



OHIO DEPARTMENT OF TRANSPORTATION

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To: David Powers, Asphalt Engineer, Office of Materials Management

From: Eric Biehl, Asphalt Materials Engineer, Office of Materials Management

Subject: 2014 PG Binder Round Robin Results

PG Binder samples of PG 58-28 and PG 70-22M for the 2014 Round Robin were sent to 42 terminal, consulting labs, and a few universities. One lab decided not to participate and there are still two labs that haven't submitted results. Each binder had a variety of tests to ensure labs were capable of performing correctly as well as a few informational tests.

After all of the results were received, a statistical analysis was performed. In the results below, if the result is highlighted yellow then the result is one to two standard deviations from the average. If the result is highlighted orange then the result is more than two standard deviations from the average. If the result is not highlighted with yellow or orange, then the result is within one standard deviation from the average. Along with the standard deviation, we looked at the overall results and how each compared with the acceptable range laid out by AASHTO or ASTM as well as looked for specific trends and importance of the individual result. Some results were not included in the statistical analysis due to being outliers and those are marked with an asterisk before or after result.

After the statistical analysis was performed, a total of eighteen labs were asked to investigate and/or review specific test results further. Of those eighteen, twelve were asked to investigate further into test results as there were significant issues and respond by Friday, March 14, 2014. The other twenty-one lab results were deemed sufficient and no responses were needed.

Ohio DOT 2014 PG Binder Round Robin Results

PG 58-28	ODOT	LAB #1	LAB #2	LAB #3	LAB #4	LAB #5	LAB #6	LAB #7	LAB #8	LAB #9	LAB #10A	LAB #10B	LAB #11	LAB #12	LAB #13	LAB #14	LAB #15	LAB #16
ROTATIONAL VISCOSITY	0.325	0.305	0.320		0.314	0.300	0.335	0.325					0.318	0.299	0.320	0.310	0.304	
PENETRATION	102	90	104		104	106	95	107			95		90	103	105	96	103	
COMPLEX MODULUS	1.59	1.61	1.51		1.55	1.60	1.56	1.58	1.57	1.77	1.73	1.84	1.64	1.64	1.61	1.68	1.63	1.61
PHASE ANGLE	86.9	86.9	86.9		86.8	86.7	86.8	86.8	86.8	86.9	86.9	85.9	86.8	86.8	85.9	86.8	87.2	86.8
ORIGINAL DSR	1.59	1.61	1.51		1.55	1.60	1.56	1.58	1.57	1.78	1.73	1.85	1.64	1.64	1.61	1.68	1.63	1.61
COMPLEX MODULUS	3.88	4.30	3.73			3.67	4.02	3.66					3.61	3.59	3.70	3.88	3.69	
PHASE ANGLE	83.1	83.0	83.0			83.2	82.8	83.4					83.2	83.6	83.2	83.0	83.5	
RTFO DSR	3.91	4.34	3.75			3.70	4.10	3.69					3.64	3.62	3.73	3.91	3.72	
MASS CHANGE %	-0.024	-0.027	-0.010			0.029	-0.056	0.019					0.033	0.019	0.034	-0.057	-0.010	
PAV WITH VDO																		
PHASE ANGLE	46.5	48.5	45.7				45.9	45.8					45.6	45.4		45.4	45.8	
PAV DSR	4850	4780	4480				4612	5418					4706	5210		4640	4590	
ESTIMATED STIFF 1	259	239	263			250	250	247					243	245		266	273	
ESTIMATED STIFF 2	248	238	257			241	259	244					240	250		234	269	
AVERAGE EST STIFF	253.50	238.50	260.00			245.50	254.50	245.50					241.50	247.50		250.00	271.00	
RANGE	11	1	6			9	9	3					3	5		32	4	
M-VALUE 1	0.311	0.310	0.315			0.325	0.315	0.316					0.308	0.310		0.308	0.310	
M-VALUE 2	0.322	0.309	0.313			0.323	0.312	0.317					0.308	0.314		0.306	0.319	
AVERAGE M-VALUE	0.317	0.310	0.314			0.324	0.314	0.317					0.308	0.312		0.307	0.315	
RANGE	0.011	0.001	0.002			0.002	0.003	0.001					0.000	0.004		0.002	0.009	
PG 70-22M																		
ROTATIONAL VISCOSITY	0.983	1.040	1.015		1.122	1.175	1.134	0.239					1.112	1.043	1.101	1.100	1.081	
COMPLEX MODULUS	1.52	1.54	1.44		1.59	1.51	1.79	1.49	1.52	1.67	1.61	1.61	1.54	1.58	1.60	1.56	1.54	1.51
PHASE ANGLE	71.9	71.9	71.8		71.5	71.7	70.9	70.0	71.9	71.8	71.9	72.3	71.8	71.7	71.1	71.7	72.1	71.7
ORIGINAL DSR	1.60	1.62	1.51		1.68	1.59	1.90	1.57	1.59	1.75	1.69	1.69	1.62	1.66	1.69	1.64	1.62	1.59
COMPLEX MODULUS	3.54	3.89	3.30			3.22	3.80	3.30					3.45	3.35	3.18	3.52	3.22	
PHASE ANGLE	68.0	68.0	68.2			68.3	67.5	70.0					68.3	68.4	68.5	67.8	68.7	
RTFO DSR	3.82	4.20	3.56			3.46	4.12	3.23					3.71	3.61	3.42	3.80	3.45	
ELASTIC RECOVERY	75.0	73.0	72.5			72.0	72.1	72.0					77.5		77.5	71.2	75.0	
PAV WITH VDO																		
PHASE ANGLE	46.9	49.9	46.8				46.6	47.2					46.9	48.4		46.8	47.5	
PAV DSR	2570	2120	2140				2235	2554					2217	2120		2240	1880	
ESTIMATED STIFF 1	151	138	138			133	150	144					146	128		150	141	
ESTIMATED STIFF 2	151	138	144			138	153	143					143	133		155	139	
AVERAGE EST STIFF	151.00	138.00	141.00			135.50	151.50	143.50					144.50	130.50		152.50	140.00	
RANGE	0	0	6			5	3	1					3	5		5	2	
M-VALUE 1	0.326	0.327	0.319			0.330	0.310	0.325					0.324	0.346		0.318	0.332	
M-VALUE 2	0.330	0.334	0.316			0.336	0.310	0.330					0.323	0.351		0.317	0.321	
AVERAGE M-VALUE	0.328	0.331	0.318			0.333	0.310	0.328					0.324	0.349		0.318	0.327	
RANGE	0.004	0.007	0.003			0.006	0.000	0.005					0.001	0.005		0.001	0.011	
MSCR at 64 °C on Original																		
Avg % Recovery @ 3.2 kPa			56.00				48.29						49.71			50.58	50.28	
Jnr @ 3.2 kPa			1.16				1.21						4.27			1.01	1.22	
% Diff. between Jnr			20.06				33.09						22.14			32.04	32.21	
MSCR at 64 °C on RTFO																		
Avg % Recovery @ 3.2 kPa			51.39			49.30	51.45						50.36			52.86	50.26	
Jnr @ 3.2 kPa			0.50			0.52	0.46						0.47			0.46	0.53	
% Diff. between Jnr			23.07			19.19	24.79						19.43			21.00	24.20	

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PG 58-28	LAB #17	LAB #18	LAB #19	LAB #20	LAB #21	LAB #22	LAB #23	LAB #24	LAB #25	LAB #26	LAB #27	LAB #28	LAB #29	LAB #30	LAB #31	LAB #32	LAB #33	LAB #34
ROTATIONAL VISCOSITY	0.310		0.283	0.305	0.308	0.300	0.315	0.313	0.288	0.325	0.325	0.318	0.315	0.315		0.335		0.305
PENETRATION	103		99	99	104	101	106	102	92	96	100	98	105	105				103
COMPLEX MODULUS	1.64	1.65	1.52	1.57	1.65	1.62	1.59	1.61	1.86	1.73	1.62	1.52	1.57	1.54		1.95	1.97	1.68
PHASE ANGLE	86.8	86.7	86.8	86.8	86.7	86.8	86.8	86.5	86.3	86.6	86.8	86.8	86.8	86.8		86.6	88.1	86.7
ORIGINAL DSR	1.64	1.66	1.52	1.57	1.65	1.62	1.59	1.61	1.86	1.73	1.62	1.53	1.57	1.54		1.96	1.99	1.70
COMPLEX MODULUS	3.70		3.54	3.63	4.37	3.59	3.68	3.60	4.09	4.12	3.93	3.27	3.62	3.52				3.65
PHASE ANGLE	83.4		83.4	83.2	82.3	83.4	83.2	83.2	82.5	83.1	83.1	83.7	83.3	83.3				83.4
RTFO DSR	3.72		3.56	3.65	4.39	3.61	3.70	3.63	4.12	4.14	3.96	3.29	3.64	3.55				3.68
MASS CHANGE %	-0.010		-0.016	0.008	-0.014	0.017	0.019	-0.040	0.018	-0.014	-0.007	0.060	0.010	-0.055				-0.016
PAV WITH VDO																		
PHASE ANGLE	45.9		46.1	47.0	46.3	48.7	46.7	47.3	45.1	46.1	43.6	49.8	46.7	47.4				46.7
PAV DSR	4460		4620	4375	4333	3769	4607	4520	4700	5203	2870	3128	4214	4310				4183
ESTIMATED STIFF 1	241		254	243	243	216	254	245	249	240	240	244	246	215				253
ESTIMATED STIFF 2	238		260	236	243	207	264	244	248	236	257	243	245	230				249
AVERAGE EST STIFF	239.50		257.00	239.50	243.00	211.50	259.00	244.50	248.50	238.00	248.50	243.50	245.50	222.50				251.00
RANGE	3		6	7	0	9	10	1	1	4	17	1	1	15				4
M-VALUE 1	0.320		0.307	0.321	0.315	0.329	0.315	0.316	0.314	0.314	0.321	0.317	0.327	0.315				0.305
M-VALUE 2	0.329		0.300	0.318	0.312	0.330	0.313	0.322	0.315	0.320	0.315	0.324	0.328	0.313				0.313
AVERAGE M-VALUE	0.325		0.304	0.320	0.314	0.330	0.314	0.319	0.315	0.317	0.318	0.321	0.328	0.314				0.309
RANGE	0.009		0.007	0.003	0.003	0.001	0.002	0.006	0.001	0.006	0.006	0.007	0.001	0.002				0.008
PG 70-22M																		
ROTATIONAL VISCOSITY	1.110		1.040	1.048	1.080	1.043	1.100	1.105	1.200	1.038	1.122	1.237	1.117	1.040		1.087		1.060
COMPLEX MODULUS	1.55	1.55	1.44	1.49	1.50	1.55	1.51	1.52	1.61	1.64	1.57	1.56	1.56	1.51		1.73	1.71	1.58
PHASE ANGLE	71.8	71.6	71.6	71.9	71.8	71.6	71.8	71.8	71.2	71.4	71.7	71.7	71.6	71.8		71.9	73.1	71.5
ORIGINAL DSR	1.63	1.63	1.52	1.57	1.58	1.63	1.59	1.60	1.70	1.73	1.65	1.64	1.65	1.59		1.82	1.79	1.67
COMPLEX MODULUS	3.46		3.02	3.58	3.44	3.14	3.26	3.14	3.82	3.55	3.85	3.21	3.49	3.33				3.46
PHASE ANGLE	68.2		68.1	67.8	67.9	68.3	68.1	68.7	67.5	68.4	67.5	68.3	67.8	67.9				67.9
RTFO DSR	3.72		3.26	3.87	3.70	3.39	3.51	3.37	4.14	3.82	4.16	3.45	3.77	3.60				3.73
ELASTIC RECOVERY	74.0				85.0	74.0	74.0	77.5	75.0			74.0	77.5	77.5		78.8		72.4
PAV WITH VDO																		
PHASE ANGLE	47.6		47.1	47.5	48.0	48.5	46.4	49.2	45.6	45.4	46.7	48.9	47.7	47.9				47.3
PAV DSR	2050		2300	2135	2060	2077	2392	2040	2900	2790	2490	1674	1997	2360				2180
ESTIMATED STIFF 1	140		156	144	146	135	151	144	142	139	137	135	147	136				142
ESTIMATED STIFF 2	140		159	142	143	134	152	139	139	142	138	134	145	134				143
AVERAGE EST STIFF	140.00		157.50	143.00	144.50	134.50	151.50	141.50	140.50	140.50	137.50	134.50	146.00	135.00				142.50
RANGE	0		3	2	3	1	1	5	3	3	1	1	2	2				1
M-VALUE 1	0.335		0.313	0.323	0.323	0.329	0.320	0.331	0.316	0.336	0.314	0.329	0.332	0.339				0.321
M-VALUE 2	0.332		0.314	0.329	0.325	0.332	0.319	0.335	0.318	0.326	0.319	0.333	0.333	0.335				0.324
AVERAGE M-VALUE	0.334		0.314	0.326	0.324	0.331	0.320	0.333	0.317	0.331	0.317	0.331	0.333	0.337				0.323
RANGE	0.003		0.001	0.006	0.002	0.003	0.001	0.004	0.002	0.010	0.005	0.004	0.001	0.004				0.003
MSCR at 64 °C on Original																		
Avg % Recovery @ 3.2 kPa	56.76		46.53	47.07	49.16	54.36	49.57	49.45			57.88	50.01	51.23	50.82				52.10
Jnr @ 3.2 kPa	1.03		1.35	1.39	1.23	1.18	1.25	1.16			1.00	1.12	1.23	1.24				1.12
% Diff. between Jnr	14.65		33.51	69.26	31.00	22.26	66.17	24.43			14.38	36.95						25.18
MSCR at 64 °C on RTFO																		
Avg % Recovery @ 3.2 kPa	51.30		49.87	51.74	51.65	52.97	49.16	54.16			54.66	52.06	52.27	51.55				55.30
Jnr @ 3.2 kPa	0.47		0.46	0.46	0.52	0.50	0.56	0.38			0.39	0.51	0.46	0.47				0.42
% Diff. between Jnr	17.02		47.31	41.62	24.66	23.65	20.15	15.48			19.80	22.22						20.34

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PG 58-28	LAB #35	LAB #36	LAB #37	LAB #38	LAB #39	LAB #40	LAB #41	AVG	2 STD DEV	1 STD DEV	STD DEV	1 STD DEV	2 STD DEV
ROTATIONAL VISCOSITY	0.328	0.311	0.315	0.300	0.290			0.3118	0.2869	0.2994	0.0125	0.3243	0.3368
PENETRATION	100	101	103	95	105			100.531	91.231	95.881	4.650	105.181	109.832
COMPLEX MODULUS	1.64	1.57	1.51		1.56		1.16	1.627	1.363	1.495	0.132	1.759	1.891
PHASE ANGLE	86.8	86.7	86.5		86.6		86.3	86.74	86.08	86.41	0.33	87.07	87.40
ORIGINAL DSR	1.64	1.57	1.52		1.57		1.16	1.630	1.361	1.495	0.135	1.764	1.899
COMPLEX MODULUS	3.66	3.44	3.79		3.99		3.32	3.741	3.236	3.489	0.253	3.994	4.247
PHASE ANGLE	83.3	83.3	83.1		82.6		82.9	83.16	82.55	82.85	0.30	83.46	83.76
RTFO DSR	3.68	3.46	3.82		4.02		3.35	3.769	3.257	3.513	0.256	4.025	4.282
MASS CHANGE %	0.011	0.010	0.004	-0.221	-0.062			-0.012	-0.109	-0.060	0.049	0.037	0.086
PAV WITH VDO													
PHASE ANGLE	45.2	45.6	46.0		45.9			46.322	43.885	45.103	1.219	47.541	48.760
PAV DSR	4875	4940	4540		4605			4501.407	3421.270	3961.339	540.069	5041.476	5581.545
ESTIMATED STIFF 1	253	249	229		282			247.5	219.7	233.6	13.9	261.5	275.4
ESTIMATED STIFF 2	260	238	230		282			246.1	217.7	231.9	14.2	260.3	274.5
AVERAGE EST STIFF	256.50	243.50	229.50		282.00			246.8	220.2	233.5	13.3	260.1	273.4
RANGE	7	11	1		0			6.5	-6.8	-0.2	6.6	13.1	19.7
M-VALUE 1	0.314	0.313	0.314		0.300			0.314	0.302	0.308	0.006	0.321	0.327
M-VALUE 2	0.317	0.315	0.319		0.303			0.316	0.302	0.309	0.007	0.323	0.330
AVERAGE M-VALUE	0.316	0.314	0.317		0.302			0.3153	0.3025	0.3089	0.0064	0.3216	0.3280
RANGE	0.003	0.002	0.005		0.003			0.0039	-0.0019	0.0010	0.0029	0.0068	0.0097
PG 70-22M								AVG	2 STD DEV	1 STD DEV	STD DEV	1 STD DEV	2 STD DEV
ROTATIONAL VISCOSITY	1.160	1.075	1.102	1.068	0.738			1.0536	0.7195	0.8865	0.1671	1.2207	1.3877
COMPLEX MODULUS	1.54	1.45	1.44		1.52		1.45	1.554	1.400	1.477	0.077	1.631	1.708
PHASE ANGLE	71.9	71.7	71.7		71.6		70.9	71.67	70.78	71.23	0.45	72.12	72.57
ORIGINAL DSR	1.60	1.53	1.52		1.60		1.54	1.636	1.473	1.554	0.081	1.717	1.798
COMPLEX MODULUS	3.16	3.28	3.58		3.37		3.00	3.397	2.931	3.164	0.233	3.630	3.863
PHASE ANGLE	68.3	68.3	68.0		68.1		68.1	68.16	67.25	67.70	0.46	68.62	69.08
RTFO DSR	3.40	3.53	3.86		3.64		3.24	3.651	3.116	3.384	0.268	3.919	4.187
ELASTIC RECOVERY	72.5	74.2			72.0			74.8	68.7	71.8	3.0	77.9	80.9
PAV WITH VDO													
PHASE ANGLE	47.7	47.1	46.2		46.8			47.4	45.3	46.3	1.0	48.4	49.4
PAV DSR	2424	2279	2484		2178			2255.0	1732.9	1994.0	261.0	2516.1	2777.1
ESTIMATED STIFF 1	145	138	137		143			142.0	129.5	135.8	6.2	148.2	154.5
ESTIMATED STIFF 2	144	142	138		142			142.4	129.6	136.0	6.4	148.8	155.2
AVERAGE EST STIFF	144.50	140.00	137.50		142.50			142.2	129.9	136.0	6.2	148.3	154.5
RANGE	1	4	1		1			2.3	-1.1	0.6	1.7	4.0	5.7
M-VALUE 1	0.318	0.332	0.320		0.313			0.325	0.308	0.317	0.009	0.334	0.342
M-VALUE 2	0.323	0.333	0.321		0.319			0.326	0.309	0.318	0.009	0.335	0.344
AVERAGE M-VALUE	0.321	0.333	0.321		0.316			0.3257	0.3092	0.3174	0.0083	0.3340	0.3422
RANGE	0.005	0.001	0.001		0.006			0.0038	-0.0016	0.0011	0.0027	0.0064	0.0091
MSCR at 64 °C on Original													
Avg % Recovery @ 3.2 kPa	49.42	55.68			57.70			51.630	44.798	48.214	3.416	55.046	58.462
Jnr @ 3.2 kPa	1.23	1.14			1.04			1.329	-0.035	0.647	0.682	2.011	2.693
% Diff. between Jnr	27.92	24.23			17.33			30.378	1.016	15.697	14.681	45.060	59.741
MSCR at 64 °C on RTFO													
Avg % Recovery @ 3.2 kPa	51.21	52.55			53.55			51.887	48.661	50.274	1.613	53.499	55.112
Jnr @ 3.2 kPa	0.54	0.50			0.46			0.478	0.389	0.433	0.045	0.523	0.568
% Diff. between Jnr	23.65	28.57			21.03			24.062	8.782	16.422	7.640	31.702	39.342