

## EVALUATION REPORT

**Title:** Evaluation of Borrowed Lites with Tempered Glass

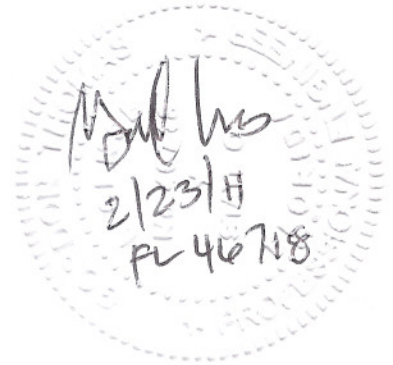
**Report #:** S05-006R1

**Manufacturer:** Ingersoll-Rand Company  
Security Technologies  
6810 Hillside Court  
Indianapolis, IN 46250

**Technical Contact** Jason Doose  
Product Manager

**Prepared by:** Gordon Thomas, P.E.  
3759 Blossom Court  
Mason, OH 45050  
Florida # 46718

**Date:** February 23, 2011



### I. Introduction/ Scope

Based on wind load test results for the borrowed lite frame structure, the following evaluation will estimate the performance of tempered glass for use on the same frame design and wind pressure.

The following report evaluates the new overall door/frame design as it compares to the door/frame design tested.

### II. Reference Material

The following items were used to prepare the evaluation report:

- A. Certified Testing Laboratories, Report #CTLA-1107W, dated 11/5/03
- B. Ingersoll-Rand Dwg # 1107W, 5 sheets, Dated 6/02/05
- C. Dade County NOA #10-0623-01
- D. ASTM E1300, Standard Practice for Determining Load Resistance of Glass in Buildings.
- E. DuPont Sentry Glas Plus, Technical data Sheet.
- F. PPG, Tempered Glass, Technical Document.

### III. Evaluation

#### A. Glass Types

The Steelcraft borrowed lites approved by Dade County were constructed with 9/16" SentryGlas Plus. This is an architectural laminated glass by DuPont for impact resistance. The current borrowed lite design will be evaluated for use with 3/8" tempered glass which is up to 5 times stronger than most annealed or laminated glasses. However, the tempered glass is not suitable for large missile impact test or High Velocity Hurricane Zones (HVHZ).

The following summary shows properties of float glass:

Modulus of Rupture (MOR) (50% probability of breakage):

6,000 psi	Annealed
12,000 psi	Heat Strengthened
24,000 psi	Tempered

Max Design Stress (0.8% probability of breakage)

2,800 psi	Annealed
5,600 psi	Heat Strengthened
11,200 psi	Tempered

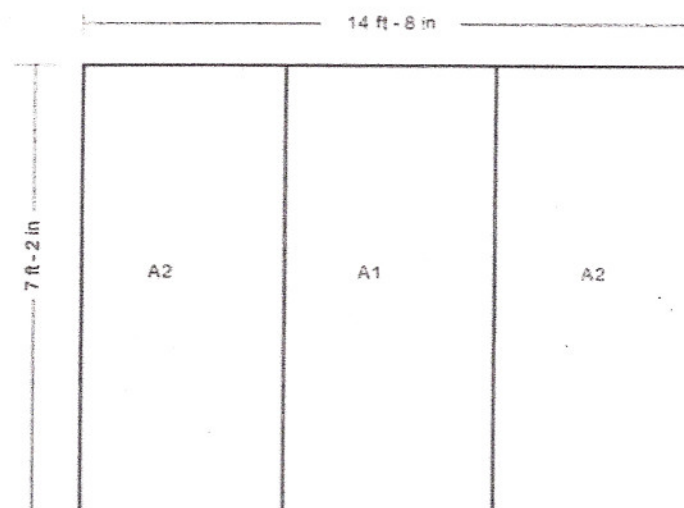
The following summary shows properties of SentryGlas Plus

Young's Modulus	43.5 kpsi
Tensile Strength	5.0 kpsi
Flex Modulus	50 kpsi

#### B. Product Comparison

The following borrowed lite frames have already been tested and approved. These will be the basis for the comparative analysis.

- 1). Tested Assembly (+60/-60 psf) – Test Report CTLA 1107W
  - a. Borrowed Lite Frame Design 1



- 1). Glass: 9/16" Laminated (SentryGlas)
- 2). Loads applied onto frame from wind pressure

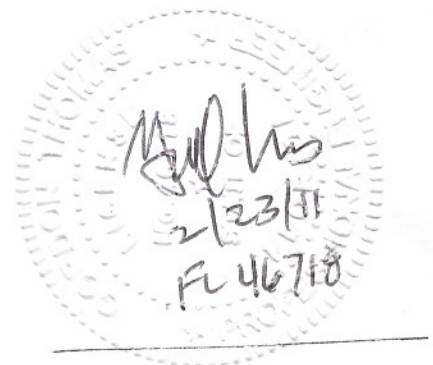
a) Total Load on Frame

$$P_t = (86" \times 176" \times 60 \text{ psf}) / 144 = 6306 \text{ lbs}$$

b) Wind load applied to each window frame

$$P_1 = (58 \times 86 \times 60) / 144 = 2078 \text{ lbs}$$

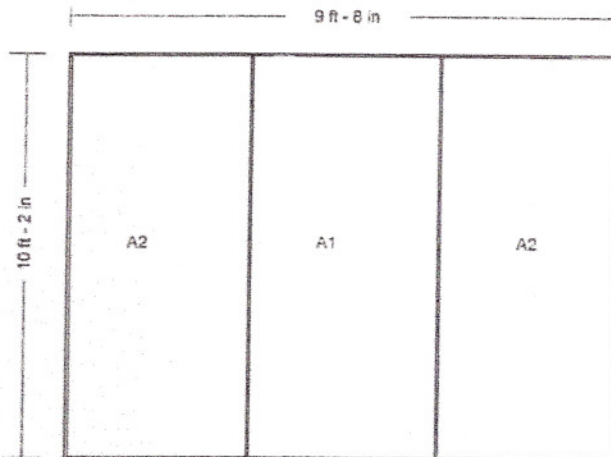
$$P_2 = (59 \times 86 \times 60) / 144 = 2114 \text{ lbs}$$



- c) Load on critical support member  
 $2078/4 + 2114/4 = 1048 \text{ lbs over } 86 \text{ inches (12.2 lbs/in)}$
- d) Maximum Stress on window (based on Roark's flat plate analysis)  
 $a/b = 84/56 = 1.46, B = 0.452$   
 $\sigma = ((60 \cdot 1.5)/144)(0.452)(56/0.5625)^2 = 2800 \text{ psi} < 5000 \text{ psi}$

Factor of Safety  $5000/2800 = 1.78$

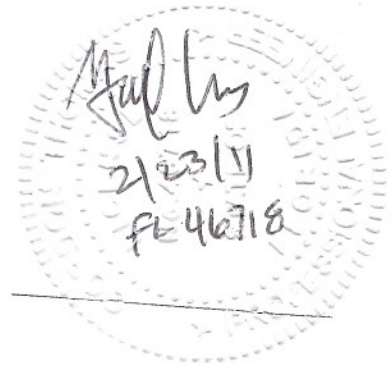
b. Borrowed Lite Frame Design 2



- 1). Glass: 9/16" Laminated (SentryGlas)  
 2). Loads applied onto frame from wind pressure

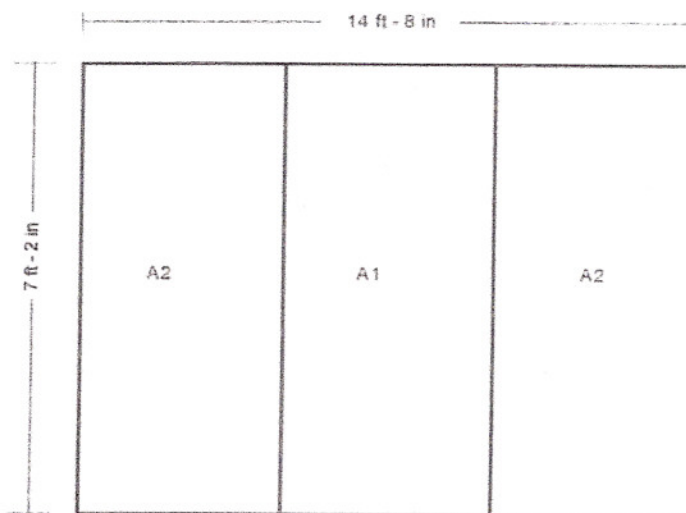
- a) Total Load on Frame  
 $P_t = (122" \times 116" \times 60 \text{ psf})/144 = 5897 \text{ lbs}$
- b) Wind load applied to each window frame  
 $P_1 = (38" \times 122" \times 60 \text{ psf})/144 = 1932 \text{ lbs}$   
 $P_2 = (39" \times 122" \times 60 \text{ psf})/144 = 1983 \text{ lbs}$
- c) Load on critical support member  
 $1932/4 + 1983/4 = 979 \text{ lbs over } 122 \text{ inches (8 lbs/in)}$
- d) Maximum Stress on window (based on Roark's flat plate analysis)  
 $a/b = 118/36 = 3.27, B = 0.5$   
 $\sigma = ((60 \cdot 1.5)/144)(0.5)(36/0.5625)^2 = 1280 \text{ psi} < 5000 \text{ psi}$

Factor of Safety  $= 5000/1280 = 3.9$





2). Tempered Glass configurations (+/- 60 psf)  
 a. Borrowed Lite Frame Design 1



- 1). Glass: tempered
- 2). Loads applied onto frame from wind pressure

a) Total Load on Frame

$$P_t = (86" \times 176" \times 60 \text{ psf}) / 144 = 6306 \text{ lbs}$$

b) Wind load applied to each window frame

$$P_1 = (58 \times 86 \times 60) / 144 = 2078 \text{ lbs}$$

$$P_2 = (59 \times 86 \times 60) / 144 = 2114 \text{ lbs}$$

c) Load on critical support member

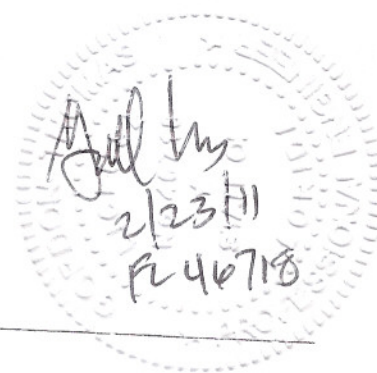
$$2078/4 + 2114/4 = 1048 \text{ lbs over 86 inches (12.2 lbs/in)}$$

d) Maximum Stress on window (based on Roark's flat plate analysis)

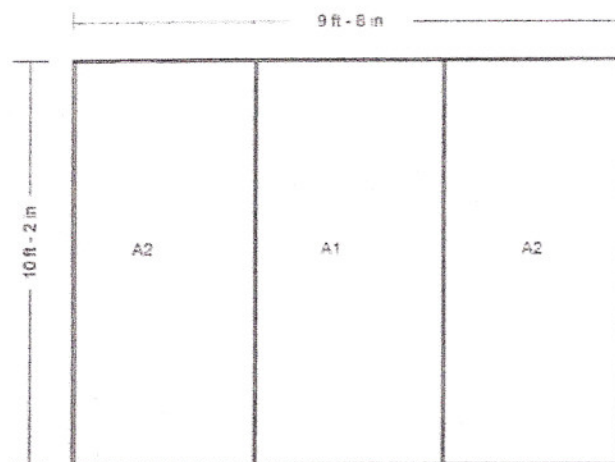
$$a/b = 84/56 = 1.46, B = 0.452$$

$$\sigma = ((60 \times 1.5) / 144)(0.452)(56/0.375)^2 = 6300 \text{ psi} < 11,200 \text{ psi}$$

$$\text{Factor of Safety} = 11,200 / 6300 = 1.78$$



b. Borrowed Life Frame Design 2



Handwritten signature: *Ad 1/2*  
Date: *2/23/11*  
Text: *FL46718*

- 1). Glass: tempered
- 2). Loads applied onto frame from wind pressure

a) Total Load on Frame

$$P_t = (122" \times 116" \times 60 \text{ psf}) / 144 = 5897 \text{ lbs}$$

b) Wind load applied to each window frame

$$P_1 = (38" \times 122" \times 60 \text{ psf}) / 144 = 1932 \text{ lbs}$$

$$P_2 = (39" \times 122" \times 60 \text{ psf}) / 144 = 1983 \text{ lbs}$$

c) Load on critical support member

$$1932/4 + 1983/4 = 979 \text{ lbs over 122 inches (8 lbs/in)}$$

d) Maximum Stress on window (based on Roark's flat plate analysis)

$$a/b = 118/36 = 3.27, \quad B = 0.5$$

$$\sigma = ((60 \times 1.5) / 144) (0.5) (36 / 0.375)^2 = 2880 \text{ psi} < 11,200$$

$$\text{Factor of Safety} = 11,200 / 2880 = 3.8$$

3) Evaluation

Even though the tempered glass has a higher maximum stress due to the reduced thickness, the glass is expected to perform equal or better than the approved laminated glass. The primary restriction for the use of tempered glass is poor impact resistance. Consequently, the tempered glass could not be used in a High Velocity Hurricane Zone (HVHZ) as defined by the building codes.

#### IV Limitation of Use

The following information summarizes the limitation of use for the doors/ frames under evaluation:

##### 1. Elevation A

Maximum Frame Width: 14 ft - 8 in  
 Maximum Frame Height: 7 ft - 2 in  
 Maximum Wind Pressure: +60/-60 psf  
 Borrowed Lite Construction: Refer to IR Dwg # 1107W,  
 Frame Anchor Type, Size & Spacing: Refer to IR Dwg # 1107W,  
 Not approved for HVHZ with tempered glass

##### 2. Elevation B

Maximum Frame Width: 9 ft - 8 in  
 Maximum Frame Height: 10 ft - 2 in  
 Maximum Wind Pressure: +60/-60 psf  
 Borrowed Lite Construction: Refer to IR Dwg # 1107W,  
 Frame Anchor Type, Size & Spacing: Refer to IR Dwg # 1107W,  
 Not approved for HVHZ with tempered glass

##### 3. Other Size Configurations: +/- 60 psf (not for HVHZ)

Maximum Window Size

		Width (ft-in)														
		2-6	3-0	3-6	4-0	4-6	5-0	5-6	6-0	6-6	7-0	7-6	8-0	8-6	9-0	9-6
Height (ft - in)	3-0	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
	3-6	X	X	X	X	X	X	X	X	X	X	X	X			
	4-0	X	X	X	X	X	X	X	X	X	X	X	X			
	4-6	X	X	X	X	X	X	X	X	X	X					
	5-0	X	X	X	X	X	X	X	X							
	5-6	X	X	X	X	X	X									
	6-0	X	X	X	X	X	X									
	6-6	X	X	X	X	X										
	7-0	X	X	X	X	X										
	7-6	X	X	X	X											
	8-0	X	X	X	X											
	8-6	X	X													
	9-0	X	X													
	9-6	X	X													
	10-0															
	10-6															
	11-0															

*Handwritten:*  
 Paul H.  
 2/23/18  
 FL 46718

#### Certification of Independence of Evaluation Entity

I hereby certify that (1) I have no financial interest in Ingersoll-Rand Company; (2) I am an independent licensed Professional Engineer in the State of Florida and; (3) I comply with the criteria of independence as stated in 9B-72.110 (3), F.A.C. and 9B-72.110(4), F.A.C.