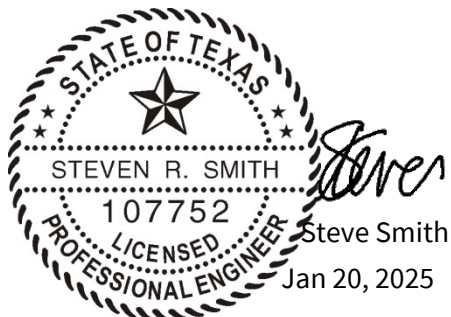


SunOptics Impact Testing
Skylight Testing
Haag Research & Testing Co.
1410 Lakeside Parkway, Suite 100
Flower Mound, TX 75028
Client File: N/A
Haag File: 51240066TX -196

SunOptics, Inc
106 Industrial South Parkway
Tallahassee, Alabama 36078

Attention: Grant Gable

January 20, 2025



January 20, 2025

SunOptics, Inc
106 Industrial South Parkway
Tallahassee, Alabama 36078

Attention: Grant Gable

Re: SunOptics Impact Testing
Skylight Testing
Haag Research & Testing Co.
1410 Lakeside Parkway, Suite 100
Flower Mound, TX 75028
Client File: N/A
Haag File: 51240066TX-196

In accordance with your request, we impact tested plastic skylights to evaluate the effects of large, frozen solid hailstones.

This report has been written for your sole use and purpose, and only you have the authority to distribute this report to any other person, firm, or corporation. Haag Research & Testing Co. and its agents and employees do not have and do disclaim any contractual relationship with, or duty or obligation to, any party other than the addressee of this report and the principals for whom the addressee is acting. Only the engineer who signed this document has the authority to change its contents and then only in writing to you. This report addresses the results of work completed to date. Should additional information become available, we reserve the right to amend, as warranted, any of our conclusions.

Description

We received a shipment of SunOptics Signature Series™ High Performance Prismatic Skylights in Flower Mound, Texas, on December 10, 2024, directly from the manufacturer, SunOptics, Inc. No product sampling was performed by laboratory personnel. Test results presented in this report are applicable to the tested skylights as received.

The tested skylights were a double-dome design. The outer dome was 0.118-inch, clear, smooth polycarbonate. The inner dome was 0.125-inch, white, prismatic polycarbonate. Domes were separated by a 1/2-inch air gap. The skylight measured nominally 61-1/2 inches wide by 73-1/2

inches long, which included the 6000 series aluminum mounting frame. A test frame was constructed using 2-inch by 4-inch (2x4) and 2x6 (nominal) lumber (six members: perimeter elements and third-span braces). Skylight frames were mounted to the test frame using screws provided by SunOptics and were repositioned as needed to facilitate perpendicular impacts. The specification sheet for the tested skylights is appended in Attachment B, and a marketing brochure for the skylights is appended as Attachment C.

Laboratory Procedures and Findings

The skylights were tested by propelling frozen solid ice balls measuring four inches in diameter, perpendicular to target locations at speeds representative of free-falling hailstones of similar size. Tested skylights were maintained at laboratory temperatures in the range of 60°F to 90°F for at least 72 hours prior to testing. Laboratory temperature during these tests was 71°F, and relative humidity was 56%. Target free-fall energies were computed from theoretical free-fall speeds derived from Equation 1, which was presented in an article, “*A General Equation for the Terminal Fall Speed of Solid Hydrometers*,” by Hannes P. Bohm, published in August 1989 by The American Meteorological Society. Target ice ball attributes are listed in Table 1.

$$\text{Equation 1: } V = 10.98 \times D^{0.638}$$

Where:

V = terminal velocity of hail (m/s)

D = diameter of hail (cm)

TABLE 1: TARGET ICE BALL ATTRIBUTES

Diameter (inches)	Mass (pound)	Free-Fall Speed (feet/sec)	Free-Fall Energy (ft·lbf)
4	1.0560	158.1	410.2

Testing was conducted by impacting six target locations on one end. Target locations are depicted in Figure 1. The opposite end of the skylight was also tested at Location 1 (Impact 1) and about 2 inches from Location 1 (Impact 1A). Table A.1 in Attachment A provides details on test equipment used during test procedures outlined in this report. A typical 4-inch-diameter ice ball used during testing is depicted in Figure 2.

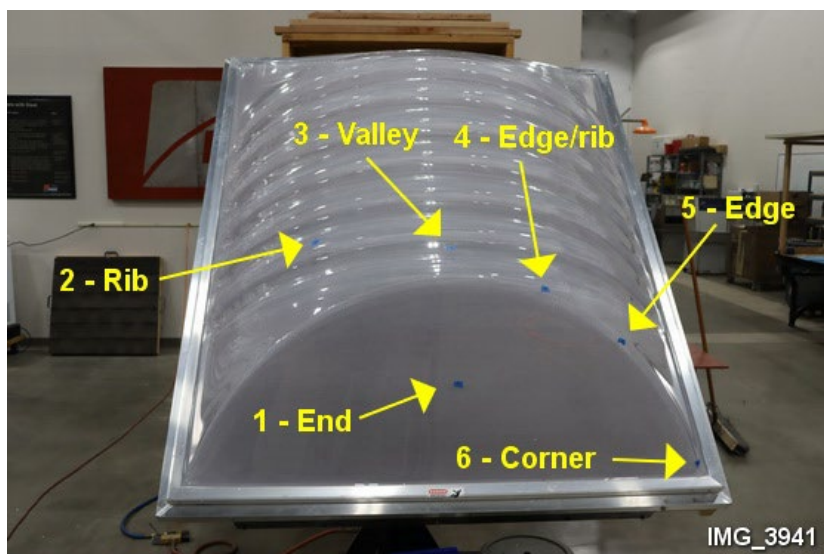


Figure 1: Target Impact Locations



Figure 2: 4-inch-diameter Ice Ball

Ice ball weights, speeds, and computed kinetic energies for each impact made during testing are listed in Table 2.

TABLE 2: ICE BALL ATTRIBUTES AND RESULTS

IMPACT No.	Location	SIZE [Inch]	MASS [Pound]	SPEED [Ft/Sec]	KE [Ft-Lbf]	FINDINGS
Skylight End 1 Test Results						
1	End	4	1.0943	159.4	432.1	dent
2	Rib	4	1.1327	219.4	847.4	dent; buckled rib
3	Valley	4	1.0927	157.8	422.9	dent
4	Edge/Rib	4	1.0748	156.5	409.1	dent
5	Edge	4	1.0870	151.4	387.3	dent
6	Corner	4	1.0956	156.7	418.1	dent
Skylight End 2 Test Results						
1	End	4	1.1003	163.3	456.0	dent
1A	End	4	1.1024	160.2	439.7	dent
Notes:	within $\pm$ 5% of target					
	within $\pm$ 10% of target					
	more than 10% above target					

Discussion

Hailstone impacts are most damaging to building components when hailstones are frozen solid and impact surfaces perpendicularly. These conditions impart the maximum impact force through the smallest possible area, resulting in the highest material stresses. Softer hailstones break apart upon impact, distributing impact forces over larger contact areas and reducing the material stresses caused by the impacts. Smaller hailstones have less mass and fall at lower terminal velocities. Consequently, smaller hailstones have less energy than larger hailstones and, therefore, are less able to damage building components.

The minimum size of hail expected to cause damage to building components varies based on angle of impact, support conditions, and the strength of impacted materials. The weathered condition of building components can have a substantial effect on their resistance to withstand damage from hailstone impacts.

Laboratory testing of the SunOptics Signature Series™ High Performance Prismatic Skylight evaluated the effects of large, frozen solid hail on new skylights striking discrete locations perpendicularly. This report does not purport to represent the effects of actual hailstorms on skylights tested in this study due to factors outside of controlled laboratory settings. Studies have shown that the hardness and strength of real-world hailstones vary substantially, and the ice balls used during this testing were representative of worst case or near worst-case hail. In general, smaller hailstones tend to fall closer together than larger hailstones. Consequently, the likelihood of two or more very large hailstones striking the same location is small, but not zero.

Simulated hail impact testing performed on the SunOptics Signature Series™ High Performance Prismatic Skylight revealed a high potential to resist fractures from individual impacts by hard hailstones measuring up to four inches in diameter.

Conclusions

Based on laboratory testing of the provided skylights, we have reached the following conclusions:

1. The skylights were subjected to impacts by simulated hailstones (frozen solid ice balls) propelled perpendicular to six target locations (Figure 1) at velocities consistent with free-fall speeds of 4-inch-diameter hail.
2. Skylights were dented at ice ball impacts.
3. Impact 2 on a rib element buckled the rib.
4. Individual ice ball impacts did not crack or puncture the skylight domes.

Respectfully submitted,

HAAG RESEARCH & TESTING, CO.



Jan 20, 2025

Steven R. Smith, P.E.
Texas License 107752
Director of Research & Testing

Haag Research & Testing Co.
CA F-20657
Expires: 02/28/2025



Jan 20, 2025

Allen W. Swan
Senior Technician

SRS/AWS:af

Lab Attachments



Lab Attachment A

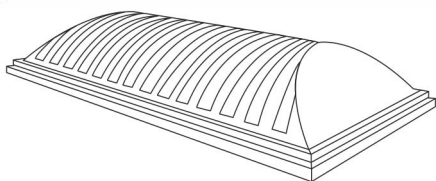


Table A.1: Ice Ball Impacting Equipment List

HAAG ASSET TAG	EQUIPMENT	MANUFACTURER	MODEL	SERIAL NO.
3753	Pneumatic Launcher (Large Missile)	Haag Engineering Co.	IBL-9	1 st Generation
3766	Chronograph	Shooting Chrony Inc.	F-1	NA
5000	Digital Level	Digi-Pas	DWL-200	A30K13103
6999	Freezer Temperature Control	Johnson Controls	A419	NA
3771	Thermometer	ACU-RITE	MAT 252015D	00592W2
3759	Precision Scale	A&D Company	FX3000i	15706278
3768	Pressure Gauge	SSI Technologies Inc	MGA-100-A-9V-R	1408140500
3769	Electro/Pneumatic Valve	Hytork	186	17500
3770	Valve Gauge/Regulator	Husky	DK648800AV	N/A

Lab Attachment B





Signature™ Series Dome

Fixed Industrial Skylight



SIG | Frame Model 800MD

AVAILABLE CERTIFICATIONS

FM Approval # 4431
FBC 2020 - FL14086-R4 HVHZ Approved
Miami-Dade County, Florida, NOA No. 21-0318.03,
NFRC Certified
CE Certified
Class 4 Hail Ratings Available



Buy American: This product is assembled in the USA and meets the Buy America(n) government procurement requirements under FAR, DFARS and DOT. Please refer to [Build America, Buy America Act](#) federal website for additional information.

Warranty: 10-year and 15-year limited warranty available. Complete warranty terms located at: www.sunoptics.com

Note: Actual performance may differ as a result of end-user environment and application.

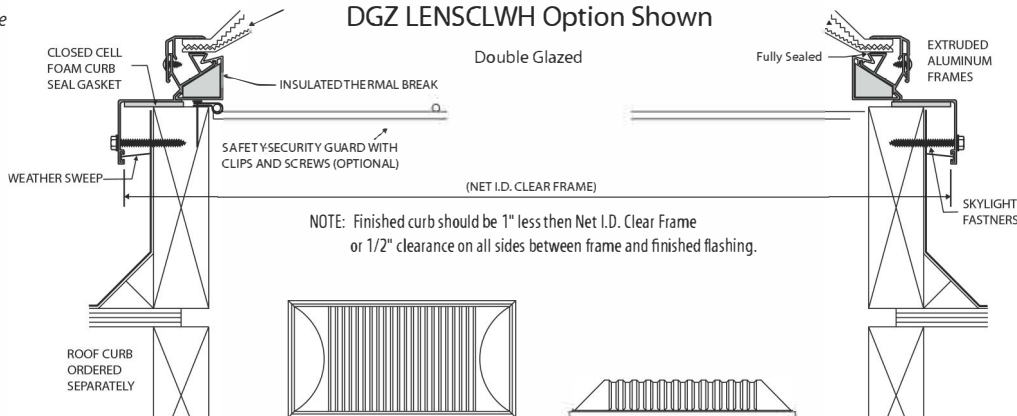
Specifications subject to change without notice.



PRODUCT PROFILE

Details Not To Scale

DGZ LENSCLWH Option Shown



SPECIFICATIONS

Skylights shall be Sunoptics model 800MD (curb mounted) as manufactured by Sunoptics, Inc. Skylights shall be glazed ready for installation.

Skylight frames shall be fabricated from extruded aluminum, finish to be natural mill. Frames shall have integral condensation and weepage gutters which drain interior moisture to the outside. Corners shall be mitered and welded. The polycarbonate glazing shall be separated from the skylight frame with a Silicon Seal.

Skylights shall be glazed using CC1 rated, Prismatic polycarbonate in a Signature Series Dome configuration.

FM Approved Prismatic Skylights shall be Double glazed using CLEAR ARMOUR® Clear Polycarbonate lens over CLEAR ARMOUR® High White Polycarbonate lens, CC1/ Class A Rated, FM Approved.

FM Approved Skylights shall be tested and approved under Factory Mutual #4431 testing method for fixed skylights. Class A / CC1 flame rating. Standard Size units up to 5080 are tested and certified to AAMA/WDMA/CSA 101/1.5.2/A440 to comply with 800MD frame section 2405.5 of the International Building Code.

Certain airborne contaminants can diminish the integrity of polycarbonate / acrylic lenses. Refer to the compatibility tables for suitable uses on our website.

Skylights not for use in Harsh, Corrosive, Marine and high-humidity Environmental Conditions such as Marina, Greenhouses, Petrol-Chemical facilities or other chemicals where the skylights may be exposed to such conditions.

Note: Multi-glazed units default to include Insulated Thermal Break (ITBR), Closed Cell Foam Curb Seal Gasket, Weather Sweep (WSW) and screws. Single-glazed units default to not included any of these options.

Testing was performed on HVHZ skylights per Florida Building Code, Test Protocols for High Velocity Hurricane Zone (HVHZ), Protocols TAS 201, TAS 202 and TAS 203. The samples tested met the performance requirements set forth in the protocols for a ± 60.0 psf Design Pressure rating. Size units up to 5080 with 800MD frame are tested and listed for HVHZ.

Sunoptics HVHZ skylights are Miami-Dade County Product Control Approved.

Skylight Hail Class Rating

Material Type	Lens Material	Resistance Rating	Hail Size
Polycarbonate over Acrylic	CC1CC2	≤ Class 4	2"
Polycarbonate	CC1	≤ Class 4	2"

Skylight Thermal Performance

Type	SHGC	U-Value	VLT
Single Glazed	.68	n/a	.74
Double Glazed Clear/White	.42	.74	.67

Cleaning Polycarbonate Lenses: Frequency of cleaning is determined by site conditions. When cleaning polycarbonate lenses, use only water or water with a mild soap. Use a soft rag to minimize scratching the polycarbonate. A pressure washer is acceptable to use as well. Never use ammonia, aromatic or petroleum based products to clean polycarbonate lenses. This will cause deterioration and cracking of the lens and will void the warranty.

Skylights should not be installed in locations with an operating temperature in excess of -75° F or 180°F.

Skylight Performance Grade Ratings

Short Description	Design Pressure
Polycarbonate Skylight	40 PSF
HVHZ Skylight	60 PSF

Rates based on FGIA. See building standard AAMA/WDMA/CSA 101/1.5.2/A440

ORDERING LOGIC

Signature™ Series Dome

▶▶▶

Fixture	ID Frame Call-Out		ID Frame Width		ID Frame Length		Glazing		Lens Material	
SIG Signature Series	4040	51-1/4" x 51-1/4"	W51.250	Width 51.250 inches	L51.250	Length 51.250 inches	SGZ	Single Glaze	CC1	Polycarbonate
	4060	51-1/4" x 75-1/4"	W51.250	Width 51.250 inches	L75.250	Length 75.250 inches	DGZ	Double Glaze	CC1CC2	Poly/Acrylic
	4070	51-1/4" x 87-1/4"	W51.250	Width 51.250 inches	L87.250	Length 87.250 inches			CC1P125	1/8" Poly (Only available for skylights with a width of up to 52-1/4")
	4080	52-1/4" x 100-1/4"	W52.250	Width 52.250 inches	L100.250	Length 100.250 inches				
	5050	63-1/4" x 63-1/4"	W63.250	Width 63.250 inches	L63.250	Length 63.250 inches				
	5060	63-5/8" x 75-5/8"	W63.625	Width 63.625 inches	L75.625	Length 75.625 inches				
	5558	67-3/4" x 70-3/4"	W67.750	Width 67.750 inches	L70.750	Length 70.750 inches				
	5080	63-1/4" x 99-1/4"	W63.250	Width 63.250 inches	L99.250	Length 99.250 inches				

Lens Color		Unit Type		Skylight Frame Finish		Options	
LENSWH	White (Single Glaze Default) ¹	800MD	Standard Frame	MI	Mill (Default)	(blank)	No Options
LENSCLWH	Clear White (Double Glaze Default) ²					FMRTG	Factory Mutual Approved
						HVHZ	High Velocity Hurricane Zone/ Miami Dade NOA***

***Select CC1CC2 Lens material for HVHZ skylights (includes: FL 14086-R4 & Miami-Dade County, Florida, NOA No. 21-0318.03. (Exp: 05/20/26). 1) Single Glaze 2) Double Glaze



Lab Attachment C



We put our *Signature* on it!

Signature Series™ High Performance Prismatic Skylight



MIAMI-DADE COUNTY
APPROVED

Patented Prismatic Polycarbonate Performance

- FGIA Certified
- FM Approved #4431
- High-Velocity Hurricane Zone (HVHZ) Approved, FBC 2020, FL14086-R4
- Miami-Dade County, Florida Approved, NOA #21-0318.03, Exp. 05/20/26
- NFRC Certified
- Class 4 Hail Rating



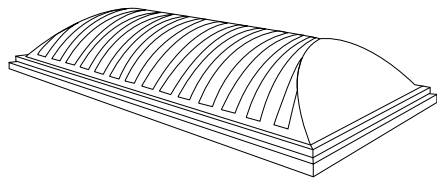
Toll Free (800) 289-4700 | Email: sales@sunoptics.com

WWW.SUNOPTICS.COM



**The Originator and Inventor of
the Modern Prismatic Skylight**

Since
1978



Signature™ Series Dome

Fixed Industrial Skylight



SIG | Frame Model 800MD

AVAILABLE CERTIFICATIONS

FM Approval # 4431
FBC 2020 - FL14086-R4 HVHZ Approved
Miami-Dade County, Florida, NOA No. 21-0318.03,
Expiration Date 05/20/2026
UL Listed
NFRS Certified
CE Certified
Class 4 Hail Ratings Available



Buy American: This product is assembled in the USA and meets the Buy America(n) government procurement requirements under FAR, DFARS and DOT. Please refer to www.sunoptics.com for additional information.

Warranty: 10-year and 15-year limited warranty available. Complete warranty terms located at: www.sunoptics.com

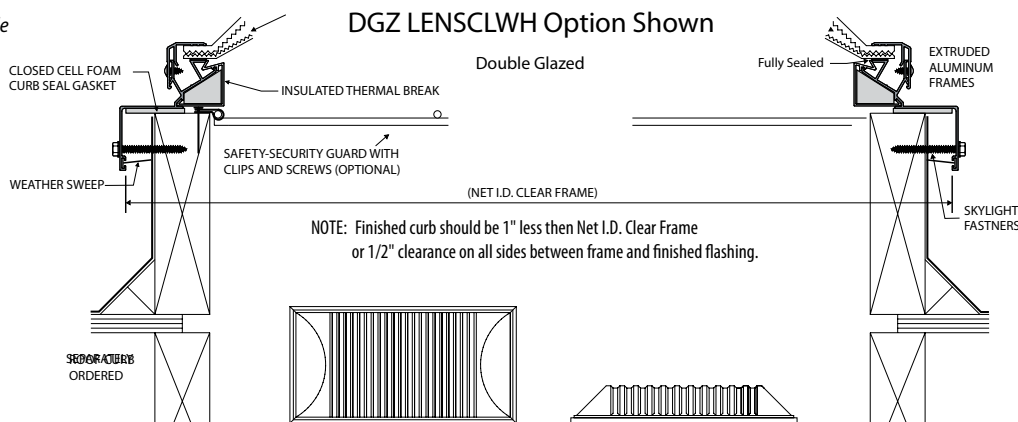
Note: Actual performance may differ as a result of end-user environment and application.

Specifications subject to change without notice.



PRODUCT PROFILE

Details Not To Scale



SPECIFICATIONS

Skylights shall be Sunoptics model 800MD (curb mounted) as manufactured by Sunoptics, Inc. Skylights shall be glazed ready for installation.

Skylight frames shall be fabricated from extruded aluminum, finish to be natural mill. Frames shall have integral condensation and weepage gutters which drain interior moisture to the outside. Corners shall be mitered and welded. The polycarbonate glazing shall be separated from the skylight frame with a Silicon Seal.

Skylights shall be glazed using CC1 rated, Prismatic polycarbonate in a Signature Series Dome configuration.

FM Approved Prismatic Skylights shall be Double glazed using CLEAR ARMOUR® Clear Polycarbonate over CLEAR ARMOUR® High White Polycarbonate lens, CC1/Class A Rated, FM Approved.

FM Approved Skylights shall be tested and approved under Factory Mutual #4431 testing method for fixed skylights. Class A / CC1 flame rating. Standard Size units up to 5080 are tested and certified to AAMA/WDMA/CSA101/I.S.2/A440 to comply with 800MD frame section 2405.5 of the International Building Code.

Certain airborne contaminants can diminish the integrity of acrylic and/or polycarbonate lenses. Refer to the compatibility tables for suitable uses on our website.

Skylights not for use in Harsh, Corrosive, Marine and high-humidity Environmental Conditions such as Marina, Greenhouses, Petrol-Chemical facilities or other chemicals where the skylights may be exposed to such conditions.

Note: Multi-glazed units default to include Insulated Thermal Break (ITBR), Closed Cell Foam Curb Seal Gasket, Weather Sweep (WSW) and screws. Single-glazed units default to not included any of these options.

Testing was performed on HVHZ skylights per Florida Building Code, Test Protocols for High Velocity Hurricane Zone (HVHZ), Protocols TAS 201, TAS 202 and TAS 203. The samples tested met the performance requirements set forth in the protocols for a ±60.0psf Design Pressure rating. Size units up to 5080 with 800MD frame are tested and listed for HVHZ.

Sunoptics HVHZ skylights are Miami-Dade County Product Control Approved.

Skylight Hail Class Rating

Material Type	Lens Material	Resistance Rating	Hail Size
Polycarbonate over Acrylic	CC1CC2	≤ Class 4	2"
Polycarbonate	CC1	≤ Class 4	2"

Skylight Thermal Performance

Type	SHGC	U-Value	VLT
Single Glazed	.68	n/a	.74
Double Glazed Clear/White	.48	.72	.67

Skylight Performance Grade Ratings

Short Description	Design Pressure
Polycarbonate Skylight	40 PSF
HVHZ Skylight	60 PSF

Rates based on FGIA. See building standard AAMA/WDMA/CSA/101/I.S.2/A440

Cleaning Polycarbonate Lenses: Frequency of cleaning is determined by site conditions. When cleaning polycarbonate lenses, use only water or water with a mild soap. Use a soft rag to minimize scratching the polycarbonate. A pressure washer is acceptable to use as well. Never use ammonia, aromatic or petroleum based products to clean polycarbonate lenses. This will cause deterioration and cracking of the lens and will void the warranty.

Size	ID Frame Call-Out	ID Frame Width	ID Frame Length
4040	51-1/4" x 51-1/4"	W51.250 Width 51.250 inches	L51.250 Length 51.250 inches
4060	51-1/4" x 75-1/4"	W51.250 Width 51.250 inches	L75.250 Length 75.250 inches
4070	51-1/4" x 87-1/4"	W51.250 Width 51.250 inches	L87.250 Length 87.250 inches
4080	52-1/4" x 100-1/4"	W52.250 Width 52.250 inches	L100.250 Length 100.250 inches
5050	63-1/4" x 63-1/4"	W63.250 Width 63.250 inches	L63.250 Length 63.250 inches
5060	63-5/8" x 75-5/8"	W63.625 Width 63.625 inches	L75.625 Length 75.625 inches
5558	67-3/4" x 70-3/4"	W67.750 Width 67.750 inches	L70.750 Length 70.750 inches
5080	63-1/4" x 99-1/4"	W63.250 Width 63.250 inches	L99.250 Length 99.250 inches

Glazing	Lens Material	Frame Type	Lens Color
SGZ	Single Glaze	800MD Standard Frame	LENSWH White (Single Glaze Default) ¹
DGZ	Double Glaze		LENSCLWH Clear White (Double Glaze Default) ²
	CC1		
	CC1CC2		
	CC1P125		

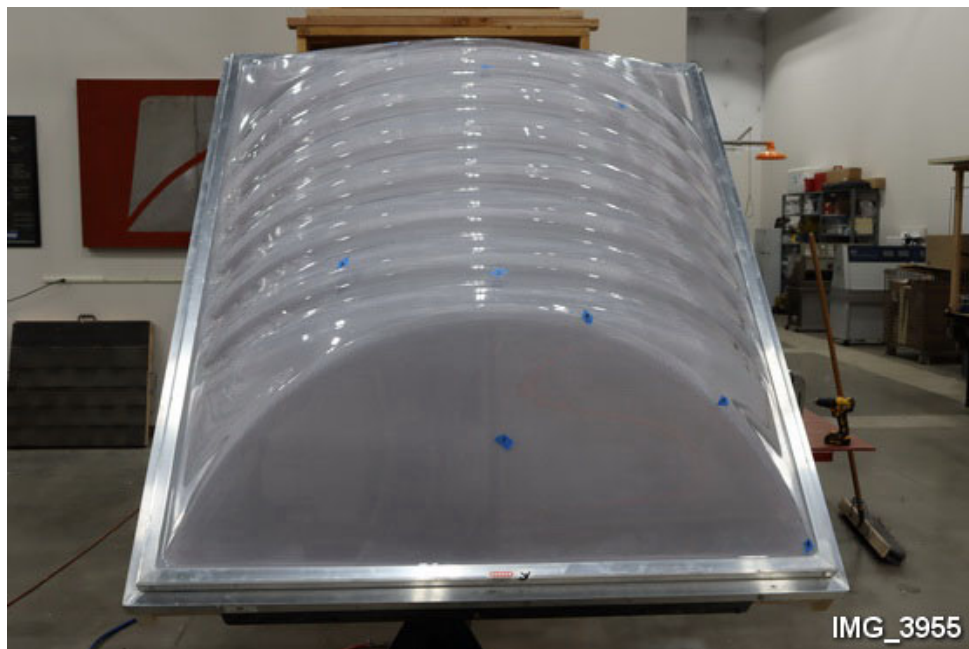
Lab Attachment D



SunOptics Inc: Impact Testing
Lab Attachment D - 4-inch Ice Ball Impact Photographs
Haag File No. 51240066TX-196



D1. Overview of test setup with Haag IBL-9 ice ball launcher.

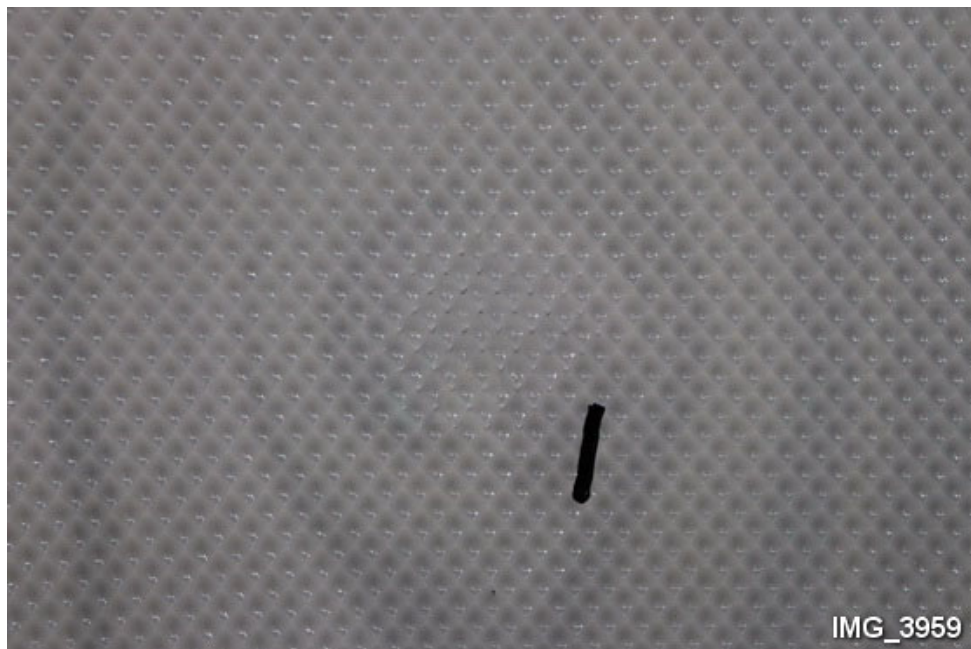


D2. Overview of the skylight before impact testing. (Note six target impact locations marked with tape.)

SunOptics Inc: Impact Testing
Lab Attachment D - 4-inch Ice Ball Impact Photographs
Haag File No. 51240066TX-196



D3. Close-up of area prior to Impact 1.



D4. Overview of Impact 1 with 4 inch ice ball. (Note impact caused dent.)

SunOptics Inc: Impact Testing
Lab Attachment D - 4-inch Ice Ball Impact Photographs
Haag File No. 51240066TX-196

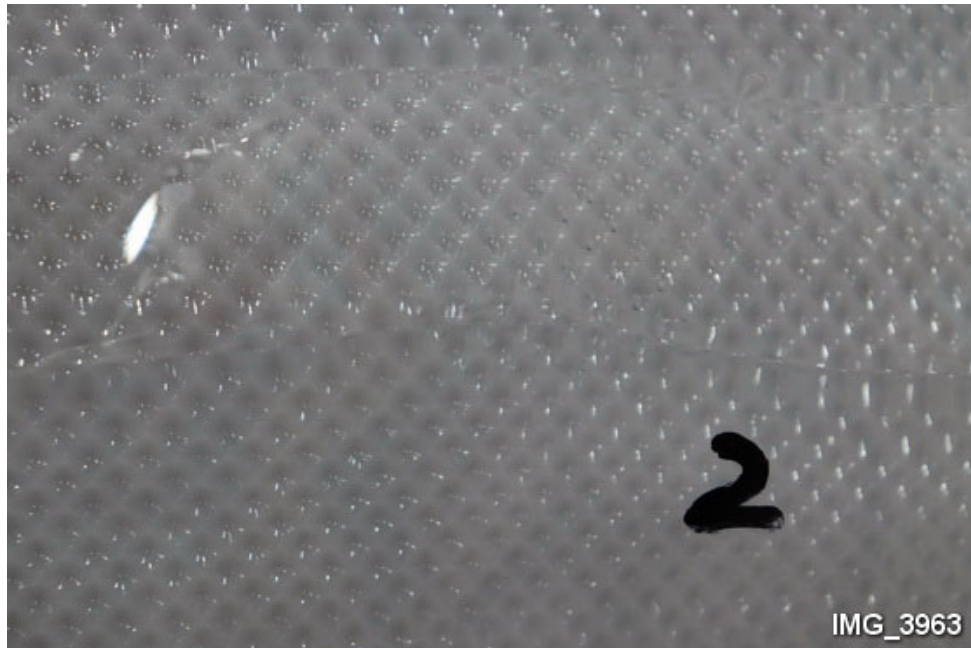


D5. Close-up of area prior to Impact 2.

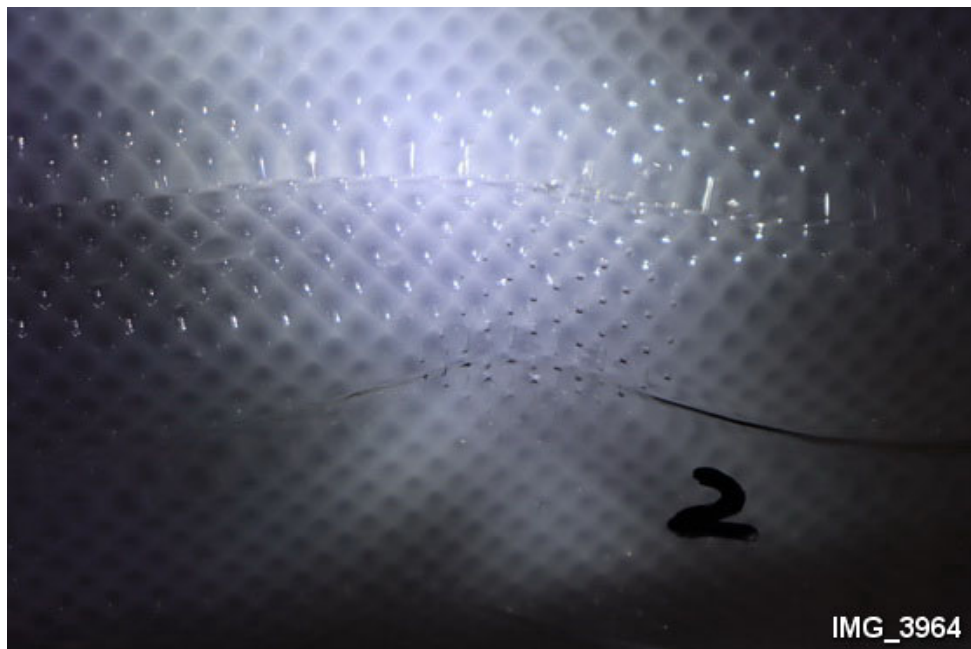


D6. Overview of Impact 2 with 4 inch ice ball. (Note impact caused dent and buckle.)

SunOptics Inc: Impact Testing
Lab Attachment D - 4-inch Ice Ball Impact Photographs
Haag File No. 51240066TX-196



D7. Close-up of Impact 2.

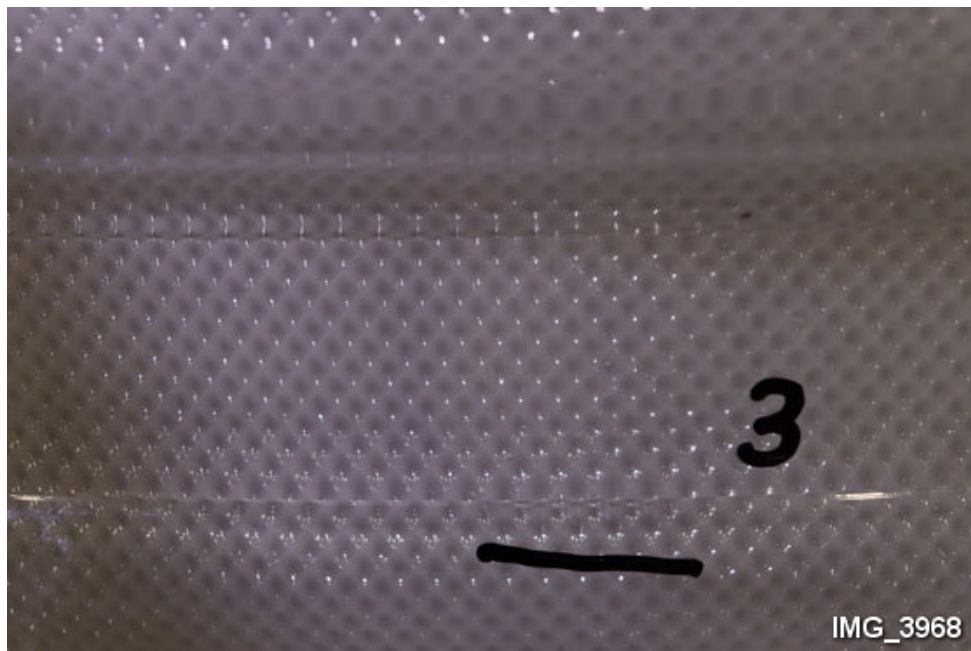


D8. Close-up of Impact 2 using low angle lighting.

SunOptics Inc: Impact Testing
Lab Attachment D - 4-inch Ice Ball Impact Photographs
Haag File No. 51240066TX-196

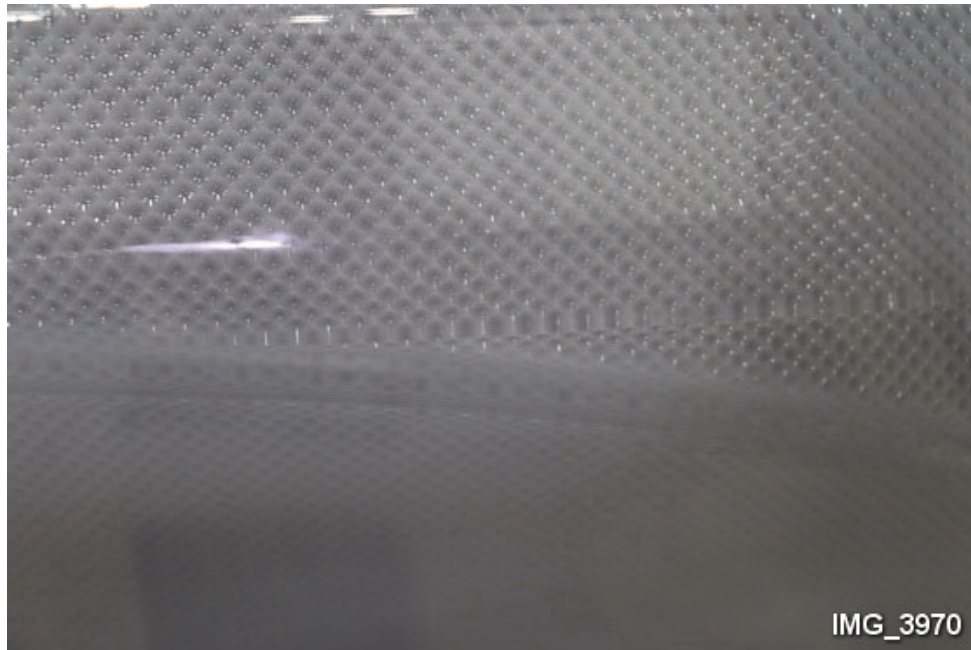


D9. Close-up of area prior to Impact 3.

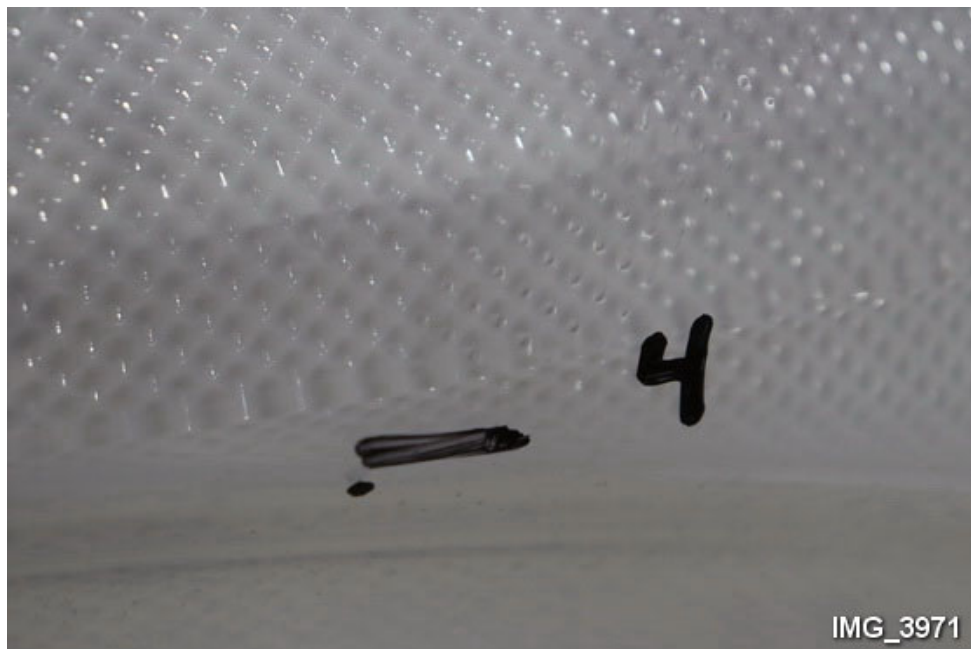


D10. Overview of Impact 3 with 4 inch ice ball. (Note impact caused dent.)

SunOptics Inc: Impact Testing
Lab Attachment D - 4-inch Ice Ball Impact Photographs
Haag File No. 51240066TX-196

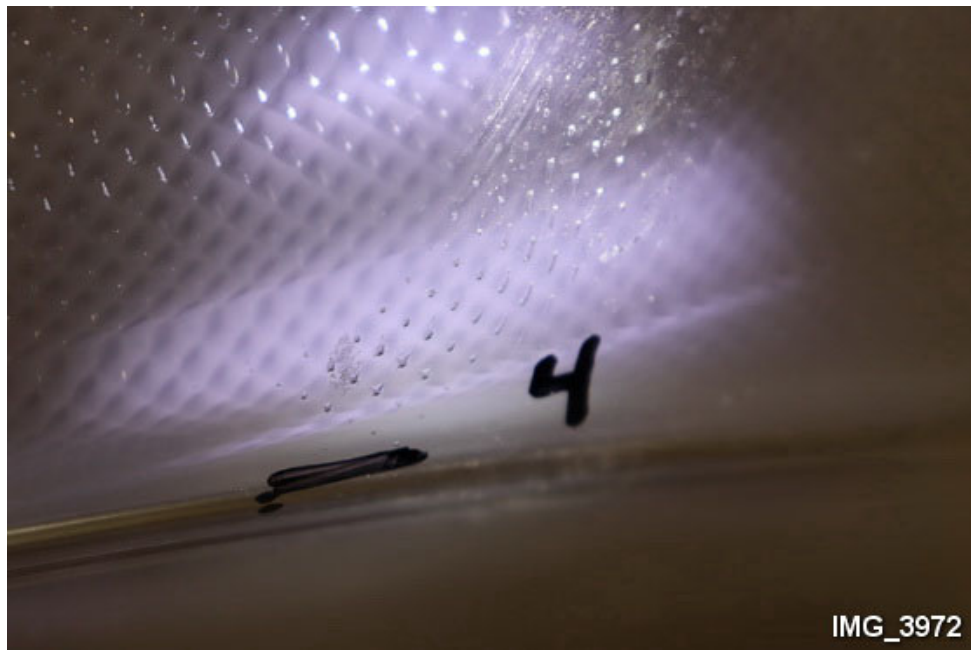


D11. Close-up of area prior to Impact 4.



D12. Overview of Impact 4 with 4 inch ice ball. (Note impact caused dent.)

SunOptics Inc: Impact Testing
Lab Attachment D - 4-inch Ice Ball Impact Photographs
Haag File No. 51240066TX-196

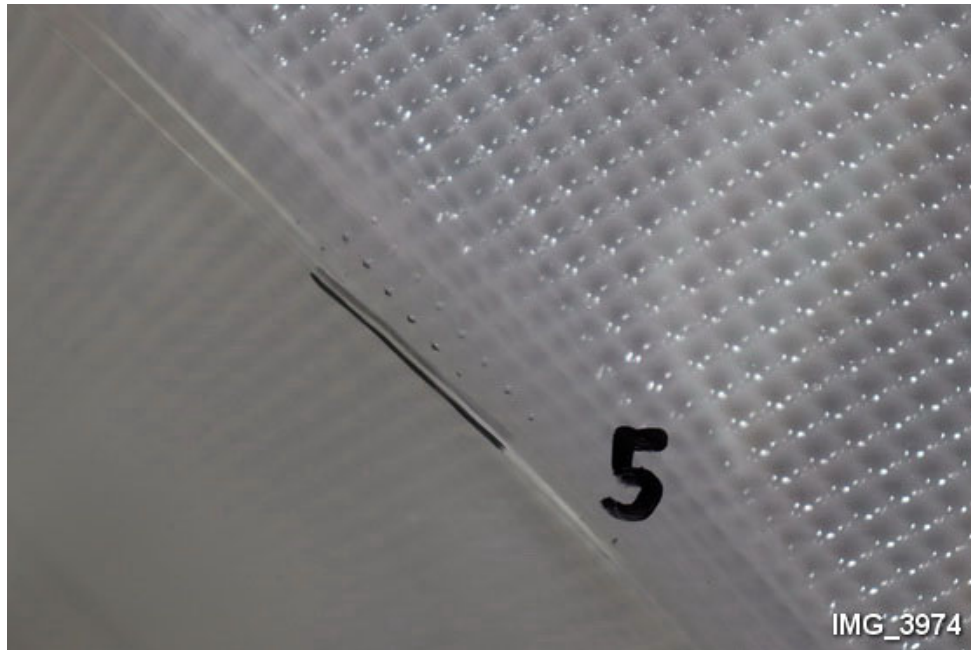


D13. Close-up of Impact 4 using low angle lighting.

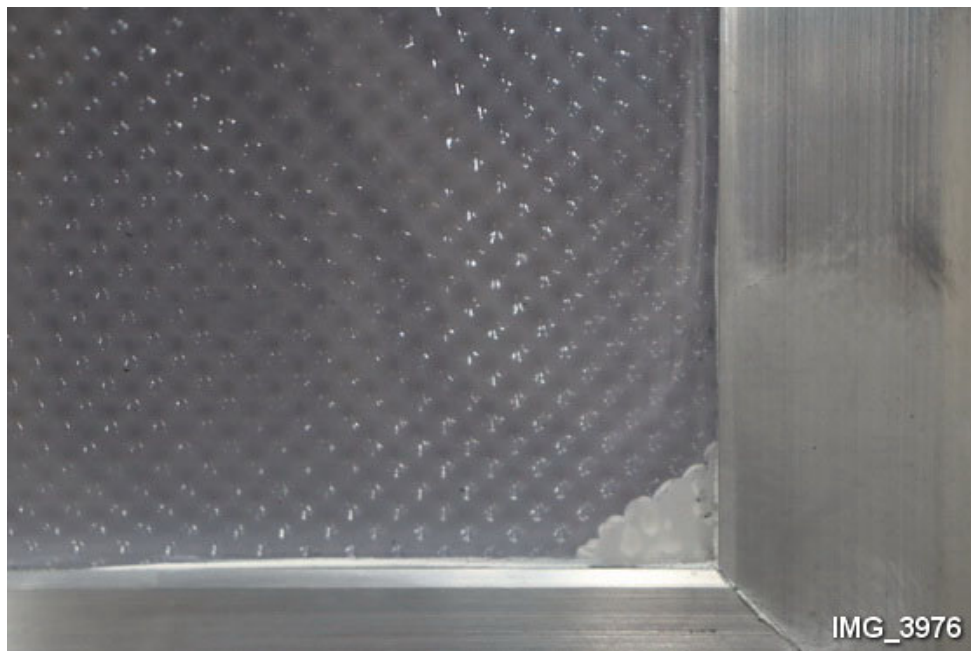


D14. Close-up of area prior to Impact 5.

SunOptics Inc: Impact Testing
Lab Attachment D - 4-inch Ice Ball Impact Photographs
Haag File No. 51240066TX-196

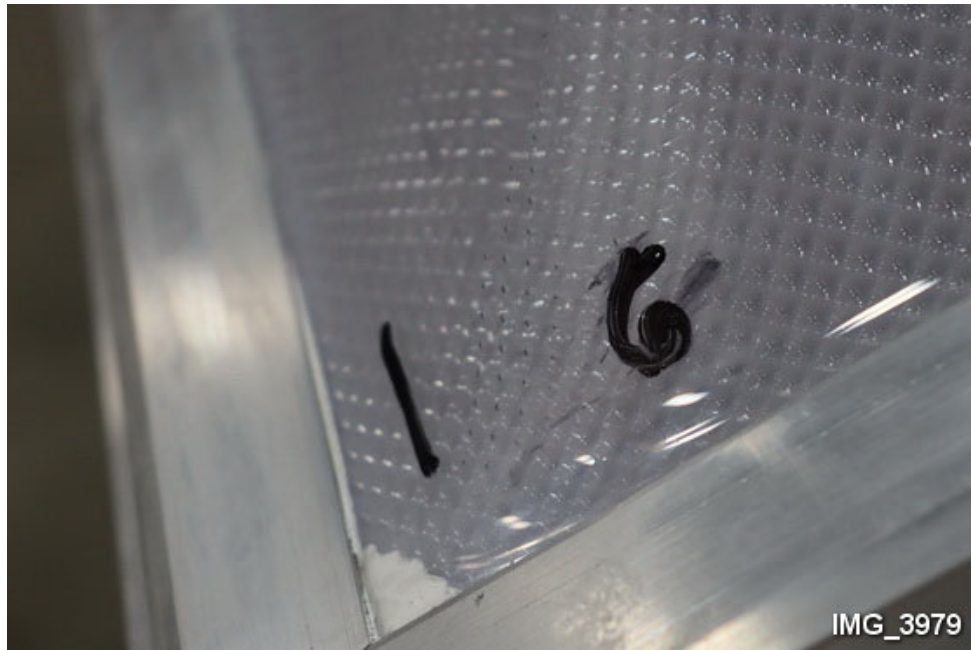


D15. Overview of Impact 5 with 4 inch ice ball. (Note impact caused dent.)

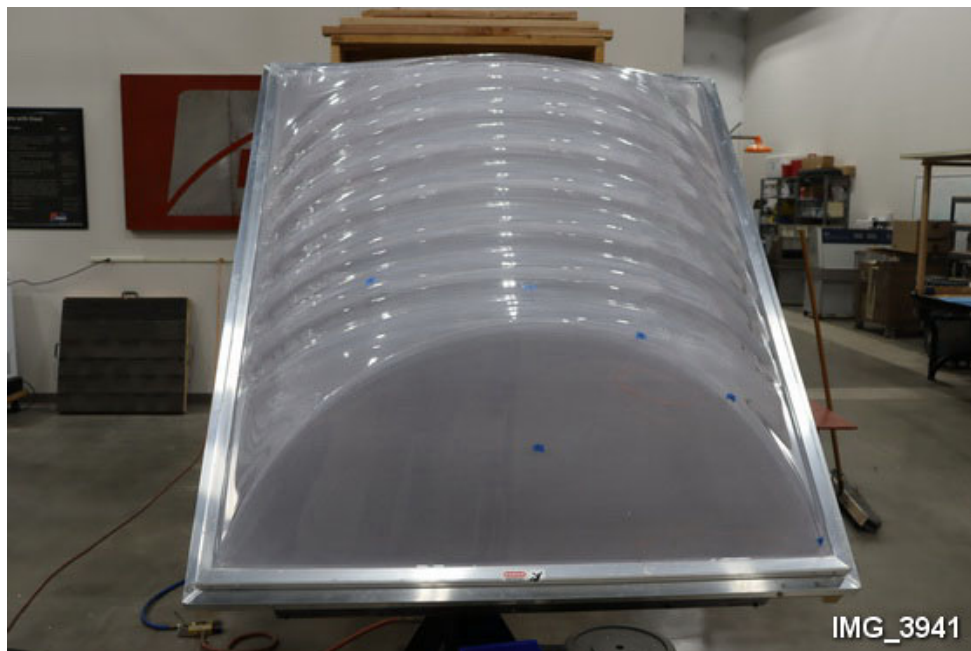


D16. Close-up of area prior to Impact 6.

SunOptics Inc: Impact Testing
Lab Attachment D - 4-inch Ice Ball Impact Photographs
Haag File No. 51240066TX-196



D17. Overview of Impact 6 with 4 inch ice ball. (Note impact caused dent.)

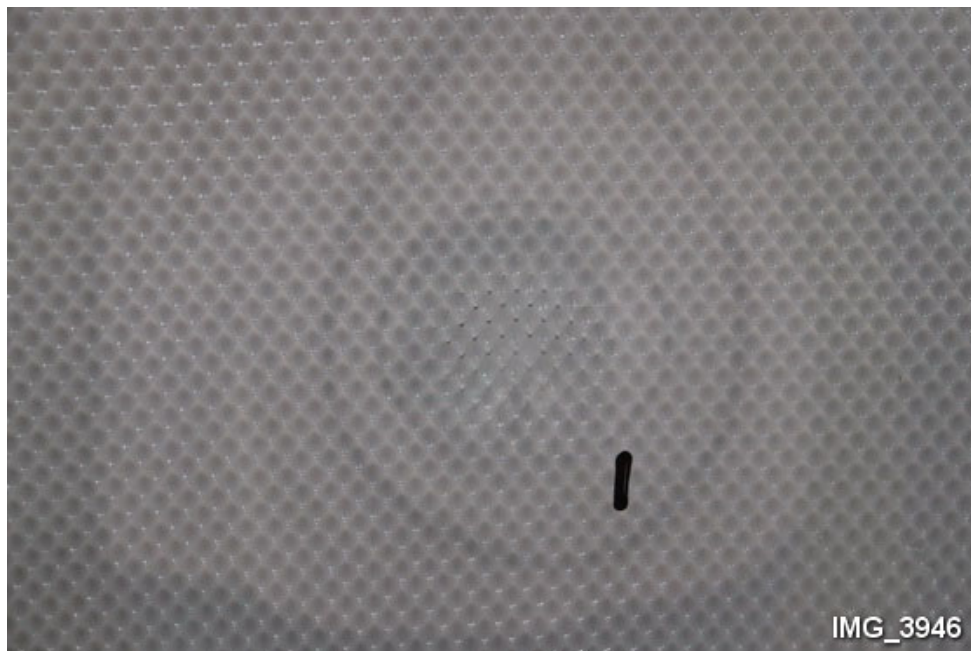


D18. Opposite end of skylight before impact testing.

SunOptics Inc: Impact Testing
Lab Attachment D - 4-inch Ice Ball Impact Photographs
Haag File No. 51240066TX-196



D19. Close-up of area prior to Impact 1.

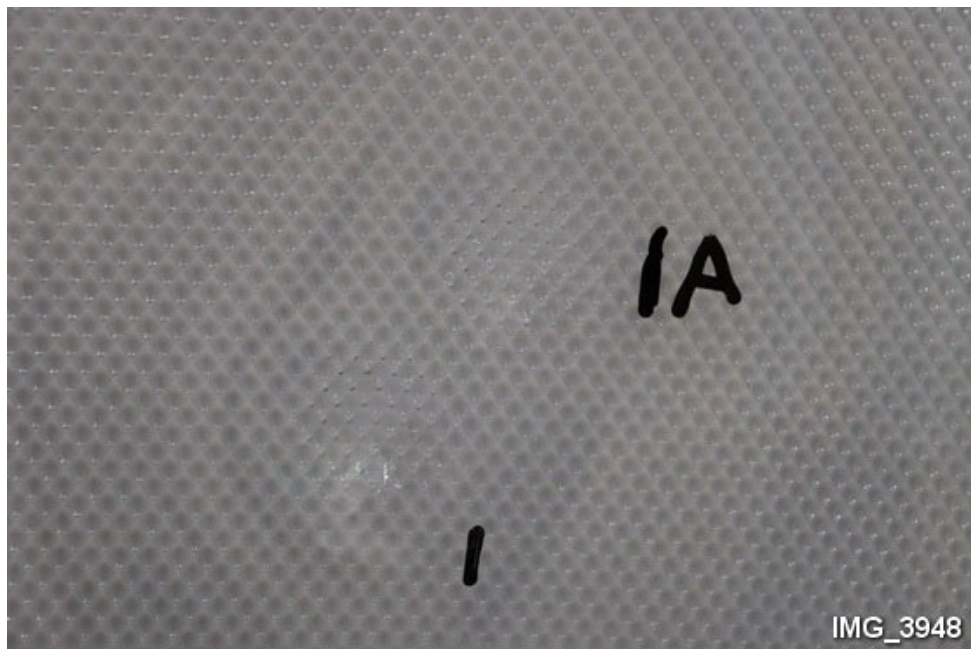


D20. Overview of Impact 1 with 4 inch ice ball. (Note impact caused dent.)

SunOptics Inc: Impact Testing
Lab Attachment D - 4-inch Ice Ball Impact Photographs
Haag File No. 51240066TX-196



D21. Close-up of area prior to Impact 1A.



D22. Overview of Impact 1A with 4 inch ice ball located about two inches from Impact 1.

End of Lab Report

