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CONTRACT TEST REPORT

CONTRACT TESTS FOR R-859 FIRE SUPPRESSION SYSTEM FOR SPECIAL HAZARDS

Prepared for:

Victaulic Company 4901 Kesslersville Road P.O. Box 31 Easton, PA 18044-0031

Project: 3031726

Class: 5560

Date of Approval:

Authorized by:

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Richard B. Dunne, Manager - Hydraulics Group

CONTRACT TESTS FOR R-859 FIRE SUPPRESSION SYSTEM FOR SPECIAL HAZARDS

from

VICTAULIC COMPANY 4901 KESSLERSVILLE ROAD P.O. BOX 31 EASTON, PA 18044-0031

I INTRODUCTION

- 1.1 Victaulic Company requested an examination of their R-859 fire suppression system with dual-fluid, nitrogen and water, in accordance with a modified version of the local application fire test protocol of UL 2127, *Inert Gas Clean Agent Extinguishing System Units*.
- 1.2 This report may be freely reproduced only in its entirety and without modification.
- 1.3 This report is limited to the examination of the R-859 fire suppression system described in Section II, in accordance with specific sections of the following standards, as described in Section III:

Title	Date
Underwriters Laboratories (UL) 2127 Inert Gas Clean Agent Extinguishing System Units	March 1999

II DESCRIPTION

- 2.1 The *R-859 Fire Suppression System for Special Hazards*, 2007, design, installation, operation, and maintenance manual, describes and illustrates the various system components, their installation, limitations, and necessary system maintenance. This manual is on file at FM Approvals under P.I. 3031726.
- 2.2 The Victaulic R-859 system is a dual-fluid system, which uses nitrogen and water to create fine water particles. The R-859 system is designed for the protection of special hazard applications. The system is used in total flooding hazards, which can be either normally occupied or unoccupied, as defined by NFPA 2001. The total flooding system is intended to protect enclosed special hazards, such as rooms or spaces involving Class A and Class B flammable liquids under UL 2127. It is suitable for applications where the cylinder ambient storage temperature is between 0 and 130 °F (-18 and 54 °C).
- 2.3 The R-859 water mist system consists of activation equipment, water and nitrogen supply components, discharge piping, and water mist nozzles.

2.4 System Activation

- 2.4.1 Activation occurs when the system's main control panel receives an electric signal from detection devices installed in the protected space. The main control panel for the R-859 system sends a signal to the Nitrogen Flow Control Module, which begins the flow of nitrogen to the protected space. When the nitrogen reaches 20 psi (1.4 bar), water flow is also initiated.
- 2.4.2 For systems servicing multiple zones, the fire detection signal is relayed from the system's main control panel to a Zone Control Module associated with the hazard area. This Zone Control Module includes a nitrogen flow control valve and a water supply control valve to direct and control the flow of nitrogen and water to the appropriate zone. The main control panel will simultaneously provide a signal to the Flow Control Panel, resulting in the flow of nitrogen and water to the initiating zone as described above.
- 2.4.3 The system may also be operated manually at the control panel.

2.5 Agent Supply

- 2.5.1 Following fire detection and system activation, the flow of nitrogen and water is initiated. As described previously, for multiple zoned systems, a nitrogen flow control valve and a water supply valve are included in the Zone Control Module to direct the agent flow to the appropriate zone.
- 2.5.2 A Gas Flow Control Needle Valve is included in the Flow Control Panel to regulate the nitrogen pressure. The inlet to the valve is connected to the main nitrogen gas supply at approximately 2500 psig (170 bar). Each zone is equipped with a separate pressure transducer, where the needle valve is also connected. The pressure transducer communicates with the needle valve, allowing the pressure to be regulated so that each nozzle in the affected zone operates at a nitrogen pressure approximately equal to 25 psi (1.7 bar). The systems are configured to flow 175 scfm (4.25 m³/min) of nitrogen per water mist nozzle.
- 2.5.3 Water is supplied from a municipal water source. The water mist nozzles operate at a water pressure equal to 1.0 psi (0.7 bar). The water supply piping includes a 100-mesh strainer to remove any large debris that could potentially block water flow through the water mist nozzles. A supervised water control valve is used to control the water supply to all fire zones. Additionally, A water flow control cartridge is included in close proximity to each nozzle to regulate the water flow to the nozzle to 1 gpm (3.8 lpm), regardless of the inlet pressure.

2.6 Discharge Piping and Emitters

- 2.6.1 The nitrogen and water are delivered in independent discharge piping to water mist nozzle(s).
- 2.6.2 The R-859 fire suppression system is installed with balanced piping configurations. The nitrogen supply lines are rated to 3000 psi (206.8 bar). This allows the pressure transducer to be installed at any emitter within the hazard area, to maintain a nitrogen discharge pressure of 25 psi (1.7 bar) at all emitters in each zone. Descriptions of balanced piping methods are included in the *R-859 Fire Suppression System for Special Hazards* manual.

2.6.3 Water flow at the emitter is controlled via the Flow Control Valve prior to the emitter's inlet, as described in Section 2.5.3. Nitrogen flow for each emitter is 175 scfm (4.25 m³/min), and the pressure is maintained at 25 psi (1.7 bar) by the Gas Flow Control Needle valve and pressure transducer described in Section 2.5.2. The nitrogen and water meet just before the emitter outlet, and water mist is produced when the two fluids exit the emitter.

III EXAMINATION AND TESTS

- 3.1 The product described in this report was examined and tested at Victaulic's facility in Stewartsville, NJ and witnessed by an FM Approvals Engineer. The following tests were conducted, at the request of Victaulic. All data remains on file at FM Approvals under P.I. 3031726, as well as other documents and correspondence applicable to this program.
- 3.2 A series of tests were conducted in accordance with UL 2127, Sections 34 and 35. All tests were conducted with R-859 fire suppression system using dual fluids (nitrogen and water).
- 3.3 The nozzle distribution verification tests were conducted in a minimum height and maximum height enclosure size. Whereas, the Class A and Class B fire tests were conducted in the maximum room height enclosure size. Pendant and sidewall nozzles were installed in both room enclosures, where the tests described in Sections 3.4, 3.5, and 3.6 of this report were conducted in each nozzle configuration.
- 3.4 The following tests were conducted as part of this examination

Test#	Height of O ₂ Measurement in. (mm)	Fuel	Nozzle Configuration ¹
1		Heptane in 8 Test Cups	Pendant ²
2	N/A	(Nozzle Distribution	Sidewall ²
3	1	Test)	Pendant
4		1050)	Sidewall
5	Measured at pan height		
6	(Pan) = 28		
7	(711)		
8	0.1 times height of enclosure	Hantono	Sidewall
9	(0.1H) = 15	Heptane	Sidewali
10	(381)		
11	0.5H=72 (1829)		
12	Dam=28		
13	Pan=28 (711)		
14	(/11)		
15	0.1H =15	Hantana	Pendant
16	1	Heptane	renuant
17	(381)		
18	0.5H=72 (1829)		

¹ Enclosure size is 20'x 20' x 12' high, unless noted otherwise.

Page 4 of 8

² Enclosure size is 17'x17'x8' high

Test#	Height of O ₂ Measurement in. (mm)	Fuel	Nozzle Configuration ¹
19	Bottom of Crib=28		
20	(711)		
21	(/11)		
22	0.1H =15	Wood Crib	Pendant
23	(381)	wood Crib	Pendant
24	(361)		
25	0.9H = 130		
26	(3302)		
27	Bottom of Crib =28		
28	(711)		
29	(/11)		
30	0.1H =15	Wood Crib	Sidewall
31	(381)	wood Crib	Sidewall
32	(381)		
33	0.9H = 130		
34	(3302)		
35			
36			Sidewall
37	17.5	Polypropylene	
38	(445)	rotypropytene	
39			Pendent
40			
41b			
42			Pendent
43	17.5	PMMA	
44	(445)	I IATIAILY	
45	_		Sidewall
46b			
47			
48	_		Sidewall
49	17.5	ABS	
50	(445)	ADS	
51			Pendent
52			

3.5 Nozzle Distribution Verification Tests

3.5.1. The Nozzle Distribution Verification Test was conducted in accordance with UL 2127, Section 35. Testing was conducted in two enclosure sizes. The first enclosure included the minimum room height, where one nozzle protected an enclosure of 17 x 17 x 8 ft. high (5.2 x 5.2 x 2.4 m), a coverage volume of 2312 ft³/nozzle (65.47 m³/nozzle). The second enclosure included the maximum room height, where two nozzles protected an enclosure of 20 x 20 x 12 ft. high, a coverage volume of 2400 ft³/nozzle (68 m³/nozzle).

- 3.5.2. The piping networks for both enclosures were installed as illustrated in Appendix A, Figure 1 and Figure 2. In the second enclosure, 20 x 20 x 12 ft. high (6.1 x 6.1 x 3.7 m), two pendant nozzles were centered in the room, spaced by 12 ft (3.7 m), and two sidewall nozzles, spaced by 10 ft. (3 m).
- 3.5.3. The test specifications of the Nozzle Distribution Verification Test, states that the extinguishing system shall extinguish all fires within 30 seconds after the end of discharge. The R-859 system is a pre-engineered system and did not have a predetermined discharge time, as outlined in UL 2127, Section 23 Discharge Test. Rather, during the Nozzle Distribution Verification Tests, the system was discharged until extinguishment.
- 3.5.4. Listed in Appendix B, Table B1 are the critical results for the Nozzle Distribution Tests.
- 3.6 Class A and B Fire Clean Agent Extinguishment Tests
 - 3.6.1. The R-859 fire suppression system was witnessed as a fire extinguishing system for use in Class A and B hazards, in accordance with UL 2127, Section 34. Testing was conducted in an enclosure with dimensions of 20 x 20 x 12 ft. high (6.0 x 6.1 x 3.7 m high). The total volume of the enclosure was 4800 ft³ (136 m³), as required by UL 2127.
 - 3.6.2. Various Class A (wood and plastics) and Class B (heptane) materials were used as test fuels. Specific details of the fire test scenarios, including pre-burn times and extinguishment criteria, are described in UL 2127.
 - 3.6.3. The system was configured to include a piping layout and nozzle arrangement as illustrated in Appendix A, Figure 2.
 - 3.6.4. Listed in Appendix B, Tables B2 through to Table B6, are the critical results for the Class A and B Fire Tests.
 - 3.6.5. The pressure and flow data measured at the emitters were consistent throughout all Class A and Class B fire tests, with the exception of the water pressure measurements. The calculated average water flow rate was 1.74 gpm (3.79 l/min), the average total nitrogen flow rate was 289 scfm, and the average nitrogen pressure was 24.1 psi (1.66 bar). The average water pressure was 0.92 psi (0.063 bar), where the average water pressure varied between 0.32 psi and 1.8 psi (0.022 and (0.124 bar). Typically the water pressure measured at the pendant nozzles had a consistent water pressure of 0.4 psi (0.028 bar), where the pressure measured at the sidewall nozzles was approximately 1.7 psi (0.117 bar). The storage containers were approximately 70 °F (21 °C) and the air temperature inside the test enclosure varied between 49-82°F (9-28°C) prior to each test.
 - 3.6.6. The percent of oxygen was continuously measured at the following elevations:
 - Class A, Polymeric Fuels: Fuel source
 - Class A, Wood Crib: Bottom of the wood crib, 0.1 and 0.9 times the height of the enclosure
 - Class B, Heptane: Test pan, 0.1 and 0.5 times the height of the enclosure
 - 3.6.7. Section 34.1.3.4. of UL 2127 requires that the agent extinguishing concentration for each test be 83.34 percent of the intended end use design concentration. This concentration was not specified during testing. Victaulic will calculate the required amount of nitrogen

needed to be discharged in an area which would cause the oxygen level to be reduced to 15%. The average oxygen concentration in the room at extinguishment varied between 12.5% to 16.45% for Polymeric Fuels, 14.9% to 16.2% for the Wood Crib fire tests, and 15.9% to 17.3% for Class B fire tests.

- 3.6.8. Section 34.2.3.8 of UL 2127 requires that the percent of oxygen within the enclosure at a level of the polymeric fuel source be within 0.5 units of the normal atmospheric conditions at the time of system discharge. Oxygen concentrations fall within this range and were deemed satisfactory.
- 3.6.9. Section 34.2.3.11 of UL 2127 requires that the weight loss of polymeric materials shall not exceed 15 grams between 10 seconds and 600 seconds after the end of discharge. The mass loss of Class A, Polymeric Fuel fires was continuously measured from ignition until 10 minutes after end of discharge. Refer to Appendix B, Table B6 for a summary of the mass loss data. The average mass loss data for the polypropylene and the ABS fuels were deemed satisfactory. The average mass loss data for PMMA exceeded the maximum permitted mass loss.

IV REMARKS

The testing described in this report does not meet the requirements of Underwriters Laboratories (UL) 2127 Standard *Inert Gas Clean Agent Extinguishing System Units or any* FM Approval Standard. This report does not constitute an FM Approval of the R-859 Fire Suppression System.

V CONCLUSION

The R-859 Fire Suppression System completed a modified version of UL 2127 test protocol for Class A and Class B fires. During the fire testing, the system successfully extinguished wood crib fires, heptane fires, and polymeric fires (Polypropylene, ABS, and PMMA).

EXAMINATION AND TESTING BY:

Angèle Morcos – FM Approvals
Victaulic Company Personnel
Underwriters Laboratories (UL) Personnel

PROJECT DATA RECORD:

3031726

ATTACHMENTS:

APPENDIX A – Room Enclosures
APPENDIX B – Summary of Results

REPORT BY:

REPORT REVIEWED BY:

Sum & Mad and M

Angèle Morcos Engineer

Hydraulics Section

Brian K. MacDonald
Technical Team Manager

Hydraulics Section

Appendix A: Room Enclosures

Appendix B: Summary of Results

Table B1: Nozzle Distribution Test

Nozzle Orientation (Number of Nozzles)	Enclosure Dimensions ft (m)	Start of Discharge (s)	Time to Extinguishment (s)	End of Discharge (s)
Pendant (1)	17 x 17 x 8 (5.2 x 5.2 x 2.4)	65	358	364
Sidewall (1)	17 x 17 x 8 (5.2 x 5.2 x 2.4)	69	334	346
Pendant (2)	20 x 20 x 12 (6.1 x 6.1 x 3.7)	163	405	419
Sidewall (2)	20 x 20 x 12 (6.1 x 6.1 x 3.7)	90	379	393

Table B2: Wood Crib Fire Extinguishment Tests – Pendant Configuration

Test	Extinguishment Time	O_2	Concen (%)			Avg. N ₂ Flow rate	Avg. N ₂ Pressure	Avg. H ₂ O Flow rate	$Avg.$ H_2O Pressure
	(s)	At Discharge	At Ext.	End of Soak	Atm.	(scfm)	(psi)	(gpm)	(psi)
Oxygen	Measurements Ta	ken at Crib	(H=28'	')					
19	175	20.86	16.81	16.02	20.87	288.1	24.4	1.7	0.4
20	199	20.87	16.37	15.29	20.85	287.5	24.4	1.7	0.4
21	221	20.86	15.91	15.54	20.87	282.8	23.8	1.9	0.5
Average	198.3	20.86	16.36	15.62	20.86	286.11	24.19	1.76	0.46
Oxygen	Measurements Ta	aken at 0.1H	I (15")						
22a	N/A	20.86	N/A	N/A	20.82	N/A	N/A	N/A	N/A
22b	249	20.69	15.26	16.16	20.69	284.0	23.9	1.6	0.4
23	300	20.89	14.46	15.29	20.89	284.9	23.7	1.7	0.4
24	225	20.90	15.65	14.98	20.89	283.4	23.8	1.7	0.4
Average	274.5	20.81	14.86	15.73	20.80	284.45	23.81	1.65	0.39
Oxyg	gen Measurements	s Taken at 0	.9H (13	0")					
25	236	20.72		15.31	20.78	284.3	23.9	1.7	0.4
26	213	20.72	16.07	15.15	20.82	285.0	23.9	1.6	0.4
Average	224.5	20.72	15.82	15.23	20.80	284.68	23.89	1.64	0.40

Table B3: Wood Crib Fire Extinguishment Tests - Sidewall Configuration

Test	Extinguishment Time	O ₂ (Concentra (%)	ation	Avg. N ₂ Flow rate	Avg. N ₂ Pressure	Avg. H ₂ O Flow rate	Avg. H ₂ O Pressure
	(Seconds)	At Discharge	At Ext.	End of Soak	(scfm)	(psi)	(gpm)	(psi)
Oxygen I	Measurements Tal	ken at Crib a	t 28"					
27	235	20.93	15.71	15.49	290.2	24.3	1.7	1.4
28	215	20.88	16.20	15.51	289.6	23.9	1.8	1.8
29	217	20.93	16.24	15.59	288.3	23.8	1.9	1.4
Average	222.3	20.91	16.05	15.53	289.34	24.00	1.81	1.53
Oxygen	Measurements Ta	aken at 0.1H	(15")					
30	211	20.93	16.17	15.14	291.04	24.13	1.81	1.26
31	228	20.85	15.70	15.58	290.8	24.2	1.8	1.1
32	230	20.90	15.78	15.70	290.1	24.3	1.8	1.2
Average	223.0	20.89	15.88	15.47	290.64	24.23	1.80	1.18
Oxygen	Measurements Ta	ken at 0.9H	(130'')					
33	208	20.62	16.22	15.29	288.9	24.0	1.8	1.2
34	194	20.77	16.62	15.41	289.8	24.1	1.8	1.2
Average	201.0	20.70	16.42	15.35	289.32	24.03	1.81	1.19

Table B4: Heptane Fire Extinguishment Tests – Pendant Configuration

	Extinguishment Time	O ₂ Concent (%)	ration	Weight of Gas	Avg. N ₂ Flow rate	Avg. N ₂ Pressure	Avg. H_2O Flow rate	Avg. H ₂ O Pressur e
	(s)	At Discharge	At Ext.	(kg)	(scfm)	(psi)	(gpm)	(psi)
Oxygen N	Measurements Tak	en at Pan Ho	eight at	28"				
12	132.0	20.9	16.3	20.8	287.9	24.4	1.6	0.5
13	129.0	21.0	16.4	20.3	287.1	24.5	1.7	0.5
14	115.0	20.8	16.9	17.4	276.8	23.6	1.7	0.5
Average	125.3	20.9	16.5	19.5	283.9	24.1	1.7	0.5
Oxygen	Measurements Ta	ken at 0.1H	(15")					
15	128.0	20.8	16.9	20.1	287.3	24.4	1.7	0.5
16	117.0	20.9	17.0	18.5	288.2	24.3	1.7	0.5
17	90.0	20.9	18.0	14.1	286.9	24.5	1.7	0.4
Average	111.7	20.8	17.3	17.6	287.5	24.4	1.7	0.5
Oxygen	Measurements Ta	ken at 0.5H	(72")					
Test 18	129.0	20.88	16.7	20.3	287.6	24.3	1.7	0.4

Table B5: Heptane Fire Extinguishment Tests – Sidewall Configuration

Test	Extinguishment Time (s)	O2 Concen (%)		Weight of Gas (kg)	Avg. N2 Flow rate (scfm)	Avg. N2 Pressure (psi)	Avg. H2O Flow rate	Avg. H2O Pressure
1030	(3)	Discharge	Ext.	(Kg)	(SCIII)	(psi)	(gpm)	(psi)
Oxygen M	Aeasurements Tak	en at Pan He	ight at 2	28''				
5	186.0	20.9	15.3	29.8	292.4	24.5	1.8	1.8
6	147.0	20.9	16.6	23.5	291.9	24.7	1.8	1.8
7	158.0	20.9	15.9	25.4	293.8	24.6	1.8	1.8
Average	163.7	20.9	15.9	26.2	292.7	24.6	1.8	1.8
Oxygen	Measurements Ta	aken at 0.1H	(15")					
8	129.0	20.9	16.7	20.6	291.7	24.4	1.8	1.6
9	148.0	20.9	16.2	23.6	291.3	24.4	1.8	1.6
10	152.0	20.9	16.0	24.4	293.2	24.6	1.8	1.7
Average	143.0	20.9	16.3	68.6	292.1	24.5	1.8	1.6
Oxygen	Measurements Ta	aken at 0.5H	(72")					
11	142.0	20.81	16.3	22.7	292.0	24.3	1.8	1.6

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221 13022.4 13018.9 3.5 20.78 20.83 16.36 229 13004.7 13003.9 0.8 20.55 20.56 16.40 229 13007.4 13003.6 3.8 20.74 20.75 16.19 229 13001.3 N/A #VALUE! 20.79 20.85 15.21 282 13031.3 N/A #VALUE! 20.83 20.81 15.21 283 1303.8 N/A #VALUE! 20.83 20.81 15.21 284 13178.3 13167.7 10.6 20.88 20.89 13.17 40 13095.2 13065.1 30.1 20.79 20.86 15.29 448 13178.3 13167.7 10.6 20.88 20.89 13.17 474 13005.3 13011 64.3 20.89 20.89 13.17 474 13005.4 13044.4 37.0 20.85 20.90 14.31 389 12627.8 12619.5 8.3 20.90 20.91 14.38 380 12687.8 12619.5 8.3 20.90 20.91 14.38 381 13268.5 13264.1 4.4 20.73 20.73 20.73 388 13264.1 4.4 20.73 20.73 13.94 387 13153.3 13149.6 3.7 20.88 20.87 12.70 388 20.89 20.89 14.31 389 13268.5 13264.1 4.4 20.73 20.73 13.94 387 13153.3 13149.6 3.7 20.88 20.86 13.72 378 20.80 20.80 13.72 378 20.80 20.80 13.72 378 20.80 20.80 13.72 378 20.80 20.90 14.31 389 13268.5 13264.1 4.4 20.73 20.73 13.94	Test#	Ext. Time No Visible Flames	Weight 10s after Discharge	Weight 600s after Discharge	Mass Loss (grams)	O ₂ @ Discharge		O ₂ @ 10 min. after xtinguishment	Avg. N2 Flow rate	Avg. N2 Pressure (psi)	Avg. H2O Flow rate (gpm)	Avg. H2O Pressure (psi)
221 13022.4 13018.9 3.5 20.78 20.83 16.36 226 12995.2 12988.1 7.1 20.88 20.55 16.40 227 13004.7 13003.6 3.8 20.55 20.56 16.40 228 13007.4 13003.6 3.8 20.74 20.75 16.19 229 13026.4 N/A	Polypropylene Pen	dent							SCFIM			
209 13004.7 13003.9 0.8 20.55 20.56 16.40 229 12095.2 12988.1 7.1 20.88 20.87 15.82 229 13007.4 13003.6 3.8 20.74 20.75 16.19 282 13031.3 N/A #VALUE! 20.90 20.91 15.21 283 13030.5 #DIY70! #VALUE! 20.83 20.81 15.21 284 13178.3 13167.7 10.6 20.88 20.89 12.76 444 13178.3 13167.7 10.6 20.88 20.89 12.76 445 13095.2 13065.1 30.1 20.79 20.76 12.53 457 13095.2 13065.1 30.1 64.3 20.89 20.89 12.76 474 13104.4 13101.6 2.8 20.87 20.90 14.31 331 13104.4 13101.6 2.8 20.87 20.90 14.38 332 12627.8 12619.5 8.3 20.90 20.90 14.38 333 1368.5 13264.1 44.4 20.73 20.73 13.94 336 13268.5 13264.1 44.4 20.73 20.73 13.72 337 13159.9 13230.7 13149.6 3.7 20.88 338 13268.5 13264.1 20.88 20.88 340 13299.9 13230.7 13330.7 341 3399 12637.7 22.88 20.88 20.88 342 3315.3 31349.6 3.7 20.88 20.88 343 340 340.7 340.7 340.8 344 340.8 340.8 340.8 345 340.8 340.8 340.8 347 340.8 340.8 340.8 348 340.8 340.8 340.8 340 340.8 340.8 340 340.8 340.8 340 340.8 340.8 340 340.8 340.8 340 340.8 340 340.8 340.8 340	38		13022.4	13018.9	3.5	20.78	20.83	16.36	289.75	24.38	1.59	0.44
1256 12995.2 12988.1 7.1 20.88 20.87 15.82 13007.4 13003.6 3.8 20.74 20.75 16.19 282 13031.3 N/A #VALUE! 20.90 20.91 15.21 283 13033.8 N/A #VALUE! 20.90 20.91 15.22 284 13033.8 N/A #VALUE! 20.83 20.81 15.21 424 13178.3 13167.7 10.6 20.84 20.86 15.25 445 13155.5 13144.9 10.6 20.88 20.89 13.17 470 13095.2 13065.1 30.1 20.79 20.85 12.94 487 13075.3 13011 64.3 20.88 20.89 12.94 474 13104.4 13101.6 2.8 20.87 20.90 14.31 331 13061.9 13049.3 12.6 20.96 20.90 14.38 330 12627.8 12619.5 8.3 20.90 20.90 14.38 331 13268.5 13264.1 4.4 20.73 20.73 13.94 331 1353.3 13149.6 3.7 20.86 20.86 13.72 332 1258.5 13264.1 4.4 20.73 20.73 13.72 333 1359.9 125.6 20.86 20.86 13.72 334 135.3 13149.6 3.7 20.86 20.86 13.72 335 125.85 13264.1 4.4 20.73 20.73 13.74 336 125.80 125.80 125.80 125.80 125.80 337 135.30 135.90 13.73 20.73 13.74 348 135.30 125.80 20.86 13.72 350 125.30 125.80 20.86 13.72 350 125.30 125.80 20.86 13.72 350 125.30 125.80 20.86 13.72 350 125.90 13.30 12.80 20.86 13.72 350 125.90 13.30 12.80 20.86 13.72 350 125.90 13.30 13.80 13.72 350 125.90 13.30 13.80 13.72 350 125.90 13.30 13.80 13.72 350 13.50 13.50 13.30 13.80 350 13.50 13.50 13.30 13.80 350 13.50 13.50 13.30 350 13.50 13.50 13.30 350 13.50 13.50 13.30 350 13.50 13.50 13.30 350 13.50 13.30 350 13.50 13.50 350 13.50 13.30 350 13.50 13.50 350 13.50 13.50 350 13.50 13.30 350 13.50 13.50 350 13.50 13.50 350 13.50 13.50 350 13.50 13.50 350 13.50 13.50 350 13.50 13.50 350 13.50 13.50 350 13.5	39	209	13004.7	13003.9	8.0	20.55	20.56	16.40	290.09	24.19	1.62	0.41
13007.4 13003.6 3.8 20.74 20.75 16.19 292 130264 N/A #VALUE 20.90 20.81 15.21 282 13031.3 N/A #VALUE 20.90 20.91 15.32 283 13033.8 N/A #VALUE 20.84 20.81 15.21 284 13030.5 #DIV/0! #YALUE 20.84 20.81 15.21 458 13274.2 13233.1 41.1 20.92 20.90 12.90 454 13178.3 13167.7 10.6 20.88 20.89 13.17 461 13155.5 13144.9 10.6 20.88 20.87 12.76 470 13095.2 13065.1 30.1 20.79 20.76 12.53 470 13095.2 13065.1 30.1 20.79 20.85 13.39 474 13075.3 13101.6 2.8 20.89 20.85 12.87 475 13077.3 13044.4 37.0 20.85 20.90 14.31 331 13061.9 13049.3 12.6 20.91 14.38 330 12627.8 12619.5 8.3 20.90 20.90 14.06 331 13268.5 13264.1 4.4 20.73 20.73 13.94 332 13153.3 13149.6 3.7 20.88 20.85 13.72 332 13506.5 132037.1 20.88 20.85 13.25 332 13153.3 13149.6 3.7 20.88 20.85 332 13506.5 132037.1 20.88 20.85 13.72 333 13506.5 13264.1 4.4 20.73 20.73 13.94 334 13268.5 13264.1 20.8 20.86 13.72 335 13506.5 132037.1 20.8 20.86 13.72 336 13209.5 13203.7 20.8 20.86 13.72 337 13506.5 13264.1 20.8 20.86 13.72 337 13506.5 13264.1 20.8 20.86 20.86 337 337 337 337 20.3 20.88 338 13268.5 13264.1 20.8 20.86 20.86 337 337 337 337 337 338	40	256	12995.2	12988.1	7.1	20.88	20.87	15.82	290.66	24.23	1.63	0.42
130264 N/A #VALUE! 20.79 20.85 15.21 282 13031.3 N/A #VALUE! 20.90 20.91 15.32 283 13033.8 N/A #VALUE! 20.83 20.81 15.21 286 13030.5 #DIVO! #VALUE! 20.84 20.86 15.25 458 13274.2 13233.1 41.1 20.92 20.90 12.90 458 13274.2 13233.1 41.1 20.92 20.90 12.90 448 13155.5 13144.9 10.6 20.88 20.89 448 13502.7 13181.9 20.8 20.89 450 13095.2 13065.1 30.1 20.79 20.76 20.79 20.85 13.94 470 13095.2 13065.1 30.1 20.79 20.85 470 13095.2 13064.4 37.0 20.89 20.85 470 13095.2 13064.4 37.0 20.89 20.89 470 13095.2 13064.4 37.0 20.89 20.89 470 13081.4 13101.6 2.8 20.89 20.90 471 13104.4 13101.6 2.8 20.90 472 13768.5 13264.1 4.4 20.73 20.73 473 13268.5 13264.1 4.4 20.73 20.73 474 13299.5 13273.7 20.80 475 13299.5 476 13299.5 477 13299.5 478 13299.5 479 13299.5 470 1411 470 1411 470 1411 47	Average	229	13007.4	13003.6	3.8	20.74	20.75	16.19	290.17	24.26	1971	0.42
292 130264 N/A #VALUEI 20.79 20.85 15.21 20.2 13031.3 N/A #VALUEI 20.90 20.91 15.22 20.81 1303.8 N/A #VALUEI 20.84 20.86 15.22 20.81 15.21 20.82 20.81 15.21 20.82 20.81 15.22 20.84 20.86 15.25 20.84 20.86 15.25 20.84 20.86 15.25 20.84 20.87 20.84 20.87 20.84 20.87 20.84 20.87 20.84 20.87 20.84 20.87 20.84 20.87 20.84 20.87 20.84 20.87 20.84 20.87 20.84 20.87	Polypropylene Side		,			1	(•	•	,	
282 13031.3 N/A #VALUE! 20.90 20.91 15.32 283 13033.8 N/A #VALUE! 20.83 20.81 15.21 286 13030.5 #DIVO! #VALUE! 20.84 20.86 15.25 458 13274.2 13233.1 41.1 20.92 20.90 12.90 424 13178.3 13167.7 10.6 20.88 20.89 13.17 448 13202.7 13181.9 20.8 20.89 12.76 13095.2 13065.1 30.1 20.79 20.76 12.53 457 13095.2 13065.1 30.1 20.79 20.86 13.39 457 13095.2 13064.4 37.0 20.89 20.85 13.39 13061.9 13049.3 12.6 20.89 20.80 14.31 331 13104.4 13101.6 2.8 20.87 20.90 14.31 336 12627.8 12619.5 8.3 20.90 20.90 14.38 350 12931.4 12923.5 7.9 20.73 20.73 13.74 387 13156.3 13149.6 3.7 20.88 20.86 13.72 31 13299.9 13277.1 22.8 20.86 20.81 311 13299.9 13277.1 22.8 20.80 20.80 13.72	35	292	13026.4	N/A	#VALUE!	20.79	20.85	15.21	292.36	24.04	1.88	1.10
283 13033.8 N/A #VALUE! 20.83 20.81 15.21 286 13030.5 #DIYOO! #FALUE! 20.84 20.86 15.25 458 13274.2 13233.1 41.1 20.92 20.90 12.90 424 13178.3 13167.7 10.6 20.88 20.89 13.17 440 13105.5 13144.9 10.6 20.88 20.87 12.76 451 13105.3 13011 64.3 20.89 20.85 13.39 496 13075.3 13011 64.3 20.89 20.85 13.39 496 13075.3 13011 64.3 20.89 20.85 13.39 474 13081.4 13044.4 37.0 20.85 20.80 14.31 331 13104.4 13101.6 2.8 20.90 20.90 14.31 389 12627.8 12619.5 8.3 20.90 20.90 14.38 350 12931.4 12923.5 7.9 20.73 20.73 13.94 381 13268.5 13264.1 4.4 20.73 20.87 14.11 387 13153.3 13149.6 3.77 20.80 20.80 13.72 378 13299.9 13277.1 22.8 20.86 20.85 13.72	36	282	13031.3	N/A	#VALUE!	20.90	20.91	15.32	296.46	24.41	1.86	1.12
286 13030.5 #DIV/O! #YALIUE! 20.84 20.86 15.25 458 13274.2 13233.1 41.1 20.92 20.90 12.90 424 13178.3 13167.7 10.6 20.88 20.89 13.17 461 13155.5 13144.9 10.6 20.88 20.87 12.76 448 13202.7 13181.9 20.8 20.89 20.89 12.94 457 13095.2 13065.1 30.1 20.79 20.89 12.94 457 13075.3 13011 64.3 20.89 20.89 12.94 474 13075.3 13044.4 37.0 20.89 20.85 12.87 474 13081.4 13044.4 37.0 20.85 20.82 12.87 389 12657.8 12619.5 8.3 20.90 20.90 14.38 350 12931.4 12923.5 7.9 20.91 20.90 14.06 387 132564.1 <td>37</td> <td>283</td> <td>13033.8</td> <td>N/A</td> <td>#VALUE!</td> <td>20.83</td> <td>20.81</td> <td>15.21</td> <td>296.35</td> <td>24.44</td> <td>1.88</td> <td>1.26</td>	37	283	13033.8	N/A	#VALUE!	20.83	20.81	15.21	296.35	24.44	1.88	1.26
458 13274.2 13233.1 41.1 20.92 20.90 12.90 424 13178.3 13167.7 10.6 20.88 20.89 13.17 461 13155.5 13144.9 10.6 20.88 20.89 12.08 448 13202.7 13181.9 20.8 20.89 20.89 12.94 470 13095.2 13065.1 30.1 20.79 20.76 12.53 457 13075.3 13011 64.3 20.89 20.84 12.70 474 13081.4 13044.4 37.0 20.85 20.84 12.70 474 13081.4 13044.4 37.0 20.85 20.82 12.87 331 13104.4 13101.6 2.8 20.90 20.90 14.31 350 12627.8 12619.5 8.3 20.90 20.90 14.06 381 13268.5 13264.1 4.4 20.73 20.91 14.06 387 13153.3 13149.6 3.7 20.86 20.86 20.86 13.77	Average	286	13030.5	#DIV/0!	#VALUE!	20.84	20.86	15.25	295.06	24.30	1.87	1.16
458 13274.2 13233.1 41.1 20.92 20.90 12.90 461 13155.5 13144.9 10.6 20.88 20.87 12.76 448 13202.7 13181.9 20.8 20.89 13.17 13095.2 13065.1 30.1 20.79 20.76 12.53 457 13075.3 13011 64.3 20.89 20.85 13.39 496 13073.8 13057.2 16.6 20.88 20.84 12.70 474 13081.4 13101.6 2.8 20.87 20.90 14.31 331 13104.4 13101.6 2.8 20.90 20.90 14.31 339 12627.8 12619.5 8.3 20.90 20.90 13.48 330 12637.8 12649.5 8.3 20.90 20.90 14.38 331 13268.5 13264.1 4.4 20.73 20.87 14.11 381 13268.5 13264.1 4.4 20.73 20.86 13.70 335 13149.6 3.7 20.86 20.81 13.72 336 12529.9 13277.1 22.8 20.86 20.86 13.72	PMMA Pendent											
424 13178.3 13167.7 10.6 20.88 20.89 13.17 461 13155.5 13144.9 10.6 20.88 20.87 12.76 448 13202.7 13181.9 20.8 20.89 12.94 1202.7 13181.9 20.8 20.89 12.94 13075.3 13011 64.3 20.89 20.85 13.39 13075.3 13011 64.3 20.89 20.85 13.39 13081.4 13087.2 16.6 20.88 20.84 12.70 13081.4 13084.4 37.0 20.89 20.85 12.87 13104.4 13101.6 2.8 20.87 20.90 14.31 13104.4 13101.6 2.8 20.90 20.90 14.31 13061.9 13049.3 12.6 20.90 20.90 14.38 1350 12627.8 12619.5 8.3 20.90 20.90 14.38 1361 13268.5 13264.1 4.4 20.73 20.73 13.94 1315.3 13149.6 3.7 20.86 20.86 13.72 13299.5 13277.1 22.8 20.86 20.86 13.72 13299.5 13277.1 22.8 20.86 20.86 13.72	41b	458	13274.2	13233.1	41.1	20.92	20.90	12.90	288.97	23.66	1.59	0.38
461 13155.5 13144.9 10.6 20.88 20.87 12.76 448 13202.7 13181.9 20.8 20.89 20.89 12.94 448 13202.7 13065.1 30.1 20.79 20.76 12.53 450 13075.3 13011 64.3 20.89 20.85 13.39 457 13075.3 13074.4 37.0 20.85 20.84 12.70 474 13081.4 13044.4 37.0 20.85 20.87 12.87 331 13104.4 13101.6 2.8 20.87 20.90 14.31 389 12627.8 12619.5 8.3 20.90 20.90 14.38 350 12931.4 12923.5 7.9 20.91 14.38 361 1358.5 13264.1 4.4 20.73 20.90 14.06 375 1359.9 13274.1 20.86 20.87 14.11 361 13299.9 13230.3 10.3 20.85 13.72 378 13330.3 13330.3 10.3	42	424	13178.3	13167.7	9.01	20.88	20.89	13.17	291.65	24.10	1.61	0.32
vall 448 13202.7 13181.9 20.8 20.89 20.89 12.94 vall 470 13095.2 13065.1 30.1 20.79 20.76 12.53 457 13075.3 13011 64.3 20.89 20.85 13.39 496 13073.8 13057.2 16.6 20.88 20.84 12.70 474 13081.4 13044.4 37.0 20.85 20.84 12.70 474 13081.4 13101.6 2.8 20.85 20.82 12.87 331 13104.4 13101.6 2.8 20.87 20.90 14.31 389 12627.8 12619.5 8.3 20.90 20.91 14.06 350 12931.4 12923.5 7.9 20.91 20.91 14.06 381 13268.5 13264.1 4.4 20.73 20.73 13.94 387 13153.3 13149.6 3.7 20.86 20.86 13.72 361 13299.9 13277.1 22.8 20.86 20.86 20.86 <t< td=""><td>43</td><td>461</td><td>13155.5</td><td>13144.9</td><td>9.01</td><td>20.88</td><td>20.87</td><td>12.76</td><td>259.97</td><td>21.27</td><td>1.50</td><td>0.34</td></t<>	43	461	13155.5	13144.9	9.01	20.88	20.87	12.76	259.97	21.27	1.50	0.34
470 13095.2 13065.1 30.1 20.79 20.76 12.53 457 13075.3 13011 64.3 20.89 20.85 13.39 496 13073.8 13057.2 16.6 20.88 20.84 12.70 474 13081.4 13044.4 37.0 20.85 20.87 12.87 331 13104.4 13101.6 2.8 20.87 20.90 14.31 389 12677.8 12619.5 8.3 20.90 20.90 14.38 331 13061.9 13049.3 12.6 20.91 14.38 350 12931.4 12923.5 7.9 20.73 20.90 14.06 387 13158.5 13264.1 4.4 20.73 20.87 14.11 361 13229.9 13277.1 22.8 20.86 20.86 13.72 361 13299.9 13277.1 22.8 20.86 20.86 13.72 362 13230.3 10.3 20.87 14.11	Average	448	13202.7	13181.9	20.8	20.89	20.89	12.94	280.19	23.01	1.57	0.35
470 13095.2 13065.1 30.1 20.79 20.76 12.53 457 13075.3 13011 64.3 20.89 20.85 13.39 496 13073.8 13057.2 16.6 20.88 20.84 12.70 474 13081.4 13044.4 37.0 20.85 20.87 12.87 331 13104.4 13101.6 2.8 20.87 20.90 14.31 389 12627.8 12619.5 8.3 20.90 20.90 14.38 331 13061.9 13049.3 12.6 20.96 20.91 14.38 350 12931.4 12923.5 7.9 20.91 20.90 14.06 381 13264.1 4.4 20.73 20.90 14.06 387 13153.3 13149.6 3.7 20.86 20.85 13.72 361 13299.9 13277.1 22.8 20.86 20.86 13.72 361 13290.6 13.333 10.3 20.85 20.87 14.11	PMMA Sidewall											
457 13075.3 13011 64.3 20.89 20.85 13.39 496 13073.8 13057.2 16.6 20.88 20.84 12.70 474 13081.4 13044.4 37.0 20.85 20.84 12.77 331 13104.4 13101.6 2.8 20.87 20.90 14.31 389 12627.8 12619.5 8.3 20.90 20.90 13.48 331 13061.9 13049.3 12.6 20.96 20.91 14.38 350 12931.4 12923.5 7.9 20.91 20.90 14.06 387 13268.5 13264.1 4.4 20.73 20.73 20.73 13.94 387 13153.3 13149.6 3.7 20.86 20.86 13.72 376 13299.9 13230.3 10.3 20.87 14.11	44	470	13095.2	13065.1	30.1	20.79	20.76	12.53	292.92	23.68	1.78	1.00
496 13073.8 13057.2 16.6 20.88 20.84 12.70 474 13081.4 13044.4 37.0 20.85 20.87 12.87 331 13104.4 13101.6 2.8 20.87 20.90 14.31 389 12627.8 12619.5 8.3 20.90 20.90 13.48 331 13061.9 13049.3 12.6 20.96 20.91 14.38 350 12931.4 12923.5 7.9 20.91 20.90 14.06 381 13268.5 13264.1 4.4 20.73 20.97 14.10 387 13153.3 13149.6 3.7 20.86 20.86 13.72 361 13299.9 13277.1 22.8 20.86 20.86 13.72 375 13230.3 10.3 20.87 14.11	45	457	13075.3	13011	64.3	20.89	20.85	13.39	291.02	23.54	1.91	1.74
474 13081.4 13044.4 37.0 20.85 20.82 12.87 331 13104.4 13101.6 2.8 20.87 20.90 14.31 389 12627.8 12619.5 8.3 20.90 20.90 13.48 331 13061.9 13049.3 12.6 20.96 20.91 14.38 350 12931.4 12923.5 7.9 20.91 20.90 14.06 381 13268.5 13264.1 4.4 20.73 20.73 13.94 387 13153.3 13149.6 3.7 20.86 20.86 13.72 361 13299.9 13277.1 22.8 20.86 20.86 13.72 376 13230.3 10.3 20.87 14.11	46b	496	13073.8	13057.2	16.6	20.88	20.84	12.70	289.80	23.64	1.92	1.65
331 13104.4 13101.6 2.8 20.87 20.90 14.31 389 12627.8 12619.5 8.3 20.90 20.90 13.48 331 13061.9 13049.3 12.6 20.91 14.38 350 12931.4 12923.5 7.9 20.91 20.90 14.06 381 13268.5 13264.1 4.4 20.73 20.73 13.94 387 13153.3 13149.6 3.7 20.86 20.86 13.72 361 13299.9 13277.1 22.8 20.86 20.86 13.72	Average	474	13081.4	13044.4	37.0	20.85	20.82	12.87	291.25	23.62	1.87	1.46
331 13104.4 13101.6 2.8 20.87 20.90 14.31 389 1267.8 12619.5 8.3 20.90 20.90 13.48 331 13061.9 13049.3 12.6 20.96 20.91 14.38 350 12931.4 12923.5 7.9 20.91 20.90 14.06 381 13268.5 13264.1 4.4 20.73 20.73 13.94 387 13153.3 13149.6 3.7 20.86 20.86 13.72 361 13299.9 13277.1 22.8 20.86 20.86 13.72 375 13230.3 10.3 20.87 14.11	ABS Pendent											
389 12619.5 8.3 20.90 20.90 13.48 331 13061.9 13049.3 12.6 20.96 20.91 14.38 350 12931.4 12923.5 7.9 20.91 14.06 381 13268.5 13264.1 4.4 20.73 20.73 13.94 387 13153.3 13149.6 3.7 20.86 20.86 14.11 361 13299.9 13277.1 22.8 20.86 20.86 13.72 375 13230.3 10.3 20.87 14.11	50	331	13104.4	13101.6	2.8	20.87	20.90	14.31	285.75	24.27	1.69	0.41
331 13061.9 13049.3 12.6 20.96 20.91 14.38 350 12931.4 12923.5 7.9 20.91 20.90 14.06 381 13268.5 13264.1 4.4 20.73 20.73 13.94 387 13153.3 13149.6 3.7 20.88 20.87 14.11 361 13299.9 13277.1 22.8 20.86 13.72 376 13330.3 10.3 20.82 13.30	51	389	12627.8	12619.5	8.3	20.90	20.90	13.48	288.01	24.18	1.61	0.40
381 13268.5 13264.1 4.4 20.73 20.73 13.94 387 13153.3 13149.6 3.7 20.86 20.86 13.72 361 13299.9 13277.1 22.8 20.86 13.72	52	331	13061.9	13049.3	12.6	20.96	20.91	14.38	286.61	23.94	1.64	0.40
381 13268.5 13264.1 4.4 20.73 20.73 13.94 387 13153.3 13149.6 3.7 20.88 20.87 14.11 361 13299.9 13277.1 22.8 20.86 13.72 375 1330.3 10.3 20.82 13.02	Average	350	12931.4	12923.5	2.9	20.91	20.90	14.06	286.79	24.13	1.65	0.40
381 13268.5 13264.1 4.4 20.73 20.73 13.94 387 13153.3 13149.6 3.7 20.88 20.87 14.11 361 13299.9 13277.1 22.8 20.86 20.86 13.72 376 13240.6 13230.3 10.3 20.82 13.02	ABS Sidewall											
387 13153.3 13149.6 3.7 20.88 20.87 14.11 361 13299.9 13277.1 22.8 20.86 20.86 13.72 276 13240.6 13230.3 10.3 20.82 20.82 13.02	47	381	13268.5	13264.1	4.4	20.73	20.73	13.94	292.91	24.16	1.81	1.37
361 13299.9 13277.1 22.8 20.86 20.86 13.72	48	387	13153.3	13149.6	3.7	20.88	20.87	14.11	292.72	24.07	1.80	1.30
376 13340 6 13330 3 103 3083 1303	49	361	13299.9	13277.1	22.8	20.86	20.86	13.72	291.08	23.92	1.72	0.94
3/0 13240.0 13230.3 10.3 20.02 20.02	Average	376	13240.6	13230.3	10.3	20.82	20.82	13.92	292.23	24.05	1.78	1.20