Styron 663 with additives

Test Report: Styron 663 with additives

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Address	Street1 Batavia, IL 60510 United States
Sample Received	11/6/2003
Sample Source	Client
Report Prepared	11/13/2003
Prepared By	
Title	Engineer
Issued By	
Title	Operations Manager

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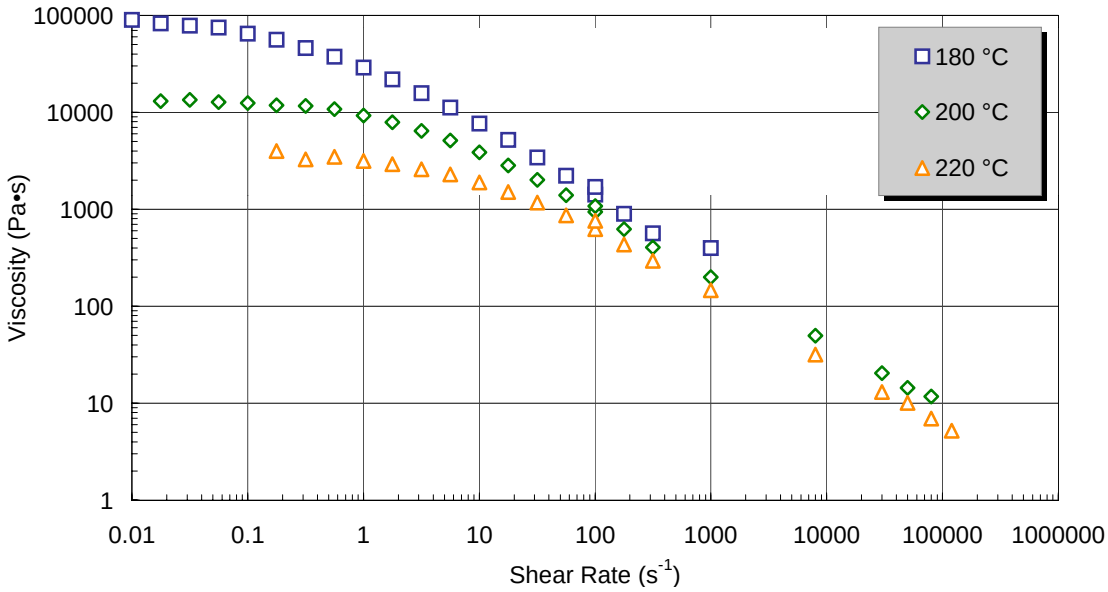
Viscosity Summary

Viscosity Data

180 °C		*200 °C*		*220 °C*	
Shear Rate s^{-1}	**Viscosity Pa·s**	**Shear Rate s^{-1}**	**Viscosity Pa·s**	**Shear Rate s^{-1}**	**Viscosity Pa·s**
0.01	89987.30	0.02	13000.00	0.18	4000.18
0.02	82681.60	0.03	13500.00	0.32	3283.87
0.03	78456.20	0.06	12800.00	0.56	3483.34
0.06	74893.00	0.10	12476.20	1.00	3158.77
0.10	64904.50	0.18	11804.60	1.78	2913.18
0.18	56325.70	0.32	11681.30	3	2592.26
0.32	45998.90	0.56	10794.60	5.62	2297.77
0.56	37385.40	1.00	9264.48	10.00	1895.89
1	29077.70	2	7887.63	17.78	1506.35
2	21888.70	3	6414.58	31.62	1172.41
3	15833.30	6	5109.40	56	866.62
6	11200.60	10	3858.33	100	622.33
10	7690.74	18	2823.44	178	432.99
18	5183.42	32	2009.96	316	293.49
32	3412.52	56	1393.89	100	763.24
56	2215.94	100	940.27	1000	146.33
100	1418.17	178	622.95	8000	31.72
178	898.65	316	404.88	30000	13.08
316	565.73	100	1075.00	50001	10.09
100	1698.50	1000	199.25	80000	6.93
1000	399.04	8000	49.81	120000	5.19
		30000	20.48		
		50001	14.42		
		80000	11.77		

Viscosity Summary Continued

Viscosity vs Shear Rate



Viscosity Summary Continued

Second Order Model (Moldflow)

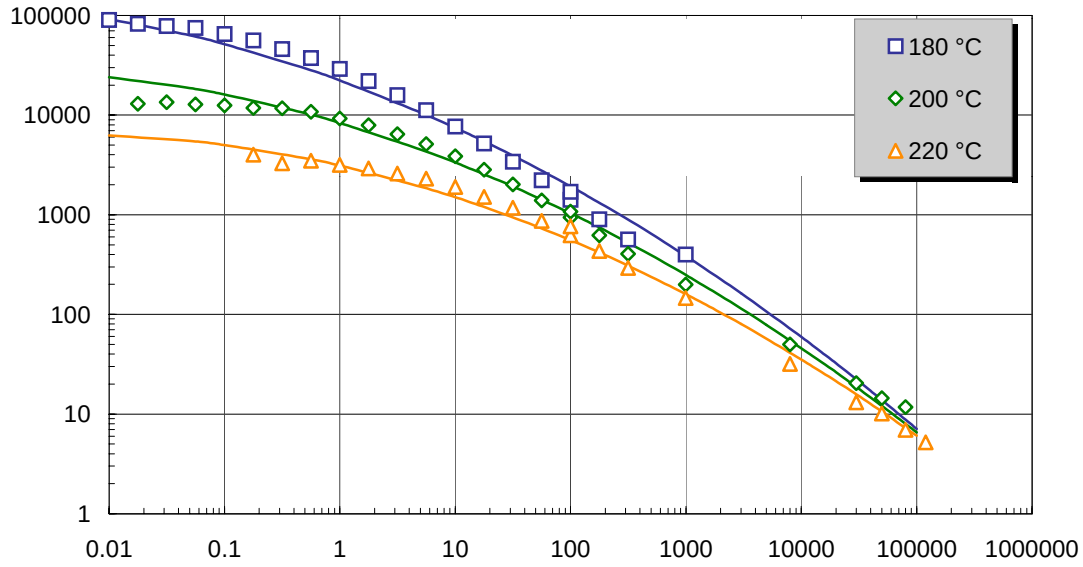
$$\ln \eta = A_1 + A_2 \ln \gamma + A_3 T + A_4 (\ln \gamma)^2 + A_5 \ln \gamma T + A_6 T^2$$

NOTE: model used for moldflow application, not good for this wide of a range

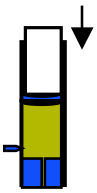
Coefficients (SI units)

A1	18.879
A2	-1.12698
A3	-0.04927
A4	-0.02432
A5	0.0039303
A6	1.230E-07

Viscosity vs Shear Rate



Viscosity



Method	ASTM D 3835 - 96 Determination of Properties of Polymeric Materials by Means of a Capillary Rheometer		
Instrument	Goettfert Rheograph 2003 Capillary Rheometer		
Specimen	type	pellets	
	drying	4 hrs @ 50°C	
	other preparation	none	
Parameters	initial pressure	0	MPa
	barrel diameter	12	mm
	die entry angle	180	°
	die inner diameter	0.5	mm
	die length	20	mm
	preheating time	6	min
Data Correction			
Precision	temperature	+/- 0.1	°C
	die inner diameter	+/- 0.0069	mm
	die length	+/- 0.025	mm
Uncertainty	per standard		

Polymer rheology characterizes the complex flow behavior of plastics. A capillary rheometer measures viscosity as a function of temperature and shear rate. The Goettfert rheometer utilizes direct measurement of melt pressures through a side mounted pressure transducer.

Data are modeled using empirical or semi-empirical equations.

Viscosity Data

180 °C		***200 °C***		***220 °C***	
Shear Rate s^{-1}	**Viscosity Pa·s**	**Shear Rate s^{-1}**	**Viscosity Pa·s**	**Shear Rate s^{-1}**	**Viscosity Pa·s**
100	1698.50	100	1075.00	100	763.24
1000	399.04	1000	199.25	1000	146.33
		8000	49.81	8000	31.72
		30000	20.48	30000	13.08
		50001	14.42	50001	10.09
		80000	11.77	80000	6.93
				120000	5.19

Tested By: *JA*

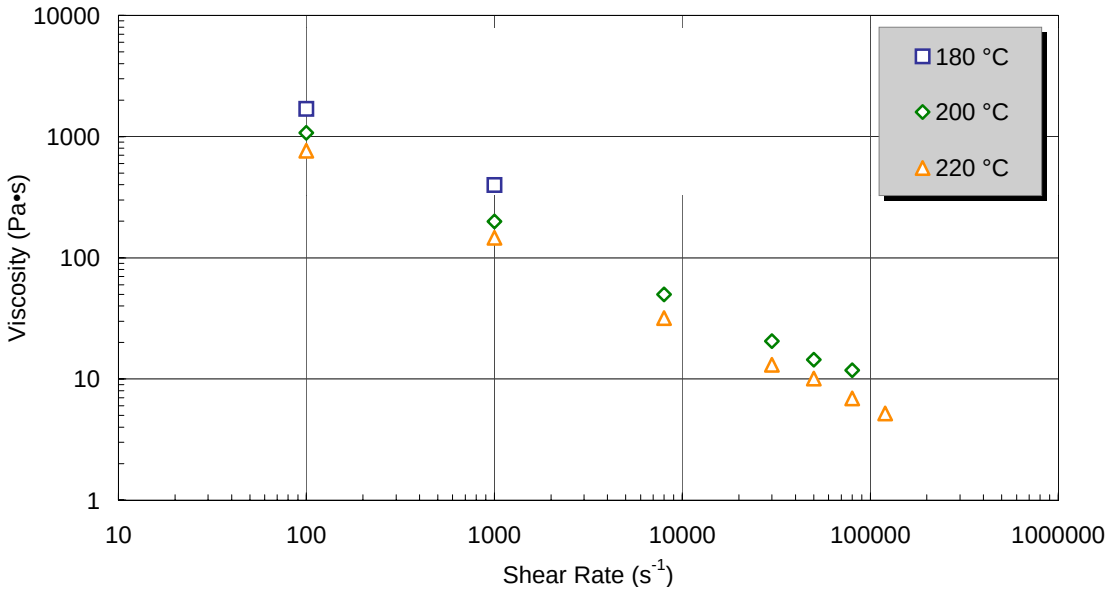
Certified By:

Test Date: *11/10/2003*

7914VIS.DTS

Viscosity Continued

Viscosity vs Shear Rate

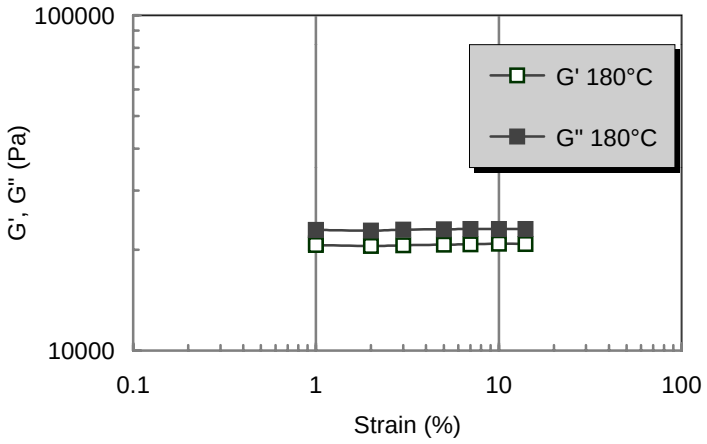


Cone & Plate Rheology: Styron 663 with additives 180°C

Method	ASTM D 4440 - 95a Rheological Measurement of Polymer Melts Using Dynamic Mechanical Procedures		
Instrument	Rheometrics ARES		
Specimen	type	pellets	
	conditioning	none	
	other preparation	none	
Parameters	plate diameter	25	mm
	cone angle	0.1	radians
	gap	50	µm
	temperature	180	°C
	frequency range	0.01-500	rad/s
	strain	1	%
Precision	temperature	±2	°C

Polymer rheology characterizes the complex flow behavior of plastics. A dynamic mechanical rheometer measures complex viscosity as a function of temperature and frequency. Assuming the applicability of the Cox Merz relationship, the frequency bears a 1:1 relationship to the shear rate.

Strain Sweep



Tested By: *JA*
Certified By: *BC*
Test Date: *11/12/2003*

7914f(180).txt

Cone and plate DMA measurements are not included in our current scope of accreditation.

Cone & Plate Rheology: Styron 663 with additives 180°C Continued

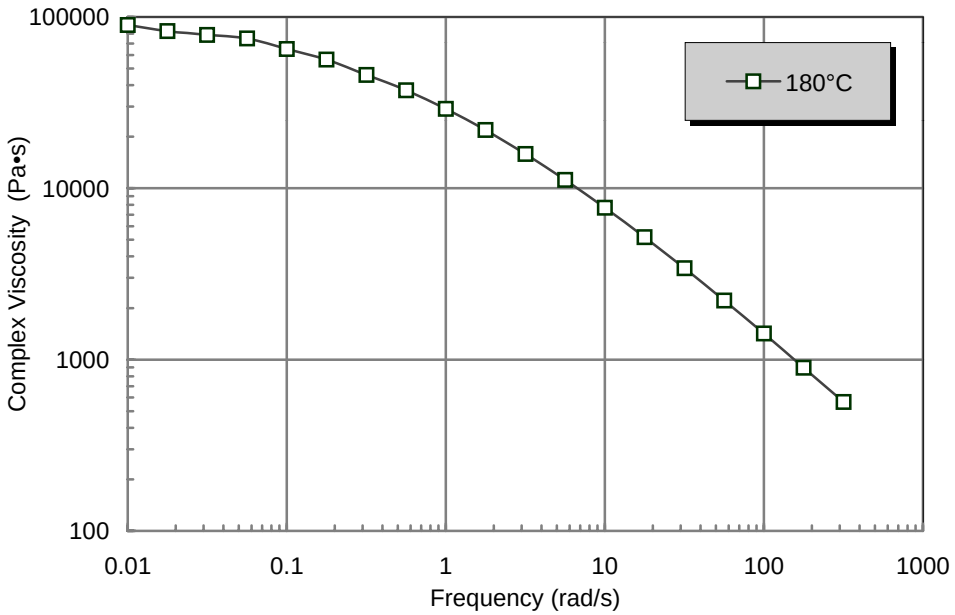
DMA Data

Temp °C	ω rad/s	η* Pa•s	G' Pa	G" Pa
180	1.00E-02	9.00E+04	4.68E+01	8.99E+02
180	1.78E-02	8.27E+04	1.51E+02	1.46E+03
180	3.16E-02	7.85E+04	4.35E+02	2.44E+03
180	5.62E-02	7.49E+04	1.09E+03	4.07E+03
180	1.00E-01	6.49E+04	2.33E+03	6.06E+03
180	1.78E-01	5.63E+04	4.37E+03	9.02E+03
180	3.16E-01	4.60E+04	7.67E+03	1.24E+04
180	5.62E-01	3.74E+04	1.27E+04	1.68E+04
180	1.00E+00	2.91E+04	1.93E+04	2.18E+04
180	1.78E+00	2.19E+04	2.82E+04	2.68E+04
180	3.16E+00	1.58E+04	3.91E+04	3.13E+04
180	5.62E+00	1.12E+04	5.18E+04	3.59E+04
180	1.00E+01	7.69E+03	6.60E+04	3.95E+04
180	1.78E+01	5.18E+03	8.16E+04	4.29E+04
180	3.16E+01	3.41E+03	9.79E+04	4.54E+04
180	5.62E+01	2.22E+03	1.15E+05	4.83E+04
180	1.00E+02	1.42E+03	1.32E+05	5.14E+04
180	1.78E+02	8.99E+02	1.50E+05	5.57E+04
180	3.16E+02	5.66E+02	1.68E+05	6.24E+04

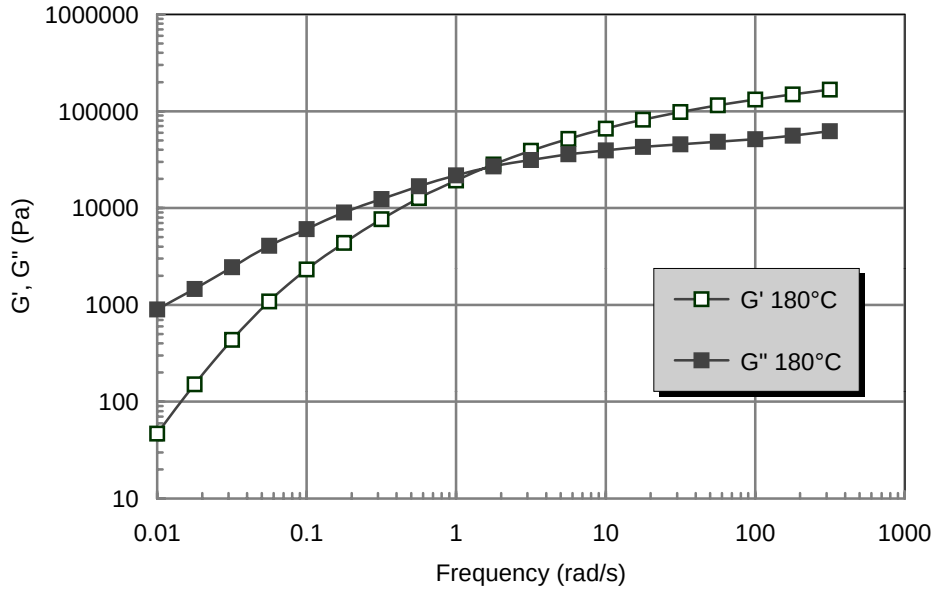
NOTE: Shaded cells denote torque below instrument limits.

Cone & Plate Rheology: Styron 663 with additives 180°C Continued

Complex Viscosity Plot



G'-G" Plot

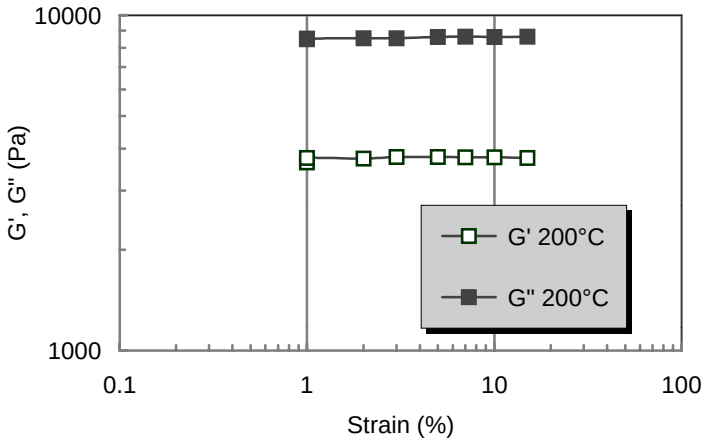


Cone & Plate Rheology: Styron 663 with additives 200°C

Method	ASTM D 4440 - 95a Rheological Measurement of Polymer Melts Using Dynamic Mechanical Procedures		
Instrument	Rheometrics ARES		
Specimen	type	pellets	
	conditioning	none	
	other preparation	none	
Parameters	plate diameter	25	mm
	cone angle	0.1	radians
	gap	50	µm
	temperature	200	°C
	frequency range	0.01-500	rad/s
	strain	1	%
Precision	temperature	±2	°C

Polymer rheology characterizes the complex flow behavior of plastics. A dynamic mechanical rheometer measures complex viscosity as a function of temperature and frequency. Assuming the applicability of the Cox Merz relationship, the frequency bears a 1:1 relationship to the shear rate.

Strain Sweep



Tested By: *JA*
Certified By: *BC*
Test Date: *11/12/2003*

7914f(200).txt

Cone and plate DMA measurements are not included in our current scope of accreditation.

Cone & Plate Rheology: Styron 663 with additives 200°C Continued

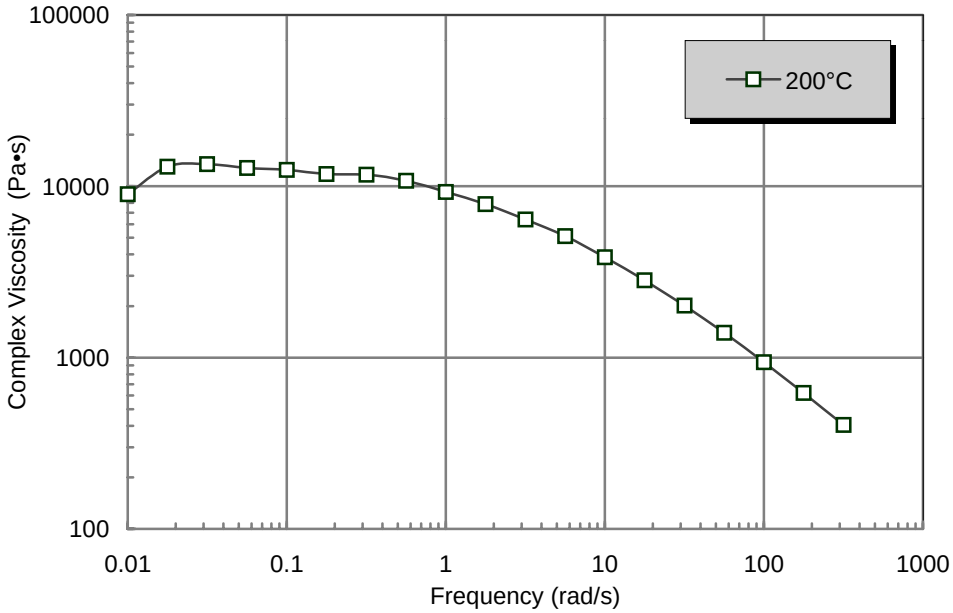
DMA Data

Temp °C	ω rad/s	η* Pa•s	G' Pa	G" Pa
200	1.00E-02	9.00E+03	-3.13E+00	-1.68E+00
200	1.78E-02	1.30E+04	7.30E+00	1.12E+02
200	3.16E-02	1.35E+04	3.15E+01	2.36E+02
200	5.62E-02	1.28E+04	5.20E+01	5.23E+02
200	1.00E-01	1.25E+04	9.29E+01	1.24E+03
200	1.78E-01	1.18E+04	3.19E+02	2.07E+03
200	3.16E-01	1.17E+04	8.28E+02	3.60E+03
200	5.62E-01	1.08E+04	1.87E+03	5.78E+03
200	1.00E+00	9.26E+03	3.64E+03	8.52E+03
200	1.78E+00	7.89E+03	6.90E+03	1.22E+04
200	3.16E+00	6.41E+03	1.16E+04	1.67E+04
200	5.62E+00	5.11E+03	1.81E+04	2.23E+04
200	1.00E+01	3.86E+03	2.71E+04	2.74E+04
200	1.78E+01	2.82E+03	3.82E+04	3.26E+04
200	3.16E+01	2.01E+03	5.16E+04	3.71E+04
200	5.62E+01	1.39E+03	6.65E+04	4.16E+04
200	1.00E+02	9.40E+02	8.25E+04	4.50E+04
200	1.78E+02	6.23E+02	9.97E+04	4.83E+04
200	3.16E+02	4.05E+02	1.17E+05	5.16E+04

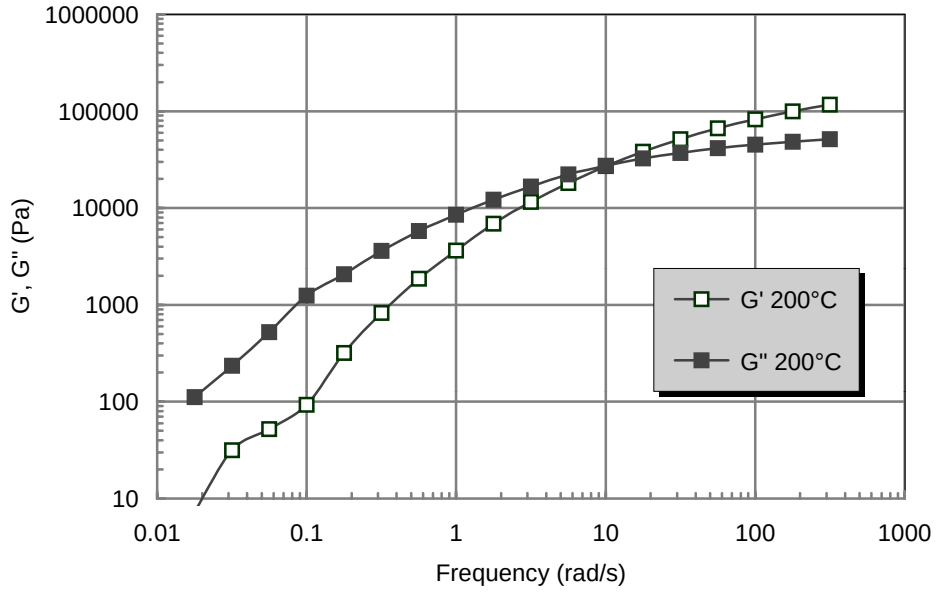
NOTE: Shaded cells denote torque below instrument limits.

Cone & Plate Rheology: Styron 663 with additives 200°C Continued

Complex Viscosity Plot



G'-G" Plot



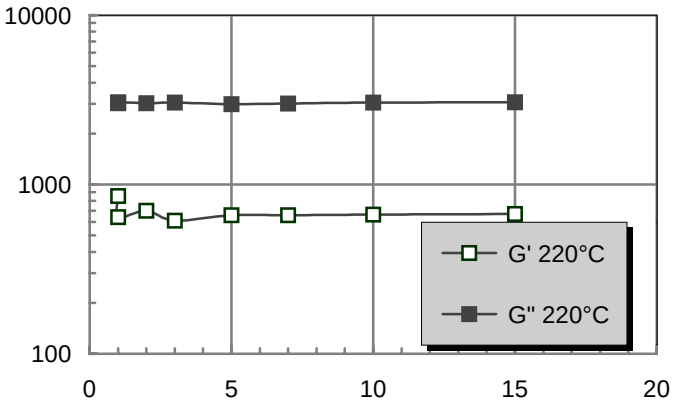
Cone & Plate Rheology: Styron 663 with additives 220°C

Method	ASTM D 4440 - 95a Rheological Measurement of Polymer Melts Using Dynamic Mechanical Procedures		
Instrument	Rheometrics ARES		
Specimen	type	pellets	
	conditioning	none	
	other preparation	none	
Parameters	plate diameter	25	mm
	cone angle	0.1	radians
	gap	50	µm
	temperature	220	°C
	frequency range	0.01-500	rad/s
	strain	1	%
Precision	temperature	±2	°C

Polymer rheology characterizes the complex flow behavior of plastics. A dynamic mechanical rheometer measures complex viscosity as a function of temperature and frequency. Assuming the applicability of the Cox Merz relationship, the frequency bears a 1:1 relationship to the shear rate.

**Calculated as 100,000/(G'-G" crossover)*

Strain Sweep



Tested By: *JA*
Certified By: *BC*
Test Date: *11/12/2003*

7914f(220).txt

Cone and plate DMA measurements are not included in our current scope of accreditation.

Cone & Plate Rheology: Styron 663 with additives 220°C Continued

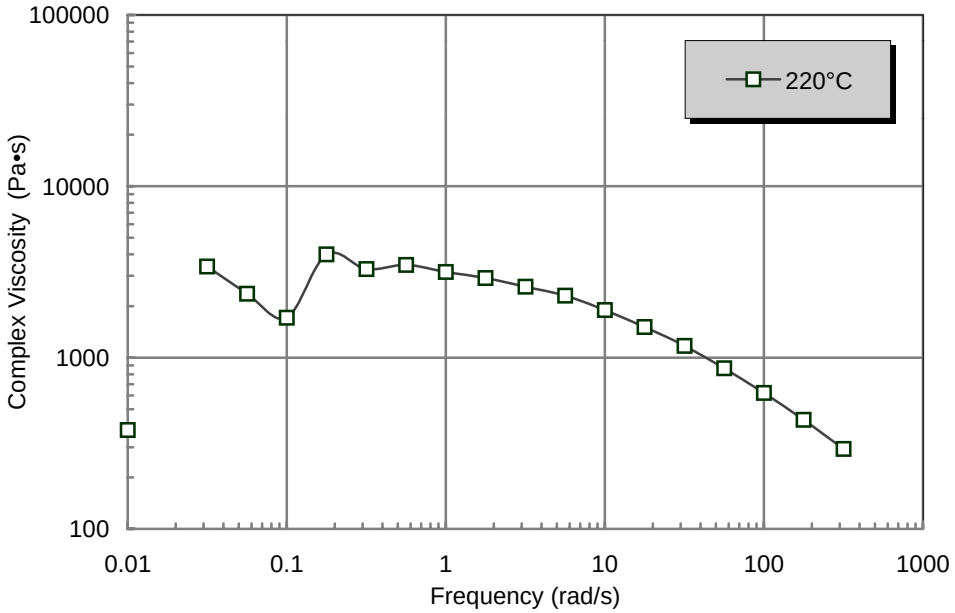
DMA Data

Temp °C	ω rad/s	η* Pa•s	G' Pa	G" Pa
220	1.00E-02	3.78E+02	-3.41E+00	-2.15E+00
220	1.78E-02	-5.30E+00	-5.63E+00	8.31E+01
220	3.16E-02	3.40E+03	1.52E+01	9.73E+01
220	5.62E-02	2.36E+03	2.13E+01	1.23E+02
220	1.00E-01	1.71E+03	2.52E+01	1.69E+02
220	1.78E-01	4.00E+03	-2.15E+01	7.11E+02
220	3.16E-01	3.28E+03	-2.81E+01	1.04E+03
220	5.62E-01	3.48E+03	4.30E+02	1.91E+03
220	1.00E+00	3.16E+03	6.24E+02	3.10E+03
220	1.78E+00	2.91E+03	1.36E+03	5.00E+03
220	3.16E+00	2.59E+03	2.94E+03	7.65E+03
220	5.62E+00	2.30E+03	5.73E+03	1.16E+04
220	1.00E+01	1.90E+03	1.01E+04	1.60E+04
220	1.78E+01	1.51E+03	1.64E+04	2.12E+04
220	3.16E+01	1.17E+03	2.54E+04	2.70E+04
220	5.62E+01	8.67E+02	3.63E+04	3.25E+04
220	1.00E+02	6.22E+02	4.96E+04	3.75E+04
220	1.78E+02	4.33E+02	6.46E+04	4.18E+04
220	3.16E+02	2.93E+02	8.09E+04	4.55E+04

NOTE: Shaded cells denote torque below instrument limits.

Cone & Plate Rheology: Styron 663 with additives 220°C Continued

Complex Viscosity Plot



G'-G" Plot