

# **Moldflow Material Testing Report**

**MAT2216**

**ISOFIL H 40 C2 F NAT**

Prepared for:

**SIRMAX SpA**

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Prepared on:

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## Summary

### Description

Family name	POLYPROPYLENES (PP)
Trade name	ISOFIL H 40 C2 F NAT
Manufacturer	SIRMAX SpA
Family abbreviation	PP
Material structure	Crystalline
Data source	Moldflow Plastics Labs : pvT-Measured : mech-Supplemental
Date last modified	25-Aug-04
Date tested	20-Aug-04
Data status	Non-Confidential
Material ID	20507
Grade code	MAT2216
Supplier code	SIRMAX
Fibers/fillers	40% Calcium Carbonate Filled

### Recommended Processing

Mold surface temperature	40	°C
Melt temperature	228	°C

<b>Mold temperature range (recommended)</b>		
Minimum	20	°C
Maximum	60	°C

<b>Melt temperature range (recommended)</b>		
Minimum	220	°C
Maximum	235	°C

Absolute maximum melt temperature	275	°C
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Ejection temperature	108	°C
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## Rheological Properties

<b>Cross WLF Viscosity Model</b>		
n	0.3162	
Tau	12354.6	Pa
D1	1.46141e+013	Pa-s
D2	263.15	K
D3	0	K/Pa
A1	26.297	
A2	51.600	K

<b>Juncture loss method coefficients</b>		
C1	0.008	Pa <sup>(1-c2)</sup>
C2	1.627	

<b>Transition temperature</b>		
Ttrans	118	°C

Moldflow Viscosity Index	VI(240)81	
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<b>Melt mass-flow rate (MFR)</b>		
Temperature	230	°C
Load	2.00	Kg
Measured MFR	13.0	g/10min

## Thermal Properties

<b>Specific heat data</b>		
Temperature (T) °C	Specific heat (Cp) J/Kg-°C	Heating/Cooling rate °C/s
230	3002.0	-0.33
122	2963.0	-0.33
120	3129.0	-0.33
119	3386.0	-0.33
115	7347.0	-0.33
112	10342.0	-0.33
109	6662.0	-0.33
105	3568.0	-0.33
102	3143.0	-0.33
97	2954.0	-0.33
84	2779.0	-0.33
50	2015.0	-0.33

<b>Thermal conductivity data</b>		
Temperature (T) °C	Thermal conductivity (k) W/m-°C	Heating/Cooling rate °C/s
243.6	0.235	0.0
231.7	0.227	0.0
221.3	0.230	0.0
200.6	0.227	0.0
180.2	0.238	0.0
159.5	0.232	0.0
143.7	0.344	0.0
119.3	0.327	0.0
98.7	0.319	0.0
77.5	0.327	0.0
58.1	0.350	0.0
38.6	0.348	0.0

### PVT Properties

Melt density	1.0639	g/cm <sup>3</sup>
Solid density	1.2590	g/cm <sup>3</sup>

2-domain Tait PVT model coefficients		
b5	433.15	K
b6	4.000e-008	K/Pa
b1m	0.000893	m <sup>3</sup> /Kg
b2m	6.890e-007	m <sup>3</sup> /Kg-K
b3m	1.31297e+008	Pa
b4m	0.008425	1/K
b1s	0.000829	m <sup>3</sup> /Kg
b2s	2.572e-007	m <sup>3</sup> /Kg-K
b3s	2.15056e+008	Pa
b4s	0.005354	1/K
b7	0.000064	m <sup>3</sup> /Kg
b8	0.09644	1/K
b9	5.692e-009	1/Pa

### Mechanical Properties

Mechanical properties data		
Elastic modulus, 1 <sup>st</sup> principal direction [E1]	2220.68	MPa
Elastic modulus, 2 <sup>nd</sup> principal direction [E2]	2220.68	MPa
Poissons ratio [v12]	0.3957	
Poissons ratio [v23]	0.3957	
Shear modulus [G12]	795.570	MPa

Transversely isotropic coefficient of thermal expansion [CTE] data		
Alpha1	5.180e-005	1/C
Alpha2	5.180e-005	1/C

**Mechanical and CTE data have not been tested for this material. The data has been supplemented with generic estimates for 40% Calcium Carbonate filled PP.**

### Shrinkage Properties

Corrected residual in-mold stress (CRIMS) model coefficients	
A1	0.426853
A2	0.028169
A3	0.007319
A4	1.008512
A5	0.029997
A6	0.006133

Residual strain model coefficients		
	Parallel	Perpendicular
A1	0.12866	0.21921
A2	0.003658	0.003059
A3	-0.000174	0.000032
A4	1.1215e-007	5.3705e-007
A5	0.003475	0.001881

**These shrinkage models are valid for Moldflow Plastics Insight™ 5 only. Shrinkage models for previous software versions are available upon request.**

### Filler Properties

Filler data	
Description	Weight %
Calcium Carbonate	40



# Viscosity

## Method:

MPL Viscosity Test Method (QOP-14-M)

## Instrument:

Arburg Allrounder 270S Injection Molding Machine

## Test Specifications:

Sample Form:	Granules
Pre-Processing:	Not required
Moisture Level:	Not measured
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 Tested:	13-Aug-04

## 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 <sup>-1</sup> )	Apparent Viscosity (Pa-s)	Die Diameter (mm)	Die L/D
205.9	64388	9.02	2	16
207.2	242	314.45	2	16
207.4	6506	37	2	16
207.8	344	256.72	2	16
208	2648	68.24	2	16
208	25529	15.17	2	16
208.6	815	147.79	2	16
208.6	12796	23.8	2	16
209.8	1362	104.91	2	16
215.9	64286	7.84	2	16
217.1	357	227.84	2	16
217.2	242	286.69	2	16
217.5	815	136.48	2	16
217.9	2648	63.88	2	16
217.9	6494	34.83	2	16
218.1	25592	13.87	2	16
218.7	12783	22.04	2	16
219.9	1375	97.92	2	16
225.7	64426	7.12	2	16
226.1	255	245.36	2	16
226.5	25618	13.07	2	16
227	357	208.12	2	16
227.3	2648	59.81	2	16
227.4	12771	20.92	2	16
227.5	815	126.51	2	16
228	6494	32.67	2	16
228.4	1388	90.6	2	16
235.8	64642	6.66	2	16
236.5	828	117.4	2	16
236.5	6519	30.91	2	16
236.9	255	225.12	2	16
237.4	357	189.28	2	16
237.7	25338	12.56	2	16
238.2	2648	56.33	2	16
238.2	12809	19.63	2	16
238.4	1388	84.75	2	16
216.7	12796	40.75	2	3.98
217	25529	27.87	2	3.98
217.2	64388	17.1	2	3.98
217.3	2648	102.35	2	3.98
217.9	242	427.95	2	3.98
217.9	6506	59.31	2	3.98
218.4	344	355.91	2	3.98
218.6	815	203.28	2	3.98
220.6	1362	142.77	2	3.98
227.3	64286	15.53	2	3.98
227.5	6494	55.37	2	3.98
227.7	25592	25.67	2	3.98

Temperature (°C)	Apparent Shear Rate (sec <sup>-1</sup> )	Apparent Viscosity (Pa-s)	Die Diameter (mm)	Die L/D
227.9	12783	37.3	2	3.98
228	2648	94.06	2	3.98
228.8	242	402.02	2	3.98
230	357	318.56	2	3.98
230.5	815	187.88	2	3.98
230.8	1375	132.32	2	3.98
237.2	6494	51.5	2	3.98
237.8	64426	14.27	2	3.98
238	2648	88.37	2	3.98
238.9	12771	34.2	2	3.98
238.9	25618	23.93	2	3.98
239.4	255	349.89	2	3.98
239.8	357	293.92	2	3.98
240.1	815	177.87	2	3.98
241	1388	123.88	2	3.98
246.9	2648	83.4	2	3.98
247.4	25338	22.41	2	3.98
247.5	12809	32.43	2	3.98
247.5	64642	13.3	2	3.98
248.1	6519	48.22	2	3.98
248.5	255	332.64	2	3.98
248.8	357	279.84	2	3.98
250.3	828	166.03	2	3.98
250.7	1388	118	2	3.98

### Calculated Viscosity Data

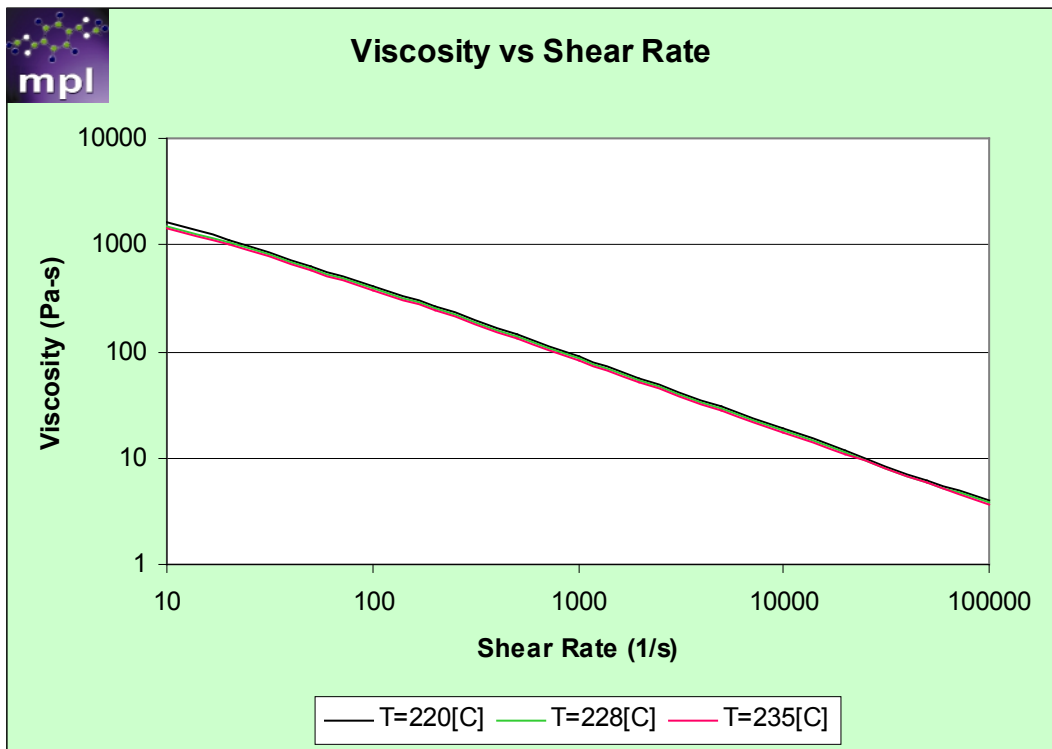
Temperature (°C)	Shear Rate (sec <sup>-1</sup> )	Calculated Viscosity (Pa-s)
205.9	64388	5.72
207.2	242	251.10
207.4	6506	27.12
207.8	344	197.92
208	2648	49.83
208	25529	10.63
208.6	815	110.34
208.6	12796	16.98
209.8	1362	77.41
215.9	64286	5.41
216.7	12796	16.21
217	25529	10.10
217.1	357	182.58
217.2	64388	5.36
217.2	242	236.22
217.3	2648	47.22
217.5	815	104.73
217.9	242	235.25
217.9	2648	47.07
217.9	6494	25.56
217.9	6506	25.53
218.1	25592	10.02
218.4	344	185.74
218.6	815	104.08
218.7	12783	16.04
219.9	1375	72.59
220.6	1362	72.77
225.7	64426	5.12
226.1	255	216.83
226.5	25618	9.57
227	357	172.66
227.3	2648	44.74
227.3	64286	5.09
227.4	12771	15.32
227.5	815	99.13
227.5	6494	24.28
227.7	25592	9.52
227.9	12783	15.27
228	6494	24.22
228	2648	44.58
228.4	1388	68.90
228.8	242	221.11
230	357	169.88
230.5	815	97.58
230.8	1375	68.48
235.8	64642	4.86
236.5	6519	23.15
236.5	828	93.63
236.9	255	204.55
237.2	6494	23.13

Temperature (°C)	Shear Rate (sec <sup>-1</sup> )	Calculated Viscosity (Pa-s)
237.4	357	163.41
237.7	25338	9.12
237.8	64426	4.82
238	2648	42.39
238.2	2648	42.35
238.2	12809	14.49
238.4	1388	65.50
238.9	25618	9.00
238.9	12771	14.47
239.4	255	201.92
239.8	357	161.43
240.1	815	92.96
241	1388	64.68
246.9	2648	40.64
247.4	25338	8.72
247.5	64642	4.60
247.5	12809	13.88
248.1	6519	21.92
248.5	255	192.92
248.8	357	154.43
250.3	828	87.62
250.7	1388	61.81

**Rheological Data**

Cross WLF Viscosity Model		
n	0.3162	
Tau	12354.6	Pa
D1	1.46141e+013	Pa-s
D2	263.15	K
D3	0	K/Pa
A1	26.297	
A2	51.600	K

Juncture loss method coefficients		
C1	0.008	Pa <sup>(1-c2)</sup>
C2	1.627	



# 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

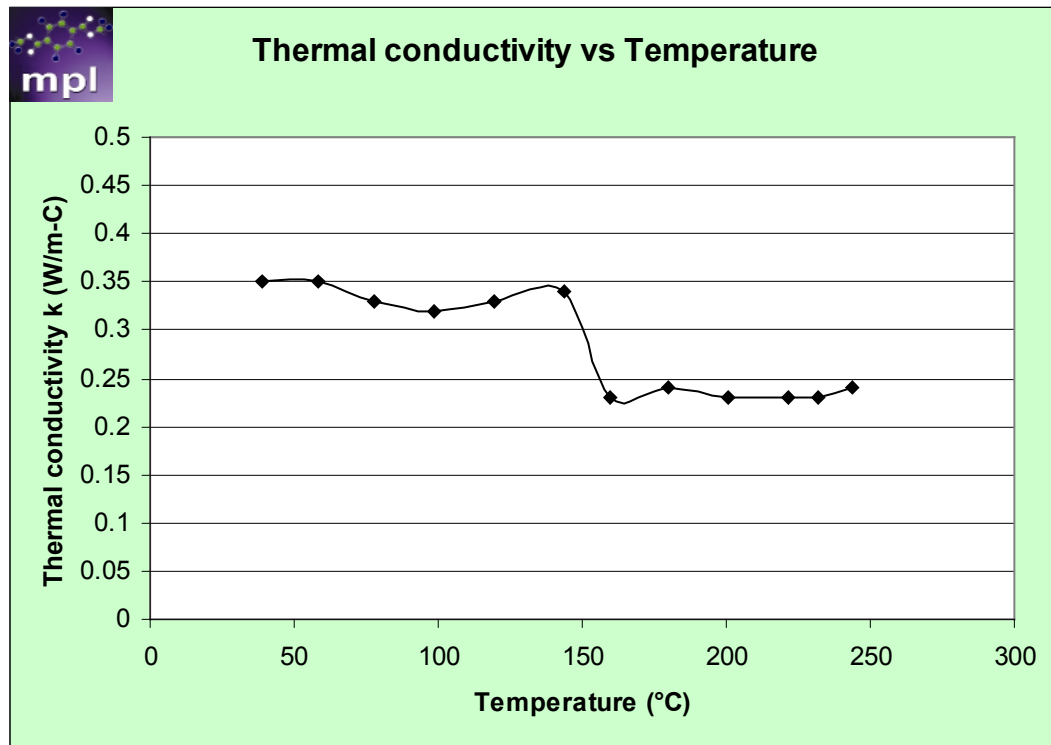
**Test Specifications:**

Sample Form:	Granules
Pre-Processing:	Not required
Moisture Level:	Not measured
Probe Constant:	0.831
Probe Length:	50 mm
Data acquisition time:	45 sec
Probe Voltage:	3.0 V
Date Tested:	13-Aug-04

**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
243.6	0.235	0.0
231.7	0.227	0.0
221.3	0.230	0.0
200.6	0.227	0.0
180.2	0.238	0.0
159.5	0.232	0.0
143.7	0.344	0.0
119.3	0.327	0.0
98.7	0.319	0.0
77.5	0.327	0.0
58.1	0.350	0.0
38.6	0.348	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 of Polymers by Differential Scanning Calorimetry

ASTM D 3417, Standard Test Method for Enthalpies of Fusion and Crystallization of Polymers by Differential Scanning Calorimetry (DSC)

## Instrument:

Perkin Elmer DSC-7 Differential Scanning Calorimeter

## Test Specifications:

Sample Form:	Granules
Pre-Processing:	Not required
Moisture Level:	Not measured
Initial Temperature:	240°C
Final Temperature:	50°C
Cooling Rate:	20°C/min
Equilibrium Time:	2 min
Sample holder material:	Aluminium
Sample holder dimensions:	6.7 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 <sup>3</sup> /sec
Date Tested:	13-Aug-04

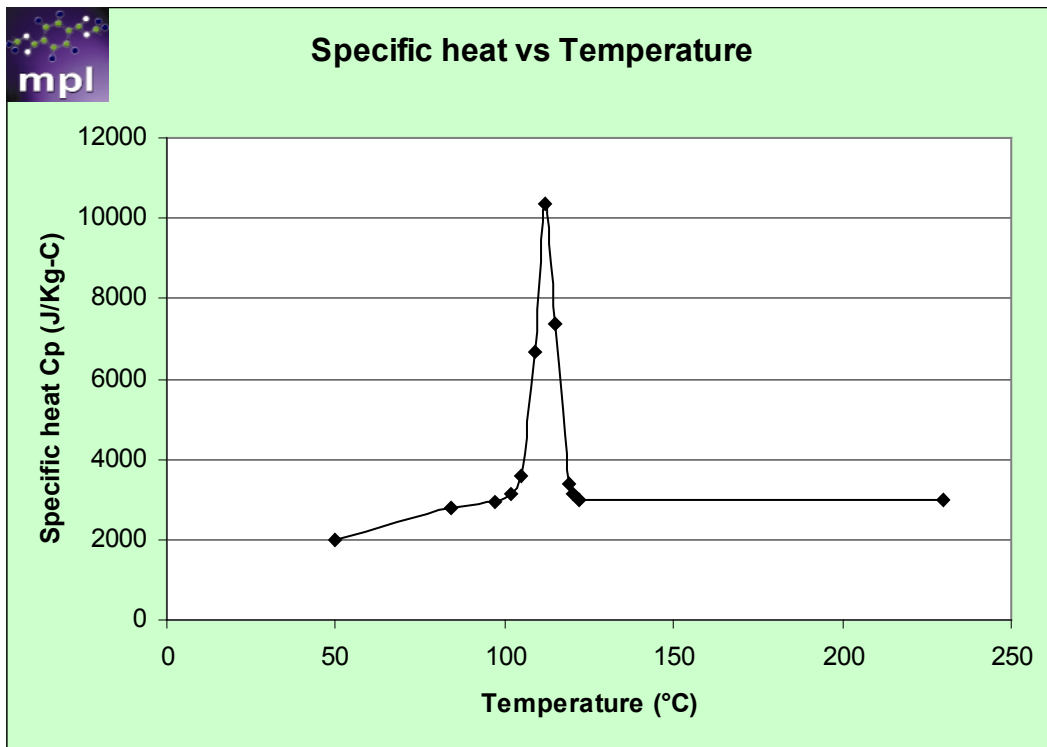
## Operator's Notes:

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
230	3002.0	-0.33
122	2963.0	-0.33
120	3129.0	-0.33
119	3386.0	-0.33
115	7347.0	-0.33
112	10342.0	-0.33
109	6662.0	-0.33
105	3568.0	-0.33
102	3143.0	-0.33
97	2954.0	-0.33
84	2779.0	-0.33
50	2015.0	-0.33

Ttrans	118	°C
Ejection temperature	108	°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 Tested:	19-Aug-04

**Operator's Notes:**

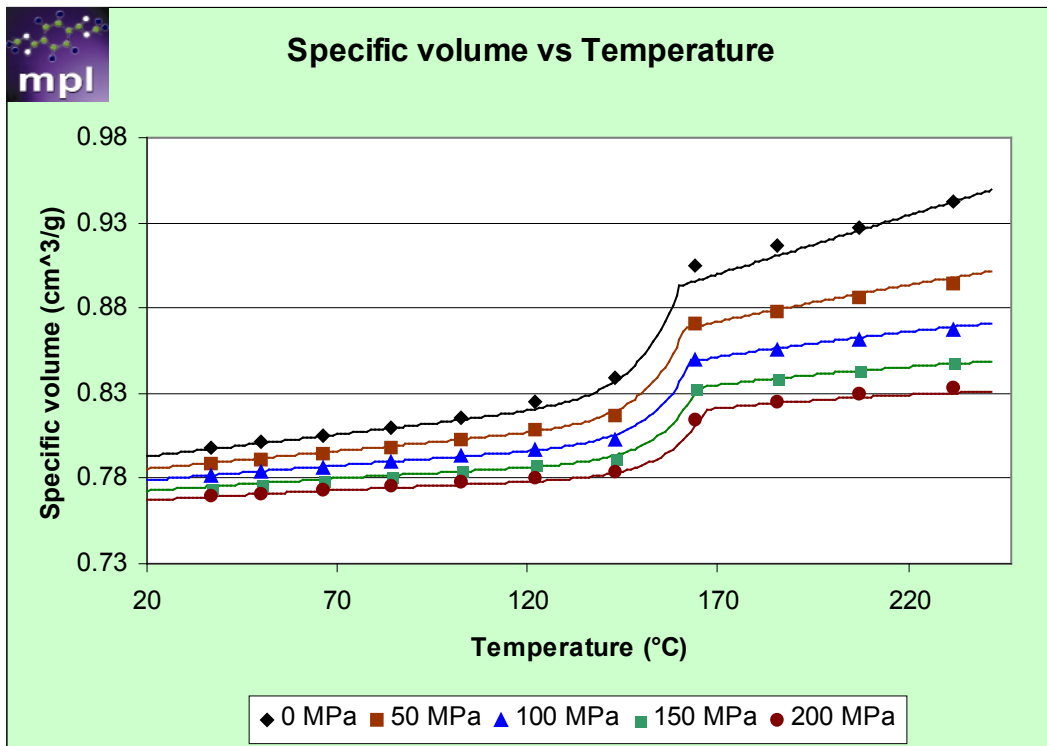
Testing was performed per standard testing procedures.  
No anomalies were noted during the course of testing.

**pvT Experimental Data**

Temperature (°C)	Pressure (MPa)				
	0 MPa	50 MPa	100 MPa	150 MPa	200 MPa
36.65	0.7980	0.7885	0.7812	0.7751	0.7696
50.04	0.8011	0.7915	0.7836	0.7772	0.7713
66.19	0.8053	0.7948	0.7867	0.7795	0.7732
83.93	0.8101	0.7984	0.7894	0.7822	0.7754
102.7	0.8162	0.8029	0.7930	0.7850	0.7780
122.2	0.8246	0.8086	0.7971	0.7886	0.7808
142.9	0.8392	0.8163	0.8023	0.7922	0.7836
164	0.9045	0.8705	0.8492	0.8328	0.8146
185.3	0.9161	0.8780	0.8554	0.8388	0.8251
207	0.9274	0.8856	0.8616	0.8441	0.8299
231.9	0.9429	0.8938	0.8668	0.8481	0.8331

Melt density	1.0639	g/cm <sup>3</sup>
Solid density	1.2590	g/cm <sup>3</sup>

2-domain Tait PVT model coefficients		
b5	433.15	K
b6	4.000e-008	K/Pa
b1m	0.000893	m <sup>3</sup> /Kg
b2m	6.890e-007	m <sup>3</sup> /Kg-K
b3m	1.31297e+008	Pa
b4m	0.008425	1/K
b1s	0.000829	m <sup>3</sup> /Kg
b2s	2.572e-007	m <sup>3</sup> /Kg-K
b3s	2.15056e+008	Pa
b4s	0.005354	1/K
b7	0.000064	m <sup>3</sup> /Kg
b8	0.09644	1/K
b9	5.692e-009	1/Pa



# Shrinkage

## Method:

MPL 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:	Not required
Moisture Level:	Not measured
Date Molded:	13-AUG-04
Post-Processing:	Conditioned at 23°C / 50% relative humidity for 7 days
Date Measured:	20-AUG-04
Shrinkage Data Correlated With:	Moldflow Plastics Insight™ 5
Default Model:	Residual Stress (CRIMS)

## 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.

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	229.2	43.6	46.8	2	21.3	10	15
2	229.2	43.6	60.2	2	21.2	10	15
3	230.1	43.1	84.3	2	21.3	10	15
4	230.1	43.9	22.8	2	21.3	10	15
5	228.3	43.6	9.3	2	21.2	10	15
6	229.7	43.9	46.8	2	21.3	10	22.5
7	229.7	43.1	46.8	2	21.2	10	30
8	229.2	43.1	46.9	2	43.6	10	15
9	228.8	43.6	45.5	2	64.8	10	15
10	230.6	45.2	42.1	2	88.2	10	15
11	229.2	44.4	60.2	2	87.9	10	15
12	229.2	43.6	84.3	2	87.5	10	15
13	230.6	44.4	25.1	2	88.1	10	15
14	231.0	43.9	9.3	2	88.2	10	15
15	230.1	43.1	46.8	2	88.2	10	22.5
16	229.7	44.8	46.8	2	88.2	10	30
17	220.1	43.6	42.1	2	88.2	10	15
18	221.0	43.6	42.1	2	21.5	10	15
19	236.5	44.8	42.1	2	88.0	10	15
20	236.5	43.9	42.1	2	21.6	10	15
21	229.7	61.2	46.8	2	88.9	10	15
22	230.1	62.0	46.8	2	21.9	10	15
23	231.0	44.8	23.2	1.1	92.9	5	15
24	229.7	45.2	25.7	1.1	14.5	5	15
25	230.1	46.1	56.5	3	89.9	20	15
26	230.1	46.1	56.1	3	11.0	20	15
27	230.1	46.9	81.0	5	90.9	35	15
28	228.3	45.6	80.0	5	11.3	35	15

### Part Shrinkage

Process Condition	Average Measured Parallel	Average Measured Perpendicular	Maximum Predicted Volumetric
1	1.22%	1.66%	5.26%
2	1.20%	1.65%	5.27%
3	1.18%	1.63%	5.24%
4	1.27%	1.67%	5.19%
5	1.38%	1.72%	5.02%
6	1.21%	1.66%	5.23%
7	1.20%	1.62%	5.26%
8	1.14%	1.41%	4.02%
9	1.04%	1.21%	3.17%
10	0.91%	1.04%	2.23%
11	0.90%	1.02%	2.26%
12	0.85%	1.02%	2.29%
13	0.94%	1.04%	2.19%
14	1.07%	1.11%	1.91%
15	0.89%	1.05%	2.24%
16	0.87%	1.03%	2.22%
17	0.92%	1.02%	2.27%
18	1.22%	1.65%	5.29%
19	0.86%	1.02%	2.23%
20	1.20%	1.69%	5.14%
21	0.93%	1.07%	2.37%
22	1.34%	1.69%	5.27%
23	0.94%	0.96%	3.89%
24	1.21%	1.32%	7.92%
25	0.72%	0.92%	1.58%
26	1.27%	1.77%	5.67%
27	0.90%	1.23%	3.91%
28	1.31%	1.92%	7.75%



### Residual Stress Coefficients

Corrected residual in-mold stress (CRIMS) model coefficients	
A1	0.426853
A2	0.028169
A3	0.007319
A4	1.008512
A5	0.029997
A6	0.006133

### Residual Strain Coefficients

Parallel				
	Coefficient	Lower Limit	Upper Limit	Centroid
1	0.12866	0.010352	0.079166	0.034883
2	0.003658	0.022029	0.68062	0.34513
3	-0.000174	2.3375	19.384	9.3674
4	1.1215e-007	5048.00	64073.00	28080.00
5	0.003475	0	0	0

Perpendicular				
	Coefficient	Lower Limit	Upper Limit	Centroid
1	0.21921	0.010352	0.077477	0.033459
2	0.003059	0.025561	0.68062	0.35705
3	0.000032	2.3375	19.384	9.0171
4	5.3705e-007	805.62	9272.30	5423.80
5	0.001881	0	0	0

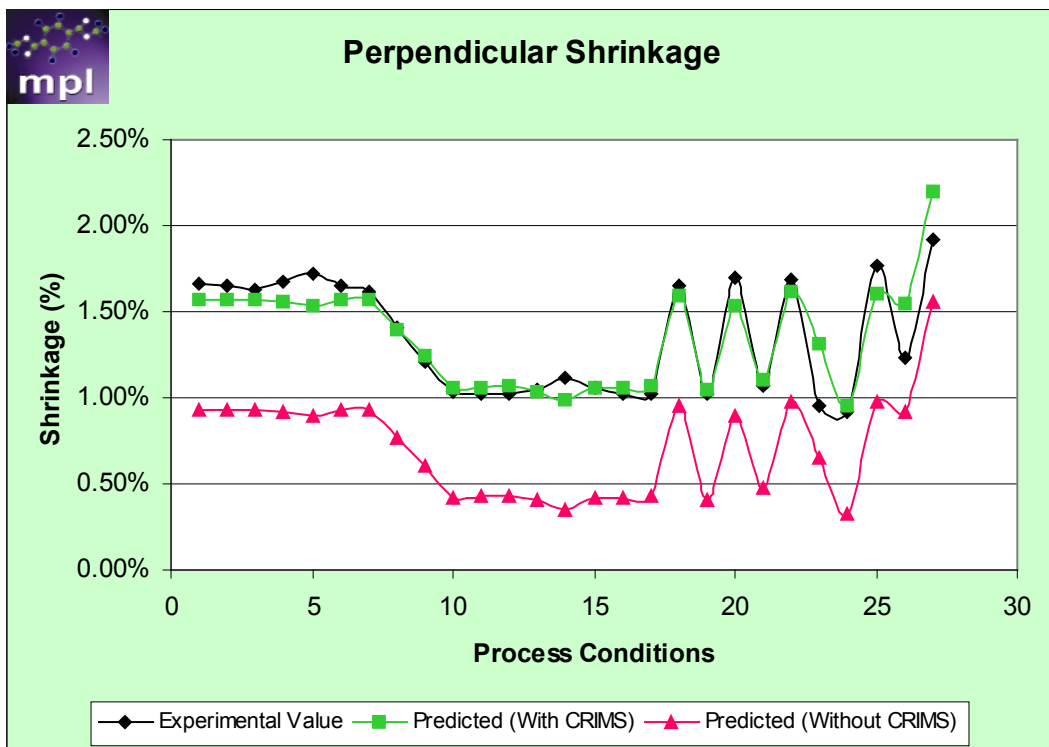
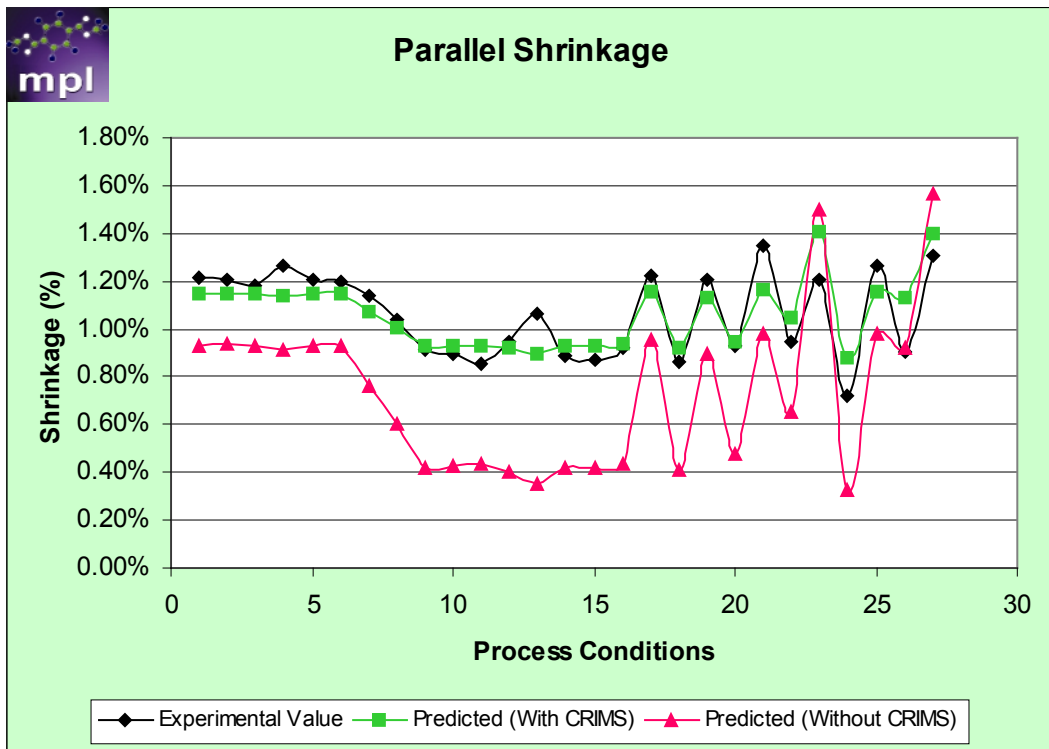
**These shrinkage models are valid for Moldflow Plastics Insight™ 5 only. Shrinkage models for previous software versions are available upon request.**

### Observed Shrinkage

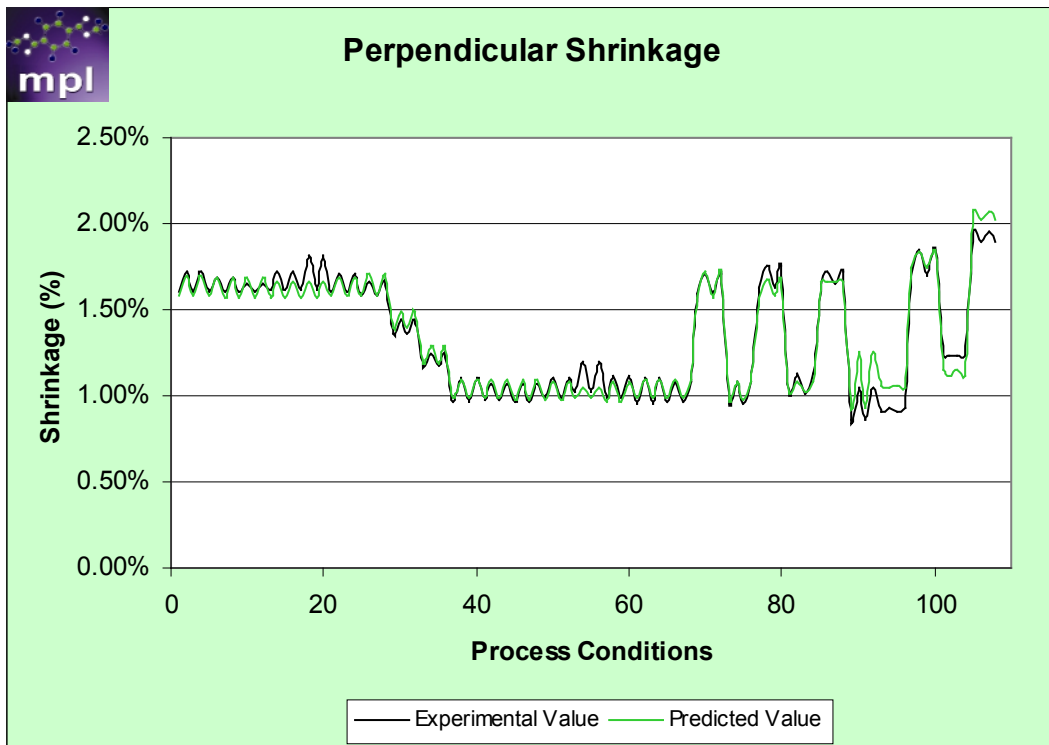
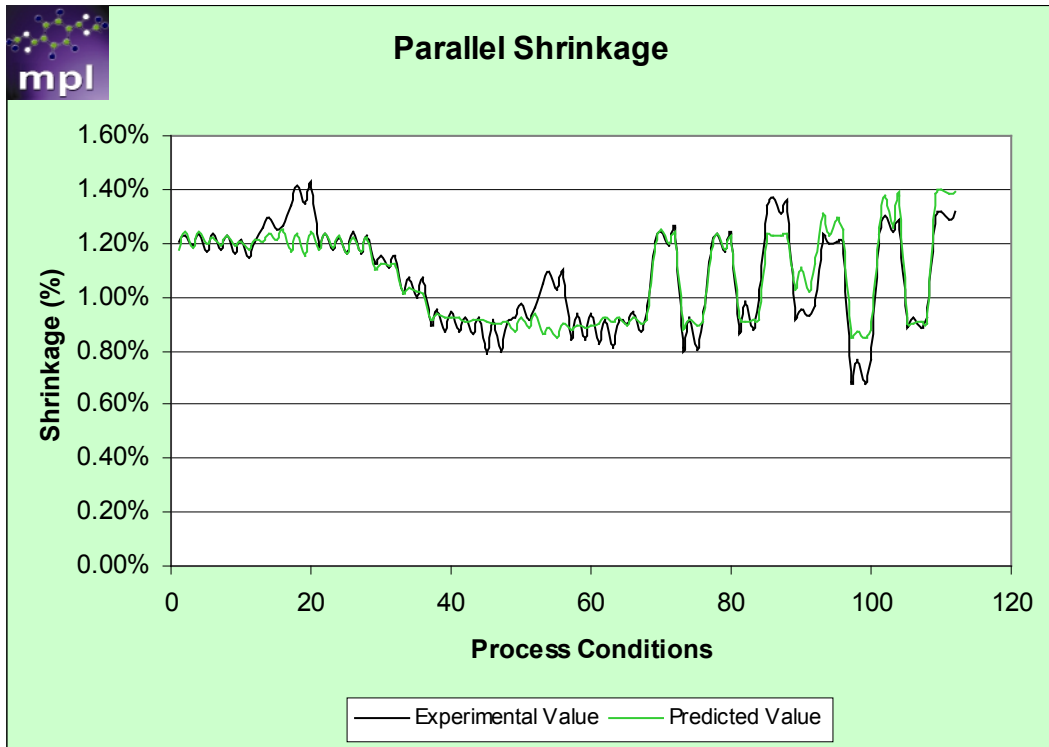
Observed nominal shrinkage	
Parallel	1.052%
Perpendicular	1.366%

Observed shrinkage	
Minimum Parallel	0.722%
Maximum Parallel	1.305%
Minimum Perpendicular	0.957%
Maximum Perpendicular	1.923%

### Residual Stress Plots



### Residual Strain Plots



# Mold verification

**Method:**

MPL Mold Verification Test Method (QOP-16-M)

**Instrument:**

Battenfeld BK-T 1500/400 Injection Molding Machine

**Test Specifications:**

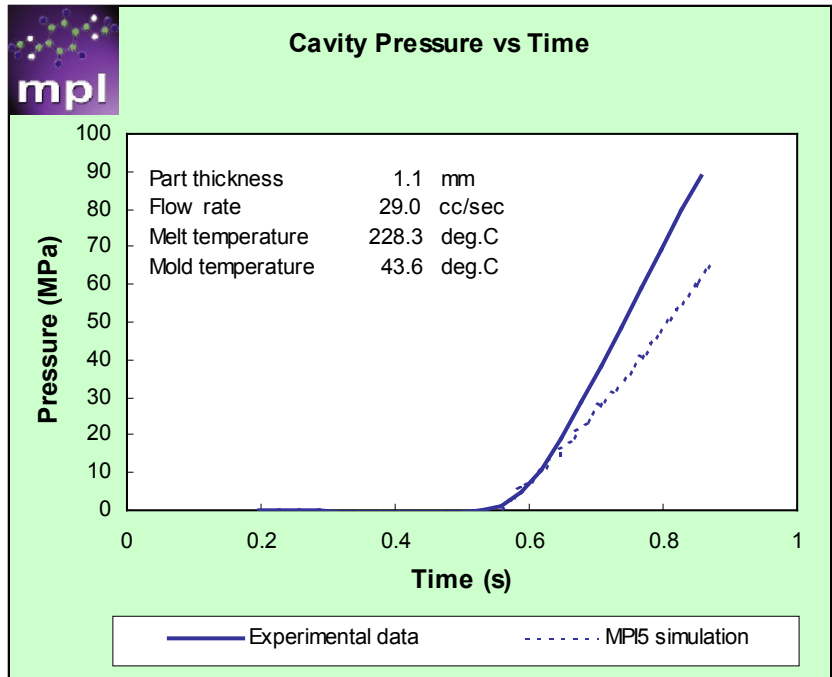
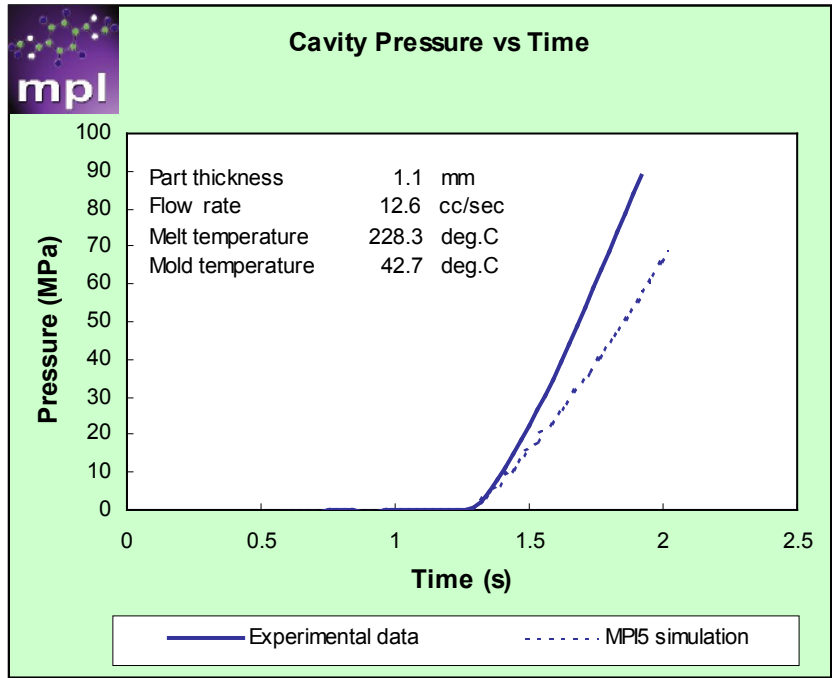
Sample Form:	Granules
Pre-Processing:	Not required
Moisture Level:	Not measured
Date Tested:	13-AUG-04

**Operator's Notes:**

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

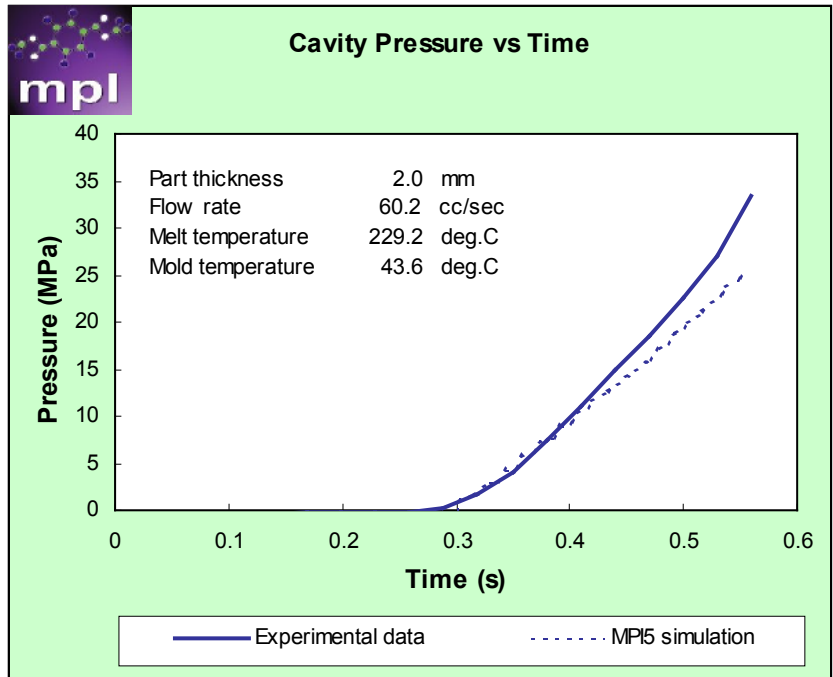
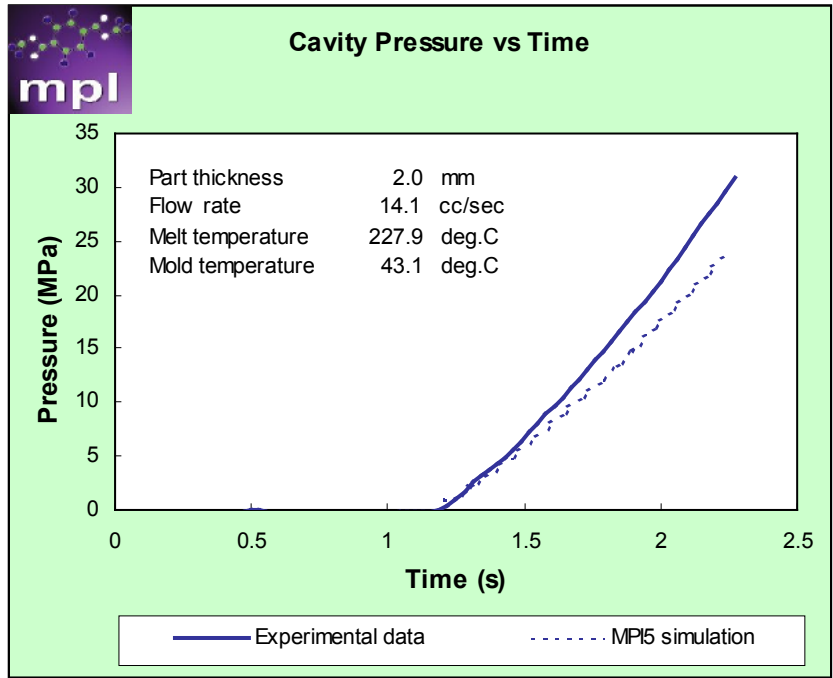
**1.1mm tag die**

Experiment Number	Flow Rate (cc/sec)	Melt Temperature	Mold Temperature
cyc1170	12.6	228.3	42.7
cyc1176	29	228.3	43.6



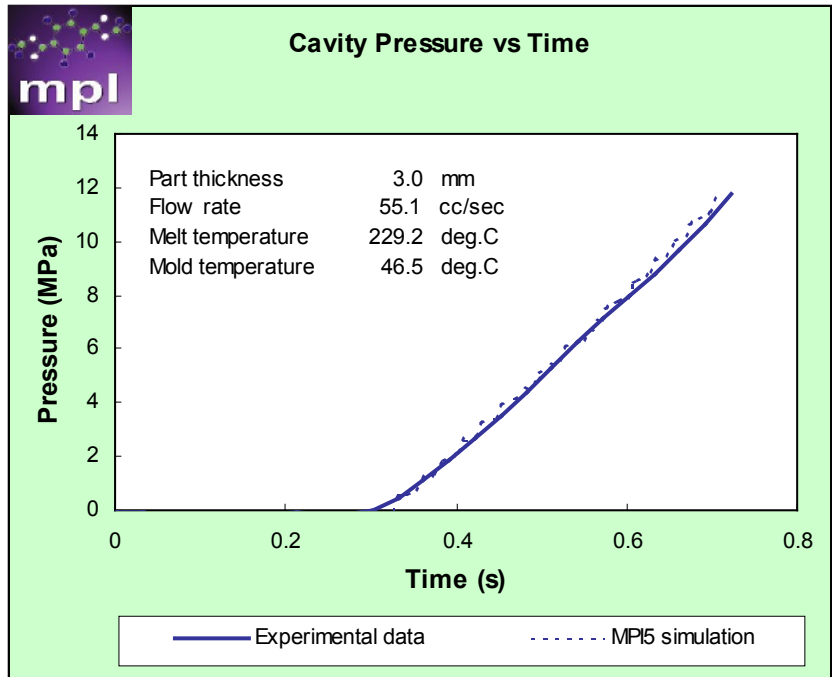
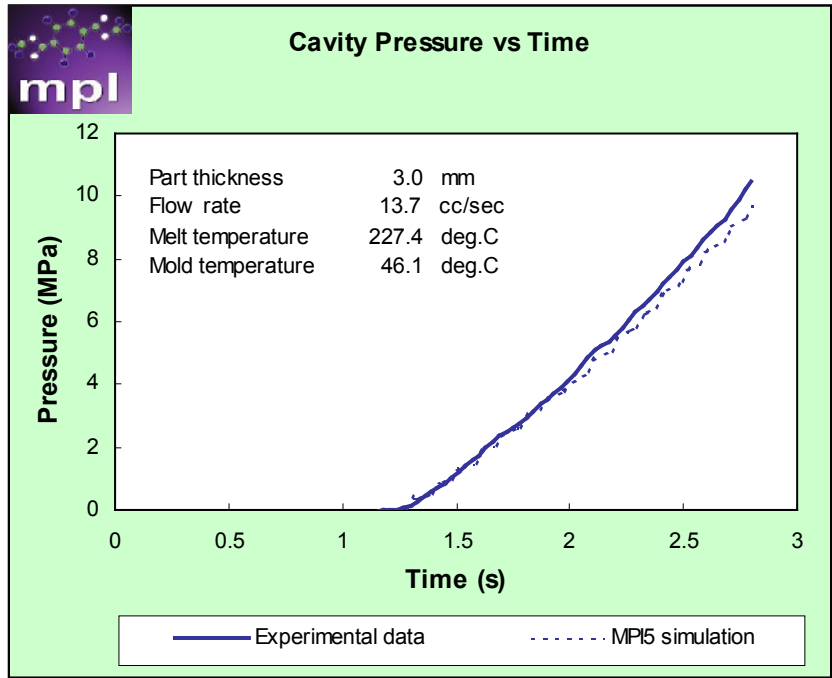
**2mm tag die**

Experiment Number	Flow Rate (cc/sec)	Melt Temperature	Mold Temperature
cyc1018	14.1	227.9	43.1
cyc1024	60.2	229.2	43.6



**3mm tag die**

Experiment Number	Flow Rate (cc/sec)	Melt Temperature	Mold Temperature
cyc1215	13.7	227.4	46.1
cyc1221	55.1	229.2	46.5



## Contact details

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For data fitting and database enquiries please email [datafitting@moldflow.com](mailto:datafitting@moldflow.com)

Find out more about Moldflow's testing service on [www.plasticszone.com](http://www.plasticszone.com)

Moldflow's corporate website: [www.moldflow.com](http://www.moldflow.com)




## Selecting material data from the User database

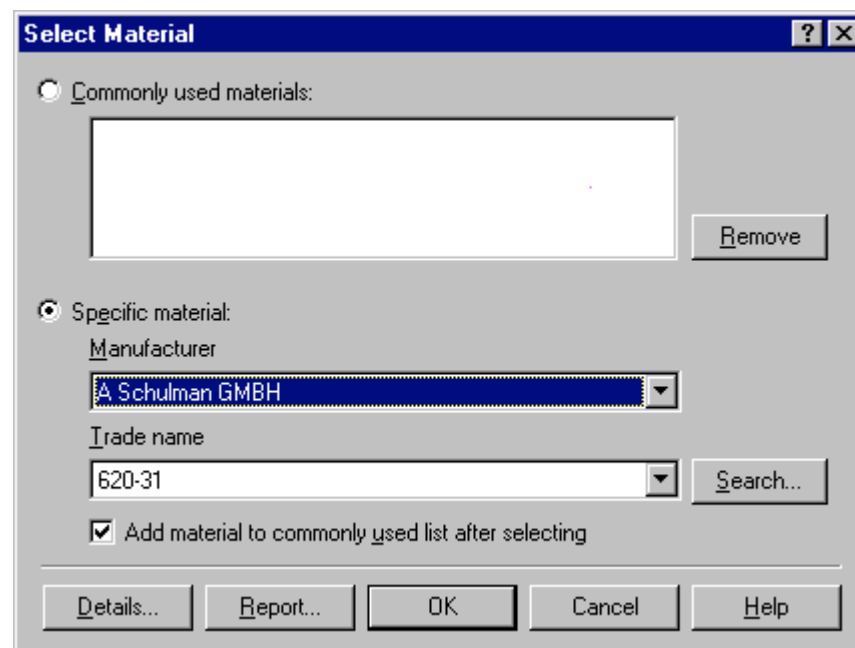
In order to use material data supplied by MPL, the 21000.udb file must be added to the User database.

A standard **PC** installation will have created a directory drive:\My MPI Projects\udb. Add the material data file to this directory.

A standard **Unix** installation will have created a directory <home directory>/mpi???-files/udb (where ??? is the version of MPI installed on the system). Add the material data file to this directory.

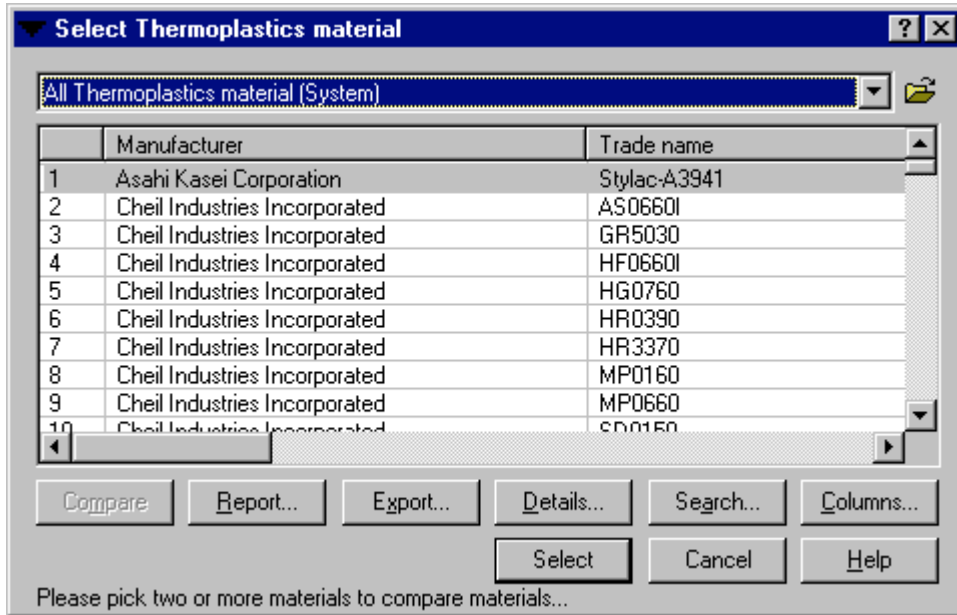
Once the material data file has been added to the appropriate directory, the material can be selected from the User database by following these steps:

- Start Moldflow Plastics Insight™.
- Open an existing project or create a new project.
- Open an existing study or create a new study. This will bring up the material icon  in the 'Study Tasks' window.
- Double click on the material icon to bring up the 'Select Material' dialog box.

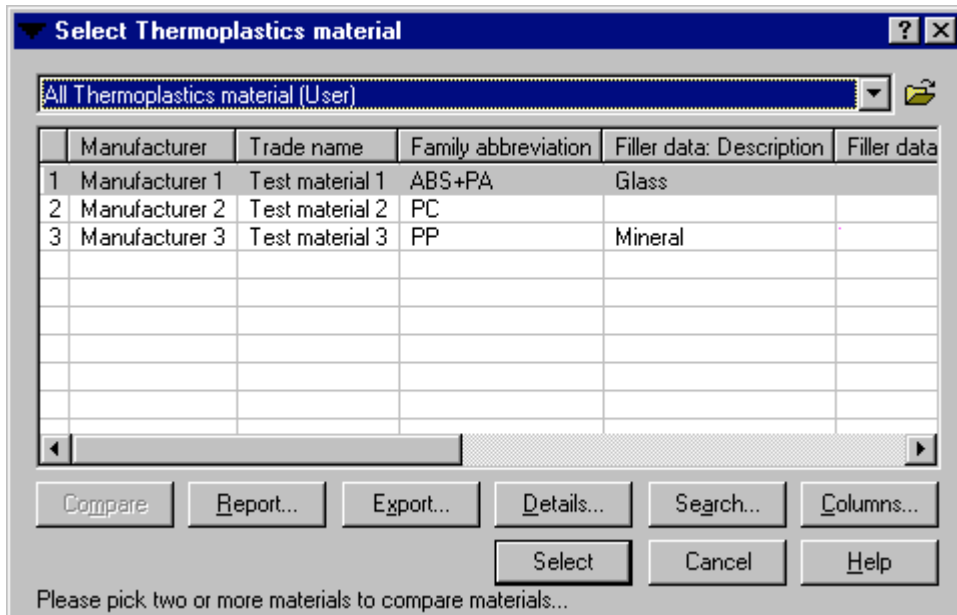


- Click **Search**.
- Click **Clear Filters** before clicking **OK**.

- From the drop down menu select 'All Thermoplastics material (User)'.



- Highlight the desired material and click **Select** or **OK** (depending on the version of MPI that is installed).



- Click **OK** to use this material in an analysis or **Details** to view the material data.