A Study OF THE LONG TERM PERFORMANCE OF OPERATING AND FIXED WINDOWS SUBJECTED TO PRESSURE CYCLING

PREPARED FOR:

CANMET Energy Technology Centre
Energy Technology Branch, Energy Sector
Department of Natural Resources Canada
Ottawa, Ontario, Canada, K1A 0E4
DSS Contract: 23440-3-9415
December 1991

PREPARED BY:

AIR-INS inc.
1320, boulevard Lionel Boulet
Varennes, Québec, Canada,J3X 1P8
Phone: (450) 652-0838; Fax: (450) 652-7588
Email: aipcinc@total.net

SCIENTIFIC AUTHORITY

Joël Allarie
The CANMET Energy Technology Centre
Energy Technology Branch, Energy Sector
Department of Natural Resources Canada
580 Booth Street, 13th Floor
Ottawa, Ontario, Canada
K1A 0E4

Third Reprint, November 18, 1999

CITATION

AIR-INS inc. *A Study of the Long Term Performance Of Operating And Fixed Windows Subjected to Pressure Cycling*. DSS Contract No. 23440-0-9415. The CANMET Energy Technology Centre, (CETC) Energy Technology Branch, Energy Sector, Department of Natural Resources Canada, Ottawa, Ontario, Canada, 1993, (42 pages)

Copies of this report may be obtained through the following:

The CANMET Energy Technology Centre (CETC)
Energy Technology Branch, Energy Sector
Department of Natural Resources Canada
580 Booth Street, 13th Floor
Ottawa, Ontario, Canada, K1A 0E4

or

Intellectual Property and Technical Information Management
Library and Documentation Service Division, CANMET
Department of Natural Resources Canada
555 Booth Street, 3rd Floor, Room 341
Ottawa, Ontario, Canada, K1A 0G1

DISCLAIMER

NOTE

Funding for this project was provided by the Federal Panel on Energy Research and Development, Department of Natural Resources, Government of Canada.

Catalogue No. M91-7/214-1993E
ISBN: 0-662-20396-8

FOREWORD

This project determines the influence of pressure cycling on ten (10) windows for the following performance criteria: ease of operation, air leakage, resistance to water penetration and condensation resistance.

Windows are subjected to a total of 2000 pressure cycles composed of two initial pressure cycling intervals of 500 cycles and a final pressure cycling interval of 1000 cycles. Before or after each interval, one or several performance criteria are checked.

The pressure cycling test showed that 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 +23% to +194%. After 2000 cyles, all specimens showed an increase in the air leakage rate ranging from 8% to 275%. With respect to resistance to water penetration, 8 specimens kept their initial rating whereas the remaining 2 specimens suffered a decrease of 1 or 2 levels of performance after 2000 cycles. For the condensation resistance criteria most specimens showed a decrease of the temperature index ranging from 2 to 30 points. Among all the criteria, condensation resistance is the criterion which suffered the largest decrease in performance from initial to final testing.

Beside providing data with respect to the influence of pressure cycling, this project showed that condensation resistance tests conducted on some non-metallic windows (wood and PVC) lead to an initial temperature index which does not meet the minimum performance level specified by the A440 Standard.

PREAMBULE

La présente étude détermine l'influence d'un essai de cyclage de la pression sur 10 fenêtres. Les critères d'évaluation utilisés pour caractériser l'influence de l'essai de cyclage sont: la facilité de fonctionnement, l'infiltration d'air, la résistance à la pénétration d'eau et la résistance à la condensation.

Chaque fenêtre a été soumise à un total de 2000 cycles, lequel est subdivisé en deux intervals initiaux de 500 cycles et un interval final de 1000 cycles. Avant ou après chaque interval un ou plusieurs critères d'évaluation sont vérifiés.

L'essai de cyclage de la pression a démontré que 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 +23% à +194% entre le début et la fin de l'essai de cyclage. En ce qui concerne l'infiltration d'air, tous les échantillons ont subi une augmentation du taux d'infiltration d'air variant de +8% à +275% entre le début et la fin de l'essai d'endurance. Pour le critère résistance à la pénétration d'eau, 8 échantillons ont conservé leur classification de base, alors que 2 échantillons ont subi une diminution de classe de 1 niveau après 2000 cycles. Pour le critère de résistance à la condensation, la plupart des échantillons ont subi une baisse de l'indice de température variant de 2 à 30 points. Parmis tous les critères évalués, la résistance à la condensation est certainement le critère qui est le plus influencé par l'essai de cyclage de la pression.

En plus de fournir des données utiles visant l'influence d'un essai de cyclage de la pression sur 4 critères d'évaluation, le projet a permis de constater que certaines fenêtres avec menuiserie non-métallique (bois, PVC) ne rencontre pas l'exigence minimale de résistance à la condensation spécifiée par la norme A440.

TABLE OF CONTENTS

1. EXECUTIVE SUMMARY

1.1 OBJECTIVES

Windows installed in building façades are subjected to wind of fluctuating directions and intensities. This project undertakes to determine the influence of pressure cycling on windows for the following criteria of performance: ease of operation (if applicable), 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, the level of performance of these criteria 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

Pressure cycling tests were conducted on ten windows. Sampling included the following window types: casement, vertical sliding, horizontal sliding and fixed windows. 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)	PC-9 (PVC)* PC-10 (PVC) PC-15 (WOOD) PC-17 (WOOD)
VERTICAL SLIDER (1000 mm x 1600 mm)	PC-1 (AL)** PC-11 (PVC) PC-18 (WOOD)
HORIZONTAL SLIDER (1600 mm x 1000 mm)	PC-8 (PVC)
FIXED (2000 mm x 2000 mm)	PC-13 (PVC) PC-16 (WOOD)

* PVC: Polyvinyl chloride
* AL : Aluminum

1.3 METHODOLOGY

All specimens were subjected to the following test sequence:

a) Find 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 pressure cycles between + 1.2 kPa and -1.2 kPa in accordance with ASTM E1233-88;

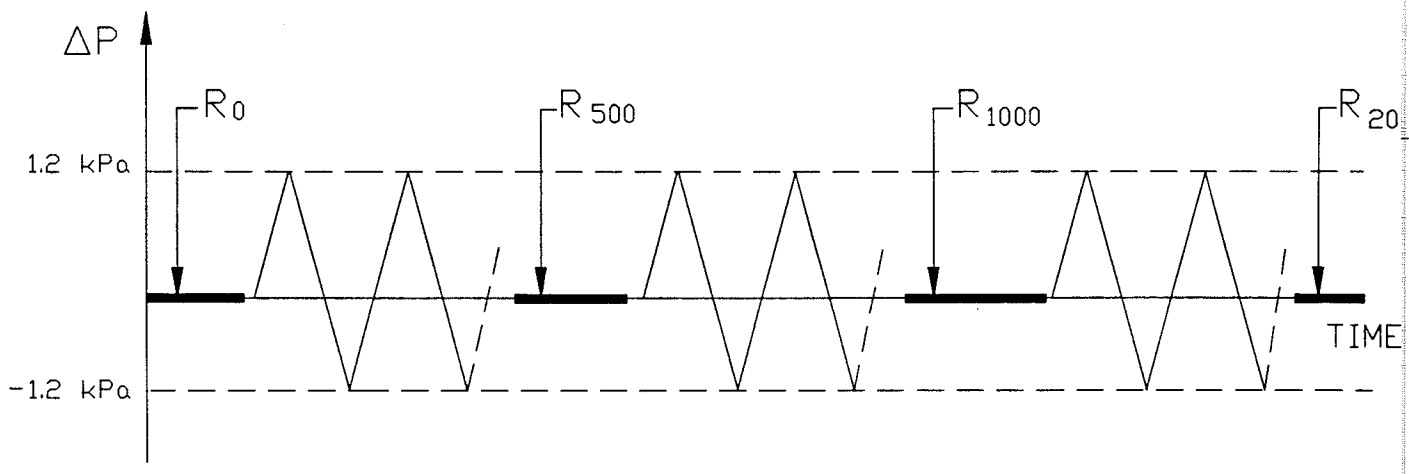
c) Determine new rating (R_{500}) with respect to ease of operation and air leakage;

d) Conduct an additional 500 pressure 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 pressure 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.



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				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	
CASEMENT									
PC-9 (PVC)	24.5 (5.5)	40 (9)	11.1 (2.5)	11.1 (2.5)	80.1* (18)	44.5 (10)	31.1* (7)	22.2 (5)	+ 129.6
PC-10 (PVC)	12.5 (2.8)	14.2 (3.2)	6.7 (1.5)	6.7 (1.5)	53.4 (12)	35.6 (8)	11.12 (2.5)	22.2 (5)	+ 193.8
PC-15 (WOOD)	22.2 (5)	26.7 (6)	6.7 (1.5)	13.3 (3)	35.6 (8)	26.7 (6)	8.9 (2)	13.3 (3)	+ 23.3
PC-17 (WOOD)	45.8 (10.3)	19.1 (4.3)	10.2 (2.3)	8.9 (2)	44.5 (10)	37.8 (8.5)	8.9 (2)	13.3 (3)	+ 32.9
VERTICAL SLIDER									
PC-1 (AL)	164.6 (37)	155.7 (35)	148.8* (33)	89 (20)	169 (38)	111.2 (25)	137.9* (31)	75.6 (17)	- 11.8
PC-11 (PVC)	160 (36)	151.2 (34)	106.8* (24)	102.3* (23)	177.9 (40)	160.1 (36)	106.8* (24)	106.8* (24)	+ 36.2
PC-18 (WOOD)	131.2 (29.5)	111.2 (25)	124.6* (28)	64.5 (14.5)	106.8 (24)	160.1 (36)	164.6* (37)	146.79* (33)	+ 46.3
HORIZONTAL SLIDER									
PC-8 (PVC)	35.6 (8)	48.9 (11)	44.5 (10)	62.3* (14)	62.3* (14)	66.7 (15)	53.4* (12)	57.8* (13)	+ 31.0

* 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						
PC-9 (PVC)	0.424-A3 (0.076)	0.663-A2 (0.119)	0.735-A2 (0.132)	1.541-A2 (0.2766)	1.117 (0.201)	+ 263
PC-10 (PVC)	1.042-A2 (0.187)	1.174-A2 (0.211)	1.087-A2 (0.195)	1.126-A2 (0.202)	0.084 (0.015)	+ 8.1
PC-15 (WOOD)	0.279-A3 (0.050)	0.312-A3 (0.056)	0.303-A3 (0.054)	0.55-A3 (0.099)	0.271 (0.049)	+ 97.1
PC-17 (WOOD)	0.518-A3 (0.093)	0.531-A3 (0.095)	0.531-A3 (0.095)	0.640-A2 (0.115)	0.122 (0.022)	+ 23.6
VERTICAL SLIDER						
PC-1 (AL)	1.020-A2 (0.183)	1.143-A2 (0.205)	1.07-A2 (0.192)	1.443-A2 (0.259)	0.423 (0.076)	+ 41.5
PC-11 (PVC)	1.95-A1 (0.35)	6.814* (1.223)	7.061* (1.267)	7.323* (1.314)	5.373 (0.964)	+ 275.4
PC-18 (WOOD)	0.736-A2 (0.132)	0.978-A2 (0.175)	0.943-A2 (0.169)	0.920-A2 (0.165)	0.184 (0.033)	+ 25
HORIZONTAL SLIDER						
PC-8 (PVC)	2.563-A1 (0.460)	2.570-A1 (0.461)	2.600-A1 (0.467)	2.814* (0.505)	0.251 (0.045)	+ 9.8
FIXED						
PC-13 (PVC)	0.141-FIXED (0.0253)	0.162-FIXED (0.0290)	0.173-FIXED (0.031)	0.173-FIXED (0.031)	0.032 (0.0057)	+ 2.27
PC-16 (WOOD)	0.0167-FIXED (0.003)	0.0167-FIXED (0.003)	0.020-FIXED (0.0036)	0.0232-FIXED (0.0042)	0.0065 (0.0012)	+ 39

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

TABLE D: RESISTANCE TO WATER PENETRATION

TYPE AND SPECIMEN NUMBER	INITIAL	1000 CYCLES	2000 CYCLES
CASEMENT			
PC-9 (PVC)	B3	B3	B3
PC-10 (PVC)	B2	B2	B2
PC-15 (WOOD)	B2	B2	B2
PC-17 (WOOD)	B3	B3	B3
VERTICAL SLIDER			
PC-1 (AL)	B1	B1	B1
PC-11 (PVC)	B2	B1	B 1/2* (75 Pa)
PC-18 (WOOD)	B7	B6	B6
HORIZONTAL SLIDER			
PC-8 (PVC)	B 1/2* (75 Pa)	B 1/2* (75 Pa)	B 1/2* (75 Pa)
FIXED			
PC-13 (PVC)	B3	B3	B3
PC-16 (WOOD)	B7	B7	B6

* Lower than the minimum acceptable level of A440

TABLE E: TEMPERATURE INDEX (CONDENSATION RESISTANCE)

TYPE AND SPECIMEN NUMBER	INITIAL		2000 CYCLES	
	TI_G	TI_F	TI_G	TI_F
CASEMENT				
PC-9 (PVC)	60	52	54	22*
PC-10 (PVC)	60	18*	54	16*
PC-15 (WOOD)	58	48	54	52
PC-17 (WOOD)	60	38*	58	40
VERTICAL SLIDER				
PC-1 (AL)	62	50	60	40
PC-11 (PVC)	60	10*	56	12*
PC-18 (WOOD)	60	32*	58	34*
HORIZONTAL SLIDER				
PC-8 (PVC)	60	40	58	40
FIXED				
PC-13 (PVC)	58	58	58	56
PC-16 (WOOD)	56	58	60	58

* TI lower than minimum acceptable value specified by A440 (TI = 40)
* TI_G: Glass temperature index
* TI_F: Frame temperature index

1.5 CONCLUSIONS

1.5.1 EASE OF OPERATION

Except for the aluminum vertical sliding window (PC-1), all specimens showed an increase in the operating forces to initiate and to maintain motion of sashes. The increase ranged from 23% to 194%. PVC casement windows (PC-9 and PC-10) showed the highest increase in the operating forces.

1.5.2 AIR LEAKAGE

All specimens showed an increase in the air leakage rate ranging from 8% to 275%.

The largest increase were met on two PVC windows (PC-9 and PC-11). Most of the air leakage increases seem to be caused by a combination of the following factors; compression set of weatherstripping, creeping of PVC sash members during pressure cycling and the lack of rigidity of sash members.

1.5.3 RESISTANCE TO WATER PENETRATION

The resistance to water penetration of most specimens did not change from the initial value.

Only two windows (PC-11 and PC-16) suffered a decrease in rating.

1.5.4 CONDENSATION RESISTANCE (TEMPERATURE INDEX)

Even though the condensation resistance test is not mandatory for PVC and wood windows (A440), the testing showed that even if the framing material is a poor heat conductor (or a good insulator), the interior frame surface temperatures can be lower than the minimum acceptable level (TI = 40). Such low surface temperatures can only be attributed to cracks that must have developed between sash and frame members when the windows were subjected to a large temperature differential.

Upon completion of the pressure cycling test, the glass temperature index (TI_G) remained nearly identical to the initial value. Nevertheless, the same pressure cycling test introduced on some windows a large decrease (δ = 30 points) of the frame temperature index (TI_F). Here again, such a decrease in performance level can only be attributed to cracks that may develop between sash and frame members.

1.6 RECOMMANDATIONS

- The pressure cycling test showed that in most cases there was a decrease in one or several of the performance criteria covered by the A440 Standard. To ensure durability of new windows, this new criteria of pressure cycling with the test procedure should be incorporated into the main boby of the Canadian standard.
- 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, even when new. Therefore, in order to make it fair for all framing materials, the evaluation of this criteria should be made mandatory for all materials.
- To improve the certainty of the performance levels given by the CCMC accreditation, manufacturers should make random inspection for quality control aspects during the manufacturing process and an independant certification system should be put in place.