



# ASPHALT TECHNOLOGIES, INC.

To: Federal Lands Highway Division

February 16, 2009

From: Laurand Lewandowski  
PRI Asphalt Technologies, Inc.

Subject: Strawman Testing, PASS Emulsion

PROPERTY	TEST METHOD	SPECIFICATION	RESULT	
<b>Asphalt Emulsion as Received</b>				
TBD				
<b>Evaporative Method Residue (24 hours @ 25°C, 24 hours @ 60°C, Forced Draft Oven)</b>				
Residue by Evaporation, %	Draft Method	Report	66.4	
Water Content, %	ASTM D 95		0.0	
Frequency Sweep (25 mm, 0.1 – 100 rad/sec, 12% Strain)	AASHTO T 315		See Graph 1, Table 1	
MSCR	70°C		TP 70-08	% Rec (100 Pa)
				$J_{nr}$ (100 Pa) $kPa^{-1}$
				% Rec (1,000 Pa)
				$J_{nr}$ (1,000 Pa) $kPa^{-1}$
				% Rec (3,200 Pa)
				$J_{nr}$ (3,200 Pa) $kPa^{-1}$
				% Rec (10,000 Pa)
$J_{nr}$ (10,000 Pa) $kPa^{-1}$				
Frequency Sweep (25 mm, 0.1 – 100 rad/sec, 12% Strain)	AASHTO T 315		See Graph 1, Table 2	
MSCR	64°C		TP 70-08	% Rec (100 Pa)
				$J_{nr}$ (100 Pa) $kPa^{-1}$
				% Rec (1,000 Pa)
				$J_{nr}$ (1,000 Pa) $kPa^{-1}$
				% Rec (3,200 Pa)
				$J_{nr}$ (3,200 Pa) $kPa^{-1}$
				% Rec (10,000 Pa)
$J_{nr}$ (10,000 Pa) $kPa^{-1}$				
Frequency Sweep (25 mm, 0.1 – 100 rad/sec, 12% Strain)	AASHTO T 315	See Graph 1, Table 3		
MSCR	58°C	TP 70-08	% Rec (100 Pa)	
			$J_{nr}$ (100 Pa) $kPa^{-1}$	
			% Rec (1,000 Pa)	
			$J_{nr}$ (1,000 Pa) $kPa^{-1}$	
			% Rec (3,200 Pa)	
			$J_{nr}$ (3,200 Pa) $kPa^{-1}$	
			% Rec (10,000 Pa)	
$J_{nr}$ (10,000 Pa) $kPa^{-1}$				

BASF 03-02-01

PRI's Accreditations: AASHTO/AAP; IAS-ES, CRRC, Metro-Dade an ISO/IEC 17025 Lab

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**RESULTS: (Continued)**

PRESSURE AGING RESIDUE (100°C, 300 psi, 20 hr.)						
Frequency Sweep (8 mm, 0.1 – 100 rad/sec, 5% Strain)		70°C	AASHTO T 315	Report	See Graph 2, Table 4	
MSCR	% Rec (100 Pa)		TP 70-08			N/A
	J <sub>nr</sub> (100 Pa) kPa <sup>-1</sup>					
	% Rec (1000 Pa)					
	J <sub>nr</sub> (1000 Pa) kPa <sup>-1</sup>					
	% Rec (3,200 Pa)					
	J <sub>nr</sub> (3,200 Pa) kPa <sup>-1</sup>					
	% Rec (10,000 Pa)					
J <sub>nr</sub> (10,000 Pa) kPa <sup>-1</sup>						
Frequency Sweep (8 mm, 0.1 – 100 rad/sec, 5% Strain)		64°C	AASHTO T 315	Report	See Graph 2, Table 5	
MSCR	% Rec (100 Pa)		TP 70-08			N/A
	J <sub>nr</sub> (100 Pa) kPa <sup>-1</sup>					
	% Rec (1000 Pa)					
	J <sub>nr</sub> (1000 Pa) kPa <sup>-1</sup>					
	% Rec (3,200 Pa)					
	J <sub>nr</sub> (3,200 Pa) kPa <sup>-1</sup>					
	% Rec (10,000 Pa)					
J <sub>nr</sub> (10,000 Pa) kPa <sup>-1</sup>						
Frequency Sweep (8 mm, 0.1 – 100 rad/sec, 5% Strain)		58°C	AASHTO T 315	Report	See Graph 2, Table 6	
MSCR	% Rec (100 Pa)		TP 70-08			N/A
	J <sub>nr</sub> (100 Pa) kPa <sup>-1</sup>					
	% Rec (1000 Pa)					
	J <sub>nr</sub> (1000 Pa) kPa <sup>-1</sup>					
	% Rec (3,200 Pa)					
	J <sub>nr</sub> (3,200 Pa) kPa <sup>-1</sup>					
	% Rec (10,000 Pa)					
J <sub>nr</sub> (10,000 Pa) kPa <sup>-1</sup>						
Frequency Sweep (8 mm, 0.1 – 100 rad/sec, 1% Strain)		10°C	AASHTO T 315	Report	See Graph 3, Table 7	
Frequency Sweep (8 mm, 0.1 – 100 rad/sec, 1% Strain)		20°C			See Graph 3, Table 8	
Strain Sweep (8 mm, 1 – 50 % Strain, 10 rad/sec)		25°C			New Method	See Graph 4, Table 9
Creep Stiffness	Stiffness, MPA (60 sec.)	-18°C	AASHTO T 313	Report	300 max.	68
	m- Value				0.300 min.	0.438
	Stiffness, MPA (60 sec.)	-12°C			300 max.	18
	m- Value				300 min.	0.476

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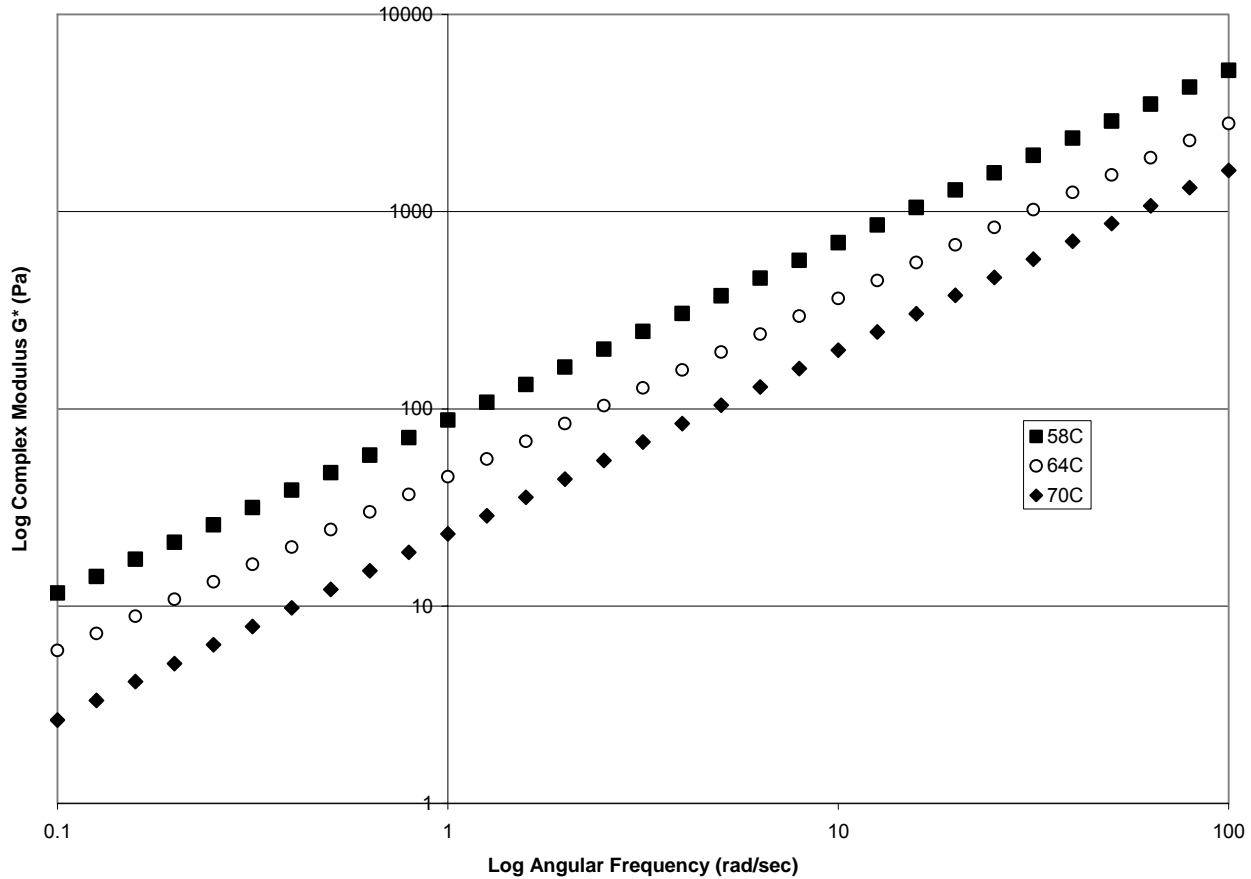
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**Graph 1: Frequency Sweep on Residue (58°C, 64°C & 70°C)**



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**Table 1. Frequency Sweep on Residue (25 mm plates, 2 mm gap, 10% strain (0. 1 to 100 rad/sec))**

ang. frequency rad/sec	delta degrees	G' Pa	G'' Pa	G*  Pa	strain	temperature °C
0.1	85.2	0.2209	2.63	2.64	0.099974	70
0.1259	84.58	0.3143	3.31	3.325	0.099959	70
0.1585	84.8	0.3758	4.128	4.145	0.099974	70
0.1995	84.54	0.4873	5.093	5.116	0.099962	70
0.2512	84.4	0.6214	6.34	6.37	0.099954	70
0.3162	84.4	0.7694	7.846	7.884	0.09996	70
0.3981	84.41	0.955	9.753	9.799	0.09995	70
0.5012	84.39	1.189	12.1	12.16	0.099948	70
0.631	84.28	1.503	15.01	15.09	0.099933	70
0.7943	84.33	1.848	18.61	18.71	0.099939	70
1	84.41	2.263	23.1	23.21	0.099932	70
1.259	84.44	2.784	28.6	28.73	0.099928	70
1.585	84.35	3.507	35.45	35.62	0.099902	70
1.995	84.34	4.353	43.88	44.1	0.099906	70
2.512	84.35	5.385	54.45	54.71	0.099894	70
3.162	84.4	6.632	67.61	67.93	0.099891	70
3.981	84.4	8.217	83.74	84.14	0.099874	70
5.012	84.35	10.27	103.8	104.3	0.099862	70
6.31	84.44	12.51	128.5	129.1	0.099869	70
7.943	84.49	15.36	159.3	160	0.099868	70
10	84.55	18.83	197.4	198.3	0.099856	70
12.59	84.67	22.82	244.6	245.6	0.099881	70
15.85	84.83	27.41	302.6	303.9	0.099899	70
19.95	85.06	32.43	374.9	376.3	0.099928	70
25.12	85.39	37.37	463.3	464.8	0.10002	70
31.62	85.87	41.3	572.3	573.8	0.10008	70
39.81	86.55	42.57	705.9	707.2	0.10024	70
50.12	87.44	38.89	869.6	870.5	0.10035	70
63.1	88.7	24.34	1071	1071	0.10053	70
79.43	90.51	-11.78	1324	1324	0.10054	70
100	92.78	-78.47	1618	1620	0.10075	70



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**Table 2. Frequency Sweep on Residue (25 mm plates, 2 mm gap, 10% strain (0. 1 to 100 rad/sec))**

ang. frequency rad/sec	delta degrees	G' Pa	G'' Pa	G*  Pa	strain %	temperature °C
0.1	78.99	1.138	5.849	5.959	9.9895	64
0.1259	78.96	1.392	7.139	7.273	9.9953	64
0.1585	79.24	1.66	8.733	8.89	9.9949	64
0.1995	79.31	2.014	10.67	10.85	9.9943	64
0.2512	79.51	2.417	13.05	13.27	9.9933	64
0.3162	79.71	2.91	16.03	16.29	9.9934	64
0.3981	79.97	3.472	19.64	19.95	9.9922	64
0.5012	80.19	4.162	24.08	24.44	9.9921	64
0.631	80.34	5.035	29.58	30.01	9.9896	64
0.7943	80.48	6.092	36.34	36.85	9.9897	64
1	80.73	7.299	44.72	45.31	9.9871	64
1.259	80.99	8.719	55.01	55.7	9.9887	64
1.585	81.14	10.55	67.66	68.48	9.9851	64
1.995	81.31	12.73	83.31	84.28	9.9859	64
2.512	81.52	15.33	102.8	103.9	9.9835	64
3.162	81.59	18.69	126.4	127.8	9.9824	64
3.981	81.7	22.73	155.8	157.4	9.9798	64
5.012	81.78	27.73	192	194	9.9794	64
6.31	81.82	34.04	236.9	239.3	9.9755	64
7.943	81.86	41.8	292.1	295.1	9.9755	64
10	81.92	51.07	359.7	363.3	9.9754	64
12.59	81.95	62.69	443.2	447.6	9.975	64
15.85	82.01	76.68	546	551.4	9.9742	64
19.95	82.06	93.6	671.4	677.9	9.9794	64
25.12	82.23	112.6	825	832.6	9.9858	64
31.62	82.4	135.3	1014	1023	9.9909	64
39.81	82.72	158.8	1243	1253	10.01	64
50.12	83.16	182.5	1522	1533	10.021	64
63.1	83.84	201.2	1866	1876	10.043	64
79.43	84.77	208.8	2283	2292	10.057	64
100	86.14	188.4	2789	2795	10.082	64

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**Table 3. Frequency Sweep on Residue (25 mm plates, 2 mm gap, 10% strain (0. 1 to 100 rad/sec))**

ang. frequency rad/sec	delta degrees	G' Pa	G'' Pa	G*  Pa	% strain	temperature °C
0.1	78.41	2.341	11.41	11.65	0.09973	58
0.1259	78.86	2.73	13.87	14.14	0.099922	58
0.1585	78.99	3.303	16.98	17.29	0.099886	58
0.1995	79.15	3.972	20.72	21.09	0.099891	58
0.2512	79.41	4.739	25.36	25.8	0.099874	58
0.3162	79.52	5.748	31.08	31.61	0.099866	58
0.3981	79.68	6.93	38.06	38.69	0.099847	58
0.5012	79.87	8.34	46.7	47.44	0.099849	58
0.631	80.06	10.05	57.34	58.21	0.099822	58
0.7943	80.2	12.15	70.33	71.37	0.09983	58
1	80.38	14.66	86.47	87.7	0.099793	58
1.259	80.54	17.73	106.4	107.9	0.099788	58
1.585	80.66	21.51	130.8	132.6	0.099751	58
1.995	80.74	26.24	160.9	163	0.099746	58
2.512	80.86	31.9	198.2	200.8	0.099707	58
3.162	80.88	39.17	244	247.2	0.099692	58
3.981	80.85	48.34	300.2	304.1	0.099637	58
5.012	80.83	59.66	369.7	374.5	0.099631	58
6.31	80.78	73.82	454.7	460.7	0.099587	58
7.943	80.71	91.45	559	566.4	0.099587	58
10	80.61	113.5	686.9	696.2	0.099539	58
12.59	80.53	140.7	843.3	854.9	0.099557	58
15.85	80.41	174.7	1034	1049	0.099543	58
19.95	80.35	215.7	1268	1286	0.099578	58
25.12	80.29	265.7	1553	1575	0.099635	58
31.62	80.28	325.2	1899	1927	0.099706	58
39.81	80.34	395.6	2323	2357	0.099844	58
50.12	80.48	475.6	2836	2875	0.099997	58
63.1	80.75	564.1	3464	3510	0.10021	58
79.43	81.19	655	4227	4278	0.10038	58
100	81.87	736.4	5155	5208	0.10071	58

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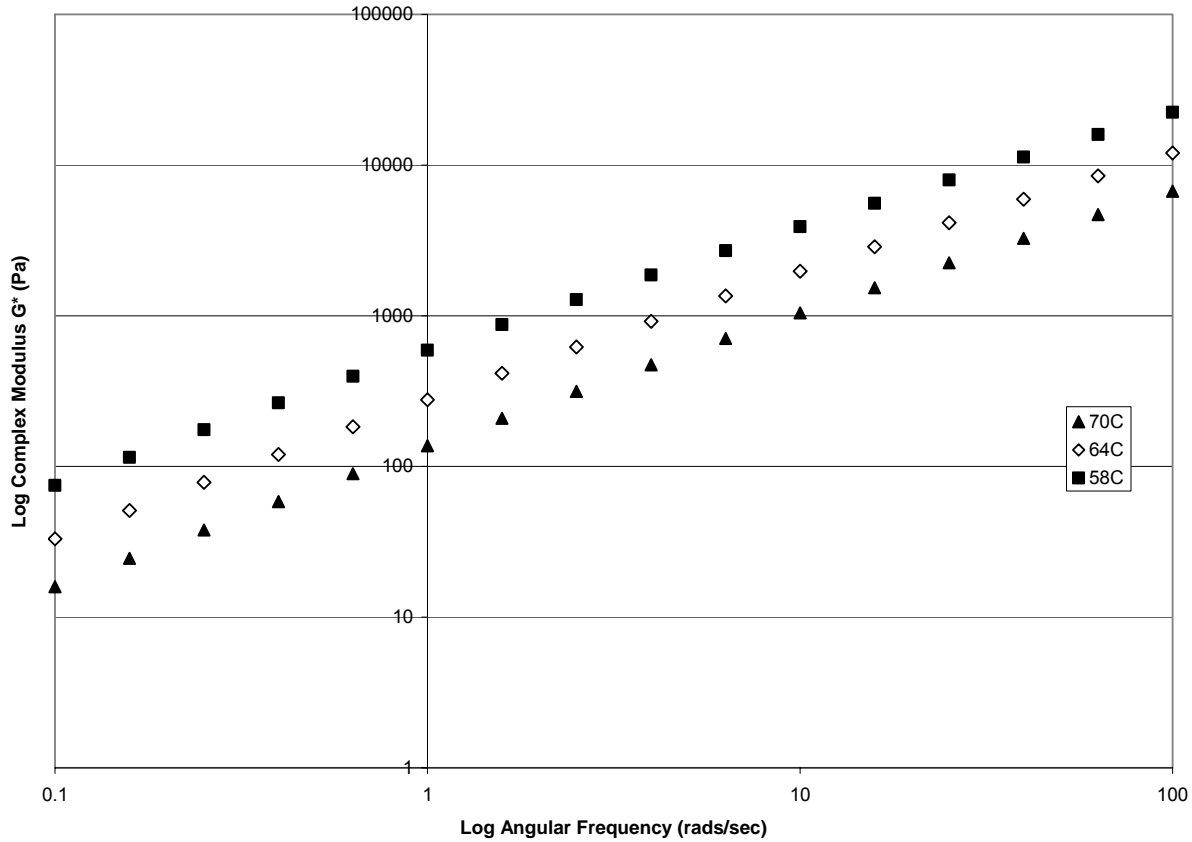
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**Graph 1: Frequency Sweep on PAV Residue (58°C, 64°C & 70°C)**





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**Table 4. Frequency Sweep on PAV Residue (8 mm plates, 2 mm gap, 5% strain (0.1 to 100 rad/sec))**

ang. frequency rad/sec	delta degrees	G' Pa	G'' Pa	G*  Pa	% strain	temperature °C
0.1	85.44	1.265	15.86	15.91	4.9921	70
0.1585	85	2.139	24.44	24.53	4.9926	70
0.2512	84.47	3.646	37.69	37.86	4.9897	70
0.3981	83.91	6.195	58.06	58.39	4.9862	70
0.631	83.15	10.67	88.91	89.55	4.9811	70
1	82.1	18.83	135.7	137	4.9725	70
1.585	81.08	32.3	205.8	208.3	4.965	70
2.512	79.93	55.06	310.2	315	4.9544	70
3.981	78.79	91.93	463.8	472.8	4.945	70
6.31	77.61	151.3	688.8	705.3	4.9356	70
10	76.48	244.3	1016	1045	4.9303	70
15.85	75.46	386	1488	1537	4.9329	70
25.12	74.56	597.9	2165	2246	4.9457	70
39.81	73.89	904.6	3132	3260	4.9908	70
63.1	73.56	1329	4504	4696	5.0251	70
100	73.8	1875	6452	6719	5.12	70



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**Table 5. Frequency Sweep on PAV Residue (25 mm plates, 1 mm gap, 5% strain (0.1 to 100 rad/sec))**

ang. frequency rad/sec	delta degrees	G' Pa	G'' Pa	G*  Pa	% strain	temperature °C
0.1	84.55	3.133	32.87	33.02	4.9791	64
0.1585	83.99	5.336	50.68	50.96	4.9885	64
0.2512	83.23	9.248	77.91	78.46	4.98	64
0.3981	82.29	16.11	119.1	120.2	4.9748	64
0.631	81.18	28.09	181	183.2	4.9656	64
1	79.99	48.09	272.5	276.7	4.9555	64
1.585	78.72	81.31	407.8	415.8	4.9432	64
2.512	77.48	134.4	605.2	620	4.9319	64
3.981	76.25	218.5	893.2	919.6	4.9202	64
6.31	75.06	348.8	1307	1353	4.9128	64
10	73.95	546.7	1900	1977	4.9114	64
15.85	72.95	841.6	2744	2870	4.9264	64
25.12	72.1	1274	3945	4145	4.9363	64
39.81	71.36	1899	5630	5942	4.9961	64
63.1	70.95	2771	8023	8488	5.0216	64
100	70.93	3935	11380	12040	5.1221	64



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**Table 6. Frequency Sweep on PAV Residue ( 25 mm plates, 1 mm gap, 5% strain (0. 1 to 100 rad/sec))**

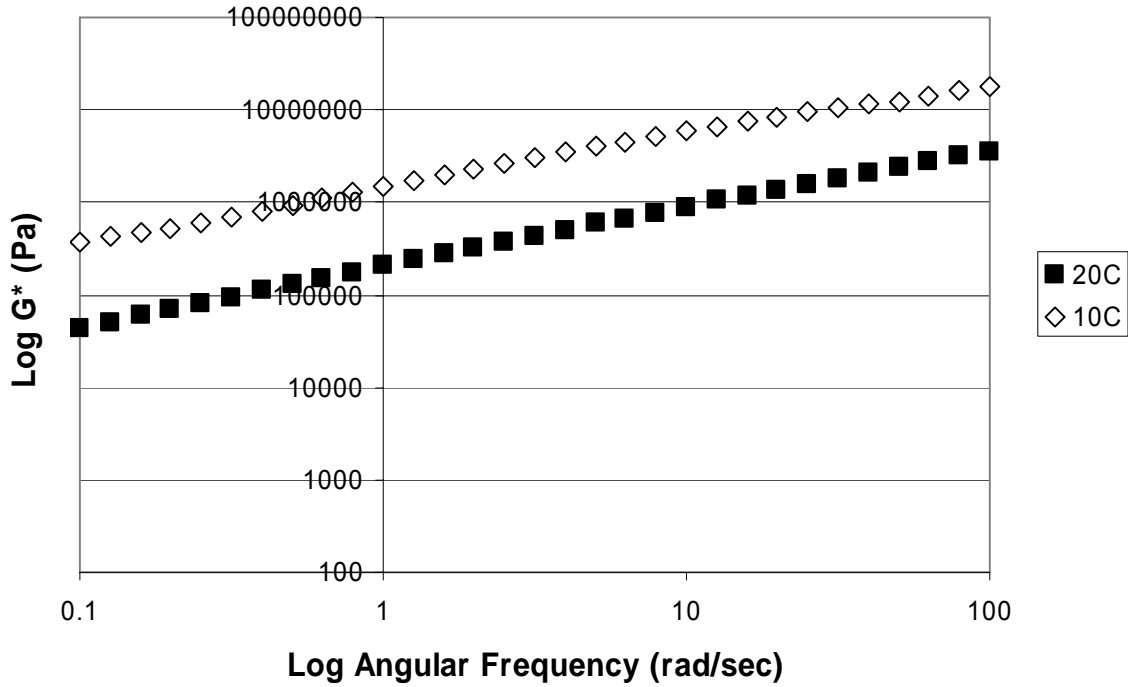
ang. frequency rad/sec	delta degrees	G' Pa	G'' Pa	G*  Pa	% strain %	temperature °C
0.1	83.16	8.935	74.46	74.99	4.934	58
0.1585	82.14	15.71	113.8	114.9	4.9745	58
0.2512	80.98	27.43	172.8	174.9	4.9652	58
0.3981	79.72	47.22	260.3	264.6	4.9543	58
0.631	78.41	79.71	388.8	396.9	4.9418	58
1	77.11	131.7	575.8	590.7	4.9291	58
1.585	75.82	213.9	846.3	872.9	4.9162	58
2.512	74.56	341.2	1235	1282	4.9046	58
3.981	73.4	533.5	1790	1867	4.8978	58
6.31	72.29	823.6	2579	2707	4.8961	58
10	71.27	1252	3693	3900	4.9004	58
15.85	70.34	1877	5256	5581	4.9333	58
25.12	69.56	2778	7455	7956	4.9424	58
39.81	68.95	4051	10530	11280	5.01	58
63.1	68.54	5833	14840	15950	5.0307	58
100	68.41	8246	20840	22410	5.1293	58



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**Graph 3. Intermediate Temperature Frequency Sweep on PAV Residue  
(8 mm plates, 2 mm gap, 5% strain (0. 1 to 100 rad/sec))**





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**Table 7. Intermediate Temperature Frequency Sweep on PAV Residue  
(8 mm plates, 2 mm gap, 1% strain (0. 1 to 100 rad/sec))**

ang. frequency	delta	G'	G''	G*	strain	temperature
rad/sec	degrees	Pa	Pa	Pa		°C
0.1	57.7	1.97E+05	3.11E+05	3.68E+05	9.85E-03	10
0.1259	56.75	2.32E+05	3.54E+05	4.24E+05	9.82E-03	10
0.1585	56.66	2.54E+05	3.86E+05	4.62E+05	9.98E-03	10
0.1995	56.42	2.91E+05	4.38E+05	5.26E+05	9.86E-03	10
0.2512	56.11	3.35E+05	4.98E+05	6.00E+05	9.85E-03	10
0.3162	55.87	3.88E+05	5.73E+05	6.92E+05	9.82E-03	10
0.3981	55.6	4.56E+05	6.66E+05	8.07E+05	9.78E-03	10
0.5012	55.13	5.28E+05	7.58E+05	9.24E+05	9.82E-03	10
0.631	54.31	6.63E+05	9.23E+05	1.14E+06	9.55E-03	10
0.7943	54.22	7.46E+05	1.04E+06	1.28E+06	9.91E-03	10
1	54.02	8.83E+05	1.22E+06	1.50E+06	9.71E-03	10
1.259	53.08	1.06E+06	1.41E+06	1.76E+06	9.70E-03	10
1.585	52.81	1.21E+06	1.59E+06	2.00E+06	9.84E-03	10
1.995	52.28	1.41E+06	1.82E+06	2.30E+06	9.76E-03	10
2.512	51.79	1.65E+06	2.09E+06	2.66E+06	9.74E-03	10
3.162	51.29	1.92E+06	2.40E+06	3.07E+06	9.76E-03	10
3.981	50.78	2.23E+06	2.73E+06	3.52E+06	9.77E-03	10
5.012	50.27	2.57E+06	3.09E+06	4.02E+06	9.79E-03	10
6.31	49.76	2.95E+06	3.49E+06	4.57E+06	9.82E-03	10
7.943	49.29	3.37E+06	3.92E+06	5.17E+06	9.84E-03	10
10	48.79	3.85E+06	4.39E+06	5.84E+06	9.84E-03	10
12.59	48.32	4.38E+06	4.92E+06	6.59E+06	9.85E-03	10
15.85	47.85	4.98E+06	5.50E+06	7.42E+06	9.88E-03	10
19.95	47.36	5.68E+06	6.16E+06	8.38E+06	9.82E-03	10
25.12	46.84	6.45E+06	6.88E+06	9.43E+06	9.85E-03	10
31.62	46.33	7.33E+06	7.68E+06	1.06E+07	9.85E-03	10
39.81	46	8.03E+06	8.32E+06	1.16E+07	0.010096	10
50.12	45.89	8.50E+06	8.77E+06	1.22E+07	0.010278	10
63.1	45.21	9.89E+06	9.97E+06	1.40E+07	9.70E-03	10
79.43	44.49	1.16E+07	1.14E+07	1.62E+07	9.66E-03	10
100	44.04	1.29E+07	1.25E+07	1.80E+07	9.96E-03	10



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**Table 8. Intermediate Temperature Frequency Sweep on PAV Residue  
(8 mm plates, 2 mm gap, 5% strain (0. 1 to 100 rad/sec))**

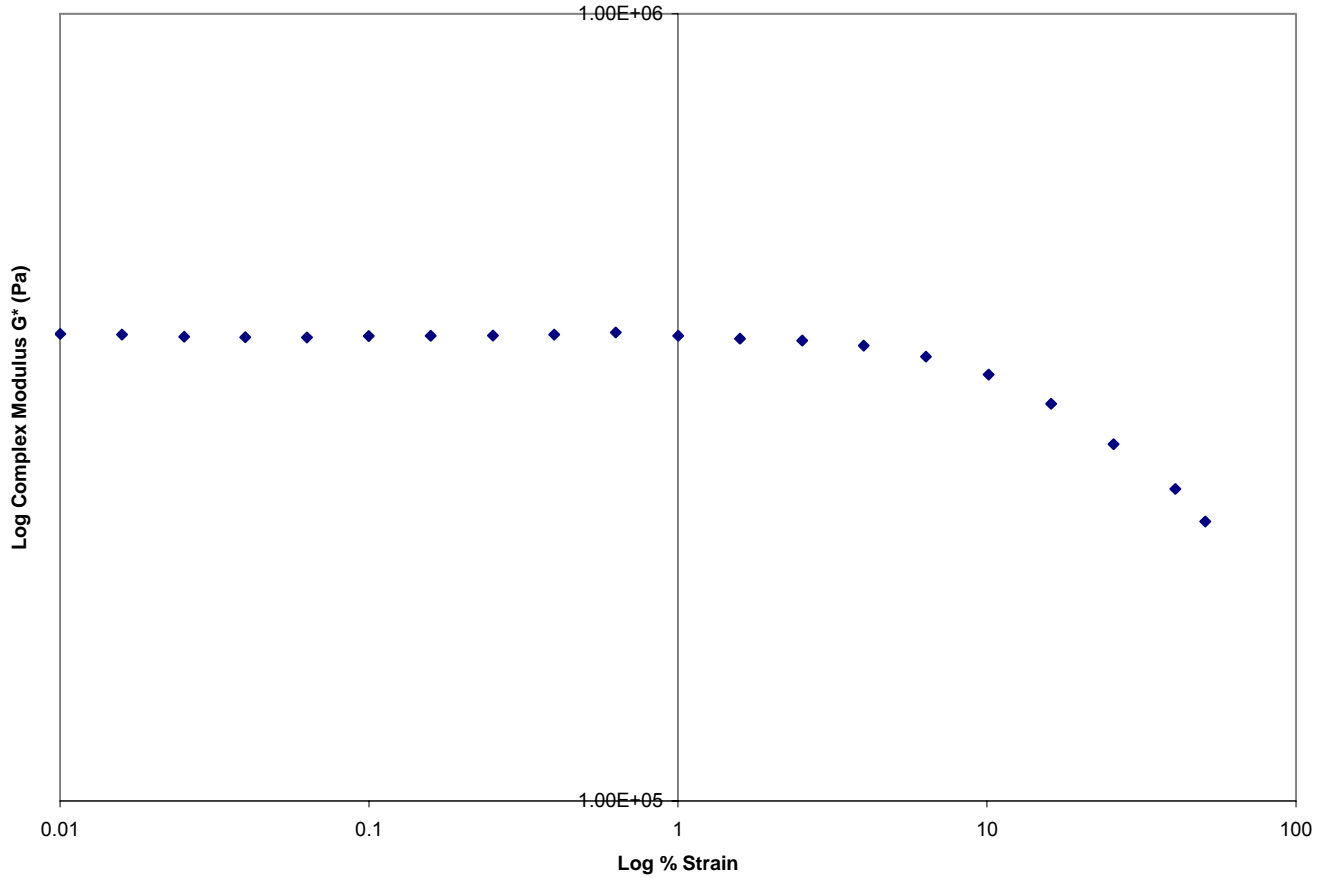
ang. frequency rad/sec	delta degrees	G' Pa	G'' Pa	G*  Pa	strain	temperature °C
0.1	61.49	20560	37850	43070	0.010006	20
0.1259	61.41	24350	44670	50880	9.92E-03	20
0.1585	61.06	28900	52270	59730	9.91E-03	20
0.1995	60.68	34360	61160	70150	9.89E-03	20
0.2512	60.38	40440	71140	81830	9.90E-03	20
0.3162	60.12	47440	82580	95240	9.89E-03	20
0.3981	60	56140	97240	1.12E+05	9.87E-03	20
0.5012	59.55	65820	1.12E+05	1.30E+05	9.89E-03	20
0.631	59.42	77520	1.31E+05	1.52E+05	9.87E-03	20
0.7943	59.18	90440	1.52E+05	1.77E+05	9.87E-03	20
1	58.99	1.06E+05	1.76E+05	2.05E+05	9.87E-03	20
1.259	58.63	1.25E+05	2.05E+05	2.40E+05	9.84E-03	20
1.585	58.45	1.47E+05	2.40E+05	2.82E+05	9.83E-03	20
1.995	58.19	1.68E+05	2.71E+05	3.19E+05	9.90E-03	20
2.512	58.01	1.98E+05	3.17E+05	3.74E+05	9.83E-03	20
3.162	57.78	2.30E+05	3.65E+05	4.31E+05	9.85E-03	20
3.981	57.51	2.70E+05	4.24E+05	5.03E+05	9.82E-03	20
5.012	57.23	3.18E+05	4.94E+05	5.87E+05	9.81E-03	20
6.31	56.93	3.69E+05	5.67E+05	6.76E+05	9.85E-03	20
7.943	56.71	4.25E+05	6.47E+05	7.74E+05	9.87E-03	20
10	56.44	4.93E+05	7.44E+05	8.92E+05	9.85E-03	20
12.59	56.1	5.81E+05	8.65E+05	1.04E+06	9.80E-03	20
15.85	55.78	6.72E+05	9.88E+05	1.20E+06	9.86E-03	20
19.95	55.46	7.81E+05	1.13E+06	1.38E+06	9.86E-03	20
25.12	55.08	9.12E+05	1.31E+06	1.59E+06	9.85E-03	20
31.62	54.74	1.05E+06	1.49E+06	1.82E+06	9.90E-03	20
39.81	54.36	1.22E+06	1.70E+06	2.10E+06	9.90E-03	20
50.12	53.97	1.41E+06	1.94E+06	2.40E+06	9.94E-03	20
63.1	53.54	1.64E+06	2.22E+06	2.75E+06	9.93E-03	20
79.43	53.1	1.89E+06	2.51E+06	3.14E+06	9.99E-03	20
100	52.62	2.19E+06	2.87E+06	3.61E+06	0.010003	20



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**Graph 4. Strain Sweep on PAV Residue**  
**(8 mm plates, 2 mm gap, 0.01-50 % strain (10 rad/sec))**



BASF 03-02-01

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**Table 9. Strain Sweep on PAV Residue  
(8 mm plates, 2 mm gap, 0.01% -50% strain, 10 rad/sec)**

ang. frequency rad/sec	delta degrees	G' Pa	G'' Pa	G*  Pa	% strain	temperature °C
10	58.71	2.04E+05	3.35E+05	3.92E+05	0.010025	25
10	58.39	2.05E+05	3.33E+05	3.91E+05	0.015866	25
10	58.31	2.04E+05	3.31E+05	3.89E+05	0.025221	25
10	58.25	2.04E+05	3.30E+05	3.88E+05	0.039792	25
10	58.33	2.04E+05	3.30E+05	3.88E+05	0.063005	25
10	58.33	2.05E+05	3.32E+05	3.90E+05	0.099884	25
10	58.31	2.05E+05	3.32E+05	3.90E+05	0.15833	25
10	58.34	2.05E+05	3.32E+05	3.90E+05	0.25194	25
10	58.34	2.05E+05	3.33E+05	3.91E+05	0.39768	25
10	58.34	2.07E+05	3.35E+05	3.94E+05	0.62903	25
10	58.41	2.04E+05	3.32E+05	3.90E+05	1.0021	25
10	58.53	2.02E+05	3.30E+05	3.87E+05	1.5869	25
10	58.68	2.00E+05	3.29E+05	3.85E+05	2.5233	25
10	58.95	1.95E+05	3.25E+05	3.79E+05	3.9943	25
10	59.43	1.87E+05	3.16E+05	3.67E+05	6.3475	25
10	60.24	1.73E+05	3.02E+05	3.48E+05	10.123	25
10	61.43	1.53E+05	2.81E+05	3.20E+05	16.13	25
10	62.87	1.30E+05	2.53E+05	2.84E+05	25.681	25
10	64.42	1.08E+05	2.25E+05	2.49E+05	40.683	25
10	65.44	94140	2.06E+05	2.27E+05	50.857	25