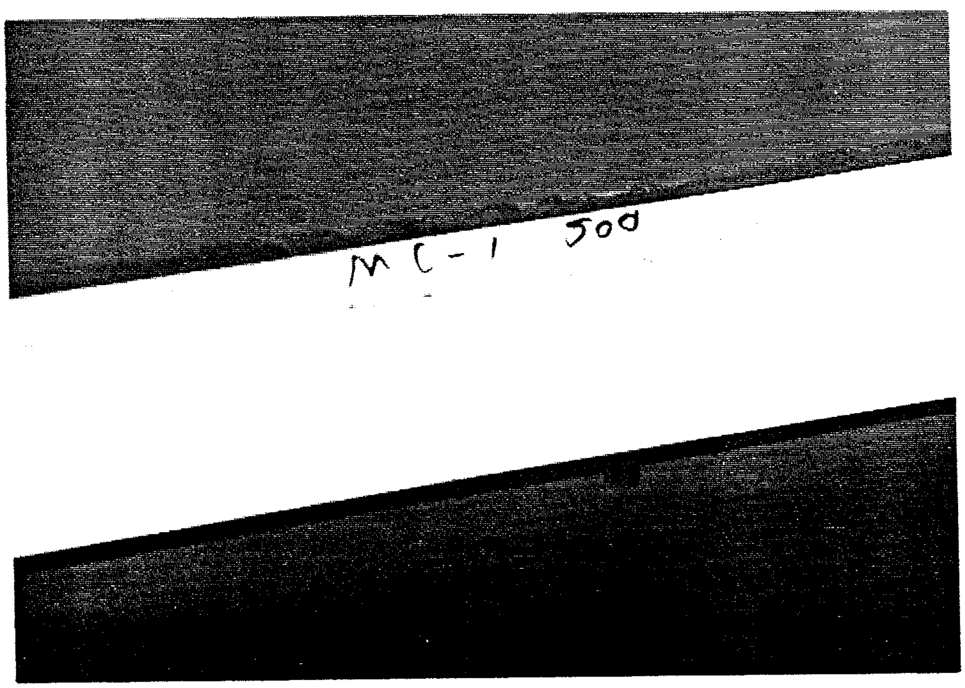
PHOTOGRAPH NO. 3: MC-1 (Aluminum-casement) after 500 cycles
- Sill (exterior view)
- Weatherstripping wear



PHOTOGRAPH NO. 4: MC-1 (Aluminum-casement) after 500 cycles
- Sill (exterior view)
- Weatherstripping wear



PHOTOGRAPH NO. 5: MC-1 (Aluminum-casement) after 500 cycles
- Top of sash - locking side
- Weatherstripping wear (corner)



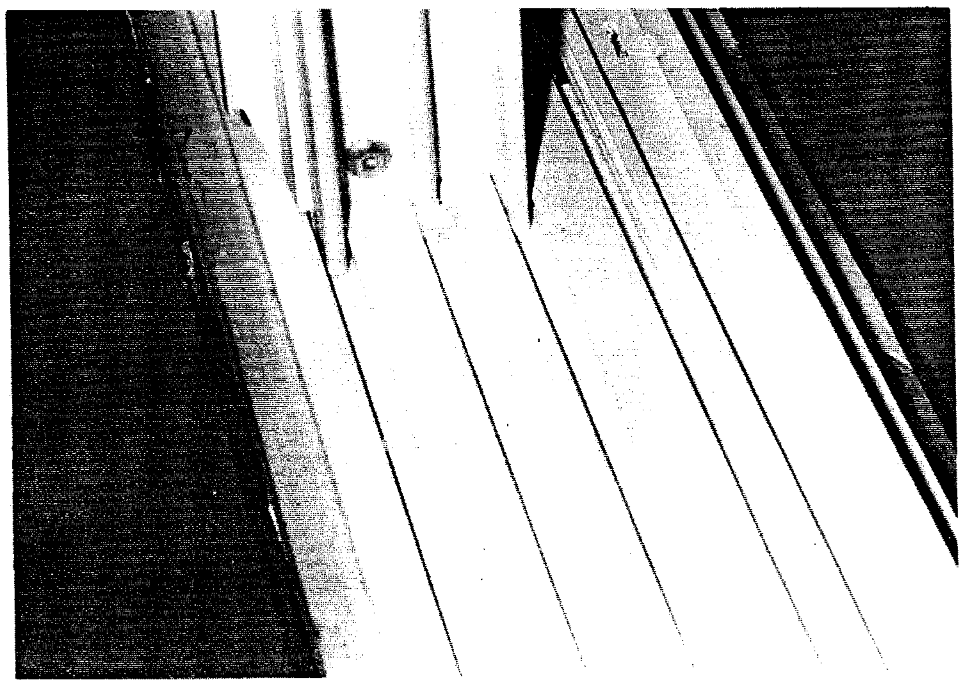
PHOTOGRAPH NO. 6: MC-1 (Aluminum-casement) after 500 cycles
- Top of sash - center
- Weatherstripping wear

PHOTOGRAPH NO. 7:

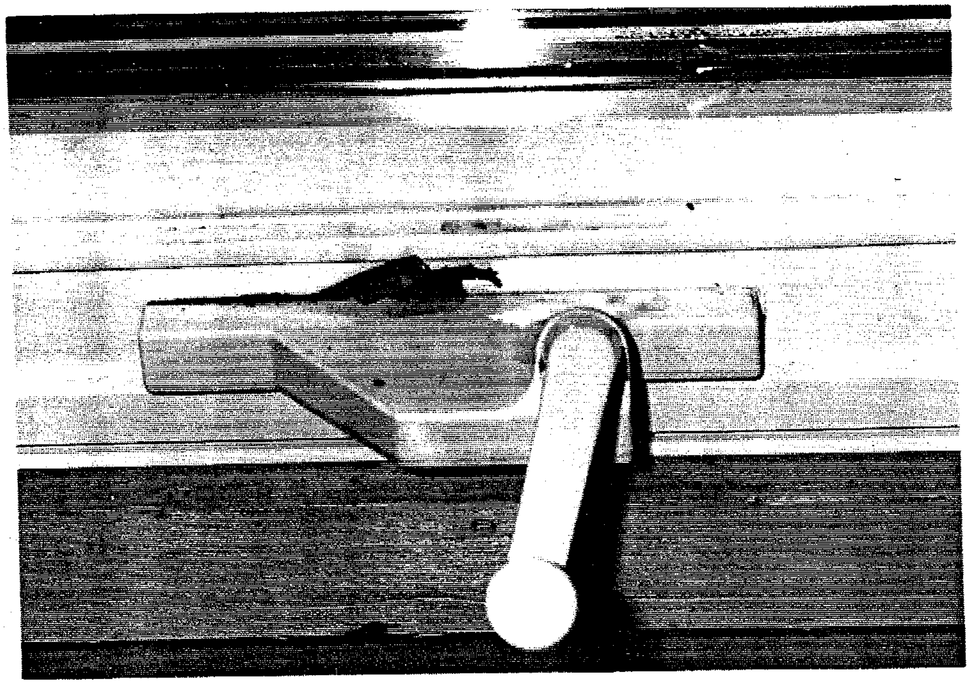
MC-2 (Fibreglass-casment)
- after 500 cyles
- Weatherstripping is torn apart at locks
- Keeper contacts weatherstripping during motion cycling

PHOTOGRAPH NO. 8:

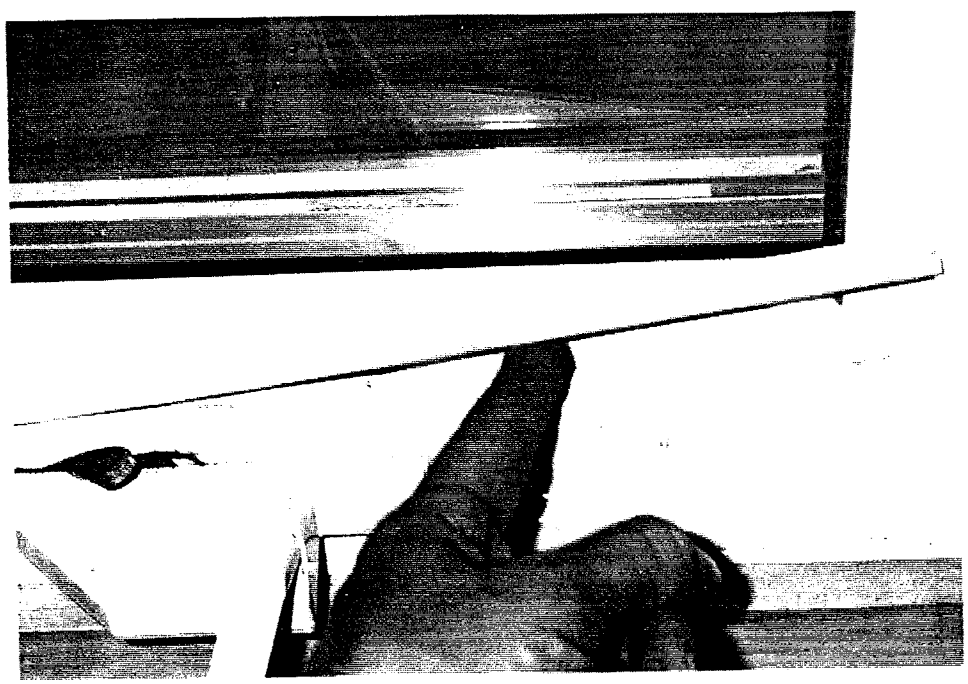
MC-2 (Fibreglass-casement)
after 500 cycles
- Loss of glue adhesion at bottom corner (lock side)
- Aluminum deposits on sill (lock side)



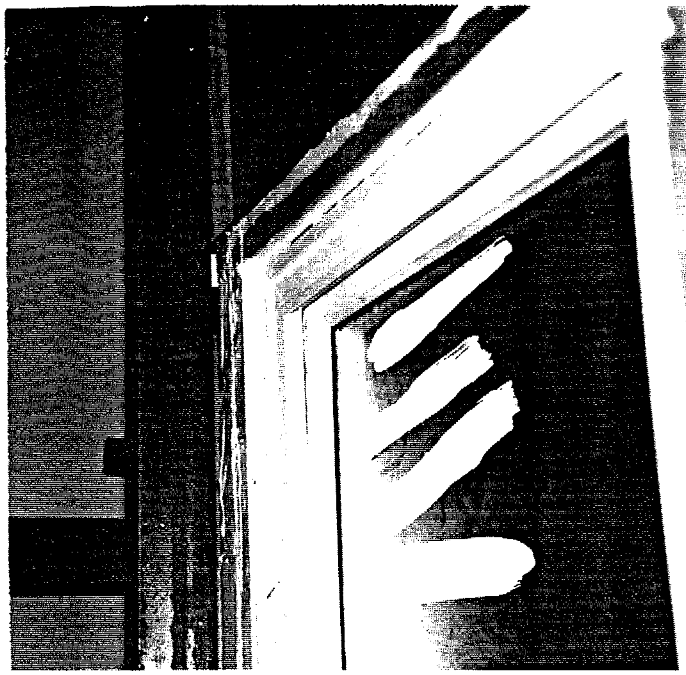
PHOTOGRAPH NO. 9: MC-7 (PVC - Hor. slider)
- Wear
- Filaments of PVC on sill



PHOTOGRAPH NO.10: MC-8 (PVC - casement) after 2000 cycles
- Gasket around operator gets loose
- Increase in air leakage

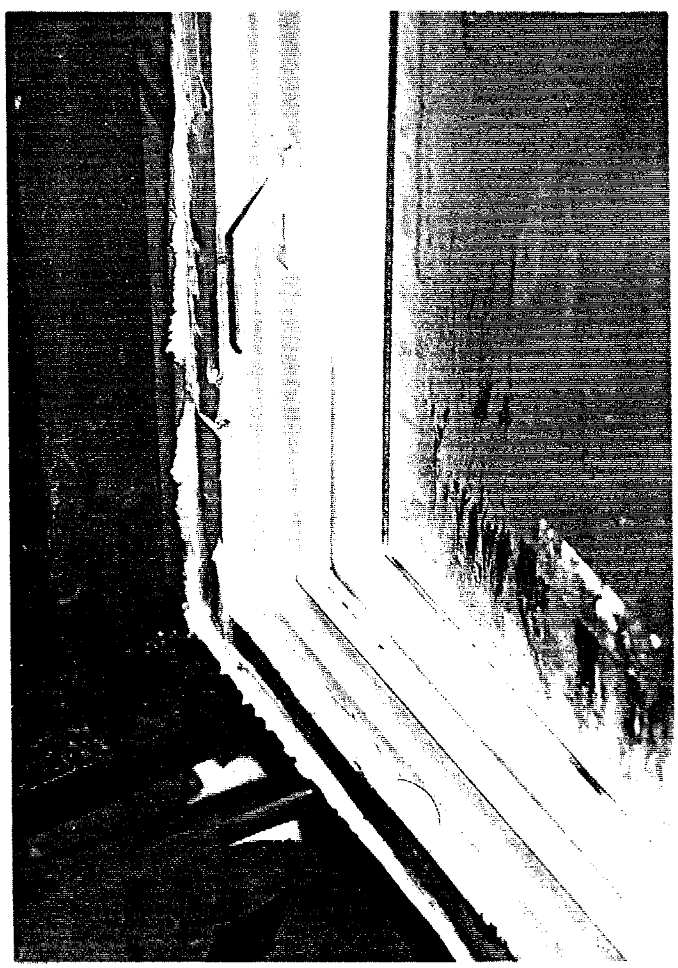


PHOTOGRAPH NO.11: MC-8 (PVC - casement) after 2000 cycles
- Loss of adhesion between screen retainer and sill
- Lack of rigidity for the sill member



PHOTOGRAPH NO.12:

MC-8 (PVC -casement)
- after 2000 cycles
- Distorsion of sash members at low temperature (top)



PHOTOGRAPH NO.13:

MC-8 (PVC - casement)
after 2000 cycles
- Distorsion of sash members at low temperature (bottom)

6. DATA ANALYSIS AND CONCLUSIONS

6.1 EASE OF OPERATION

Table 6 shows that ease of operation may increase or decrease after motion cycling.

A decrease in the force required to initiate and maintain the sash movement with respect to the frame can only be explained by the loss of compression between weatherstrips and adjacent surfaces and/or by surface smoothening or polishing. The latter has a minimum effect in window applications.

An increase in the force required to initiate and maintain the sash movement with respect to the frame can only be caused by wear within the operating device (roto-operator, sash-balance) or by undercutting of one component.

Table 6 shows the resultant effect of both wear and weatherstrip compression loss. As such, the variation of operating forces from initial to final testing ranged from -50 to +207%. Except for two windows (MC-13 and MC-7) the variations are very acceptable.

6.2 AIR LEAKAGE

Except for specimen MC-9, Table 7 shows that all windows recorded an increase in the air leakage rate from initial to final testing. Variations for 8 windows ranged from 4 to 136%.

Among all tested specimens, three specimens (MC-8, MC-14 and MC-7) reduced their air leakage rating by one level. If the motion cycle test would be part of the A440 Standard, unit MC-7 would be disqualified.

The observed increase in air leakage rate is mainly caused by the compression loss of weatherstrips versus adjacent surface. Unit MC-8 suffered an additional leak at the gasket versus roto-operator interface (see P-10).

6.3 RESISTANCE TO WATER PENETRATION

Table 8 shows that:

- The rating of six specimens remained unchanged between initial and final testing;
- One specimen (MC-1) suffered a reduction of 1 level (B3 to B2);
- One specimen (MC-5) suffered a reduction of 2 levels (B5 to B3);
- One specimen (MC-2) would be disqualified if motion cycling was part of the A440 Standard.

For all specimens that suffered a reduction in their rating, the only explanation one can give is that the relative airtightness of the inner window plane was reduced compared to the outer window plane, thereby reducing pressure equalization between the exterior and the cavity formed by the inner and outer plane of airtightness. To maintain the resistance to water penetration, the inner plane must be controlling the airtightness of the assembly.

6.4 CONDENSATION RESISTANCE

Table 9 shows that:

- Only one specimen (MC-2) kept a constant temperature index for the glass and frame portions between initial and final testing;
- Eight out of nine specimens showed a decrease of their temperature index;
- When a reduction of the temperature index for glass occured (8 units), such reductions were always less than 4 points (MC-7, MC-15);
- When a reduction of the temperature index for the frame occured (8 units), such reductions could be as large as 24 points (MC-7, MC-14);
- Prior to motion cycling, three specimens (MC-1, MC-8 and MC-9) failed to pass the minimum acceptable value of the A440 Standard.

Among all selection criteria, condensation resistance is certainly the factor which shows the largest decrease in performance from initial to final testing.

For a given specimen, a large reduction of the temperature index can be explained by a loss of airtightness at the outer face of the "sash-frame" interface allowing cold air to circulate within the cavity. The reduction of TI could be worsened if in addition to the above, a loss of airtightness at the inner face (air-barrier) of the "sash-frame" interface occurs. Photographs no. 12 and 13 (MC-8) may represent such a case.

7. RECOMMENDATIONS

- The condensation resistance tests conducted on non-metallic windows (wood and PVC) showed that some of these new products did not meet the minimum performance level specified by the A440 Standard. Therefore, in order to make it fair and acceptable to the consumer, the evaluation of this criterion should be made mandatory for all materials.
- In view of the fact that 2 out of 9 specimens did not meet the minimum performance level of the A440 Standard, a certification program or spot reevaluations should be put in place. Such a program will improve the certainty of the performance levels recorded by CCMC.
- The motion cycling test showed that in all cases there was a decrease in one or several of the performance criteria covered by the existing A440 Standard. To ensure that windows will maintain their performance level over their life span, this new criterion should be incorporated into the main body of the A440 Standard.
- This subjected matter, although not previously discussed shall now be brought forward to the A440 Committee given the conclusions of this report.

- In addition to the above, a higher number of motion cycles as suggested by several standards (see Appendix B3) could also be used to provide information on the durability of components such as weatherstripping, friction hinges, sash balances, roller assemblies and rotory-operators.
- Appendix "B" describes a proposal of the "window endurance test" including the requirements which may be part of the A440 Standard in the near future.

APPENDIX "A"

DESCRIPTION OF WINDOWS

AIR-INS inc.

IDENTIFICATION: MC-1

TYPE OF WINDOW: CASEMENT

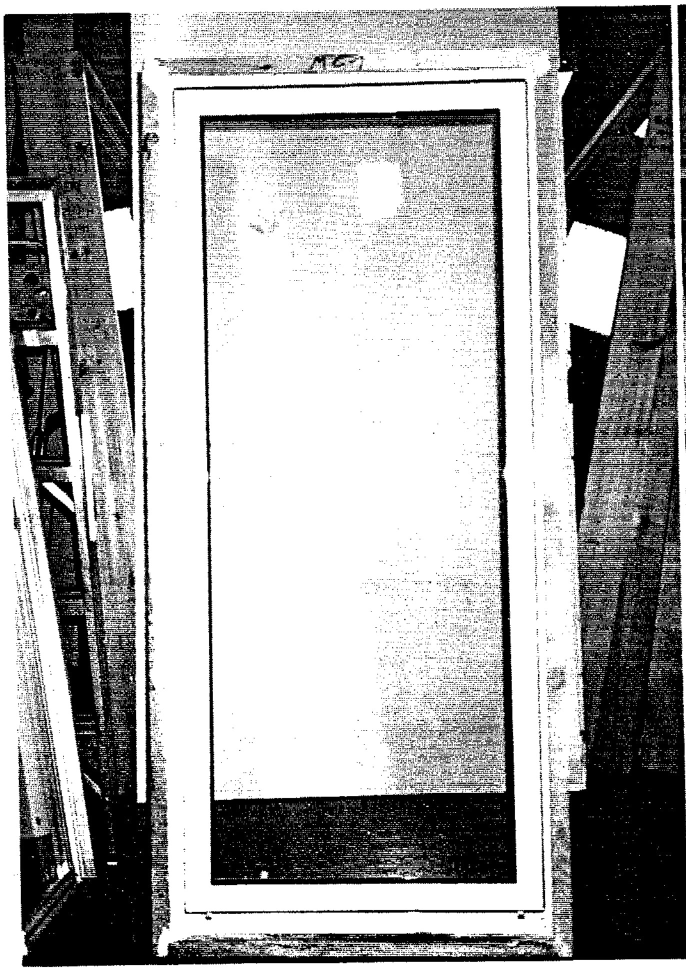
FRAME AND SASH MATERIAL: ALUMINUM

SASH DIMENSIONS: 25.25" x 60"

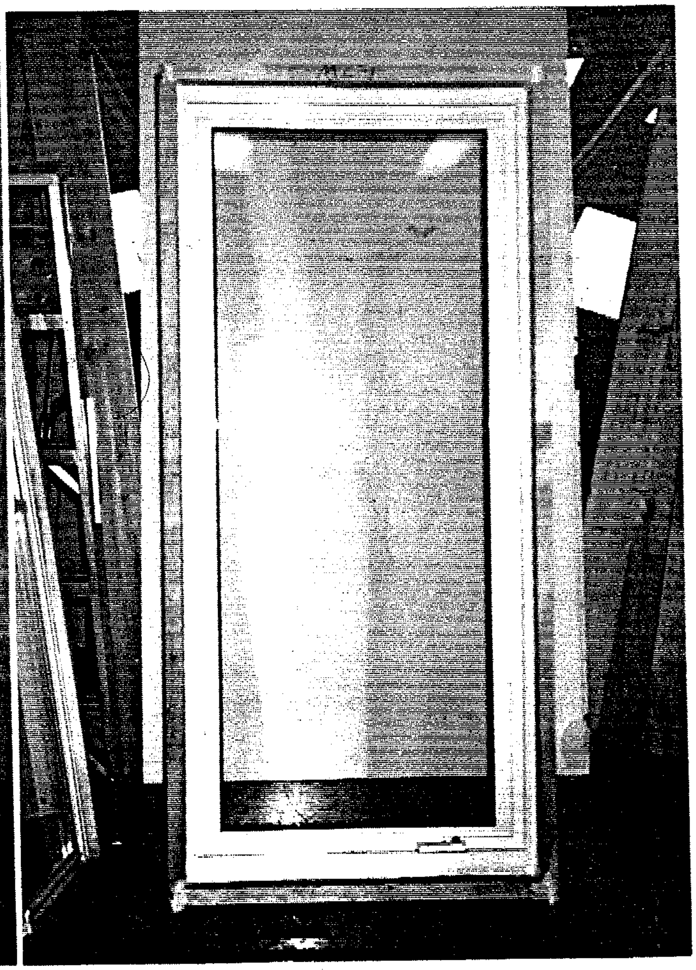
CRACK LENGTH: 14.21'

WEATHERSTRIPPING: INTERIOR: Polyflex

EXTERIOR: "Hi-Fin"



Photograph A1



Photograph A2

AIR-INS inc.

IDENTIFICATION: MC-2

TYPE OF WINDOW: CASEMENT

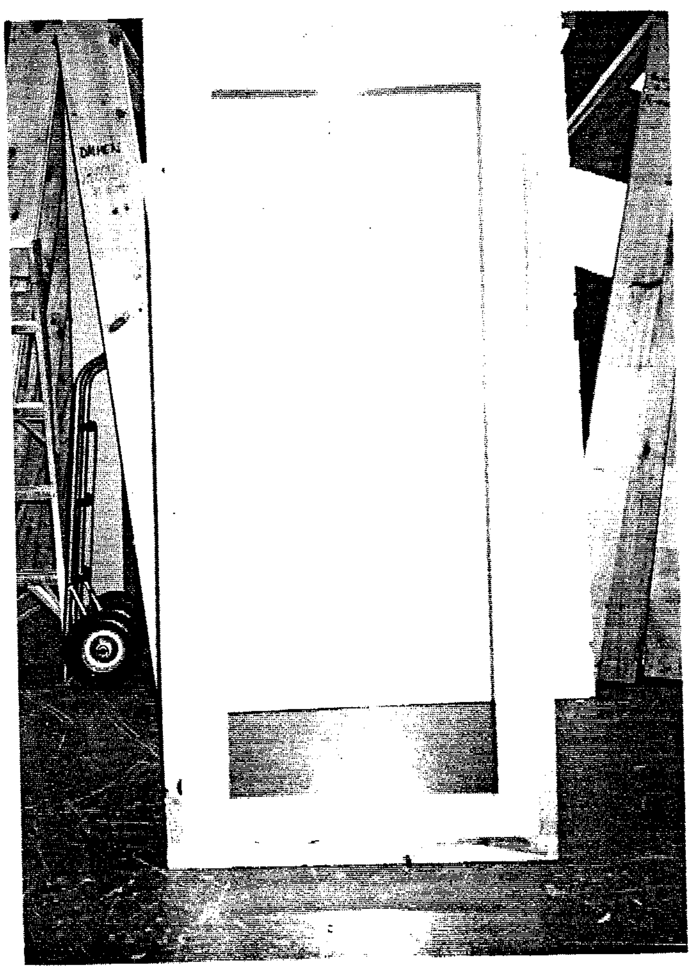
FRAME AND SASH MATERIAL: FIBREGLASS

SASH DIMENSIONS: 25" x 61"

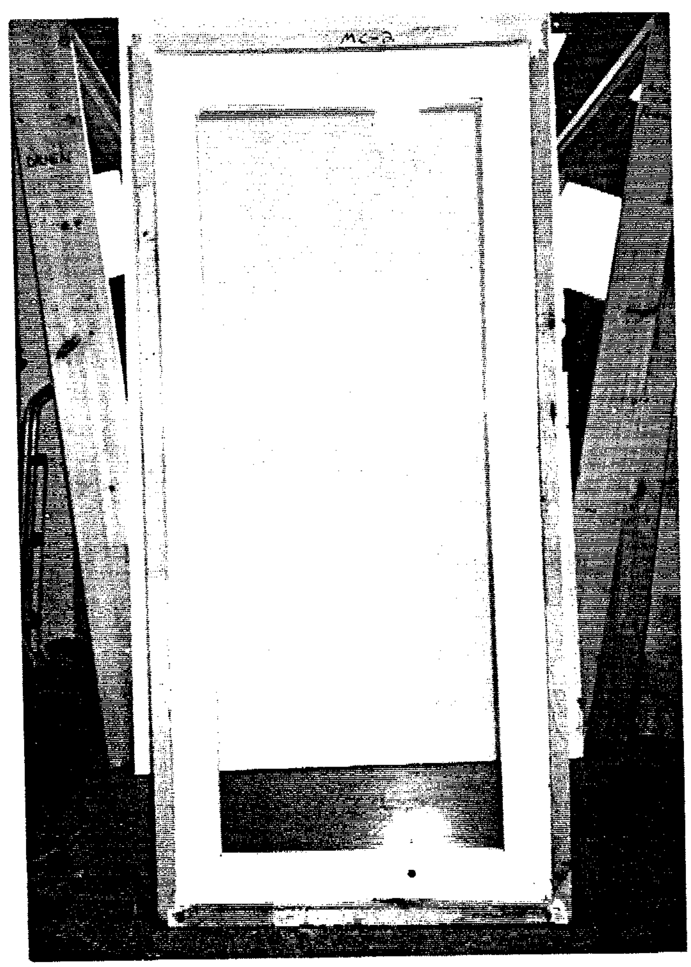
CRACK LENGTH: 14.33'

WEATHERSTRIPPING: INTERIOR: "Q-lon" bulb type

EXTERIOR: "Q-lon" bulb type



Photograph A3



Photograph A4

AIR-INS inc.

IDENTIFICATION: MC-3

TYPE OF WINDOW: VERTICAL SLIDING WINDOW

FRAME AND SASH MATERIAL: ALUMINUM

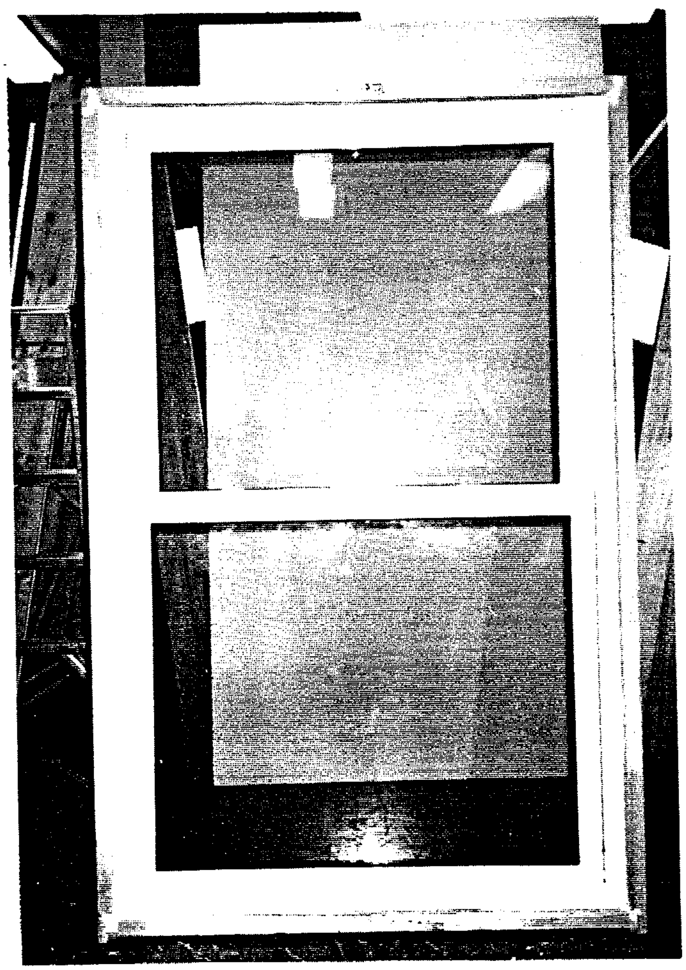
SASH DIMENSIONS: 36.125" x 60.5"

CRACK LENGTH: 19.11'

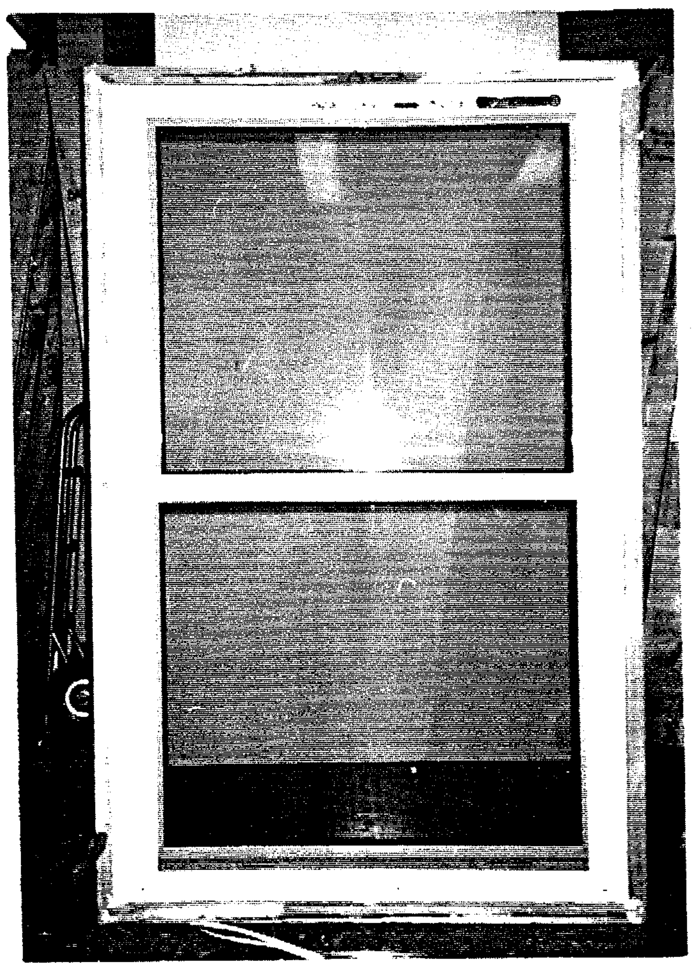
WEATHERSTRIPPING: INTERIOR: Pile type weatherstripping with low height polypropylene fin

MEETING RAIL: "Hi-Fin"

EXTERIOR: Pile type polypropylene fin



Photograph A5



Photograph A6

AIR-INS inc.

IDENTIFICATION: MC-7

TYPE OF WINDOW: HORIZONTAL SLIDING WINDOW

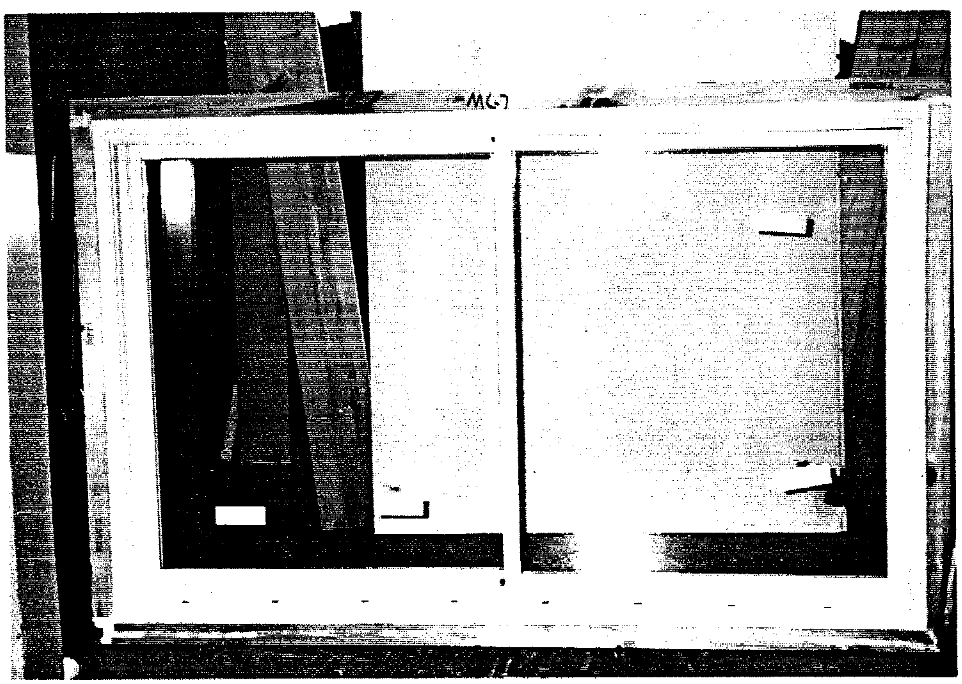
FRAME AND SASH MATERIAL: PVC

SASH DIMENSIONS: 60.75" x 35.375"

CRACK LENGTH: 18.97'

WEATHERSTRIPPING: SASH HEAD AND BASE: "Hi-Fin"

MEETING RAIL: Pile type weatherstripping



Photograph A7

AIR-INS inc.

IDENTIFICATION: MC-8

TYPE OF WINDOW: CASEMENT

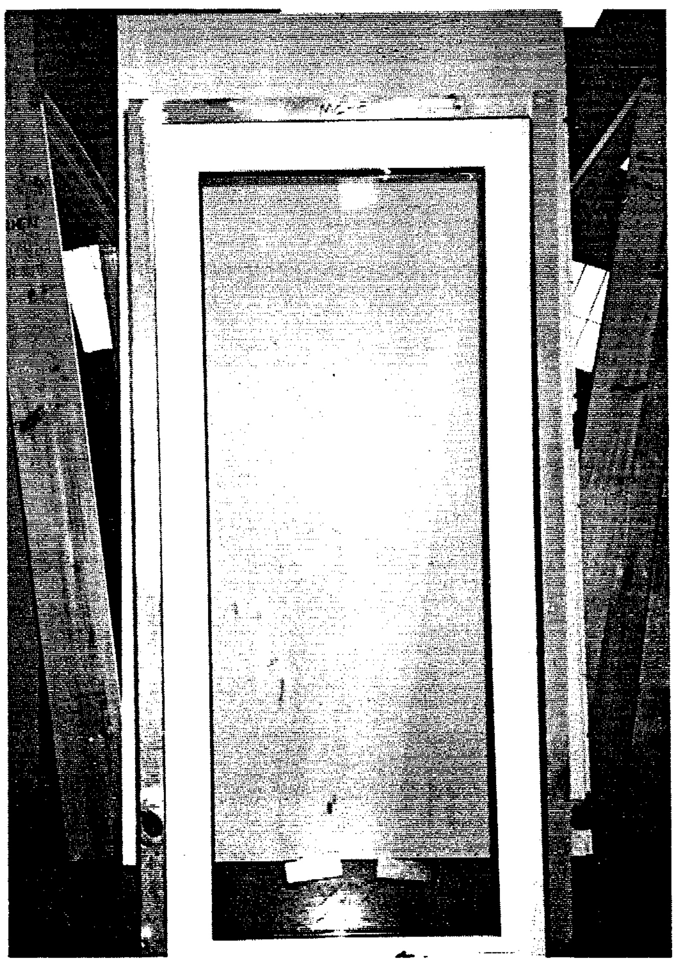
FRAME AND SASH MATERIAL: PVC

SASH DIMENSIONS: 23.375" x 63.5"

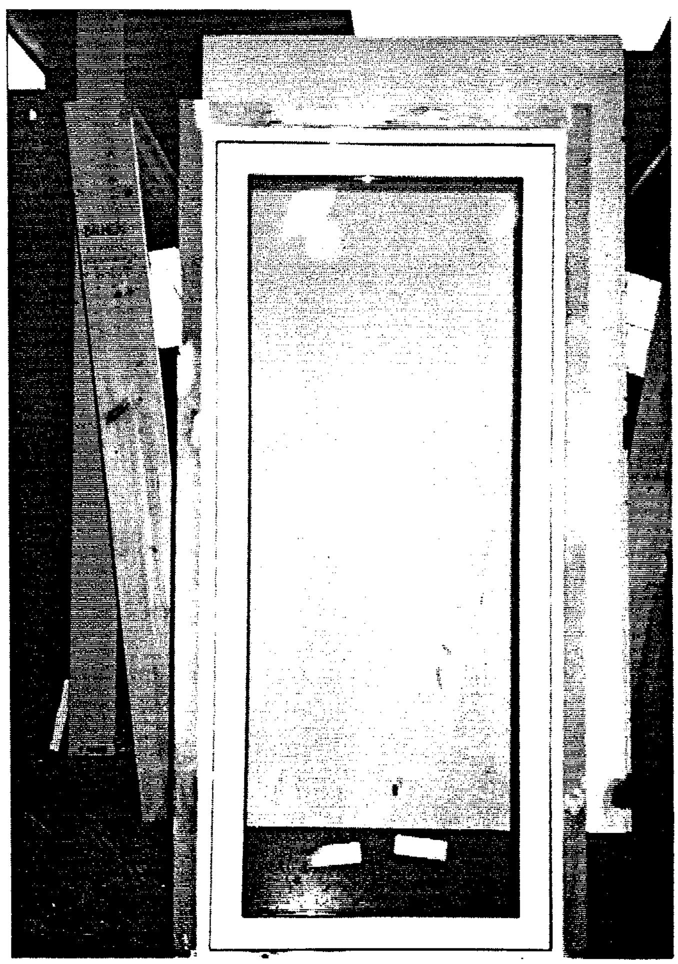
CRACK LENGTH: 15.31'

WEATHERSTRIPPING: INTERIOR: PVC bulb

EXTERIOR: Rubber gasket



Photograph A8



Photograph A9

AIR-INS inc.

IDENTIFICATION: MC-9

TYPE OF WINDOW: HORIZONTAL SLIDING WINDOW

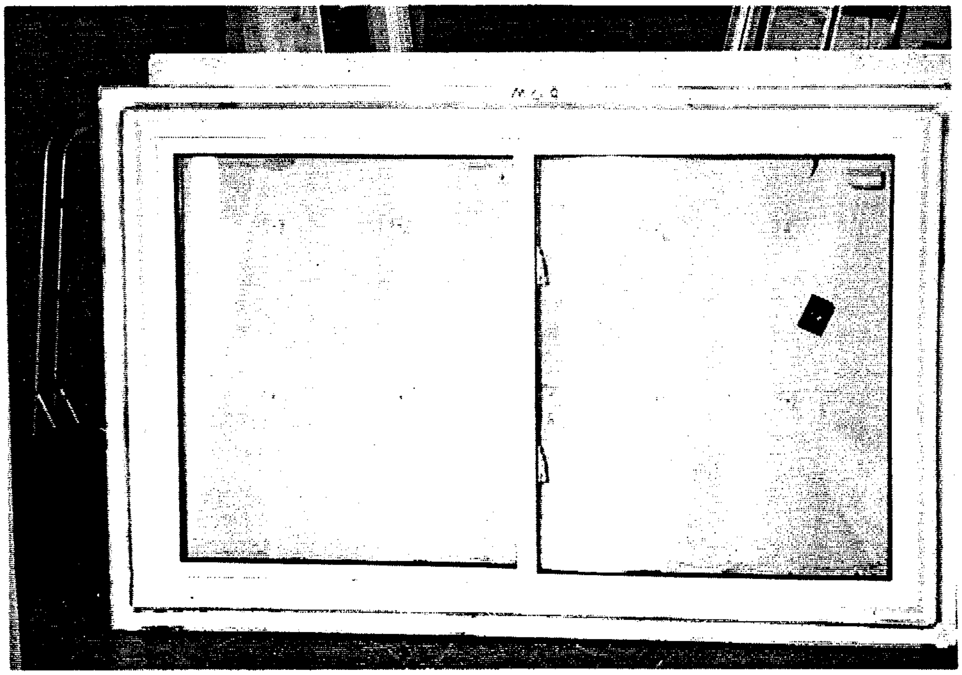
FRAME AND SASH MATERIAL: PVC

SASH DIMENSIONS: 59.125" x 35.5"

CRACK LENGTH: 18.73'

WEATHERSTRIPPING: ON SASHES: "Hi-Fin"

ON JAMBS : Pile type weatherstripping



Photograph A10

AIR-INS inc.

IDENTIFICATION: MC-13

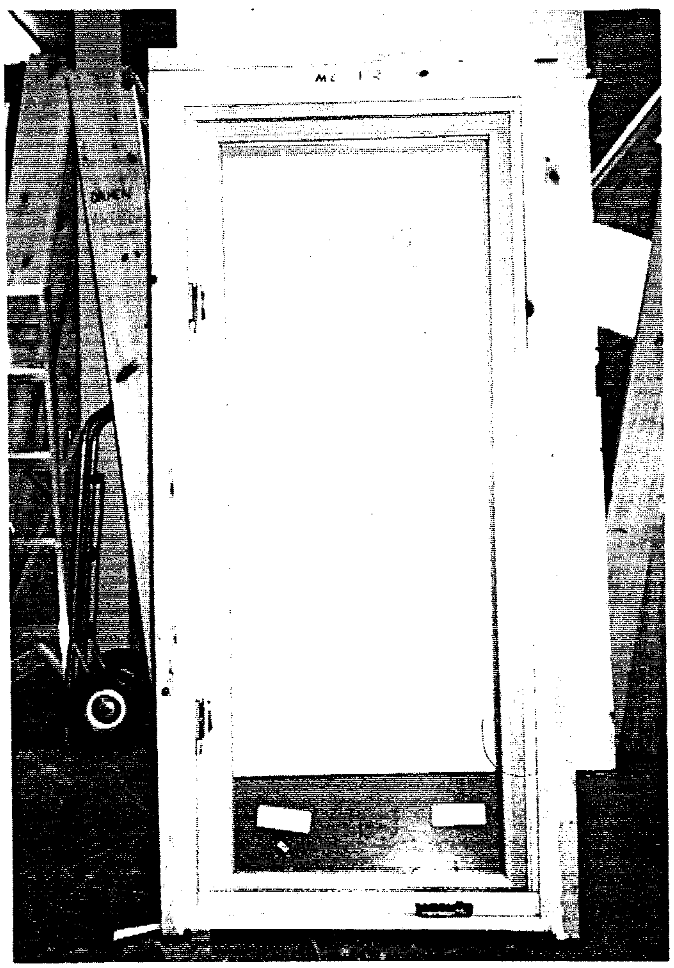
TYPE OF WINDOW: CASEMENT

FRAME AND SASH MATERIAL: WOOD

SASH DIMENSIONS: 25.25" x 60.75"

CRACK LENGTH: 14.33'

WEATHERSTRIPPING: LOZARON GASKET ON THE SASH



Photograph A11

AIR-INS inc.

IDENTIFICATION: MC-14

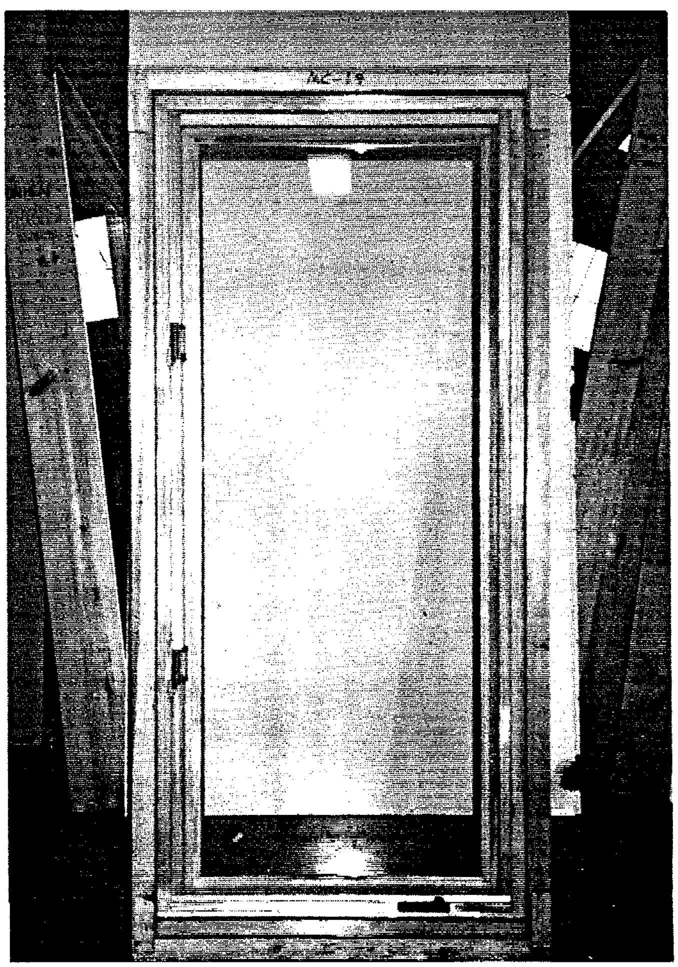
TYPE OF WINDOW: CASEMENT

FRAME AND SASH MATERIAL: WOOD

SASH DIMENSIONS: 25.75" x 60.5"

CRACK LENGTH: 14.38'

WEATHERSTRIPPING: INTERIOR: Lozaron gasket



Photograph A12

Photograph A13

AIR-INS inc.

IDENTIFICATION: MC-15

TYPE OF WINDOW: VERTICAL SLIDING WINDOW

FRAME AND SASH MATERIAL: WOOD

SASH DIMENSIONS: 31" x 59.5"

CRACK LENGTH: 17.67'

WEATHERSTRIPPING: HEAD INTERIOR: Pile type weatherstripping with low height polypropylene film

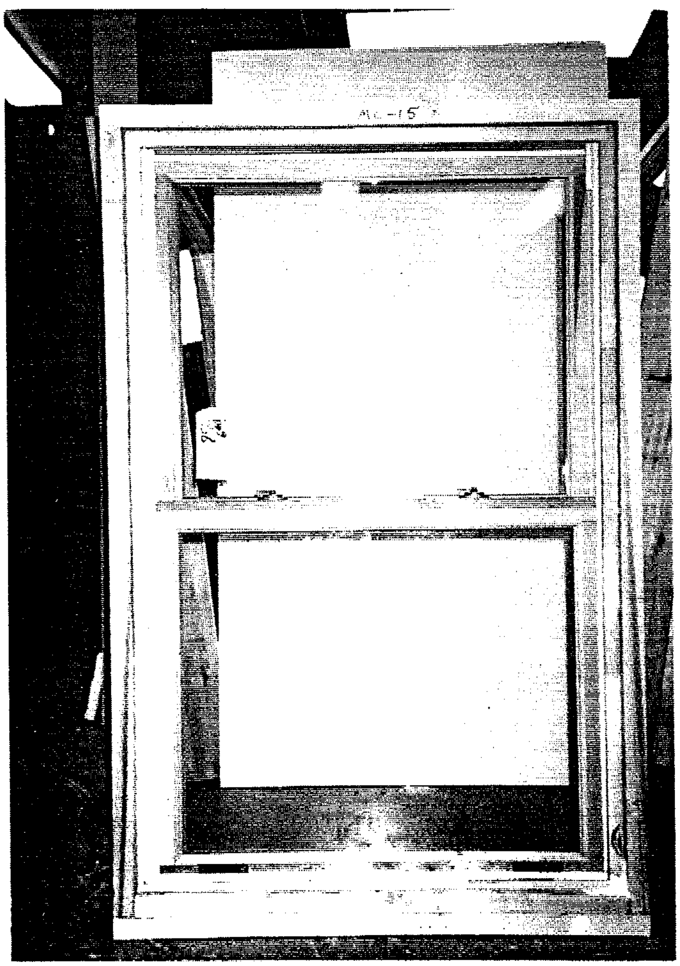
EXTERIOR: Rubber bulb

MEETING RAIL: Lozaron type gasket

SILL: INT.: "Hi-Fin"

EXT.: Polyflex type gasket

JAMBS: "Q-Lon" bulb



Photograph A14

AIR-INS inc.

APPENDIX "B"

PROPOSED

WINDOW ENDURANCE TEST

WINDOW ENDURANCE TEST

OPEN-CLOSE CYCLING

1. SCOPE

This test method covers all types of operable windows.

2. PURPOSE

This test method is intended for evaluating the durability of the window components and to determine if a unit maintains or decreases its performance levels with regards to ease of operation, air infiltration and resistance to water penetration after it is submitted to the endurance test.

The test consists of submitting the sash(es) to a number of opening/closing cycles in conditions that approximate normal use.

The movement is initiated at the usual operation device, so that all components are submitted to the cycling including the locking operation (for awning, casement and tilt-and-turn windows) or without locking (for horizontal and vertical sliding windows).

3. SAMPLE PREPARATION

If required, perform lubrification and adjustments as required by the manufacturer.

4. <u>TEST METHOD</u>

4.1 Testing procedure

4.1.1 Measurement of the required load to initiate and maintain the opening and closing movements of the sash(es);

4.1.2 Measurement of the initial air infiltration (T = 20 ± 2°C, RH = 40% ± 10%), according to ASTM E283 Standard;

4.1.3. Measurement of initial water penetration resistance, according to ASTM E547 Standard;

4.1.4. Tune the testing apparatus so as to obtain, for each cycle, the prescribed opening and complete closing, with or without locking operation, accordingly.

4.2 For horizontal and vertical sliding windows, the movement lineal speed shall be 5m/min (± 10%) with a deceleration (acceleration) at the end (beginning) of each stroke to prevent abrupt stop (start) of the sash. In the case of windows comprising of two or more sashes, the test is to be performed on each sash.

4.3 For rotating windows, the sash shall complete a cycle within six seconds (± 20%). The sash angular rotation shall be equal to the maximum opening angle with a tolerance of +0° and -5°. At the end of each cycle, a four second delay (minimum) shall occur to allow the opening and closing of the locks. Each sash is then submitted to the back-and-forth movement for 4000 continuous cycles, at the rates mentioned above.

SOURCE OF DATA	
Windows:	NFP 25-501 (7000 cycles)
Sash Balances:	AAMA 902.2-87 (4000 cycles)
Sliding Glass Door Roller Assemblies:	AAMA 906.3-87 (2500 cycles)
Rotary Operators:	ASTM E405-70 (3500 cycl.min)
Sliding Glass Door Roller Assemblies:	CAN/CGSB 82.1-M89 (60000 cycles)
Horizontal Sliding Window Roller Assemblies:	CGSB 63-GP-2M (2500 cycles) CGSB 63-GP-3M (2500 cycles)
Friction Hinges:	AAMA 904-1 87 (8000 cycles)

4.4 After endurance test:

4.4.1 All incurred damages are to be noted with particular attention to articulation devices and mechanisms.

4.4.2. Wear on any window component is to be noted.

4.4.3. Measurement of the required load to initiate and maintain the opening and closing movements of the sash(es).

4.4.4. Measurement of air infiltration rate at ambient conditions (T = 20°C, ± 2°C RH = 40% ± 10%), according to ASTM E283 Standard.

4.4.5. Measurement of water penetration resistance, according to ASTM E547 Standard.

5. REQUIREMENTS

After endurance test, the window must meet the following criteria:

5.1 No breakage of articulation devices or mechanisms necessary to the sash's operation.

5.2 No permanent deformation of any window component that could impair its good working order.

5.3 The required load to initiate and maintain the sash's opening and closing shall be inferior to 1.25 times the initial measurements.

5.4 The air infiltration rate through the window shall be inferior to 1.25 times the initial air infiltration rate. In the event where the infiltration rate has increased by more than 25% following the endurance test, the window shall be re-rated according to the final test.

5.5 The initial water penetration resistance rating must be maintained following the endurance test. In the event where the performance rating has decreased following the endurance test, the window shall be re-rated according to the final test.

ESSAI D'ENDURANCE POUR LES FENETRES

CYCLAGE OUVERTURE - FERMETURE

1. DOMAINE D'APPLICATION

Cet essai vise toutes les fenêtres ouvrantes.

2. BUT DE L'ESSAI

L'essai a pour but d'évaluer la durabilité des composantes d'une fenêtre et de vérifier s'il y a maintien ou dégradation du comportement de celle-ci vis-à-vis les critères de fonctionnement, d'infiltration d'air et d'étanchéité à l'eau, lorsque la fenêtre est soumise à l'essai d'endurance.

L'essai consiste à soumettre le ou les ouvrants à un nombre de cycles d'ouverture et de fermeture dans des conditions se rapprochant de l'utilisation normale, qu'il s'agisse d'une manoeuvre ou d'une motorisation.

Le mouvement est transmis à l'organe de manoeuvre habituel afin que toutes les pièces soient sollicitées avec verrouillage (pour les fenêtres à battant, à auvent et oscillo-battantes) et sans verrouillage (pour les fenêtres coulissantes verticales et horizontales).

3. PREPARATION DE L'ESSAI

Réaliser s'il y a lieu la lubrification et les ajustements préconisés par le fabricant.

4. ESSAI

Séquence des opérations:

- Mesure de l'effort nécessaire pour initier et maintenir l'ouverture et la fermeture du (des) châssis;
- Mesure du taux d'infiltration d'air initial aux conditions ambiantes (T = 20°C ± 2°C, HR = 40 ± 10%), conformément à la norme ASTM E283;
- Mesure de la résistance à la pénétration d'eau, conformément à la norme ASTM E547;
- Régler la machine d'essai de manière à obtenir à chaque cycle, l'ouverture prescrite et la fermeture complète avec ou sans verrouillage, selon le cas.

Pour les fenêtres coulissantes verticales et horizontales la vitesse linéaire moyenne de déplacement sera de 5m/min (avec une tolérance de + ou - 10%) avec une décélération (accélération) à chaque fin (début) de course pour prévenir l'arrêt (départ) brusque du châssis. Dans le cas de fenêtres comportant deux châssis ou plus, l'essai est effectué sur chacun des châssis.

Pour les fenêtres à rotation le châssis décrit le déplacement angulaire complet en six secondes (avec une tolérance de + ou- 20%) avec décélération (accélération) à chaque fin (début) de course. A chaque fin de course il y a temporisation d'un minimum de quatre secondes pour permettre la fermeture et l'ouverture des loquets. Chaque châssis est ensuite soumis au mouvement de va-et-vient répété de 4000 cycles continus aux cadences fixées ci-dessus.

- Fenêtres: (Windows)	NF P 25-501 (7000 cycles)
- Equilibreurs de charge: (Sash balances)	AAMA 902-2-87 (4000 cycles)

- Roulettes de porte-patio: AAMA 906.3-87 (2500 cycles)
  (Sliding glass door roller assemblies)
- Opérateurs à manivelle: ASTM E405-70 (3500 cycles min.)
  (Rotary operators)
- Roulettes de porte-patio: CAN/CGSB-82.1-M89 (60000 cycles)
  (Sliding glass door roller assemblies)
- Roulettes de fenêtres: CGSB 63-GP-2M, CGSB 63-GP-3M (25000 cycles)
  (Horizontal sliding window roller assemblies)

- Au terme de l'essai d'endurance:
  - On note les dommages éventuels subis et plus particulièrement aux organes d'articulation et aux mécanismes.
  - On note l'usure de certaines composantes de la fenêtre.
  - Mesure de l'effort nécessaire pour initier et maintenir l'ouverture et la fermeture du (des) châssis;
  - Mesure du taux d'infiltration d'air aux conditions ambiantes (T = 20 ± 2°C, HR = 40 ± 10%), conformément à la norme ASTM E283;
  - Mesure de la résistance à la pénétration d'eau, conformément à la norme ASTM E547.

5. EXIGENCES

Après l'essai d'endurance, la fenêtre doit satisfaire les critères suivants:

1) Aucun bris des organes d'articulation ou des mécanismes essentiels au bon fonctionnement du châssis;
2) Aucune déformation permanente des éléments de la fenêtre qui pourraient nuire au bon fonctionnement de celle-ci;
3) L'effort nécessaire pour initier et maintenir l'ouverture et la fermeture du (des) châssis doit être inférieur à 1.25 fois l'effort initial requis;

4) Le taux d'infiltration d'air à travers la fenêtre doit être inférieur à 1.25 fois le taux d'infiltration d'air initial. Dans le cas où la variation du taux d'infiltration d'air serait supérieure à 25% après l'essai d'endurance, la fenêtre sera reclassifiée suivant le résultat obtenu lors de l'essai final;

5) Le niveau de classification initial pour la résistance à la pénétration d'eau doit être conservé. Dans le cas où le niveau de performance serait inférieur à la fin de l'essai d'endurance, la fenêtre sera reclassifiée suivant le résultat obtenu lors de l'essai final.

AIR-INS inc.

APPENDIX "C"

CONDENSATION RESISTANCE RESULTS

AIR-INS inc.

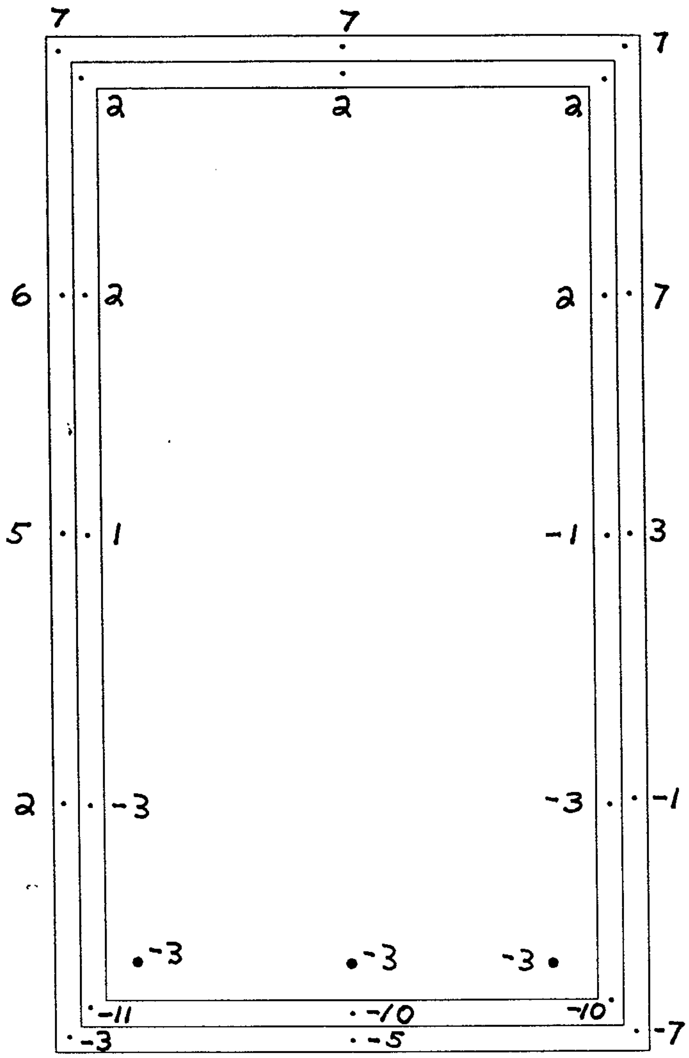
CONDENSATION RESISTANCE

INITIAL TEST RESULTS

CYCLE = 0

C-1

CASEMENT MC-1 CYC: 0



REMARKS:

-WARM SIDE AIR TEMPERATURE = 20°C

-COLD SIDE AIR TEMPERATURE = -30°C

AIR INS Inc.			
TITRE / TITLE SURFACE TEMPERATURE (WARM SIDE)			
DESSINE PAR / DWG.BY	RENAUD DESROSIERS	FEUILLE NO. / SHEET NO. 1	DE / OF 1
VERIFIE PAR / CHK. BY	C.GIASSON	LEGENDE NO. / MTL.LIST NO.	
ECHELLE / SCALE NONE	DATE 14/05/92	DESSIN NO. / DWG.NO. 1	

AIR-INS inc.

MC-1 CYC: O

Determination of the "Temperature index" (I)

For the glass

$$Ig = \frac{Tg - Tc}{Th - Tc} \times 100$$

For the frame

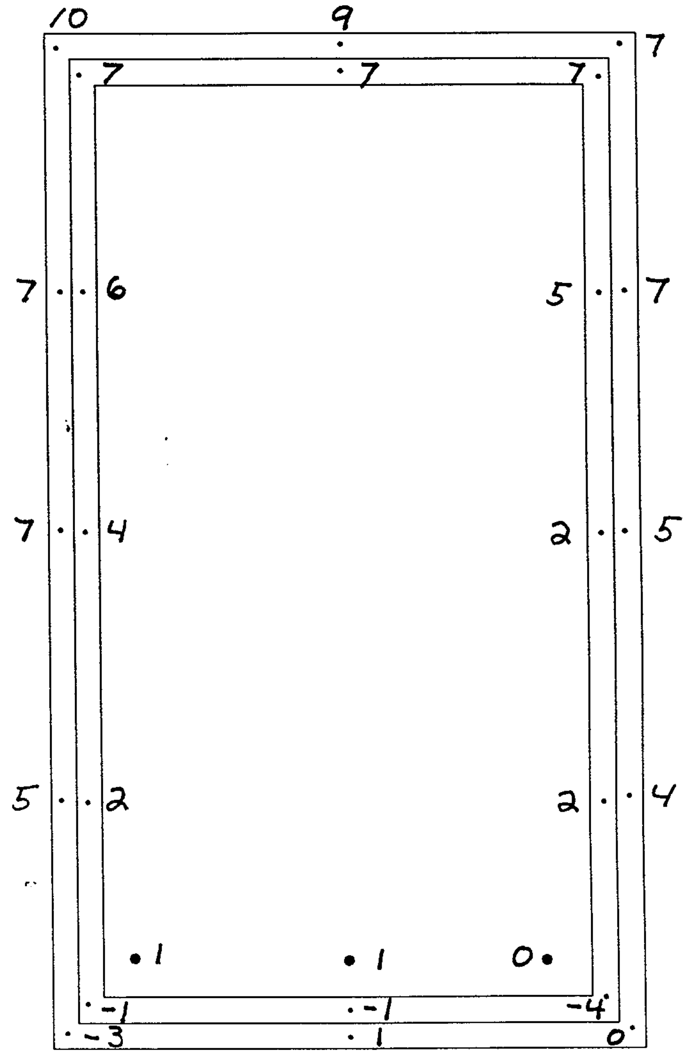
$$If = \frac{Tf - Tc}{Th - Tc} \times 100$$

- Average surface temperature of glass (Tg) = -3 °C
- Coldest frame temperature (Tf) = -11 °C
- Difference between the temperature (Tg) and the weather side temperature (Tc) = 27 °C
- Difference between the temperature (Tf) and the weather side temperature (Tc) = 19 °C
- Difference between the room-side temperature (Th) and the weather-side temperature (Tc) = 50 °C
- Temperature index for the glass $Ig = \frac{27}{50} \times 100$ = 54
- Temperature index for the frame $If = \frac{19}{50} \times 100$ = 38

The minimum acceptable value of I is 40

C-3

CASEMENT MC-2 CYC:0



REMARKS:

-WARM SIDE AIR TEMPERATURE = 20°C

-COLD SIDE AIR TEMPERATURE = -30°C

AIR INS Inc.			
TITRE / TITLE	SURFACE TEMPERATURE (WARM SIDE)		
DESSINE PAR / DWG.BY	RENAUD DESROSIERS	FEUILLE NO. / SHEET NO. 1	DE / OF 1
VERIFIE PAR / CHK. BY	C.GIASSON	LEGENDE NO. / MTL.LIST NO.	
ECHELLE / SCALE NONE	DATE 14/05/92	DESSIN NO. / DWG.NO. 1	

AIR-INS inc.

MC-2 CYC: O

Determination of the "Temperature index" (I)

For the glass

$$Ig = \frac{Tg - Tc}{Th - Tc} \times 100$$

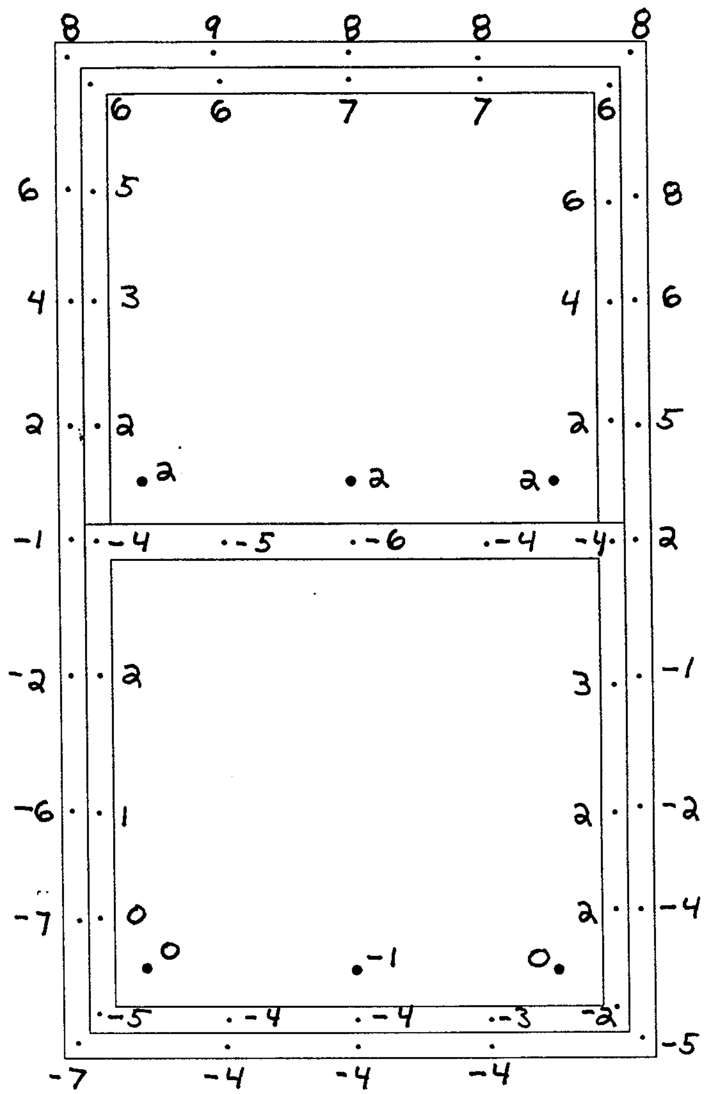
For the frame

$$If = \frac{Tf - Tc}{Th - Tc} \times 100$$

- Average surface temperature of glass (Tg) = 1 °C
- Coldest frame temperature (Tf) = -4 °C
- Difference between the temperature (Tg) and the weather side temperature (Tc) = 31 °C
- Difference between the temperature (Tf) and the weather side temperature (Tc) = 26 °C
- Difference between the room-side temperature (Th) and the weather-side temperature (Tc) = 50 °C
- Temperature index for the glass $Ig = \frac{31}{50} \times 100$ = 62
- Temperature index for the frame $If = \frac{26}{50} \times 100$ = 52

The minimum acceptable value of I is 40

VERTICAL SLIDING WINDOW MC-3 CYC: 0



REMARKS:

-WARM SIDE AIR TEMPERATURE = 20°C

-COLD SIDE AIR TEMPERATURE = -30°C

AIR INS Inc.			
TITRE TITLE SURFACE TEMPERATURE (WARM SIDE)			
DESSINE PAR DWG.BY	RENAUD DESROSIERS	FEUILLE NO. SHEET NO. 1	DE OF 1
VERIFIE PAR CHK. BY	C.GIASSON	LEGENDE NO. MTL.LIST NO.	
ECHELLE SCALE NONE	DATE 14/05/92	DESSIN NO. DWG.NO. 1	

AIR-INS inc.

MC-3 CYC: 0

Determination of the "Temperature index" (I)

For the glass

$$Ig = \frac{Tg - Tc}{Th - Tc} \times 100$$

For the frame

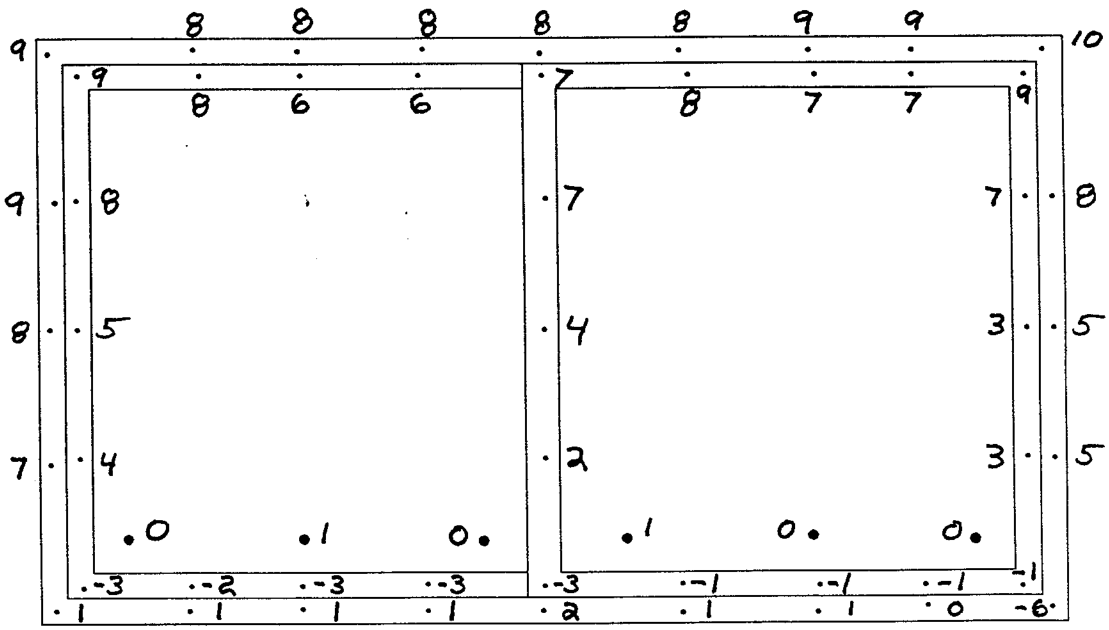
$$If = \frac{Tf - Tc}{Th - Tc} \times 100$$

- Average surface temperature of glass (Tg) = 0 °C
- Coldest frame temperature (Tf) = -7 °C
- Difference between the temperature (Tg) and the weather side temperature (Tc) = 30 °C
- Difference between the temperature (Tf) and the weather side temperature (Tc) = 23 °C
- Difference between the room-side temperature (Th) and the weather-side temperature (Tc) = 50 °C
- Temperature index for the glass $Ig = \frac{30}{50} \times 100$ = 60
- Temperature index for the frame $If = \frac{23}{50} \times 100$ = 46

The minimum acceptable value of I is 40

C-7

HORIZONTAL SLIDER MC-7 CYC:0



REMARKS:

-WARM SIDE AIR TEMPERATURE = 20°C

-COLD SIDE AIR TEMPERATURE = -30°C

AIR INS Inc.			
TITRE TITLE	SURFACE TEMPERATURE (WARM SIDE)		
DESSINE PAR DWG.BY	RENAUD DESROSIERS	FEUILLE NO. SHEET NO. 1	DE OF 1
VERIFIE PAR CHK. BY	C.GIASSON	LEGENDE NO. MTL.LIST NO.	
ECHELLE SCALE NONE	DATE 14/05/92	DESSIN NO. DWG.NO. 1	

AIR-INS inc.

MC-7 CYC: O

Determination of the "Temperature index" (I)

For the glass

$$Ig = \frac{Tg - Tc}{Th - Tc} \times 100$$

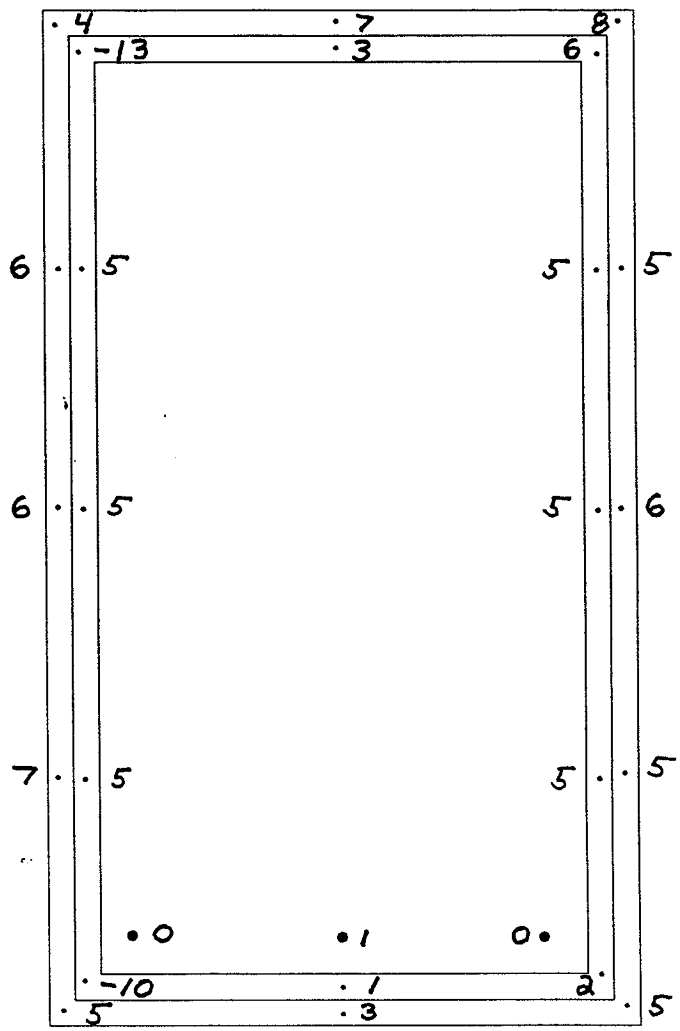
For the frame

$$If = \frac{Tf - Tc}{Th - Tc} \times 100$$

- Average surface temperature of glass (Tg) = 0 °C
- Coldest frame temperature (Tf) = -6 °C
- Difference between the temperature (Tg) and the weather side temperature (Tc) = 30 °C
- Difference between the temperature (Tf) and the weather side temperature (Tc) = 24 °C
- Difference between the room-side temperature (Th) and the weather-side temperature (Tc) = 50 °C
- Temperature index for the glass $Ig = \frac{30}{50} \times 100$ = 60
- Temperature index for the frame $If = \frac{24}{50} \times 100$ = 48

The minimum acceptable value of I is 40

CASEMENT MC-8 CYC:0



REMARKS:

-WARM SIDE AIR TEMPERATURE = 20°C

-COLD SIDE AIR TEMPERATURE = -30°C

AIR INS Inc.			
TITRE TITLE SURFACE TEMPERATURE (WARM SIDE)			
DESSINE PAR DWG.BY	RENAUD DESROSIERS	FEUILLE NO. SHEET NO. 1	DE OF 1
VERIFIE PAR CHK. BY	C.GIASSON	LEGENDE NO. MTL.LIST NO.	
ECHELLE SCALE NONE	DATE 14/05/92	DESSIN NO. DWG.NO. 1	

AIR-INS inc.

MC-8 CYC: 0

Determination of the "Temperature index" (I)

For the glass

$$Ig = \frac{Tg - Tc}{Th - Tc} \times 100$$

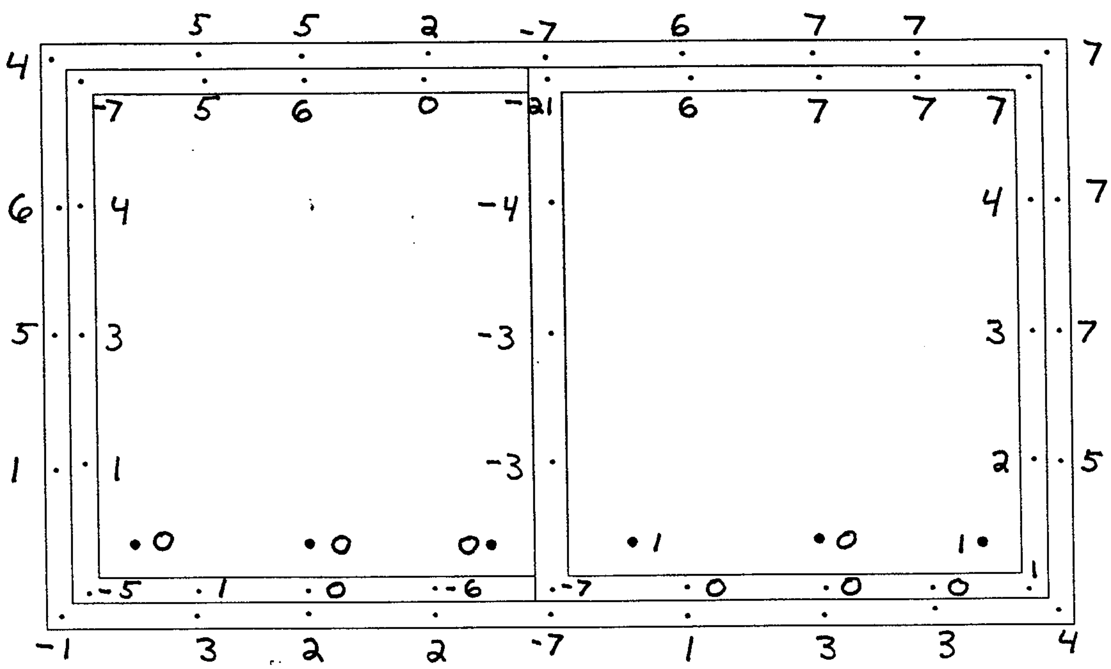
For the frame

$$If = \frac{Tf - Tc}{Th - Tc} \times 100$$

- Average surface temperature of glass (Tg) = 0 °C
- Coldest frame temperature (Tf) = -13 °C
- Difference between the temperature (Tg) and the weather side temperature (Tc) = 30 °C
- Difference between the temperature (Tf) and the weather side temperature (Tc) = 17 °C
- Difference between the room-side temperature (Th) and the weather-side temperature (Tc) = 50 °C
- Temperature index for the glass $Ig = \frac{30}{50} \times 100$ = 60
- Temperature index for the frame $If = \frac{17}{50} \times 100$ = 34

The minimum acceptable value of I is 40

HORIZONTAL SLIDER MC-9 CYC: 0



REMARKS:

-WARM SIDE AIR TEMPERATURE =

-COLD SIDE AIR TEMPERATURE =

AIR INS Inc.			
TITRE / TITLE	SURFACE TEMPERATURE (WARM SIDE)		
DESSINE PAR / DWG.BY	RENAUD DESROSIERS	FEUILLE NO. / SHEET NO. 1	DE / OF 1
VERIFIE PAR / CHK. BY	C.GIASSON	LEGENDE NO. / MTL.LIST NO.	
ECHELLE / SCALE NONE	DATE 14/05/92	DESSIN NO. / DWG.NO. 1	

AIR-INS inc.

MC-9 CYC: O

Determination of the "Temperature index" (I)

For the glass

$$Ig = \frac{Tg - Tc}{Th - Tc} \times 100$$

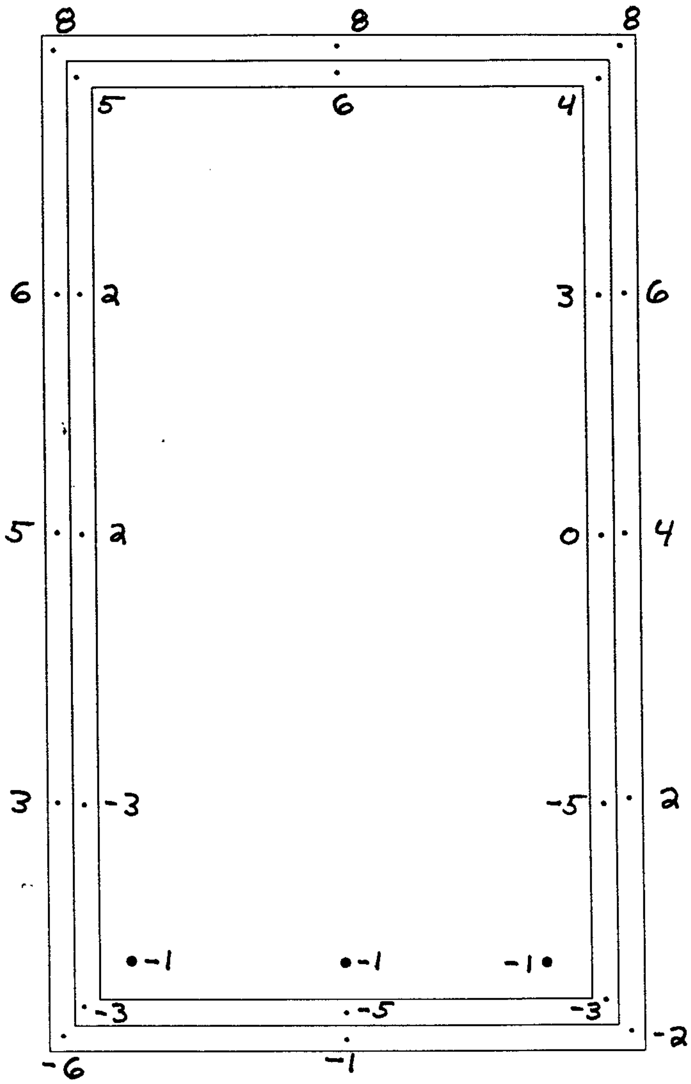
For the frame

$$If = \frac{Tf - Tc}{Th - Tc} \times 100$$

- Average surface temperature of glass (Tg) = 0 °C
- Coldest frame temperature (Tf) = -21 °C
- Difference between the temperature (Tg) and the weather side temperature (Tc) = 30 °C
- Difference between the temperature (Tf) and the weather side temperature (Tc) = 9 °C
- Difference between the room-side temperature (Th) and the weather-side temperature (Tc) = 50 °C
- Temperature index for the glass $Ig = \frac{30}{50} \times 100$ = 60
- Temperature index for the frame $If = \frac{9}{50} \times 100$ = 18

The minimum acceptable value of I is 40

CASEMENT MC-13 CYC: 0



REMARKS:

-WARM SIDE AIR TEMPERATURE = 20°C

-COLD SIDE AIR TEMPERATURE = -30°C

AIR INS Inc.			
TITRE TITLE SURFACE TEMPERATURE (WARM SIDE)			
DESSINE PAR DWG.BY	RENAUD DESROSIERS	FEUILLE NO. SHEET NO. 1	DE OF 1
VERIFIE PAR CHK. BY	C.GIASSON	LEGENDE NO. MTL.LIST NO.	
ECHELLE SCALE NONE	DATE 14/05/92	DESSIN NO. DWG.NO. 1	

AIR-INS inc.

MC-13 CYC: 0

Determination of the "Temperature index" (I)

For the glass

$$Ig = \frac{Tg - Tc}{Th - Tc} \times 100$$

For the frame

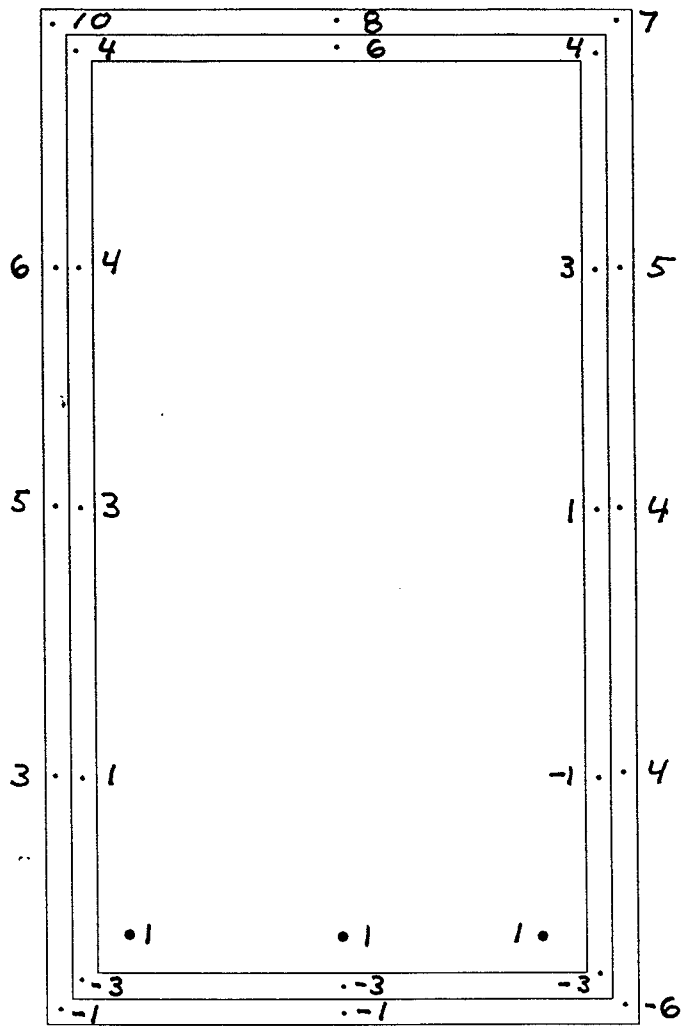
$$If = \frac{Tf - Tc}{Th - Tc} \times 100$$

- Average surface temperature of glass (Tg) = -1 °C
- Coldest frame temperature (Tf) = -6 °C
- Difference between the temperature (Tg) and the weather side temperature (Tc) = 29 °C
- Difference between the temperature (Tf) and the weather side temperature (Tc) = 24 °C
- Difference between the room-side temperature (Th) and the weather-side temperature (Tc) = 50 °C
- Temperature index for the glass $Ig = \frac{29}{50} \times 100$ = 58
- Temperature index for the frame $If = \frac{24}{50} \times 100$ = 48

The minimum acceptable value of I is 40

C-15

CASEMENT MC-14 CYC:0



REMARKS:

-WARM SIDE AIR TEMPERATURE = 20°C

-COLD SIDE AIR TEMPERATURE = -30°C

AIR INS Inc.			
TITRE / TITLE	SURFACE TEMPERATURE (WARM SIDE)		
DESSINE PAR / DWG.BY	RENAUD DESROSIERS	FEUILLE NO. / SHEET NO. 1	DE / OF 1
VERIFIE PAR / CHK. BY	C.GIASSON	LEGENDE NO. / MTL.LIST NO.	
ECHELLE / SCALE NONE	DATE 14/05/92	DESSIN NO. / DWG.NO. 1	

AIR-INS inc.

MC-14 CYC: O

Determination of the "Temperature index" (I)

For the glass

$$Ig = \frac{Tg - Tc}{Th - Tc} \times 100$$

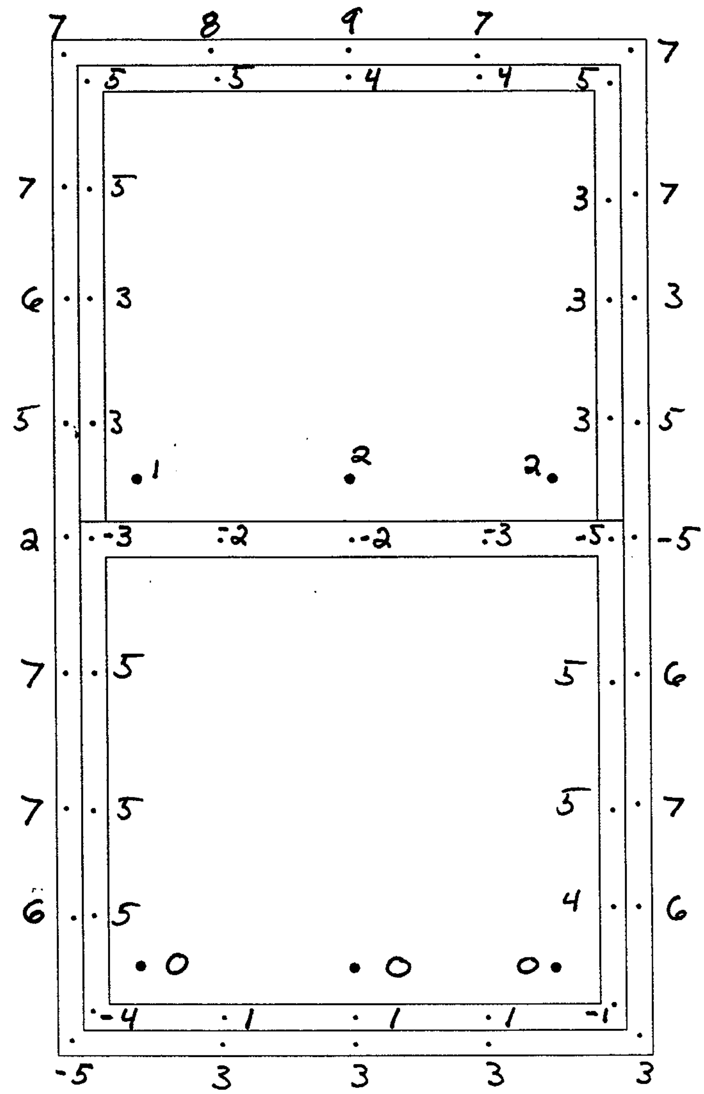
For the frame

$$If = \frac{Tf - Tc}{Th - Tc} \times 100$$

- Average surface temperature of glass (Tg) = 1 °C
- Coldest frame temperature (Tf) = -6 °C
- Difference between the temperature (Tg) and the weather side temperature (Tc) = 31 °C
- Difference between the temperature (Tf) and the weather side temperature (Tc) = 24 °C
- Difference between the room-side temperature (Th) and the weather-side temperature (Tc) = 50 °C
- Temperature index for the glass $Ig = \frac{31}{50} \times 100$ = 62
- Temperature index for the frame $If = \frac{24}{50} \times 100$ = 48

The minimum acceptable value of I is 40

VERTICAL SLIDING WINDOW MC-15 CYC:0



REMARKS:

-WARM SIDE AIR TEMPERATURE = 20°C

-COLD SIDE AIR TEMPERATURE = -30°C

AIR INS Inc.			
TITRE / TITLE	SURFACE TEMPERATURE (WARM SIDE)		
DESSINE PAR / DWG.BY	RENAUD DESROSIERS	FEUILLE NO. / SHEET NO. 1	DE / OF 1
VERIFIE PAR / CHK. BY	C.GIASSON	LEGENDE NO. / MTL.LIST NO.	
ECHELLE / SCALE NONE	DATE 14/05/92	DESSIN NO. / DWG.NO.	

AIR-INS inc.

MC-15 CYC: 0

Determination of the "Temperature index" (I)

For the glass

$$Ig = \frac{Tg - Tc}{Th - Tc} \times 100$$

For the frame

$$If = \frac{Tf - Tc}{Th - Tc} \times 100$$

- Average surface temperature of glass (Tg) = 0 °C
- Coldest frame temperature (Tf) = -5 °C
- Difference between the temperature (Tg) and the weather side temperature (Tc) = 30 °C
- Difference between the temperature (Tf) and the weather side temperature (Tc) = 25 °C
- Difference between the room-side temperature (Th) and the weather-side temperature (Tc) = 50 °C
- Temperature index for the glass $Ig = \frac{30}{50} \times 100$ = 60
- Temperature index for the frame $If = \frac{25}{50} \times 100$ = 50

The minimum acceptable value of I is 40

C-19

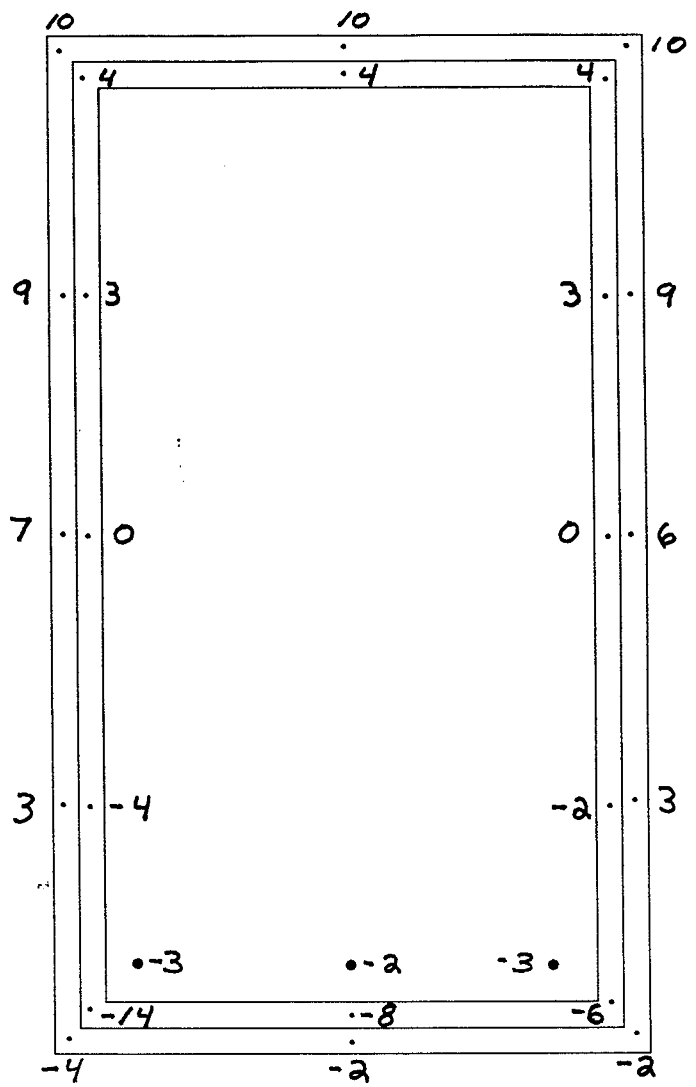
AIR-INS inc.

CONDENSATION RESISTANCE

FINAL TEST RESULTS

2000 CYCLES

CASEMENT MC-1 CYC:2000



REMARKS:

-WARM SIDE AIR TEMPERATURE = 20°C

-COLD SIDE AIR TEMPERATURE = -30°C

AIR INS Inc.			
TITRE / TITLE SURFACE TEMPERATURE (WARM SIDE)			
DESSINE PAR / DWG.BY	RENAUD DESROSIERS	FEUILLE NO. / SHEET NO. 1	DE / OF 1
VERIFIE PAR / CHK. BY	C.GIASSON	LEGENDE NO. / MTL.LIST NO.	
ECHELLE / SCALE NONE	DATE 14/05/92	DESSIN NO. / DWG.NO. 1	

AIR-INS inc.

MC-1 CYC: 2000

Determination of the "Temperature index" (I)

For the glass

$$Ig = \frac{Tg - Tc}{Th - Tc} \times 100$$

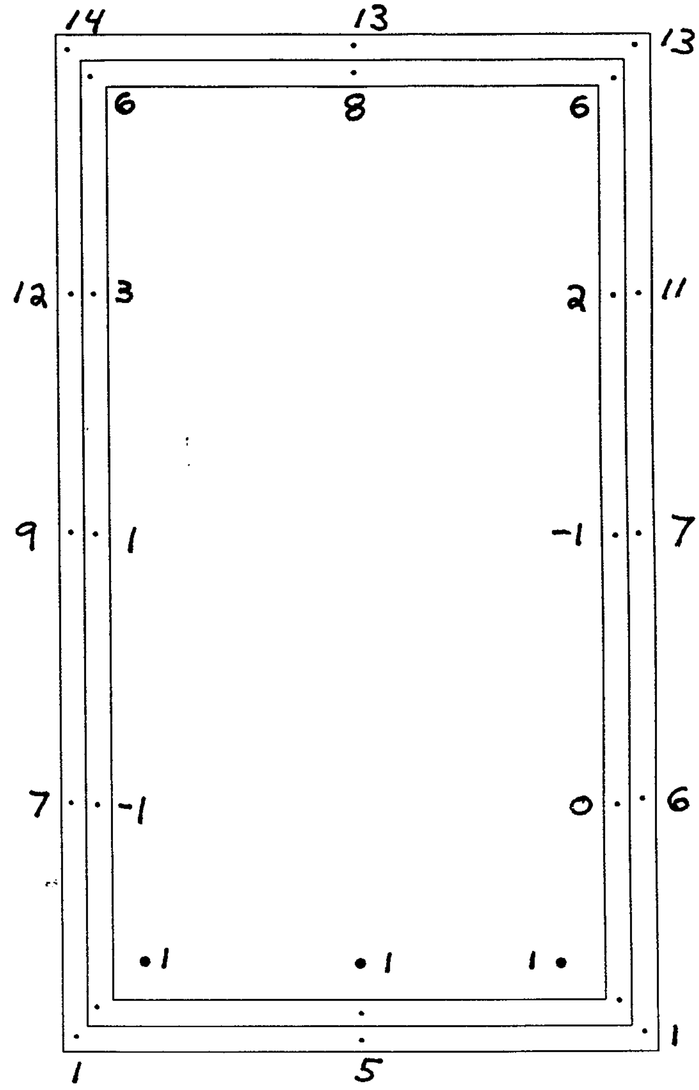
For the frame

$$If = \frac{Tf - Tc}{Th - Tc} \times 100$$

- Average surface temperature of glass (Tg) = -3 °C
- Coldest frame temperature (Tf) = -14 °C
- Difference between the temperature (Tg) and the weather side temperature (Tc) = 27 °C
- Difference between the temperature (Tf) and the weather side temperature (Tc) = 16 °C
- Difference between the room-side temperature (Th) and the weather-side temperature (Tc) = 50 °C
- Temperature index for the glass $Ig = \frac{27}{50} \times 100$ = 54
- Temperature index for the frame $If = \frac{16}{50} \times 100$ = 32

The minimum acceptable value of I is 40

CASEMENT MC-2 CYC: 2000



REMARKS:

–WARM SIDE AIR TEMPERATURE = 20 °C

–COLD SIDE AIR TEMPERATURE = -30 °C

AIR INS Inc.			
TITRE TITLE	SURFACE TEMPERATURE (WARM SIDE)		
DESSINE PAR DWG.BY	RENAUD DESROSIERS	FEUILLE NO. SHEET NO. 1	DE OF 1
VERIFIE PAR CHK. BY	C.GIASSON	LEGENDE NO. MTL.LIST NO.	
ECHELLE SCALE NONE	DATE 14/05/92	DESSIN NO. DWG.NO. 1	

AIR-INS inc.

MC-2 CYC: 2000

Determination of the "Temperature index" (I)

For the glass

$$I_g = \frac{T_g - T_c}{T_h - T_c} \times 100$$

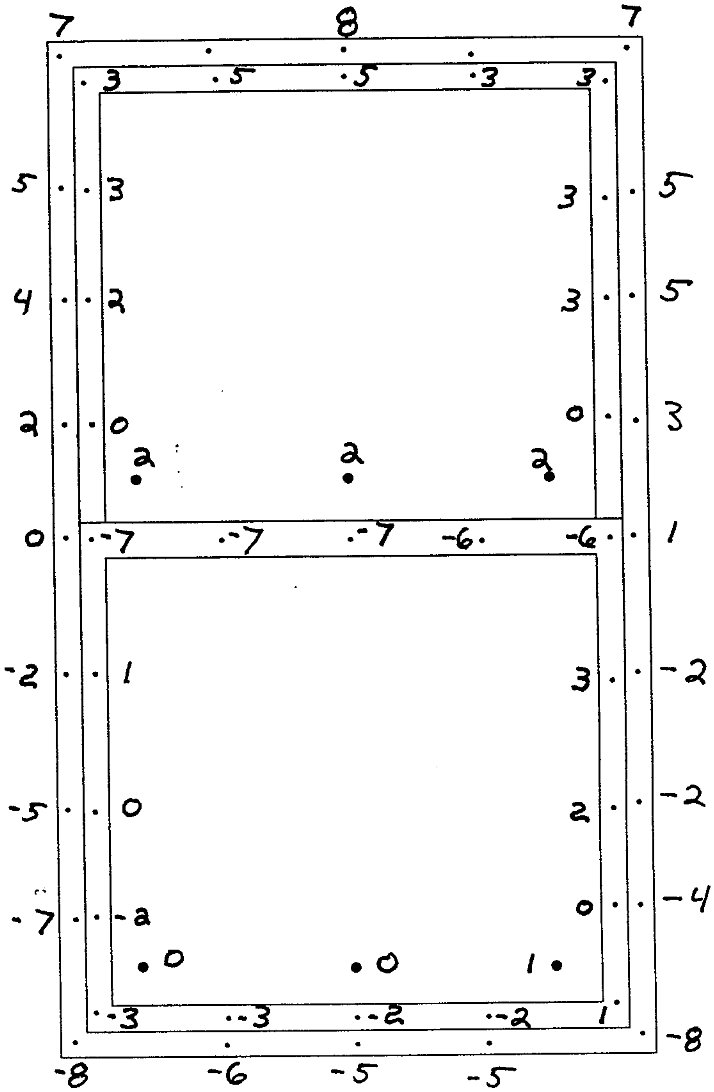
For the frame

$$I_f = \frac{T_f - T_c}{T_h - T_c} \times 100$$

- Average surface temperature of glass (Tg) = 1 °C
- Coldest frame temperature (Tf) = -6 °C
- Difference between the temperature (Tg) and the weather side temperature (Tc) = 31 °C
- Difference between the temperature (Tf) and the weather side temperature (Tc) = 26 °C
- Difference between the room-side temperature (Th) and the weather-side temperature (Tc) = 50 °C
- Temperature index for the glass $I_g = \frac{31}{50} \times 100$ = 62
- Temperature index for the frame $I_f = \frac{26}{50} \times 100$ = 52

The minimum acceptable value of I is 40

VERTICAL SLIDING WINDOW MC-3 CYC:2000



REMARKS:

-WARM SIDE AIR TEMPERATURE = 20°C

-COLD SIDE AIR TEMPERATURE = -30°C

AIR INS Inc.			
TITRE TITLE	SURFACE TEMPERATURE (WARM SIDE)		
DESSINE PAR DWG.BY	RENAUD DESROSIERS	FEUILLE NO. SHEET NO. 1	DE OF 1
VERIFIE PAR CHK. BY	C.GIASSON	LEGENDE NO. MTL.LIST NO.	
ECHELLE SCALE NONE	DATE 14/05/92	DESSIN NO. DWG.NO. 1	

AIR-INS inc.

MC-3 CYC: 2000

Determination of the "Temperature index" (I)

For the glass

$$I_g = \frac{T_g - T_c}{T_h - T_c} \times 100$$

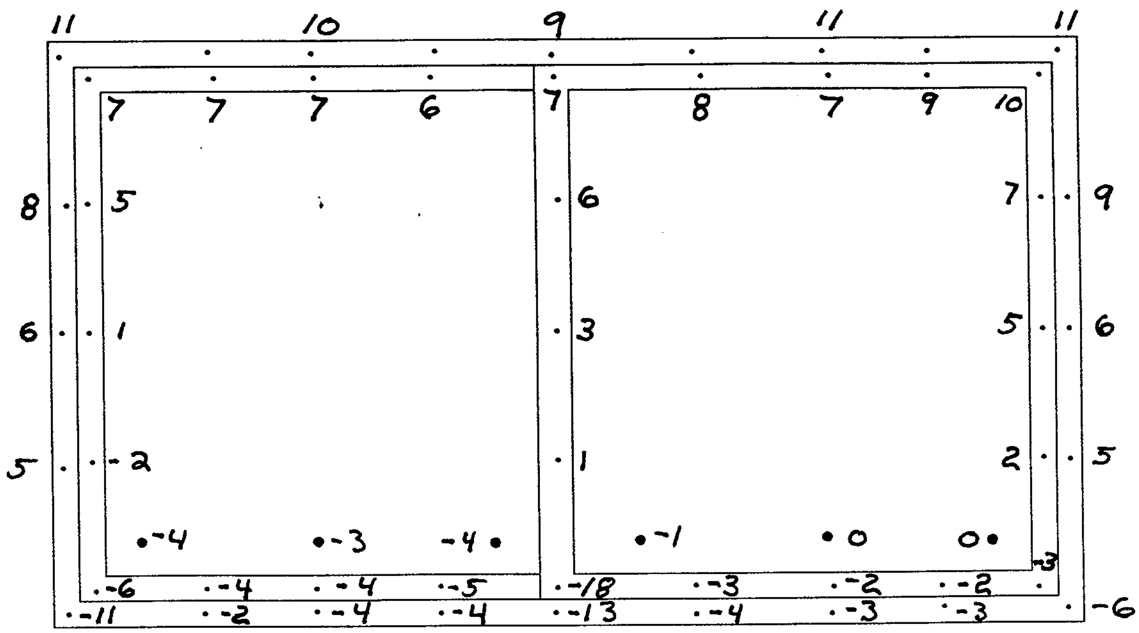
For the frame

$$I_f = \frac{T_f - T_c}{T_h - T_c} \times 100$$

- Average surface temperature of glass (Tg) = 0 °C
- Coldest frame temperature (Tf) = -8 °C
- Difference between the temperature (Tg) and the weather side temperature (Tc) = 30 °C
- Difference between the temperature (Tf) and the weather side temperature (Tc) = 22 °C
- Difference between the room-side temperature (Th) and the weather-side temperature (Tc) = 50 °C
- Temperature index for the glass $I_g = \frac{30}{50} \times 100$ = 60
- Temperature index for the frame $I_f = \frac{22}{50} \times 100$ = 44

The minimum acceptable value of I is 40

HORIZONTAL SLIDER MC-7 CYC: 2000



REMARKS:

-WARM SIDE AIR TEMPERATURE = 20°C

-COLD SIDE AIR TEMPERATURE = -30°C

AIR INS Inc.			
TITRE / TITLE SURFACE TEMPERATURE (WARM SIDE)			
DESSINE PAR / DWG.BY	RENAUD DESROSIERS	FEUILLE NO. / SHEET NO. 1	DE / OF 1
VERIFIE PAR / CHK. BY	C.GIASSON	LEGENDE NO. / MTL.LIST NO.	
ECHELLE / SCALE NONE	DATE 14/05/92	DESSIN NO. / DWG.NO. 1	

C-27

AIR-INS inc.

MC-7 CYC: 2000

Determination of the "Temperature index" (I)

For the glass

$$Ig = \frac{Tg - Tc}{Th - Tc} \times 100$$

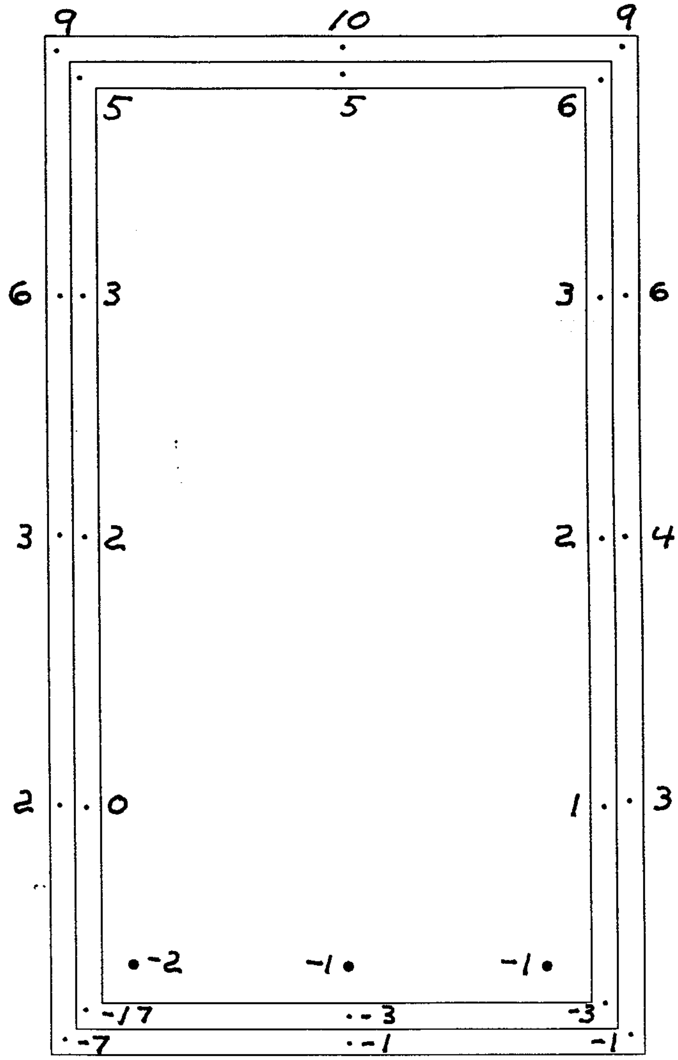
For the frame

$$If = \frac{Tf - Tc}{Th - Tc} \times 100$$

- Average surface temperature of glass (Tg) = -2 °C
- Coldest frame temperature (Tf) = -18 °C
- Difference between the temperature (Tg) and the weather side temperature (Tc) = 28 °C
- Difference between the temperature (Tf) and the weather side temperature (Tc) = 12 °C
- Difference between the room-side temperature (Th) and the weather-side temperature (Tc) = 50 °C
- Temperature index for the glass $Ig = \frac{28}{50} \times 100$ = 56
- Temperature index for the frame $If = \frac{12}{50} \times 100$ = 24

The minimum acceptable value of I is 40

CASEMENT MC-8 CYC:2000



REMARKS:

-WARM SIDE AIR TEMPERATURE = 20°C

-COLD SIDE AIR TEMPERATURE = -30°C

AIR INS Inc.			
TITRE TITLE SURFACE TEMPERATURE (WARM SIDE)			
DESSINE PAR DWG.BY	RENAUD DESROSIERS	FEUILLE NO. SHEET NO. 1	DE OF 1
VERIFIE PAR CHK. BY	C.GIASSON	LEGENDE NO. MTL.LIST NO.	
ECHELLE SCALE NONE	DATE 14/05/92	DESSIN NO. DWG.NO. 1	

AIR-INS inc.

MC-8 CYC: 2000

Determination of the "Temperature index" (I)

For the glass

$$I_g = \frac{T_g - T_c}{T_h - T_c} \times 100$$

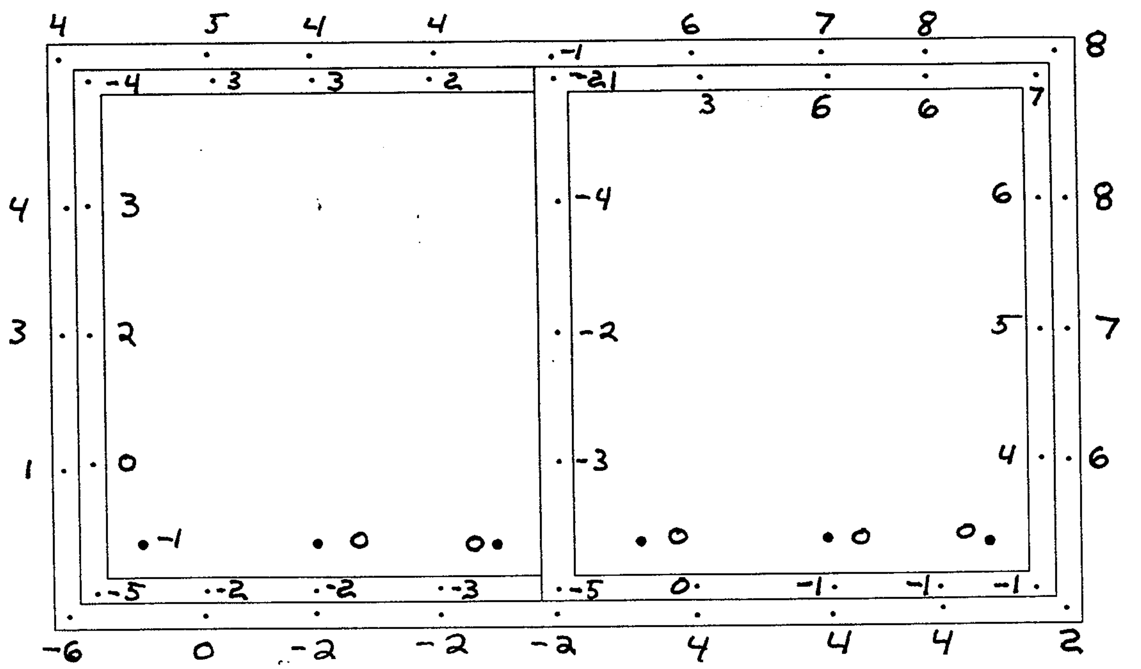
For the frame

$$I_f = \frac{T_f - T_c}{T_h - T_c} \times 100$$

- Average surface temperature of glass (Tg) = -1 °C
- Coldest frame temperature (Tf) = -17 °C
- Difference between the temperature (Tg) and the weather side temperature (Tc) = 29 °C
- Difference between the temperature (Tf) and the weather side temperature (Tc) = 13 °C
- Difference between the room-side temperature (Th) and the weather-side temperature (Tc) = 50 °C
- Temperature index for the glass $I_g = \frac{29}{50} \times 100$ = 58
- Temperature index for the frame $I_f = \frac{13}{50} \times 100$ = 26

The minimum acceptable value of I is 40

HORIZONTAL SLIDER MC-9 CYC: 2000



REMARKS:

-WARM SIDE AIR TEMPERATURE = 20 °C

-COLD SIDE AIR TEMPERATURE = -30 °C

AIR INS Inc.			
TITRE / TITLE	SURFACE TEMPERATURE (WARM SIDE)		
DESSINE PAR / DWG.BY	RENAUD DESROSIERS	FEUILLE NO. / SHEET NO. 1	DE / OF 1
VERIFIE PAR / CHK. BY	C.GIASSON	LEGENDE NO. / MTL.LIST NO.	
ECHELLE / SCALE NONE	DATE 14/05/92	DESSIN NO. / DWG.NO. 1	

AIR-INS inc.

MC-9 CYC: 2000

Determination of the "Temperature index" (I)

For the glass

$$I_g = \frac{T_g - T_c}{T_h - T_c} \times 100$$

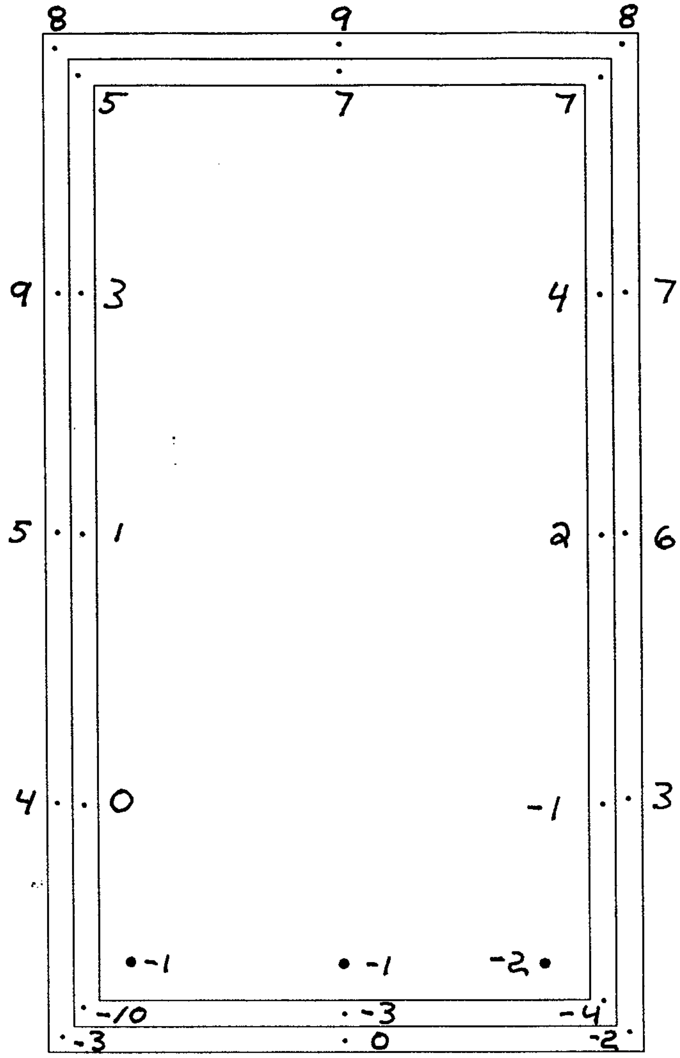
For the frame

$$I_f = \frac{T_f - T_c}{T_h - T_c} \times 100$$

- Average surface temperature of glass (Tg) = 0 °C
- Coldest frame temperature (Tf) = -21 °C
- Difference between the temperature (Tg) and the weather side temperature (Tc) = 30 °C
- Difference between the temperature (Tf) and the weather side temperature (Tc) = 9 °C
- Difference between the room-side temperature (Th) and the weather-side temperature (Tc) = 50 °C
- Temperature index for the glass $Ig= \frac{30}{50} \times 100$ = 60
- Temperature index for the frame $If= \frac{9}{50} \times 100$ = 18

The minimum acceptable value of I is 40

CASEMENT MC-13 CYC: 2000



REMARKS:

–WARM SIDE AIR TEMPERATURE = 20°C

–COLD SIDE AIR TEMPERATURE = -30°C

AIR INS Inc.		
TITRE / TITLE: SURFACE TEMPERATURE (WARM SIDE)		
DESSINE PAR / DWG.BY: RENAUD DESROSIERS		FEUILLE NO. / SHEET NO. 1 DE / OF 1
VERIFIE PAR / CHK. BY: C.GIASSON		LEGENDE NO. / MTL.LIST NO.
ECHELLE / SCALE: NONE	DATE 14/05/92	DESSIN NO. / DWG.NO. 1

AIR-INS inc.

MC-13 CYC: 2000

Determination of the "Temperature index" (I)

For the glass

$$Ig = \frac{Tg - Tc}{Th - Tc} \times 100$$

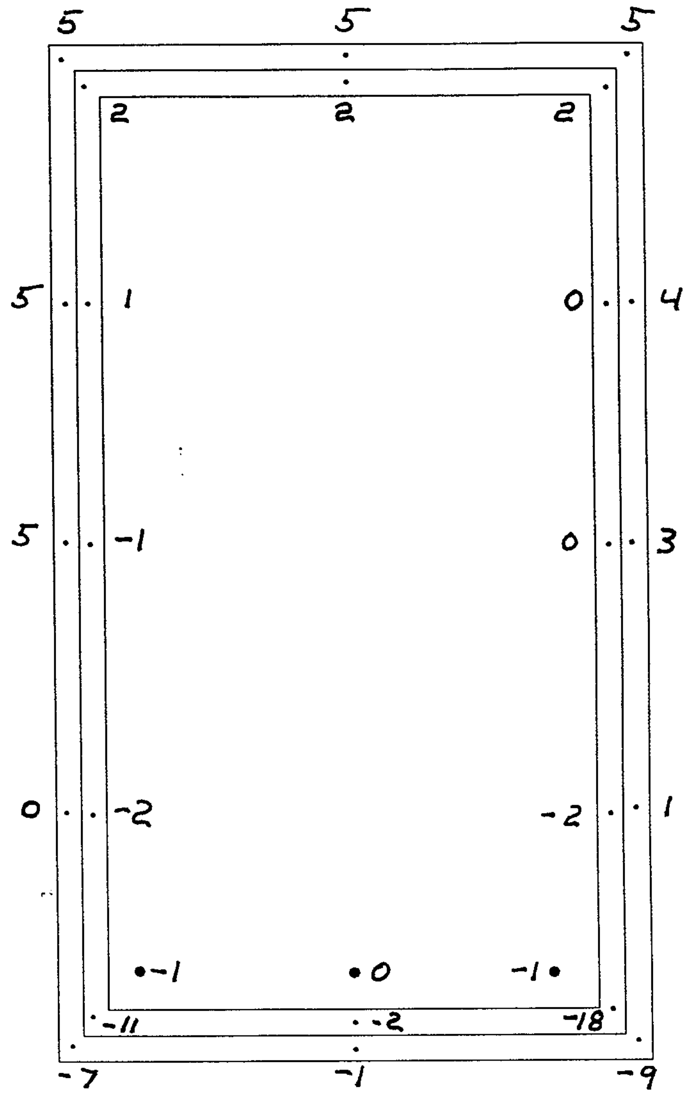
For the frame

$$If = \frac{Tf - Tc}{Th - Tc} \times 100$$

- Average surface temperature of glass (Tg) = -1 °C
- Coldest frame temperature (Tf) = -10 °C
- Difference between the temperature (Tg) and the weather side temperature (Tc) = 29 °C
- Difference between the temperature (Tf) and the weather side temperature (Tc) = 20 °C
- Difference between the room-side temperature (Th) and the weather-side temperature (Tc) = 50 °C
- Temperature index for the glass $Ig = \frac{29}{50} \times 100$ = 58
- Temperature index for the frame $If = \frac{20}{50} \times 100$ = 40

The minimum acceptable value of I is 40

CASEMENT MC-14 CYC:2000



REMARKS:

-WARM SIDE AIR TEMPERATURE =

-COLD SIDE AIR TEMPERATURE =

AIR INS Inc.			
TITRE TITLE SURFACE TEMPERATURE (WARM SIDE)			
DESSINE PAR DWG.BY	RENAUD DESROSIERS	FEUILLE NO. SHEET NO. 1	DE OF 1
VERIFIE PAR CHK. BY	C.GIASSON	LEGENDE NO. MTL.LIST NO.	
ECHELLE SCALE NONE	DATE 14/05/92	DESSIN NO. DWG.NO. 1	

AIR-INS inc.

MC-14 CYC: 2000

Determination of the "Temperature index" (I)

For the glass

$$Ig = \frac{Tg - Tc}{Th - Tc} \times 100$$

For the frame

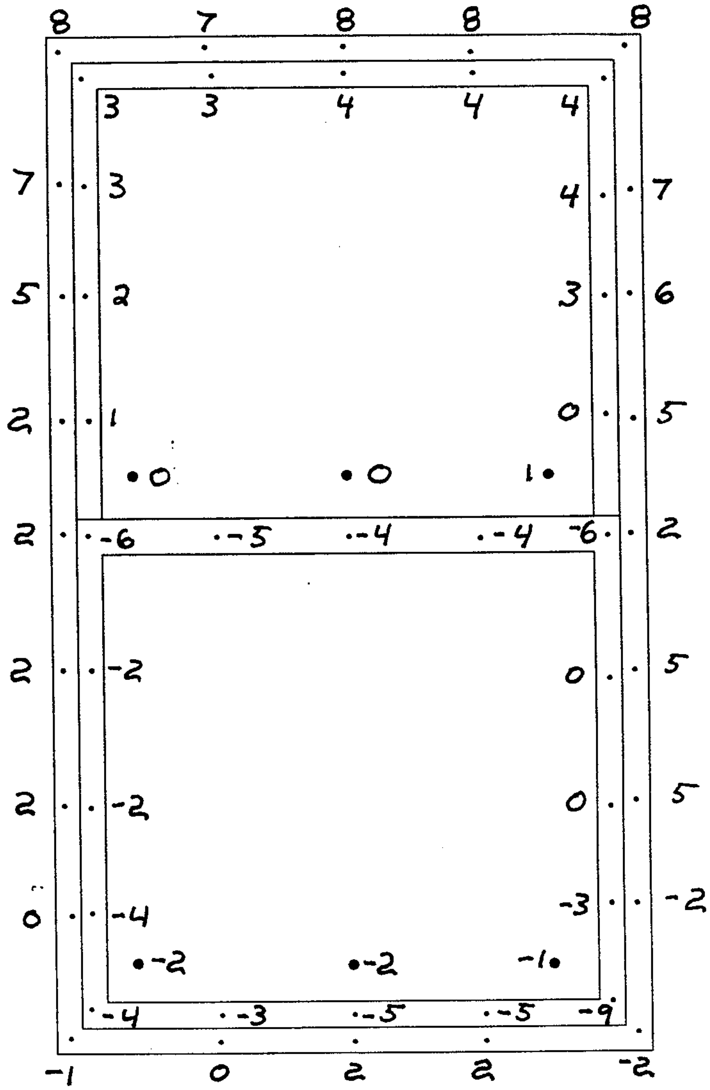
$$If = \frac{Tf - Tc}{Th - Tc} \times 100$$

- Average surface temperature of glass (Tg) = -1 °C
- Coldest frame temperature (Tf) = -18 °C
- Difference between the temperature (Tg) and the weather side temperature (Tc) = 29 °C
- Difference between the temperature (Tf) and the weather side temperature (Tc) = 12 °C
- Difference between the room-side temperature (Th) and the weather-side temperature (Tc) = 50 °C
- Temperature index for the glass $Ig = \frac{29}{50} \times 100$ = 58
- Temperature index for the frame $If = \frac{12}{50} \times 100$ = 24

The minimum acceptable value of I is 40

C-36

VERTICAL SLIDING WINDOW MC-15 CYC: 2000



REMARKS:

-WARM SIDE AIR TEMPERATURE = 20 °C

-COLD SIDE AIR TEMPERATURE = -30 °C

AIR INS Inc.			
TITRE / TITLE	SURFACE TEMPERATURE (WARM SIDE)		
DESSINE PAR / DWG.BY	RENAUD DESROSIERS	FEUILLE NO. / SHEET NO. 1	DE / OF 1
VERIFIE PAR / CHK. BY	C.GIASSON	LEGENDE NO. / MTL.LIST NO.	
ECHELLE / SCALE NONE	DATE 14/05/92	DESSIN NO. / DWG.NO. 1	

AIR-INS inc.

MC-15 CYC: 2000

Determination of the "Temperature index" (I)

For the glass

$$Ig = \frac{Tg - Tc}{Th - Tc} \times 100$$

For the frame

$$If = \frac{Tf - Tc}{Th - Tc} \times 100$$

- Average surface temperature of glass (Tg) = -2 °C
- Coldest frame temperature (Tf) = -9 °C
- Difference between the temperature (Tg) and the weather side temperature (Tc) = 28 °C
- Difference between the temperature (Tf) and the weather side temperature (Tc) = 21 °C
- Difference between the room-side temperature (Th) and the weather-side temperature (Tc) = 50 °C
- Temperature index for the glass $Ig = \frac{28}{50} \times 100$ = 56
- Temperature index for the frame $If = \frac{21}{50} \times 100$ = 42

The minimum acceptable value of I is 40