Ohio DOT 2018 PG Binder Round Robin Results

PG 58-28	ODOT A	ODOT B	LAB #1	LAB #2	LAB #3	LAB #4	LAB #5	LAB #6	LAB #7	LAB #8	LAB #9	LAB #10	LAB #10B	LAB #11	LAB #12	LAB #13	LAB #14	LAB #15
ROTATIONAL VISCOSITY	0.313	0.308	0.280	0.257	0.273		0.228	0.271	0.282					0.338	0.238	0.280	0.282	0.279
PENETRATION	117	120	127	125	125	130	124	118	123			103	105	115	122	125	114	118
COMPLEX MODULUS	1.34	1.33	1.33	1.35	1.36	1.22	1.35	1.37	1.32	1.40	1.19			1.47	1.35	1.30	1.31	1.28
PHASE ANGLE	87.4	87.2	87.4	86.9	87.3	81.1	87.3	87.1	87.3	87.3	87.5			87.1	86.9	87.4	87.2	87.3
ORIGINAL DSR	1.34	1.33	1.33	1.35	1.36	1.23	1.36	1.38	1.32	1.36	1.19			1.47	1.35	1.30	1.31	1.28
COMPLEX MODULUS	3.40	3.42	3.42	3.44	3.62		3.57	3.51	3.69					3.67	3.56	3.27	3.28	3.13
PHASE ANGLE	83.9	83.8	83.9	83.7	83.5		83.7	83.4	83.6					83.5	83.4	83.9	83.9	84.0
RTFO DSR	3.42	3.44	3.44	3.46	3.65		3.59	3.53	3.71					3.70	3.59	3.29	3.30	3.15
MASS CHANGE %	-0.532	-0.505	-0.539	-0.501	-0.573		-0.532	-0.486	-0.411					-0.457	-0.442	-0.499	-0.352	-0.548
PAV WITH VDO																		
PHASE ANGLE	49.2	48.5	48.8	49.3	48.1		48.9	49.2	49.1					47.5	49.5		48.3	48.5
PAV DSR	4120	4620	4730	4716	4317		4940	4140	4630					4781	4120		4140	4590
ESTIMATED STIFF 1	257	266	247	270	265		268	207	258					237	273		297	264
ESTIMATED STIFF 2	246	262	248	276	267		257	212	254					241	277		287	272
AVERAGE EST STIFF	251.5	264.0	247.5	273.0	266.0		262.5	209.5	256.0					239.0	275.0		292.0	268.0
RANGE	11	4	-1	-6	-2		11	-5	4					-4	-4		10	-8
M-VALUE 1	0.345	0.340	0.325	0.335	0.318		0.326	0.336	0.331					0.339	0.327		0.321	0.326
M-VALUE 2	0.338	0.337	0.326	0.328	0.322		0.328	0.326	0.327					0.326	0.327		0.319	0.322
AVERAGE M-VALUE	0.342	0.339	0.326	0.332	0.320		0.327	0.331	0.329					0.333	0.327		0.320	0.324
RANGE	0.007	0.003	-0.001	0.007	-0.004		-0.002	0.010	0.004					0.013	0.000		0.002	0.004
PG 70-22M																		
ROTATIONAL VISCOSITY	1.212	1.137	1.188	1.079	1.140		1.133	1.114	1.190					1.125	0.938	1.182	1.238	1.183
COMPLEX MODULUS	1.92	1.89	1.83	1.86	1.89	1.75	1.90	1.76	1.90	1.80	1.89			2.01	1.92	1.82	1.80	1.87
PHASE ANGLE	70.4	70.5	70.7	70.6	70.7	71.3	70.6	70.4	70.6	70.8	70.9			69.9	70.1	70.7	70.6	70.6
ORIGINAL DSR	2.04	2.01	1.94	1.97	2.00	1.85	2.01	1.87	2.02	1.95	2.00			2.14	2.05	1.93	1.91	1.99
COMPLEX MODULUS	4.59	4.69	4.69	4.98	4.95		5.19	5.04	4.55					4.71	4.81	4.46	4.75	4.50
PHASE ANGLE	62.0	61.6	61.5	61.0	61.3		60.7	60.5	61.7					61.2	70.0	61.8	61.1	62.0
RTFO DSR	5.20	5.33	5.33	5.69	5.64		5.95	5.79	5.16					5.37	5.51	5.06	5.43	5.10
ELASTIC RECOVERY	75.2	74.8	75.5	72.0	75.0		73.8		74.8					81.0		72.5		76.0
PAV WITH VDO																		
PHASE ANGLE	41.4	42.4	41.8	42.2	41.2		41.4	40.5	42.6					40.3	41.4		40.5	41.9
PAV DSR	2070	2020	2380	1485	2186		2530	2459	2160					2187	2070		2330	1970
ESTIMATED STIFF 1	129	125	129	123	131		129	123	111					125	131		138	138
ESTIMATED STIFF 2	130	128	130	123	137		136	127	109					130	135		135	131
AVERAGE EST STIFF	129.5	126.5	129.5	123.0	134.0		132.5	125.0	110.0					127.5	133.0		136.5	134.5
RANGE	-1	-3	-1	0	-6		-7	-4	2					-5	-4		3	7
M-VALUE 1	0.317	0.320	0.316	0.319	0.306		0.316	0.303	0.322					0.321	0.319		0.310	0.317
M-VALUE 2	0.320	0.316	0.317	0.316	0.305		0.313	0.304	0.328					0.319	0.313		0.308	0.314
AVERAGE M-VALUE	0.319	0.320	0.317	0.318	0.306		0.315	0.304	0.325					0.320	0.316		0.309	0.316
RANGE	-0.003	0.004	-0.001	0.003	0.001		0.003	-0.001	-0.006					0.002	0.006		0.002	0.003
MSCR at 58 °C on RTFO																		
Avg % Recovery @ 3.2 kPa	0.31	0.43	0.35	0.71	0.30		0.74	73.33	0.25					1.51	0.64	0.44	0.37	0.33
Jnr @ 3.2 kPa	2.99	2.83	2.85	2.86	2.72		2.58	2.81	2.76					2.57	2.73	2.98	3.00	2.85
% Diff. between Jnr	9.63	9.29	9.69	16.33	13.00		9.87	11.05	8.73					10.39	8.60	8.67	8.95	8.51
MSCR at 64 °C on RTFO																		
Avg % Recovery @ 3.2 kPa	73.04	74.68		78.40	77.80		76.91	77.48	71.54					76.59	78.64	74.43	75.64	73.63
Jnr @ 3.2 kPa	0.17	0.14		0.11	0.12		0.12	0.12	0.18					0.14	0.11	0.16	0.14	0.16
% Diff. between Jnr	44.21	42.33		37.39	105.40		43.01	47.27	41.62					8.98	40.05	7.48	43.44	42.99
O DSR ELASTIC RECOVERY	53.53	52.99							49.80								44.70	
R DSR ELASTIC RECOVERY	58.08	56.63	47.40						59.40								46.20	

Between 1 & 2 Std. Dev

Greater than 2 Std Dev

Ohio DOT 2018 PG Binder

PG 58-28	LAB #16	LAB #17	LAB #18A	LAB #18B	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
ROTATIONAL VISCOSITY		0.286		0.292	0.273	0.283		0.279	0.297	0.283	0.320	0.288	0.277	0.325	0.278	0.282	0.275	
PENETRATION		130			115	120		119	118	119	110	114	125	126	125	126		
COMPLEX MODULUS	1.41	1.39		1.31	1.35	1.34		1.39	1.30	1.41	1.40	1.34	1.33	1.26	1.29	1.23	1.53	1.51
PHASE ANGLE	87.3	87.2		87.3	87.3	87.3		87.2	87.4	87.2	87.0	87.3	87.3	87.4	87.3	87.4	87.1	86.7
ORIGINAL DSR	1.41	1.39		1.31	1.35	1.34		1.39	1.30	1.41	1.41	1.34	1.33	1.26	1.29	1.23	1.53	1.51
COMPLEX MODULUS		3.41			3.92	3.11		3.14	3.11	3.28	4.13	3.22	3.34	3.10	3.45	3.53		
PHASE ANGLE		83.7			83.1	84.4		83.9	84.2	83.9	82.8	84.1	83.8	84.2	83.6	83.4		
RTFO DSR		3.43			3.95	3.12		3.16	3.12	3.29	4.16	3.24	3.36	3.10	3.47	3.56		
MASS CHANGE %		-0.530			-0.056	-0.424		-0.470	-0.503	-0.469	-0.394	-0.438	-0.473	-0.411	-0.568	-0.614		
PAV WITH VDO																		
PHASE ANGLE		49.1			49.0	49.7		50.1	49.3	50.2	47.2	49.0	48.1	52.2	48.0	47.8		
PAV DSR		4080			5000	4260		3897	4147	4420	5220	4580	4756	3220	4564	4880		
ESTIMATED STIFF 1		237			256	278		260	245	244	254	249	261	217	230	243		
ESTIMATED STIFF 2		243			249	267		255	240	240	244	245	281	209	240	240		
AVERAGE EST STIFF		240.0			252.5	272.5		257.5	242.5	242.0	249.0	247.0	271.0	213.0	235.0	241.5		
RANGE		-6			7	11		5	5	4	10	4	-20	8	-10	3		
M-VALUE 1		0.332			0.321	0.329		0.335	0.329	0.327	0.324	0.333	0.320	0.349	0.343	0.336		
M-VALUE 2		0.336			0.320	0.325		0.338	0.328	0.333	0.327	0.334	0.324	0.343	0.342	0.331		
AVERAGE M-VALUE		0.334			0.321	0.327		0.337	0.329	0.330	0.326	0.334	0.322	0.346	0.343	0.334		
RANGE		-0.004			0.001	0.004		-0.003	0.001	-0.006	-0.003	-0.001	-0.004	0.006	0.001	0.005		
PG 70-22M																		
ROTATIONAL VISCOSITY		1.199		1.167	1.058	1.171		1.205	1.152	1.235	1.105	1.263	1.133	1.212	1.212	1.198	1.150	
COMPLEX MODULUS	1.88	1.95		1.86	1.85	1.86		1.80	1.83	1.86	1.86	1.89	1.82	1.76	1.81	1.74	2.05	1.87
PHASE ANGLE	70.6	70.2		70.7	70.4	70.7		70.6	70.7	70.6	71.2	70.8	70.6	70.9	70.7	70.5	70.4	69.5
ORIGINAL DSR	2.00	2.07		1.97	1.96	1.96		1.91	1.94	1.97	1.96	2.00	1.93	1.86	1.92	1.85	2.18	2.00
COMPLEX MODULUS		4.79			4.56	4.68		4.51	4.53	4.63	4.54	4.75	4.71	4.11	4.65	4.44		
PHASE ANGLE		61.4			61.5	61.5		61.5	61.6	61.9	62.4	61.5	61.2	62.1	61.2	61.3		
RTFO DSR		5.46			5.19	5.33		5.13	5.15	5.25	5.13	5.41	5.37	4.65	5.31	5.20		
ELASTIC RECOVERY		73.4						72.7	73.5	75.0	82.0	75.6	72.5	73.0	87.5	75.0		
PAV WITH VDO																		
PHASE ANGLE		41.6			43.0	41.6		43.0	40.7	44.6	40.6	42.6	41.2	47.8	40.7	42.1		
PAV DSR		2120			2070	2225		2119	2466	1960	2730	2150	2391	2822	2223	2110		
ESTIMATED STIFF 1		127			124	124		125	126	118	118	124	130	101	126	124		
ESTIMATED STIFF 2		123			124	120		129	128	122	130	131	132	108	128	123		
AVERAGE EST STIFF		125.0			124.0	122.0		127.0	127.0	120.0	124.0	127.5	131.0	104.5	127.0	123.5		
RANGE		4			0	4		-4	-2	-4	-12	-7	-2	-7	-2	1		
M-VALUE 1		0.319			0.317	0.318		0.325	0.303	0.333	0.314	0.317	0.319	0.334	0.315	0.323		
M-VALUE 2		0.320			0.317	0.309		0.322	0.305	0.325	0.310	0.318	0.317	0.338	0.320	0.324		
AVERAGE M-VALUE		0.320			0.317	0.314		0.324	0.304	0.329	0.312	0.318	0.318	0.336	0.318	0.324		
RANGE		-0.001			0.000	0.009		0.003	-0.002	0.008	0.004	-0.001	0.002	-0.004	-0.005	-0.001		
MSCR at 58 °C on RTFO																		
Avg % Recovery @ 3.2 kPa		0.33				0.25		1.17	0.96	0.64	1.83	0.42	0.34	0.54	1.33	0.73		
Jnr @ 3.2 kPa		2.86				3.46		2.94	3.19	2.75	2.29	2.72	2.90	3.22	2.69	2.74		
% Diff. between Jnr		9.67				9.21		10.10	8.18	14.03	9.70	9.49	9.45	12.47	9.13	9.27		
MSCR at 64 °C on RTFO																		
Avg % Recovery @ 3.2 kPa		72.22			71.07	73.85		75.44	73.30	69.75	74.59	73.62	74.96	72.95	75.90	75.57		
Jnr @ 3.2 kPa		0.17			0.19	0.16		0.15	0.16	0.21	0.14	0.16	0.15	0.18	0.14	0.14		
% Diff. between Jnr		36.12			16.68	42.61		42.25	42.51	46.48	40.04	44.03	43.01	78.74	41.31	43.16		
O DSR ELASTIC RECOVERY		45.50				44.80				51.00		44.60			57.40	53.10		
R DSR ELASTIC RECOVERY		50.90				45.90				54.30		43.80			63.50	53.80		

Between 1 & 2 Std. Dev

Greater than 2 Std Dev

Ohio DOT 2018 PG Binder

PG 58-28	LAB #33	LAB #34	LAB #35	LAB #36	LAB #37	LAB #38	LAB #39	AVG	2 STD DEV	1 STD DEV	STD DEV	1 STD DEV	2 STD DEV
ROTATIONAL VISCOSITY	1.337	0.280	3.125	0.288	0.293	0.273	0.284	0.3984	-0.6161	-0.1088	0.5073	0.9057	1.4130
PENETRATION	114	125	131	145	123	122	117	121.000	105.776	113.388	7.612	128.612	136.224
COMPLEX MODULUS	1.33	1.35	1.33	1.33	1.29	1.29	1.40	1.343	1.207	1.275	0.068	1.411	1.479
PHASE ANGLE	87.3	87.3	87.3	87.5	87.4	87.3	87.3	87.10	85.13	86.11	0.99	88.08	89.07
ORIGINAL DSR	1.33	1.35	1.33	1.33	1.29	1.29	1.40	1.343	1.208	1.275	0.068	1.411	1.478
COMPLEX MODULUS	3.28	3.38	3.82	3.28	2.97	3.19	3.62	3.414	2.908	3.161	0.253	3.668	3.921
PHASE ANGLE	83.8	83.6	83.2	84.0	84.3	83.8	83.6	83.74	83.05	83.40	0.34	84.08	84.42
RTFO DSR	3.30	3.41	3.85	3.30	2.99	3.21	3.65	3.436	2.919	3.177	0.258	3.694	3.952
MASS CHANGE %	-0.504	-0.530	-0.472	-0.497	-0.396	-0.437	-0.471	-0.470	-0.657	-0.564	0.094	-0.376	-0.282
PAV WITH VDO													
PHASE ANGLE	49.3	48.8	48.9	49.0	49.5	49.2	49.7	49.000	47.189	48.094	0.906	49.906	50.811
PAV DSR	4440	4356	4380	4821	4510	4050	4336	4443.903	3671.594	4057.749	386.155	4830.058	5216.212
ESTIMATED STIFF 1	245	247	246	258	248	245	250	252.3	218.1	235.2	17.1	269.4	286.6
ESTIMATED STIFF 2	247	255	257	256	253	261	253	252.7	219.0	235.9	16.8	269.6	286.4
AVERAGE EST STIFF	246.0	251.0	251.5	257.0	250.5	253.0	251.5	252.5	219.5	236.0	16.5	269.0	285.5
RANGE	-2	-8	-11	2	-5	-16	-3	-0.4	-16.4	-8.4	8.0	7.6	15.6
M-VALUE 1	0.334	0.329	0.333	0.326	0.336	0.314	0.333	0.331	0.315	0.323	0.008	0.339	0.346
M-VALUE 2	0.326	0.326	0.333	0.332	0.339	0.321	0.337	0.330	0.317	0.323	0.006	0.336	0.343
AVERAGE M-VALUE	0.330	0.328	0.333	0.329	0.338	0.318	0.335	0.3302	0.3167	0.3234	0.0068	0.3370	0.3438
RANGE	0.008	0.003	0.000	-0.006	-0.003	-0.007	-0.004	0.0010	-0.0089	-0.0039	0.0049	0.0059	0.0109

PG 70-22M								AVG	2 STD DEV	1 STD DEV	STD DEV	1 STD DEV	2 STD DEV
ROTATIONAL VISCOSITY	1.125	1.188	1.175	1.155	1.185	1.164		1.1609	1.0422	1.1016	0.0594	1.2203	1.2797
COMPLEX MODULUS	1.86	1.89	1.91	1.77	1.92	1.81	1.85	1.859	1.730	1.794	0.065	1.924	1.989
PHASE ANGLE	70.7	70.7	70.2	70.8	70.2	70.4	70.6	70.57	69.94	70.25	0.31	70.88	71.19
ORIGINAL DSR	1.97	2.00	2.02	1.88	2.04	1.92	1.97	1.973	1.834	1.904	0.070	2.043	2.113
COMPLEX MODULUS	4.91	4.87	5.57	4.21	4.11	3.96	4.75	4.662	4.039	4.350	0.312	4.974	5.286
PHASE ANGLE	60.9	60.9	60.3	62.1	62.1	61.9	61.4	61.72	58.60	60.16	1.56	63.28	64.85
RTFO DSR	5.62	5.57	6.41	4.77	4.65	4.49	5.41	5.314	4.567	4.941	0.374	5.688	6.062
ELASTIC RECOVERY	77.5	76.3	75.5	73.0		75.7	70.0	75.3	68.4	71.9	3.5	78.8	82.3
PAV WITH VDO													
PHASE ANGLE	41.8	42.1	42.7	43.0	42.3	42.5	43.0	42.1	39.3	40.7	1.4	43.5	44.9
PAV DSR	2230	2223	2180	2038	2190	1970	2064	2197.7	1711.6	1954.6	243.0	2440.7	2683.8
ESTIMATED STIFF 1	119	122	124	129	123	124	124	124.6	111.0	117.8	6.8	131.4	138.3
ESTIMATED STIFF 2	119	126	128	129	122	124	128	126.6	113.5	120.1	6.5	133.2	139.7
AVERAGE EST STIFF	119.0	124.0	126.0	129.0	122.5	124.0	126.0	125.6	112.9	119.2	6.4	132.0	138.4
RANGE	0	-4	-4	0	1	0	-4	-2.0	-9.7	-5.8	3.9	1.9	5.8
M-VALUE 1	0.318	0.321	0.321	0.324	0.321	0.315	0.335	0.319	0.304	0.311	0.007	0.326	0.333
M-VALUE 2	0.320	0.321	0.320	0.324	0.317	0.315	0.332	0.318	0.303	0.310	0.007	0.325	0.333
AVERAGE M-VALUE	0.319	0.321	0.321	0.324	0.319	0.315	0.334	0.3182	0.3039	0.3110	0.0072	0.3254	0.3325
RANGE	-0.002	0.000	0.001	0.000	0.004	0.000	0.003	0.0010	-0.0060	-0.0025	0.0035	0.0045	0.0080
MSCR at 58 °C on RTFO													
Avg % Recovery @ 3.2 kPa	1.25	0.51	0.94	1.38	0.30	0.43	1.40	3.047	-22.631	-9.792	12.839	15.886	28.725
Jnr @ 3.2 kPa	2.91	2.87	2.42	3.03	3.10	3.10	2.73	2.853	2.395	2.624	0.229	3.082	3.311
% Diff. between Jnr	9.11	11.93	9.60	9.65	7.80	10.56	9.20	10.041	6.474	8.257	1.784	11.824	13.608
MSCR at 64 °C on RTFO													
Avg % Recovery @ 3.2 kPa	75.92	75.92	76.39	74.24	72.25	72.18	76.00	74.674	70.371	72.523	2.151	76.825	78.977
Jnr @ 3.2 kPa	0.14	0.14	0.13	0.17	0.19	0.20	0.14	0.153	0.102	0.127	0.025	0.178	0.203
% Diff. between Jnr	43.26	67.00	6.04	5.42	11.62	12.85	40.00	38.945	-2.272	18.337	20.608	59.553	80.162
O DSR ELASTIC RECOVERY		52.80						50.02	41.509	45.765	4.255	54.275	58.531
R DSR ELASTIC RECOVERY		60.50						53.37	40.928	47.148	6.220	59.587	65.807

Between 1 & 2 Std. Dev

Greater than 2 Std Dev