Material Testing Report

MAT6128

ISOGLASS H 30 CGF S HS BK1

Prepared for:

SIRMAX SPA

VIA DELL'ARTIGIANATO 42

CITTADELLA, IT 35013

Italy

Prepared by:

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Prepared on:

11 May, 2017

Report Created By:

Juliah Lai

Material Technician

11 May, 2017

Contents

Summary

Description

Family name	POLYPROPYLENES (PP)
Trade name	ISOGLASS H 30 CGF S HS BK1
Manufacturer	Sirmax SpA
Family abbreviation	PP
Material structure	Crystalline
Data source	Autodesk Moldflow Plastics Labs : pvT-Measured : mech-Measured
Date last modified	11-MAY-17
Date tested	11-MAY-17
Data status	Non-Confidential
Material ID	24419
Grade code	MAT6128
Supplier code	SIRMAX
Fibers/fillers	30% Glass Fiber Filled

Recommended Processing

Mold surface temperature	40	°C
Melt temperature	235	°C

Mold temperature range (recommended)		
Minimum	20	°C
Maximum	60	°C

Melt temperature range (recommended)		
Minimum	210	°C
Maximum	260	°C

Absolute maximum melt temperature	290	°C

Ejection temperature	110	°C

Maximum shear stress	0.25	MPa
Maximum shear rate	100000	1/s

Maximum shear stress and maximum shear rate values have been supplemented with generic estimates.

Rheological Properties

Cross WLF Viscosity Model		
n	0.29655	
Tau	2960.57	Pa
D1	4.69171e+017	Pa-s
D2	263.15	K
D3	0	K/Pa
A1	33.246	
A2	51.600	K

Juncture loss method coefficients		
C1	0.03849	Pa^(1-c2)
C2	1.528	

Transition temperature		
Ttrans	120	°C

Moldflow Viscosity Index	VI(240)105	

Melt mass-flow rate (MFR)		
Temperature	230	°C
Load	5.00	Kg
Measured MFR	5.0	g/10min

Thermal Properties

Specific heat data		
Temperature (T) °C	Specific heat (Cp) J/Kg-°C	Heating/Cooling rate °C/s
6	1307.8	-0.33
20	1386.2	-0.33
50	1591.3	-0.33
80	1748.6	-0.33
100	1967.8	-0.33
105	2100.2	-0.33
108	2480.5	-0.33
110	3481.8	-0.33
113	7318.6	-0.33
116	12588.0	-0.33
119	5059.6	-0.33
120	3290.2	-0.33
121	2488.4	-0.33
123	2024.9	-0.33
128	1957.1	-0.33
150	2020.3	-0.33
180	2098.0	-0.33
210	2168.4	-0.33
250	2266.4	-0.33
260	2275.3	-0.33

Thermal conductivity data		
Temperature (T) °C	Thermal conductivity (k) W/m-°C	Heating/Cooling rate °C/s
256.100	1.839000e-01	0.0
236.600	1.813000e-01	0.0
217.200	1.817000e-01	0.0
198.200	1.839000e-01	0.0
179.100	1.852000e-01	0.0
159.400	1.851000e-01	0.0
140.370	2.211000e-01	0.0
119.800	2.259000e-01	0.0
99.800	2.292000e-01	0.0
79.833	2.309000e-01	0.0
59.800	2.308000e-01	0.0
39.800	2.297000e-01	0.0
29.800	2.303000e-01	0.0

PVT Properties

Melt density	0.9455	g/cm^3
Solid density	1.1445	g/cm^3

2-domain Tait PVT model coefficients		
b5	437.15	K
b6	7.200e-008	K/Pa
b1m	0.001008	m^3/Kg
b2m	7.028e-007	m^3/Kg-K
b3m	1.04073e+008	Pa
b4m	0.005848	1/K
b1s	0.000914	m^3/Kg
b2s	2.868e-007	m^3/Kg-K
b3s	2.39008e+008	Pa
b4s	0.004382	1/K
b7	0.000094	m^3/Kg
b8	0.061133	1/K
b9	8.856e-009	1/Pa

Mechanical Properties

Mechanical properties data		
Elastic modulus, 1st principal direction [E1]	4862.00	MPa
Elastic modulus, 2nd principal direction [E2]	4024.87	MPa
Poisson's ratio [v12]	0.3980	
Poisson's ratio [v23]	0.4180	
Shear modulus [G12]	1419	MPa

Transversely isotropic coefficient of thermal expansion [CTE] data		
Alpha1	4.200e-005	1/°C
Alpha2	6.480e-005	1/°C

Shrinkage Properties

Corrected residual in-mold stress (CRIMS) model coefficients	
A1	0.828293
A2	0.028728
A3	0.000752
A4	0.619646
A5	-0.05764
A6	0.008548

Residual strain model coefficients		
	Parallel	Perpendicular
A1	0.006016	0.14464
A2	-0.000071	0.000449
A3	-0.000085	0.000134
A4	3.0706e-008	3.482e-007
A5	0.001167	0.003422

The shrinkage models shown above are valid for Autodesk Simulation Moldflow Insight 2017. Shrinkage models for previous software versions are included in the 21000.udb file.

Filler Properties

Filler data	
Description	Weight %
Glass Fiber	30

Viscosity

Method:
AMPL Viscosity Test Method (QOP-14-M)

Instrument:
Arburg Allrounder 270S Injection Molding Machine

Test Specifications:

Sample Form:		Granules
Pre-Processing:		Dried at 70°C for 1 hours in a hopper dryer
Moisture Level:		0.02 %
Capillary A:	Length:	32.0097 mm
	L/D:	16.00485
	Die Entry Angle:	90 degrees
Capillary B:	Length:	7.9688 mm
	L/D:	3.9844
	Die Entry Angle:	90 degrees
Barrel Diameter:		30 mm
Plastication Time:		20 sec
Dwell Time:		20 sec
Corrections:		Bagley, Rabinowitsch and shear heating
Date Received:		03-APR-17
Date Tested:		27-APR-17

Operator's Notes:
Testing was performed per standard testing procedures.
No anomalies were noted during the course of testing.

Apparent Viscosity Data

Temperature (°C)	Apparent Shear Rate (sec^{-1})	Apparent Viscosity (Pa-s)	Die Diameter (mm)	Die L/D (-)
198.7	203	594.21	2.00	16.00
198.9	301	463.82	2.00	16.00
199.9	765	241.61	2.00	16.00
200.8	1357	160.37	2.00	16.00
202.3	2536	103.96	2.00	16.00
204.9	6464	55.70	2.00	16.00
207.3	12584	37.29	2.00	16.00
208.7	60116	13.38	2.00	16.00
209.1	25179	24.57	2.00	16.00
219.1	205	509.77	2.00	16.00
219.2	319	379.71	2.00	16.00
220.1	793	201.97	2.00	16.00
220.8	1347	140.56	2.00	16.00
222.0	2571	89.21	2.00	16.00
224.1	6472	45.80	2.00	16.00
225.7	12500	29.59	2.00	16.00
226.6	63730	11.16	2.00	16.00
227.0	25313	18.97	2.00	16.00
239.3	220	414.91	2.00	16.00
239.4	318	335.00	2.00	16.00
240.1	786	181.39	2.00	16.00
240.7	1317	128.84	2.00	16.00
241.8	2589	79.66	2.00	16.00
243.5	6361	41.58	2.00	16.00
244.8	12608	25.42	2.00	16.00
245.7	63380	9.12	2.00	16.00
245.9	25321	15.86	2.00	16.00
259.4	200	405.27	2.00	16.00
259.6	318	299.03	2.00	16.00
260.3	759	169.15	2.00	16.00
260.8	1339	114.04	2.00	16.00
261.7	2536	74.09	2.00	16.00
263.1	6394	37.91	2.00	16.00
264.3	12582	23.18	2.00	16.00
265.2	25257	14.17	2.00	16.00
265.2	62622	7.97	2.00	16.00
195.0	203	1010.17	2.00	3.98
195.5	301	804.88	2.00	3.98
197.0	765	432.60	2.00	3.98
198.6	1357	290.24	2.00	3.98
201.0	2536	192.07	2.00	3.98
205.2	6464	103.82	2.00	3.98
207.7	12584	71.19	2.00	3.98

Temperature (°C)	Apparent Shear Rate (sec^{-1})	Apparent Viscosity (Pa-s)	Die Diameter (mm)	Die L/D (-)
207.7	60116	29.94	2.00	3.98
209.1	25179	47.93	2.00	3.98
217.0	205	847.86	2.00	3.98
217.1	319	647.93	2.00	3.98
218.0	793	357.44	2.00	3.98
219.0	1347	251.63	2.00	3.98
221.1	2571	162.49	2.00	3.98
224.1	6472	86.99	2.00	3.98
225.9	12500	58.10	2.00	3.98
226.3	63730	23.38	2.00	3.98
227.2	25313	38.83	2.00	3.98
238.0	220	664.90	2.00	3.98
238.1	318	551.85	2.00	3.98
238.7	786	311.91	2.00	3.98
239.6	1317	225.33	2.00	3.98
241.3	2589	142.63	2.00	3.98
243.9	6361	77.79	2.00	3.98
245.4	12608	49.72	2.00	3.98
245.7	63380	19.74	2.00	3.98
246.2	25321	32.64	2.00	3.98
258.9	200	641.93	2.00	3.98
258.9	318	484.68	2.00	3.98
259.6	759	286.96	2.00	3.98
260.3	1339	198.15	2.00	3.98
261.8	2536	129.67	2.00	3.98
264.0	6394	69.68	2.00	3.98
265.3	12582	44.37	2.00	3.98
265.4	62622	17.42	2.00	3.98
265.8	25257	28.77	2.00	3.98

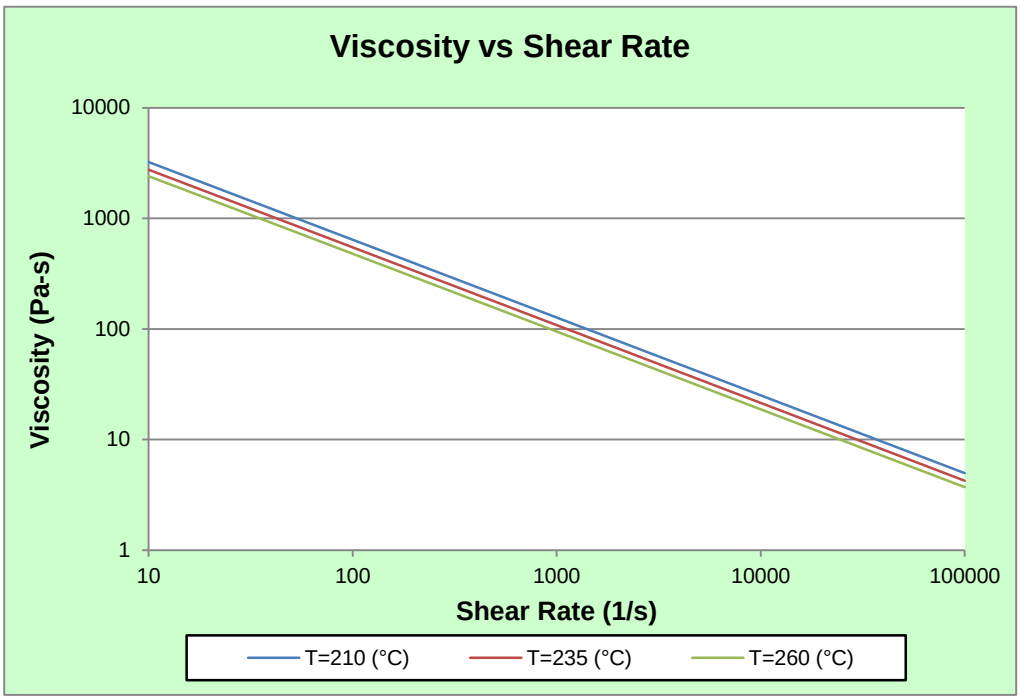
Calculated Viscosity		
Temperature (°C)	Shear Rate (sec)	Calculated Viscosity (Pa-s)
195.0	203	434.90
195.5	301	328.16
197.0	765	168.32
198.6	1357	111.19
198.7	203	422.81
198.9	301	319.86
199.9	765	164.74
200.8	1357	109.40
201.0	2536	70.37
202.3	2536	69.70
204.9	6464	35.40
205.2	6464	35.34
207.3	12584	21.79
207.7	12584	21.73
207.7	60116	7.23
208.7	60116	7.18
209.1	25179	13.21
209.1	25179	13.21
217.0	205	369.46
217.1	319	270.64
218.0	793	141.63
219.0	1347	96.97
219.1	205	364.53
219.2	319	266.86
220.1	793	139.78
220.8	1347	95.89
221.1	2571	60.74
222.0	2571	60.38
224.1	6472	31.12
224.1	6472	31.12
225.7	12500	19.39
225.9	12500	19.37
226.3	63730	6.14
226.6	63730	6.13
227.0	25313	11.71
227.2	25313	11.70
238.0	220	309.24
238.1	318	238.39
238.7	786	125.77
239.3	220	306.95
239.4	318	236.54
239.6	1317	87.04
240.1	786	124.77
240.7	1317	86.50

Temperature (°C)	Shear Rate (sec)	Calculated Viscosity (Pa-s)
241.3	2589	53.58
241.8	2589	53.44
243.5	6361	28.13
243.9	6361	28.06
244.8	12608	17.26
245.4	12608	17.21
245.7	63380	5.52
245.7	63380	5.52
245.9	25321	10.50
246.2	25321	10.49
258.9	318	213.67
258.9	200	295.70
259.4	200	294.96
259.6	318	212.96
259.6	759	115.46
260.3	759	115.07
260.3	1339	77.15
260.8	1339	76.99
261.7	2536	48.91
261.8	2536	48.87
263.1	6394	25.34
264.0	6394	25.23
264.3	12582	15.65
265.2	62622	5.04
265.2	25257	9.54
265.3	12582	15.58
265.4	62622	5.03
265.8	25257	9.52

Rheological Data

Cross WLF Viscosity Model		
n	0.29655	
Tau	2960.57	Pa
D1	4.69171e+017	Pa-s
D2	263.15	K
D3	0	K/Pa
A1	33.246	
A2	51.600	K

Juncture loss method coefficients		
C1	0.03849	Pa^(1-c2)
C2	1.528	



Thermal conductivity

Method:

ASTM D 5930, Standard Test Method for Thermal Conductivity of Plastics by Means of a Transient Line-Source Technique.

Instrument:

Moldflow K-System II

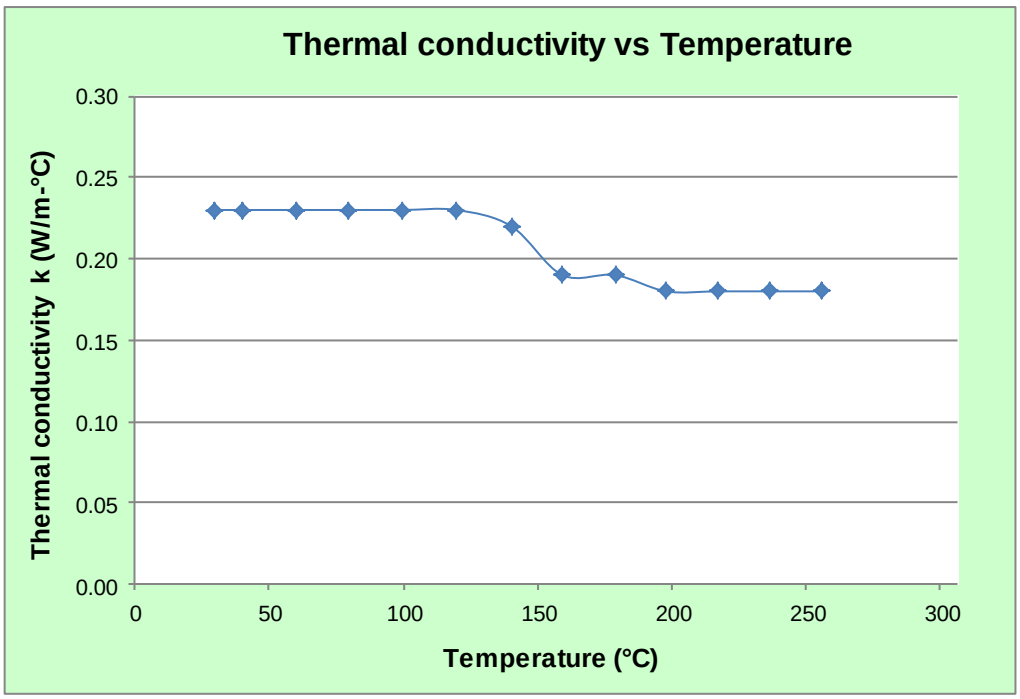
Test Specifications:

Sample Form:	Granules
Pre-Processing:	Dried at 70°C for 1 hours in a hopper dryer
Moisture Level:	0.02 %
Probe Constant:	0.6418
Probe Length:	50 mm
Data acquisition time:	45 sec
Probe Voltage:	4.0 V
Date Received:	03-APR-17
Date Tested:	27-APR-17

Operator's Notes:

Testing was performed per standard testing procedures.
No anomalies were noted during the course of testing.

Thermal conductivity data		
Temperature (T) °C	Thermal conductivity (k) W/m-°C	Heating/Cooling rate °C/s
256.100	1.839000e-01	0.0
236.600	1.813000e-01	0.0
217.200	1.817000e-01	0.0
198.200	1.839000e-01	0.0
179.100	1.852000e-01	0.0
159.400	1.851000e-01	0.0
140.370	2.211000e-01	0.0
119.800	2.259000e-01	0.0
99.800	2.292000e-01	0.0
79.833	2.309000e-01	0.0
59.800	2.308000e-01	0.0
39.800	2.297000e-01	0.0
29.800	2.303000e-01	0.0



Specific heat

Method:

ASTM E 1269, Standard Test Method for Determining Specific Heat Capacity by Differential Scanning Calorimetry
ASTM D 3418, Standard Test Method for Transition Temperatures and Enthalpies of Fusion and Crystallization of Polymers by Differential Scanning Calorimetry

Instrument:

TA Discovery DSC

Test Specifications:

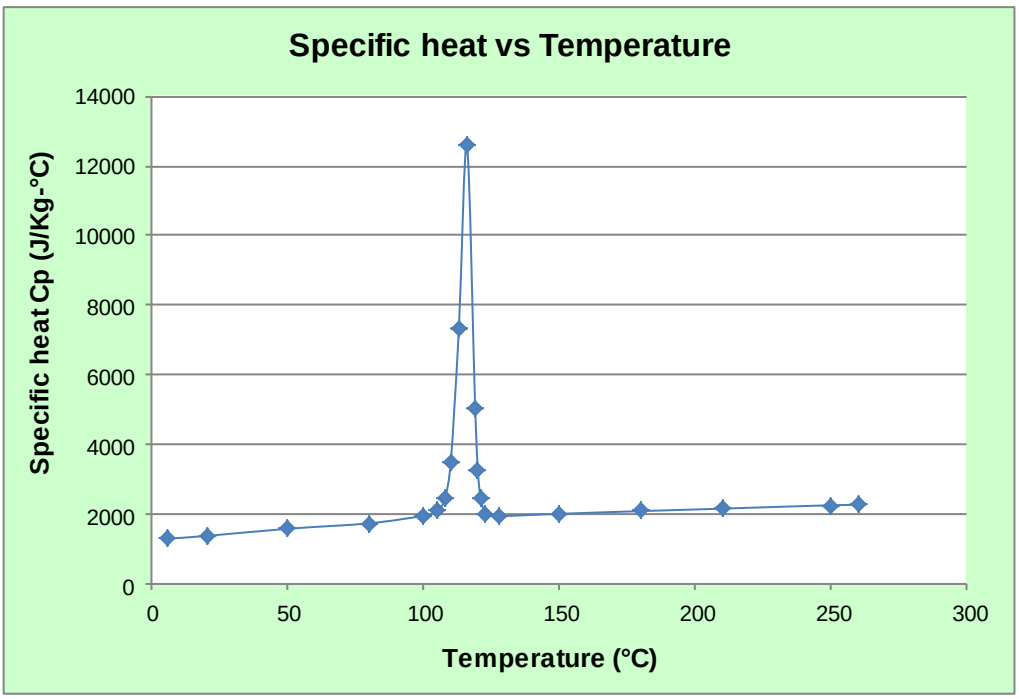
Sample Form:	Granules
Pre-Processing:	Dried at 70°C for 1 hours in a hopper dryer
Moisture Level:	0.02 %
Initial Temperature:	260°C
Final Temperature:	30°C
Cooling Rate:	20°C/min
Equilibrium Time:	2 min
Sample holder material:	Aluminium
Sample holder volume:	20µL6.7 mm diameter, 1.6 mm tall
Sample holder mass:	25 mg (pan + lid)
Purge gas:	99.99% pure nitrogen
Purge gas flow rate:	30 cm^3/sec
Date Received:	03-APR-17
Date Tested:	28-APR-17

Operator's Notes:

Testing was performed per standard testing procedures.
No anomalies were noted during the course of testing.

Specific heat data		
Temperature (T) °C	Specific heat (Cp) J/Kg-°C	Heating/Cooling rate °C/s
6	1307.8	-0.33
20	1386.2	-0.33
50	1591.3	-0.33
80	1748.6	-0.33
100	1967.8	-0.33
105	2100.2	-0.33
108	2480.5	-0.33
110	3481.8	-0.33
113	7318.6	-0.33
116	12588.0	-0.33
119	5059.6	-0.33
120	3290.2	-0.33
121	2488.4	-0.33
123	2024.9	-0.33
128	1957.1	-0.33
150	2020.3	-0.33
180	2098.0	-0.33
210	2168.4	-0.33
250	2266.4	-0.33
260	2275.3	-0.33

Ttrans	120	°C
Ejection temperature	110	°C



Pressure-Volume-Temperature

Method:
High Pressure Indirect Dilatometry

Instrument:
Gnomix pvT Apparatus

Test Specifications:

Sample Form**:**	Molded Plaque
Pre-Processing**:**	Not required
Scan type**:**	Isothermal Cooling
Date Received:	03-APR-17
Date Tested**:**	01-MAY-17

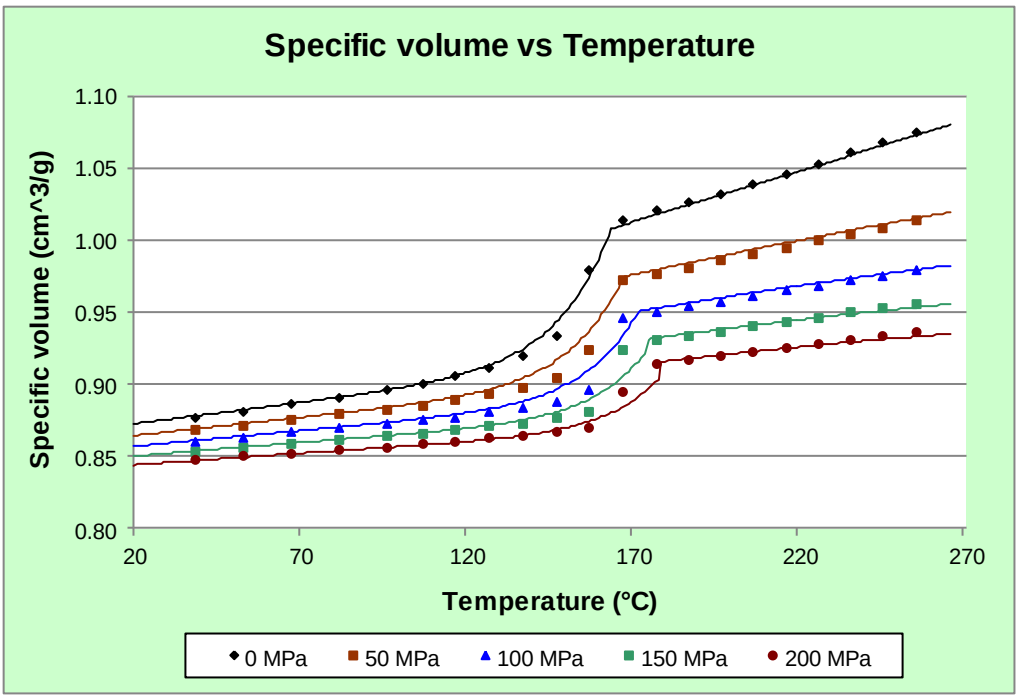
Operator's Notes:
Testing was performed per standard testing procedures.
No anomalies were noted during the course of testing.

pvT Experimental Data

Temperature (°C)	Pressure (MPa)				
	0MPa	50MPa	100MPa	150MPa	200MPa
38.2	0.8770	0.8679	0.8602	0.8533	0.8472
52.6	0.8812	0.8715	0.8633	0.8561	0.8497
67.6	0.8858	0.8750	0.8663	0.8587	0.8518
81.9	0.8905	0.8787	0.8693	0.8614	0.8543
96.5	0.8957	0.8824	0.8724	0.8640	0.8565
106.9	0.9003	0.8855	0.8748	0.8660	0.8582
116.8	0.9052	0.8888	0.8772	0.8679	0.8598
126.9	0.9112	0.8929	0.8806	0.8707	0.8622
137	0.9193	0.8976	0.8839	0.8731	0.8642
147.2	0.9328	0.9049	0.8882	0.8762	0.8664
157.4	0.9791	0.9232	0.8954	0.8801	0.8691
167.2	1.0130	0.9715	0.9454	0.9238	0.8952
177.6	1.0200	0.9764	0.9501	0.9304	0.9144
187.3	1.0260	0.9806	0.9535	0.9333	0.9171
196.7	1.0320	0.9853	0.9575	0.9368	0.9201
206.7	1.0390	0.9899	0.9609	0.9398	0.9227
216.7	1.0460	0.9947	0.9647	0.9430	0.9256
226.5	1.0530	0.9992	0.9683	0.9460	0.9283
236.3	1.0600	1.0040	0.9720	0.9494	0.9312
245.6	1.0670	1.0080	0.9754	0.9522	0.9337
255.8	1.0750	1.0130	0.9791	0.9548	0.9360

Melt density	0.9455	g/cm^3
Solid density	1.1445	g/cm^3

2-domain Tait PVT model coefficients		
b5	437.15	K
b6	7.200e-008	K/Pa
b1m	0.001008	m^3/Kg
b2m	7.028e-007	$m^3/Kg-K$
b3m	1.04073e+008	Pa
b4m	0.005848	1/K
b1s	0.000914	m^3/Kg
b2s	2.868e-007	$m^3/Kg-K$
b3s	2.39008e+008	Pa
b4s	0.004382	1/K
b7	0.000094	m^3/Kg
b8	0.061133	1/K
b9	8.856e-009	1/Pa



Shrinkage

Method:

AMPL Shrinkage Test Method (QOP-17-M)

Instrument:

Battenfeld BK-T 1500/400 Injection molding machine
Test mold inscribed with a fine grid pattern
Thermoline TRH 460 Temperature-Humidity Cabinet
OGP Smartscope Flash 400 metrology system

Test Specifications:

Sample Form**:**	Granules
Pre-Processing**:**	Dried at 70°C for 1 hours in a hopper dryer
Moisture Level**:**	0.02 %
Date Molded**:**	27-APR-17
Post-Processing**:**	Conditioned at 23°C / 50% relative humidity for 7 days
Date Measured**:**	04-MAY-17
Shrinkage Data Correlated With**:**	Autodesk Simulation Moldflow Insight 2017
Default Model**:**	Residual Stress (CRIMS)
Date Received:	03-APR-17

Operator's Notes:

Testing was performed per standard testing procedures.
No anomalies were noted during the course of testing.
Shrinkage measurements have been corrected to account for mold thermal expansion.
Data for some process conditions may have been removed in the determination of the favored model.

Shrinkage Experimental Data

Process Condition	Melt Temperature (°C)	Mold Temperature (°C)	Flow Rate (cc/sec)	Part Thickness (mm)	Packing Pressure (MPa)	Packing Time (sec)	Cooling Time (sec)
1	235.2	46.5	44.7	3	25.4	20.1	15
2	235.1	46.7	43.6	3	44.5	20.1	15
3	235.7	46.9	45.7	3	61.1	20.1	15
4	235.2	46.1	21.3	3	44.4	20.1	15
5	235.3	46.9	64.0	3	44.6	20.1	15
6	237.0	43.3	27.1	1.5	69.6	10.1	15
7	237.4	43.4	27.9	1.5	78.4	10.1	15
8	237.7	43.4	27.9	1.5	86.7	10.1	15
9	237.5	42.9	12.7	1.5	78.1	10.1	15
10	237.6	43.5	41.3	1.5	77.6	10.1	15
11	235.2	44.6	36.5	2	44.7	15.1	15
12	235.7	44.6	36.5	2	53.0	15.1	15
13	236.2	44.6	35.5	2	60.9	15.1	15
14	236.0	44.1	17.0	2	53.5	15.1	15
15	235.9	44.9	55.6	2	53.5	15.1	15
16	211.2	42.3	34.5	2	45.1	15.1	15
17	211.4	42.7	35.5	2	54.5	15.1	15
18	211.8	42.8	34.5	2	64.0	15.1	15
19	211.6	42.4	16.4	2	55.1	15.1	15
20	211.5	43.2	51.1	2	55.0	15.1	15
21	261.0	44.4	35.5	2	43.4	15.1	15
22	261.6	45.0	36.5	2	50.4	15.1	15
23	262.0	45.3	35.5	2	58.9	15.1	15
24	261.4	44.9	17.0	2	50.5	15.1	15
25	261.1	45.7	55.6	2	50.8	15.1	15

Part Shrinkage

Process Condition	Average Measured Parallel	Average Measured Perpendicular	Average Predicted Volumetric
1	0.196%	1.403%	4.604%
2	0.177%	1.233%	3.205%
3	0.168%	1.092%	2.524%
4	0.177%	1.273%	3.214%
5	0.184%	1.189%	3.196%
6	0.180%	1.206%	3.634%
7	0.173%	1.151%	3.152%
8	0.174%	1.109%	2.787%
9	0.175%	1.365%	2.995%
10	0.182%	1.058%	3.213%
11	0.190%	1.300%	4.014%
12	0.178%	1.258%	3.441%
13	0.173%	1.189%	3.105%
14	0.173%	1.407%	3.355%
15	0.180%	1.184%	3.423%
16	0.210%	1.271%	4.129%
17	0.201%	1.202%	3.467%
18	0.186%	1.160%	3.071%
19	0.200%	1.413%	3.410%
20	0.207%	1.095%	3.455%
21	0.173%	1.328%	3.948%
22	0.166%	1.273%	3.457%
23	0.167%	1.197%	3.099%
24	0.173%	1.375%	3.387%
25	0.175%	1.207%	3.439%

Residual Stress Coefficients

Corrected residual in-mold stress (CRIMS) model coefficients	
A1	0.828293
A2	0.028728
A3	0.000752
A4	0.619646
A5	-0.05764
A6	0.008548

Residual Strain Coefficients

Parallel				
	Coefficient	Lower Limit	Upper Limit	Centroid
1	0.006016	0.019454	0.055808	0.03389
2	-0.000071	0.054543	0.56821	0.37497
3	-0.000085	1.1786	11.928	6.3303
4	3.0706e-008	14969.00	54262.00	32939.00
5	0.001167	0	0	0

Perpendicular				
	Coefficient	Lower Limit	Upper Limit	Centroid
1	0.14464	0.019454	0.055808	0.03389
2	0.000449	0.054543	0.56821	0.37497
3	0.000134	1.1786	11.928	6.3303
4	3.482e-007	5648.80	12649.00	8716.10
5	0.003422	0	0	0

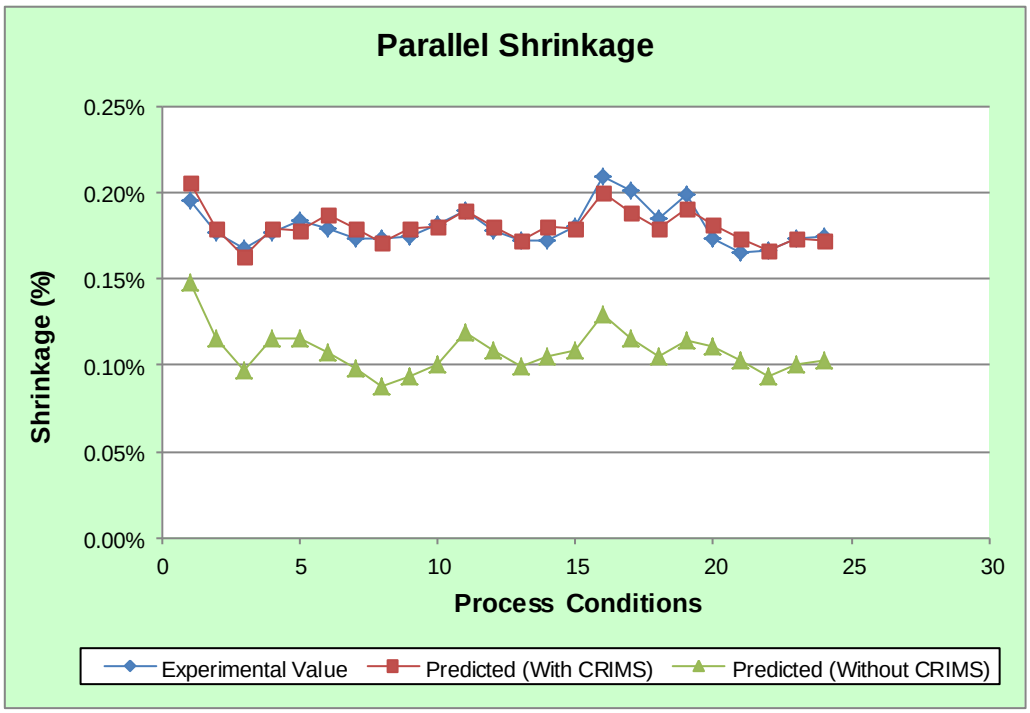
The shrinkage models shown above are valid for Autodesk Simulation Moldflow Insight 2017. Shrinkage models for previous software versions are included in the .21000.udb file.

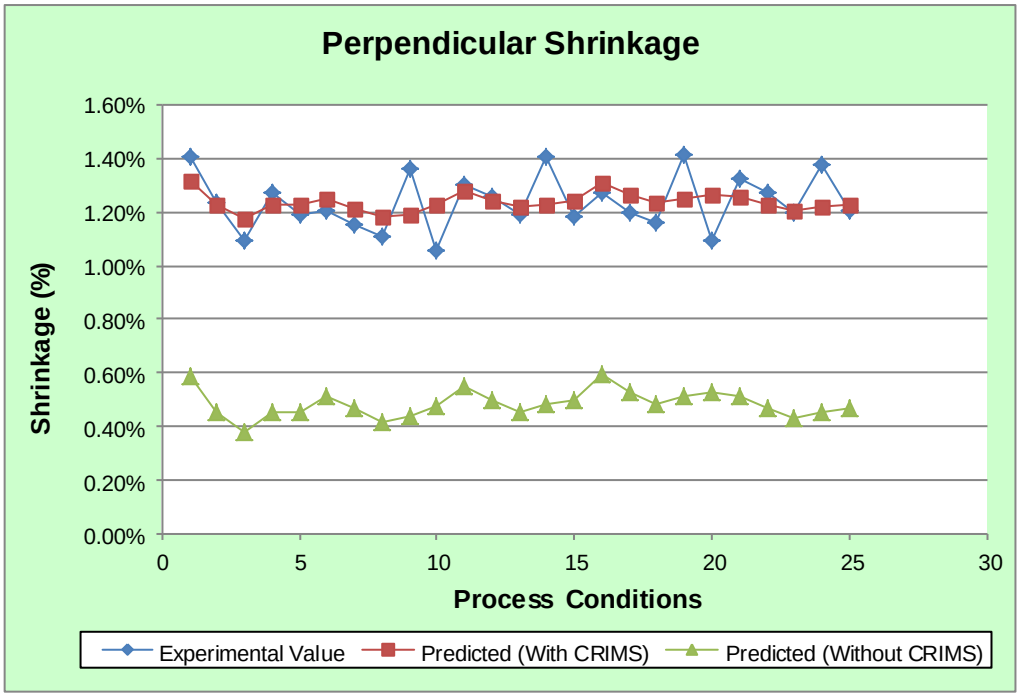
Observed Shrinkage

Observed nominal shrinkage	
Parallel	0.181%
Perpendicular	1.238%

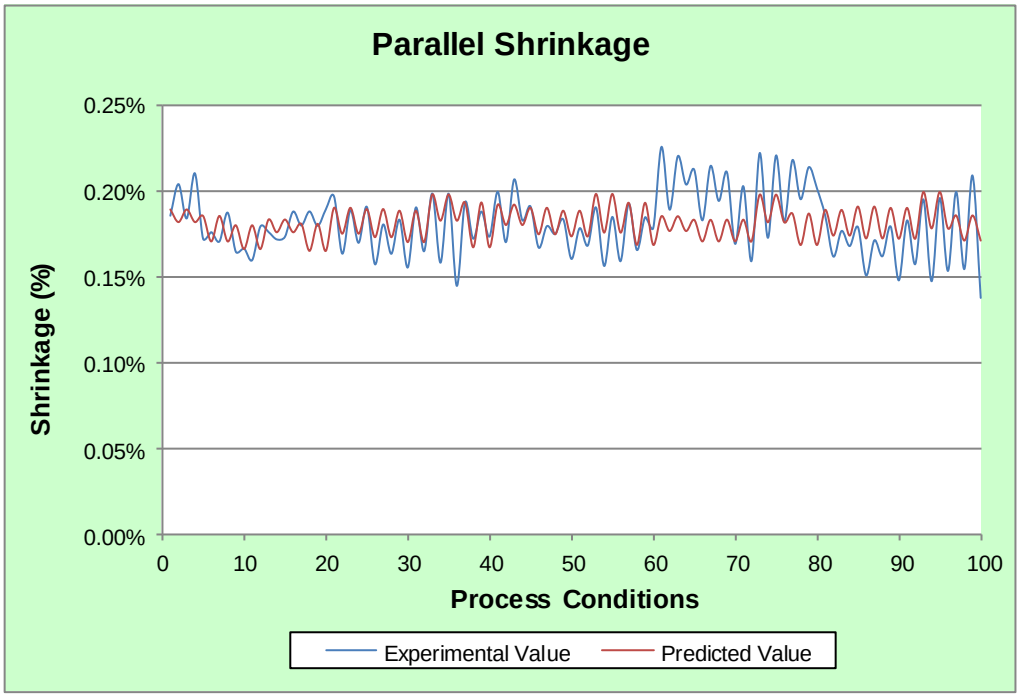
Observed shrinkage	
Minimum Parallel	0.166%
Maximum Parallel	0.210%
Minimum Perpendicular	1.058%
Maximum Perpendicular	1.413%

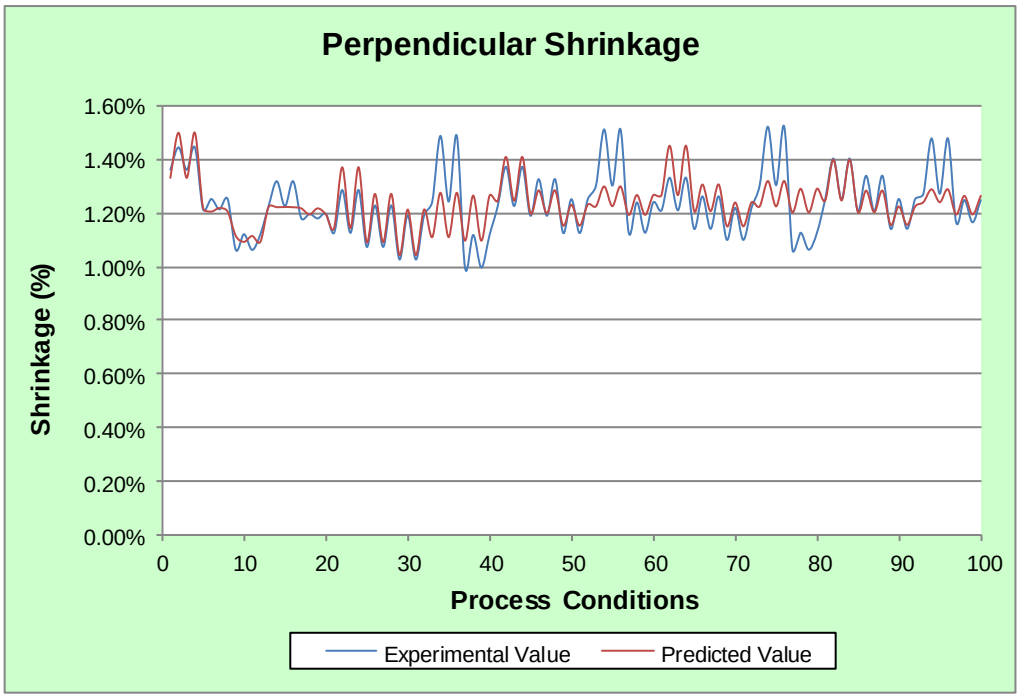
Residual Stress Plots





Residual Strain Plots





Mechanical

Elastic modulus and Poisson's ratio

Method:
ASTM D 638, Standard Test Method for Tensile Properties of Plastics
ASTM E 132, Standard Test Method for Poisson's Ratio at Room Temperature

Instrument:
Instron 3367 Universal Testing Machine

Test Specifications:

Specimens Tested:	8 (per direction)
Pre-Processing:	23°C +/-2°C at 50% +/-5% relative humidity for a minimum of 40 hours
Sample Form:	Machined from molded plaques
Test Speed:	5 mm/min
Date Received:	03-APR-17
Date Tested:	03-MAY-17

Operator's Notes:
Testing was performed per standard testing procedures.
No anomalies were noted during testing.

Elastic modulus		
Elastic modulus, 1st principal direction [E1]	4862.00	MPa
Elastic modulus, 2nd principal direction [E2]	4024.87	MPa

Poisson's ratio		
Poisson's ratio [v12]	0.3980	
Poisson's ratio [v23]	0.4180	

Shear modulus

Method:
ASTM D 638, Standard Test Method for Tensile Properties of Plastics

Instrument:
Instron 3367 Universal Testing Machine

Test Specifications:

Specimens Tested:	8
Pre-Processing:	23°C +/-2°C at 50% +/-5% relative humidity for a minimum of 40 hours
Sample Form:	Machined from molded plaques
Test Speed:	5 mm/min
Date Received:	03-APR-17
Date Tested:	03-MAY-17

Operator's Notes:
Shear modulus is calculated using orthotropic elasticity from the tensile modulus measured on a sample cut at an angle of 45° with the flow direction.
Testing was performed per standard testing procedures.
No anomalies were noted during testing.

Shear modulus		
Shear modulus [G12]	1419	MPa

Coefficient of linear thermal expansion

Method:
ISO 11359-2, Plastics – Thermomechanical analysis (TMA)

Instrument:
TA Instruments Thermomechanical Analyser Q400

Test Specifications:

Specimens Tested:	4 (per direction)
Pre-Processing:	23°C +/-2°C at 50% +/-5% relative humidity for a minimum of 40 hours
Sample Form:	Machined from molded plaques
Specimen Geometry:	Square, 10mm x 10mm, full thickness
Temperature Range:	10°C to 40°C
Date Received:	03-APR-17
Date Tested:	03-MAY-17

Operator's Notes:
Testing was performed per standard testing procedures.
No anomalies were noted during testing.

Transversely isotropic coefficient of thermal expansion [CTE] data		
Alpha 1	4.200e-005	1/°C
Alpha 2	6.480e-005	1/°C

Mold verification

Method:
AMPL Mold Verification Test Method (QOP-16-M)

Instrument:
Battenfeld BK-T 1500/400 Injection Molding Machine

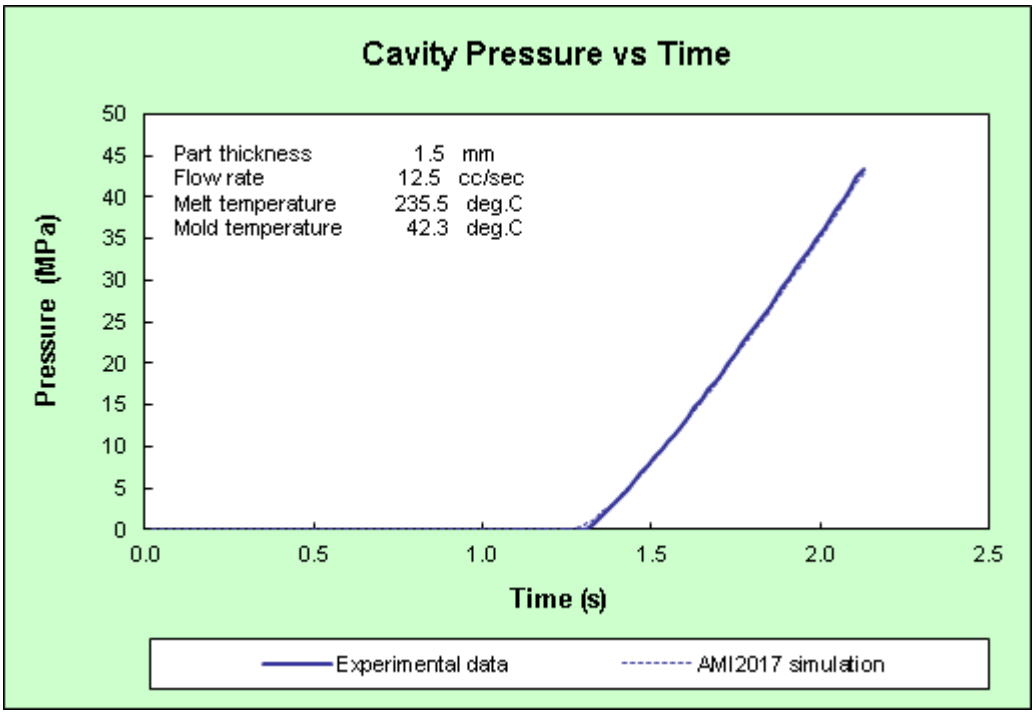
Test Specifications:

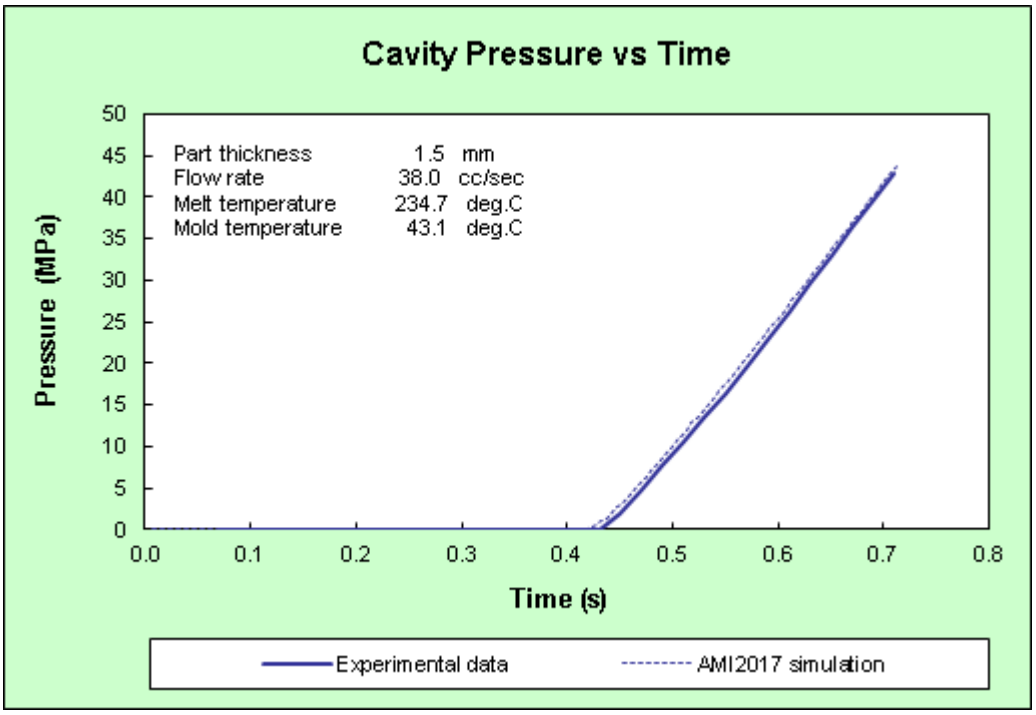
Sample Form:	Granules
Pre-Processing:	Dried at 70°C for 1 hours in a hopper dryer
Moisture Level:	0.02 %
Date Received:	03-APR-17
Date Tested:	27-APR-17

Operator's Notes:
Testing was performed per standard testing procedures.
No anomalies were noted during the course of testing.

1.5mm tag die

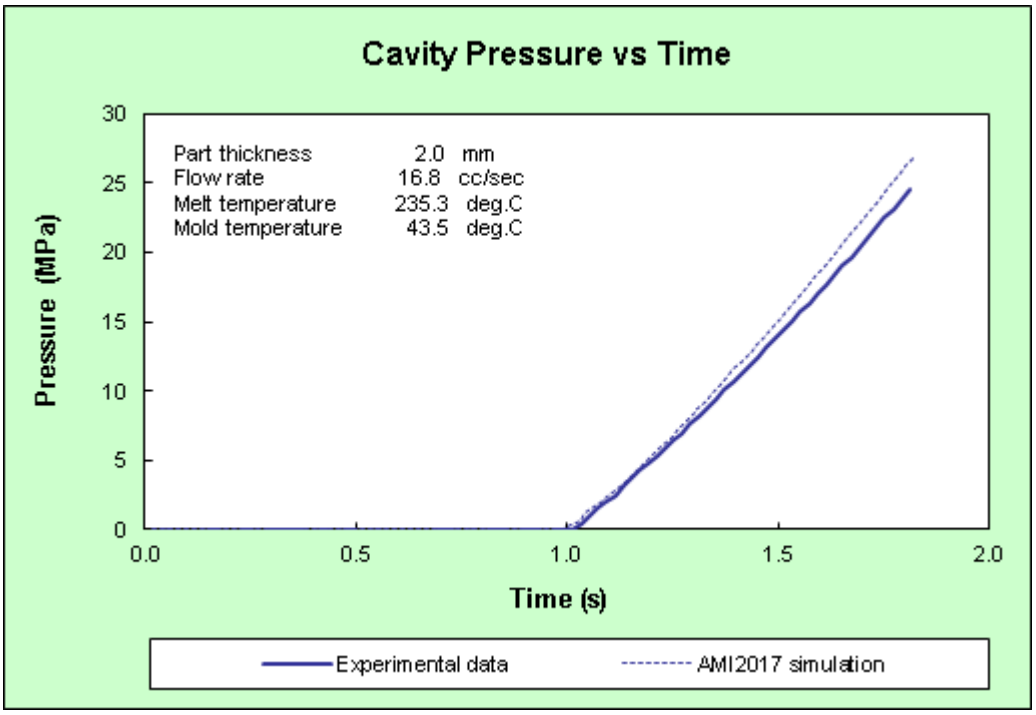
Experiment Number	Flow Rate (cc/sec)	Melt Temperature	Mold Temperature
Cyc0049	12.5	235.5	42.3
Cyc0059	38	234.7	43.1

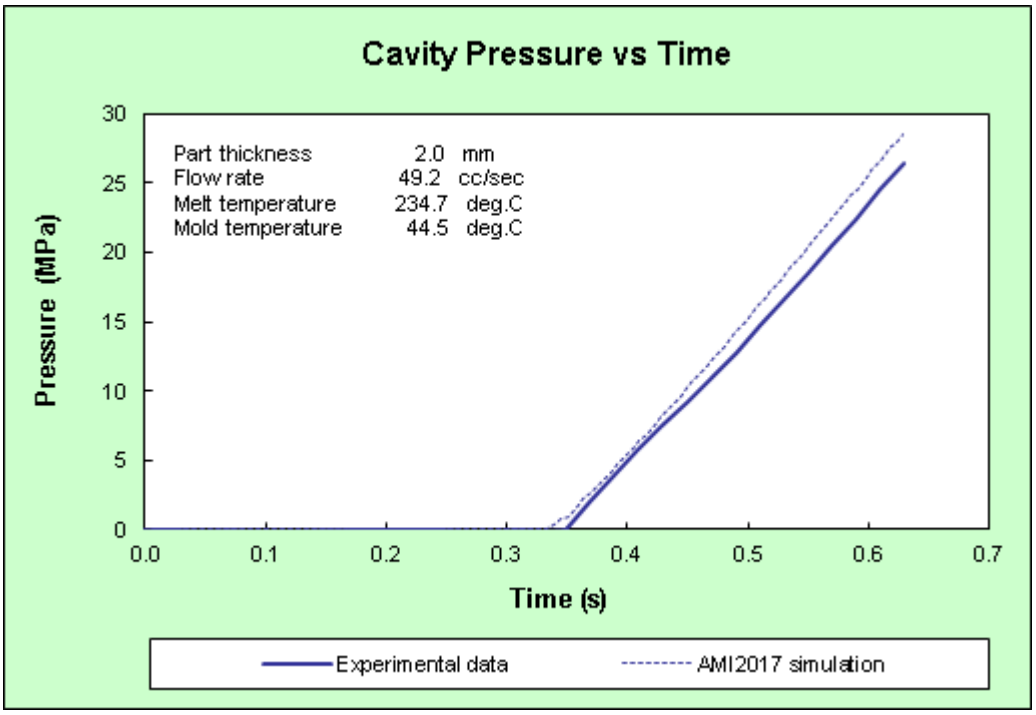




2mm tag die

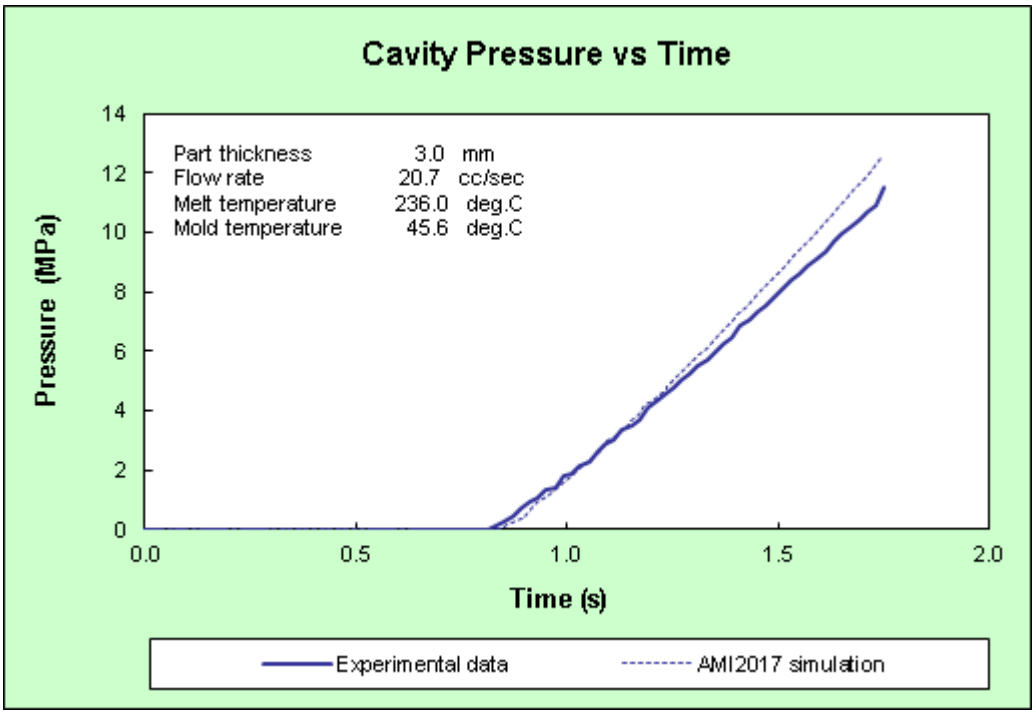
Experiment Number	Flow Rate (cc/sec)	Melt Temperature	Mold Temperature
Cyc0100	16.8	235.3	43.5
Cyc0110	49.2	234.7	44.5

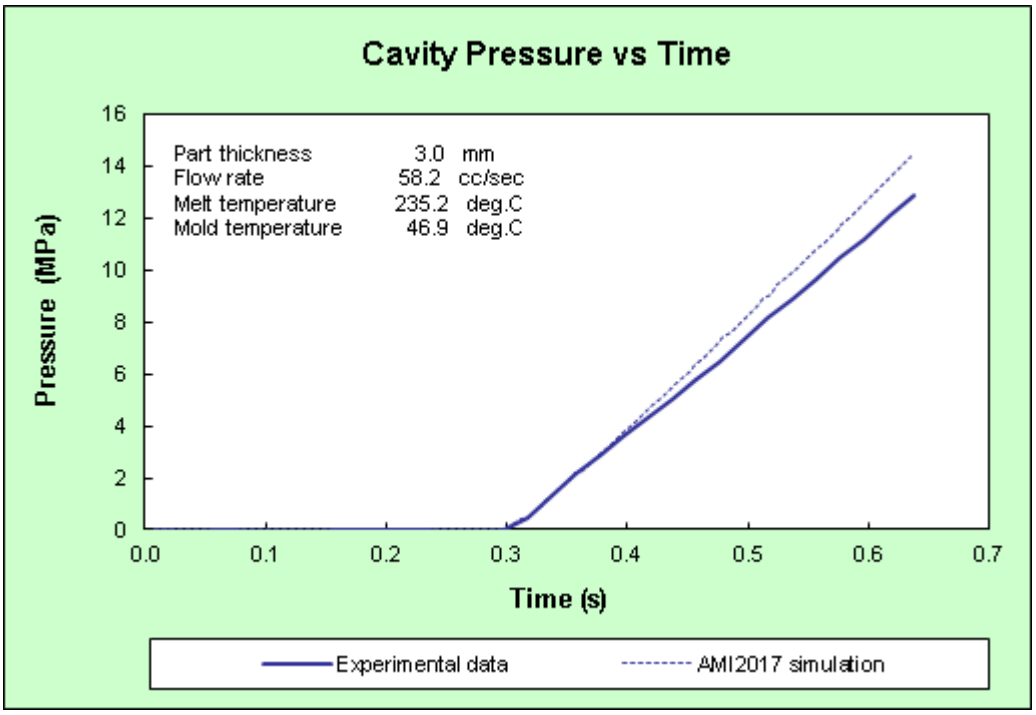




3mm tag die

Experiment Number	Flow Rate (cc/sec)	Melt Temperature	Mold Temperature
Cyc0008	20.7	236	45.6
Cyc0018	58.2	235.2	46.9





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