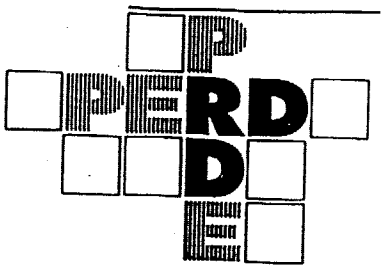

THE LONG TERM PERFORMANCE OF OPERATING WINDOWS SUBJECTED TO MOTION CYCLING

PREPARED FOR:

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Energy Technology Branch, Energy Sector
Department of Natural Resources Canada
Ottawa, Ontario, Canada, K1A 0E4
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DISCLAIMER

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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.

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_0) 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);

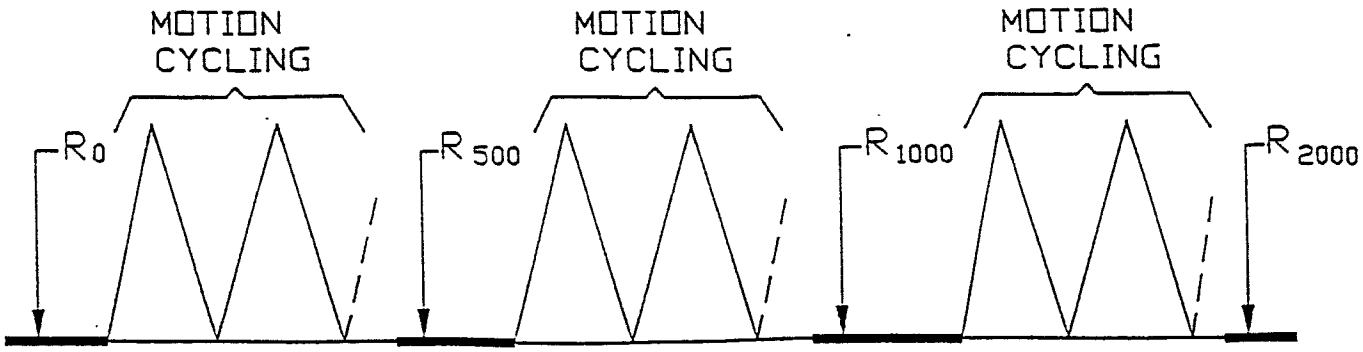
c) Determine new rating (R_{500}) with respect to ease of operation and air leakage;

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.



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	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 (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.

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.