8 March 2012

Southeast Asphalt User-Producer Group Interlaboratory Study to Determine the Precision of AASHTO TP70 – the Multiple-Stress Creep-Recovery (MSCR) Test

Prepared for the Southeast Asphalt User-Producer Group (SEAUPG)

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in cooperation with
the Federal Highway Administration

through
DTFH61-08-H-00030
and
DTFH61-11-H-00033

asphalt institute

Introduction

In 2011, the Southeast Asphalt User-Producer Group (SEAUPG) initiated an interlaboratory study (ILS) for participating labs to evaluate the repeatability and reproducibility of AASHTO TP70, *Multiple Stress Creep Recovery (MSCR) Test of Asphalt Binder Using a Dynamic Shear Rheometer (DSR)*. This ILS was seen as a follow-up to the ILS conducted by the Asphalt Binder Expert Task Group in 2008-09 that established the initial precision statement and the ILS conducted by the Northeast Asphalt User Producer Group (NEAUPG) in 2010.

Twenty-three (23) laboratories, principally located in the SEAUPG, agreed to participate in the study. Included were Users (13 labs), Producers (8 labs), and Industry/Academia (2 labs). These labs are shown in Table 1. More detailed contact information can be found in the Appendix.

Table 1: Participating Labs

Users	**Producers**	**Industry/Academia**
Alabama DOT	BETA R&D	Asphalt Institute
Federal Highway Administration (FHWA) Office of Pavement Technology (3 labs/DSRs)	Ergon Asphalt& Emulsions (5 Labs)	National Center for Asphalt Technology
Florida DOT	Marathon	
Georgia DOT	Paragon Technical Services	
Louisiana Transportation Research Center		
Mississippi DOT		
North Carolina DOT		
Oklahoma DOT		
South Carolina DOT		
Texas DOT		
Virginia Center for Transportation Innovation and Research		

Each laboratory was asked to perform a temperature verification on the DSR that would be used before beginning the testing. Technicians were also requested to be familiar with the MSCR test before participating. Other than reviewing the AASHTO TP70 test procedure, technicians were referred to the MSCR seminar (http://www.ct.gov/dot/cwp/view.asp?a=1617&q=448116) hosted by the Connecticut DOT Division of Research and conducted by the Asphalt Institute and FHWA in 2009.

Each participating laboratory received samples of three asphalt binders (labeled as A, B, and C): PG 64-22, PG 76-22, and a lab blend of the two (most similar to a PG 70-22). For each binder, there were three 1-oz tins and one 6-oz tin of unaged material supplied. Labs were asked to do the following:

- Before conducting any testing, heat the 6-oz tin of each unaged asphalt binder and pour two RTFO bottles. Conduct the RTFO aging in accordance with AASHTO T240. After the RTFO aging is complete, scrape the two bottles for each asphalt binder into a single container and stir. At this point, it is recommended that the RTFO-aged binder be split into three separate 1-oz containers, if possible, so that reheating can be minimized. Label each tin with the Sample Identification and "RTFO".
- Heat the 1-oz tins of unaged ("ORIG") asphalt binder only once when preparing to conduct testing.
- Perform the MSCR test (AASHTO TP70) at 64°C on each asphalt binder sample as identified on the supplied data form. Perform the testing in the order indicated on the data form. A total of 18 tests will be performed (3 binders x 2 aged conditions x 3 replicates).
- Report all results and either e-mail or scan/fax the data form to AI when complete.

Each participating lab also received a randomized test plan (data sheet) indicating the experimental testing sequence. Note that three different data sheets were used for participating labs (as shown in the Appendix). Asphalt binder samples were tested using the MSCR test at 0.1 kPa and 3.2 kPa shear stress at 64°C for all three asphalt binders.

It was stressed to the participating lab that it was important to follow the randomized testing sequence indicated on the experimental test plan. The testing was randomized to minimize the chance of a systematic error affecting just one set of test results. Labs were also informed that it was preferable that the testing technician and DSR should be the same for all samples, but at a minimum, must be the same for each asphalt binder sample with the same letter designation (i.e., A, B, or C). This last requirement allows for a proper estimate of single operator precision.

ILS Procedure

The ILS procedure followed the guidelines in ASTM E691, *Standard Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method*. The purpose of an ILS is to develop information needed for a precision statement. However, the practice cautions the reader that:

> "The precision statistics obtained by an ILS such as described in this practice must not be treated as exact mathematical quantities which are applicable to all circumstances and uses…The repeatability limit and reproducibility limit should be considered as general guides, and the associated probability of 95% as only a rough indicator of what can be expected."

Results

Data was analyzed separately for each asphalt binder sample and test result – J_{nr} @ 0.1 kPa shear stress (Jnr-0.1), Recovery @ 0.1 kPa shear stress (Rec-0.1), J_{nr} @ 3.2 kPa shear stress (Jnr-3.2), Recovery @ 3.2 kPa shear stress (Rec-3.2), and Stress Sensitivity (Jnr-Diff). An example of the data is shown in Table 2. The Appendix contains all thirty data tables.

Table 2: Sample AR (PG 64-22 Binder, RTFO-aged) Data for Jnr-3.2

Binder AR

PG 64-22

Jnr (3.2 kPa)

Lab No.	Lab Name	Results, x 1	2	3	Average	s	d	h	k
1		2.292	2.279	2.268	2.27967	0.01201	0.12040	0.73	0.12
2		2.290	2.318	2.377	2.32833	0.04441	0.16907	1.03	0.45
3		2.057	2.070	2.042	2.05633	0.01401	-0.10293	-0.63	0.14
4		2.266	2.228	2.263	2.25233	0.02113	0.09307	0.57	0.21
5		1.762	1.999	1.859	1.87307	0.11886	-0.28620	-1.74	1.21
6		2.361	1.916	1.886	2.05403	0.26610	-0.10523	-0.64	2.70
7		1.854	2.129	2.210	2.06433	0.18660	-0.09493	-0.58	1.89
8		2.291	2.149	2.200	2.21333	0.07193	0.05407	0.33	0.73
9		1.915	1.957	1.892	1.92153	0.03319	-0.23773	-1.45	0.34
10		2.491	2.260	2.276	2.34233	0.12900	0.18307	1.11	1.31
11		2.065	2.078	2.236	2.12633	0.09495	-0.03293	-0.20	0.96
12		2.053	2.046	1.996	2.03160	0.03125	-0.12767	-0.78	0.32
13		2.465	2.454	2.447	2.45533	0.00907	0.29607	1.80	0.09
14		2.311	2.345	2.309	2.32153	0.01991	0.16227	0.99	0.20
15		2.037	2.015	2.080	2.04380	0.03303	-0.11547	-0.70	0.34
16		2.152	2.156	2.128	2.14533	0.01499	-0.01393	-0.08	0.15
17		2.143	2.242	2.279	2.22133	0.07044	0.06207	0.38	0.71
18		2.244	2.248	2.243	2.24520	0.00263	0.08593	0.52	0.03
19		2.221	2.315	2.424	2.32000	0.10174	0.16073	0.98	1.03
20		2.521	2.182	2.156	2.28643	0.20383	0.12717	0.77	2.07
21		2.264	2.295	2.236	2.26497	0.02957	0.10570	0.64	0.30
22		1.897	1.935	1.977	1.93633	0.04002	-0.22293	-1.36	0.41
23		1.938	1.821		1.87960	0.08259	-0.27967	-1.70	0.84
24									
25									
26									
27									
28									

Average of Cell Averages	X-bar	2.159	
Standard Deviation of Cell Averages	$s_{X\text{-}bar}$	0.164	
Repeatability Standard Deviation	s_r	0.09855	0.183
Reproducibility Standard Deviation	s_R	0.183	

Shaded cells were removed after outlier analysis

A quality review of the data was initiated to ensure that there were no obvious errors that would require removal of some data points from the participating labs. Although there were some reporting errors, these were corrected before conducting the analysis.

The values for Repeatability Standard Deviation (s_r) and Reproducibility Standard Deviation (s_R) are used to determine the 1s, 1s%, d2s, and d2s% values for repeatability (within-lab) and reproducibility (between-lab), respectively.

The data can also be represented graphically as shown in Figure 1 and Figure 2 (with bands shown for data within one, two, and three standard deviations).

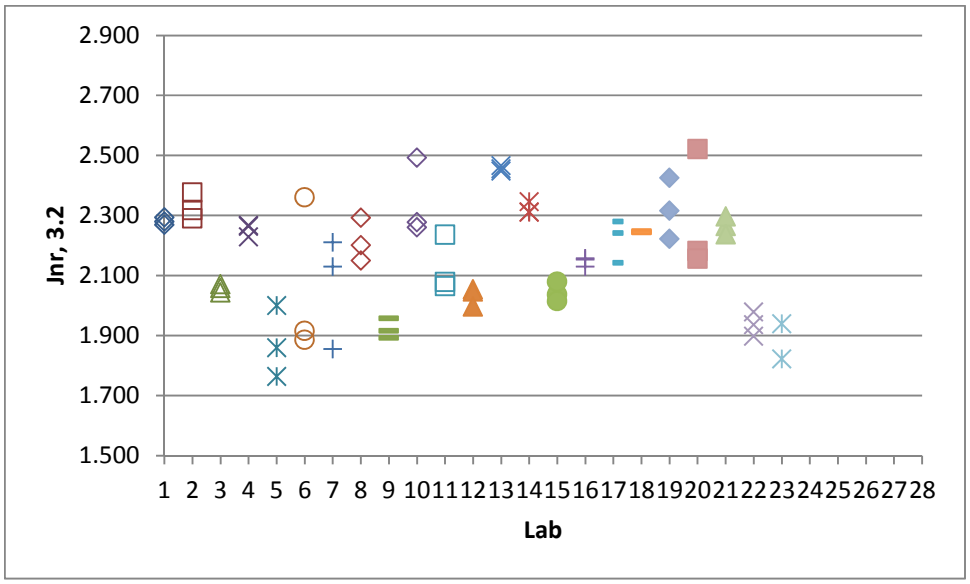

Figure 1: Binder AR (PG 64-22, RTFO-aged) Data for Jnr-3.2

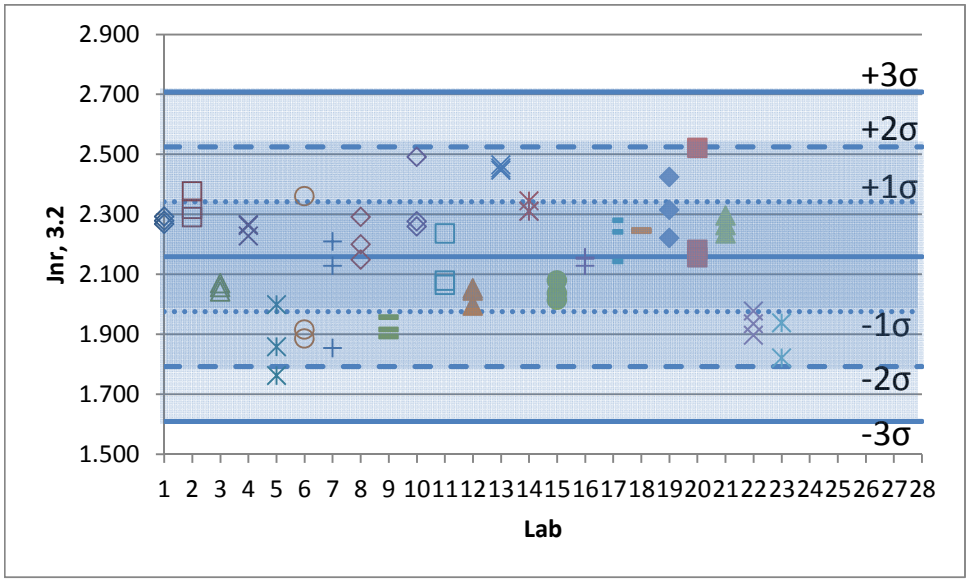

Figure 2: Binder AR (PG 64-22, RTFO-aged) Data for Jnr-3.2 with Standard Deviation Bands

The ILS procedure recommends that outliers should be identified through a consistency analysis. The consistency analysis in ASTM E691 considers two consistency statistics. The "h" consistency statistic is "…an indicator of how one laboratory's cell average, for a particular material, compares with the average of the other laboratories." The "k" consistency statistic is "…an indicator of how one laboratory's within-laboratory variability, under repeatability conditions, on a particular material, compares with all of the laboratories combined. Values of 'k' larger than 1 indicate greater within-laboratory variability than the average for all laboratories." Critical values are chosen at a significance level of 0.5%.

Tables of the “h” and “k” consistency statistics were created for each of the five test parameters: Jnr-0.1, Rec-0.1, Jnr-3.2, Rec-3.2, and Jnr-Diff. These tables are provided in the Appendix with an example table provided below.

Table 3: Consistency Statistic “h” for Rec-3.2

h

Critical Value = 2.59		2.59	2.59	2.59	2.59	2.59	2.59
Recovery (3.2 kPa)							
		Material					
Lab No.	Lab Name	Binder AO	Binder BO	Binder CO	Binder AR	Binder BR	Binder CR
1		0.56	-0.21	-0.75	0.48	0.25	0.10
2		0.57	-0.20	0.21	0.46	0.01	0.02
3		0.75	0.28	0.37	0.69	0.36	0.44
4		0.66	-0.03	0.37	0.52	0.17	0.30
5		0.30	-0.40	-0.20	0.51	-0.32	1.32
6		-1.32	1.40	1.49	-1.04	1.51	0.71
7		0.73	-0.67	-0.31	0.64	-1.06	-0.80
8		0.73	-3.82	-1.89	0.50	-3.77	-1.32
9		0.44	0.31	0.08	0.42	0.04	0.06
10		0.61	-0.11	-0.43	0.48	0.33	-0.78
11		-1.31	-0.47	0.00	-1.18	0.62	-0.64
12		0.13	0.55	1.04	0.27	0.39	0.19
13		0.57	0.10	-0.34	0.39	0.12	-0.33
14		0.06	1.27	0.40	0.14	0.38	0.17
15		0.03	0.67	0.61	0.19	0.70	1.29
16		0.12	0.40	0.49	0.26	0.10	1.14
17		0.02	0.14	-0.31	0.15	0.15	0.98
18		0.16	0.62	0.28	0.17	0.38	0.14
19		-3.30	-0.28	-2.24	-3.45	-0.46	-2.50
20		-1.83	0.07	-1.46	-1.99	-0.07	-1.80
21		0.33	-0.49	-0.37	0.14	-1.19	-0.63
22		0.62	-0.15	0.71	0.70	0.45	0.74
23		0.36	1.02	2.24	0.53	0.88	1.22
24		0.00	0.00	0.00	0.00	0.00	0.00
25		0.00	0.00	0.00	0.00	0.00	0.00
26		0.00	0.00	0.00	0.00	0.00	0.00
27		0.00	0.00	0.00	0.00	0.00	0.00
28		0.00	0.00	0.00	0.00	0.00	0.00

exceeds h
exceeds h-0.5

In Table 3, purple-shaded cells highlight values that exceed the critical value of “h”, indicating inconsistent or questionable data. Yellow-shaded cells are warning indicators that the value is approaching the critical value of “h”.

The data in the consistency tables can be used with graphs to identify if inconsistent data should be eliminated when determining the precision estimates. For example, Lab 8 has “h” values

exceeding the critical value for both Binder BO and Binder BR. Lab 19 has "h" values exceeding the critical value for Binders AO and AR, and values approaching the critical value for Binders CO and CR. An examination of the plot (shown in Figure 3, with Labs 8 and 19 highlighted by dashed lines), verifies that the Rec-3.2 values for Labs 8 and 19 are lower than the average lab values. This can also be seen graphically in the following six figures, where Lab 19 data (Figures 4,5,8, and 9) and Lab 8 data (Figures 6 and 7) are circled.

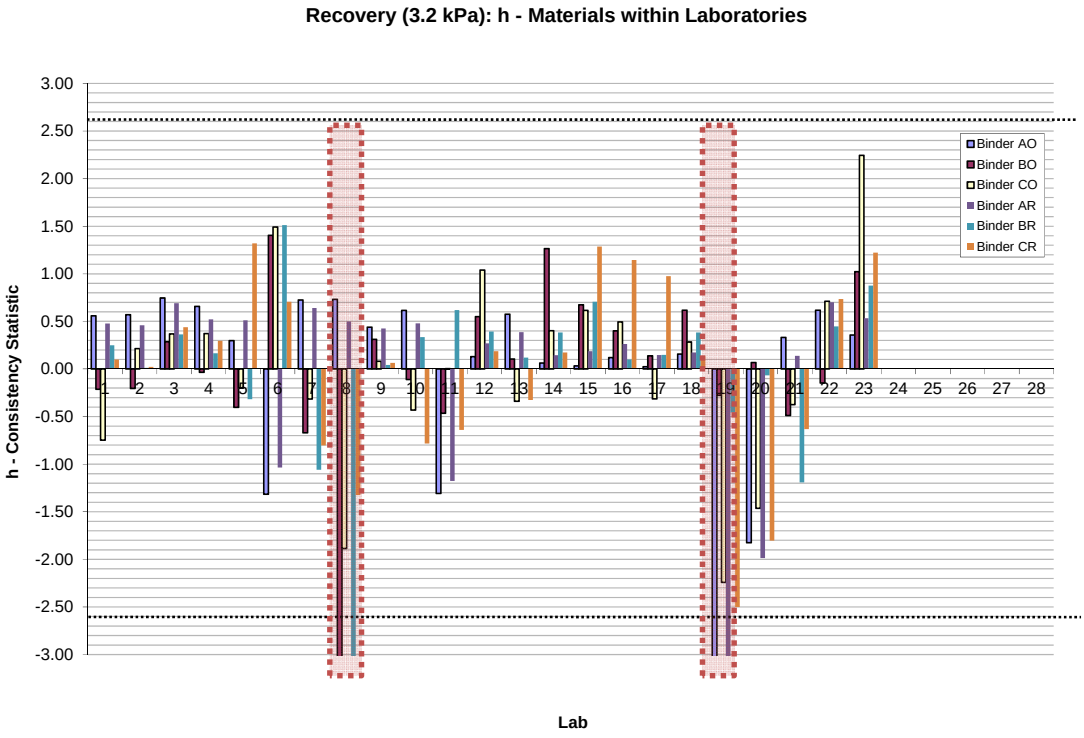

Figure 3: Consistency Statistic "h" for Jnr-3.2 – All Labs and Materials

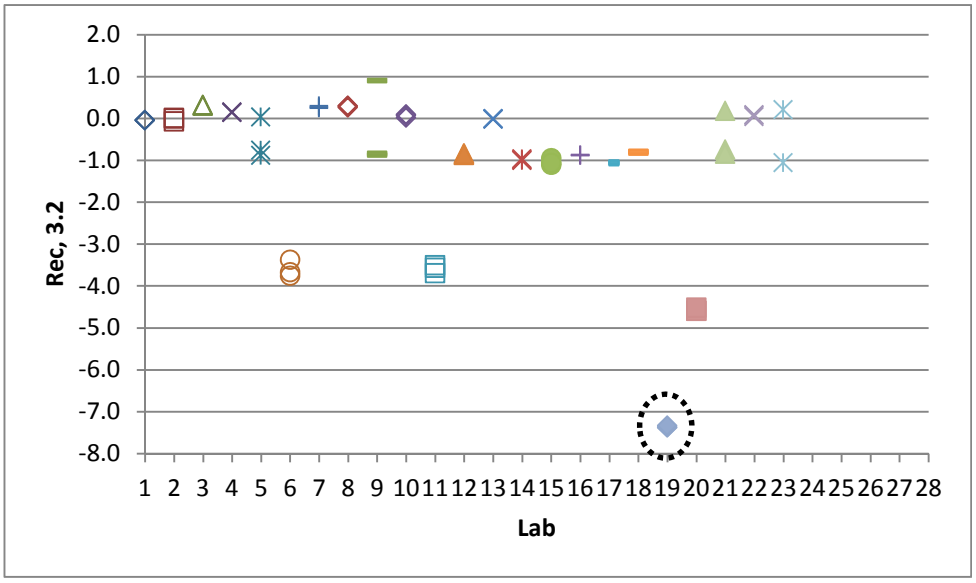

Figure 4: Rec-3.2 Data for Binder AO

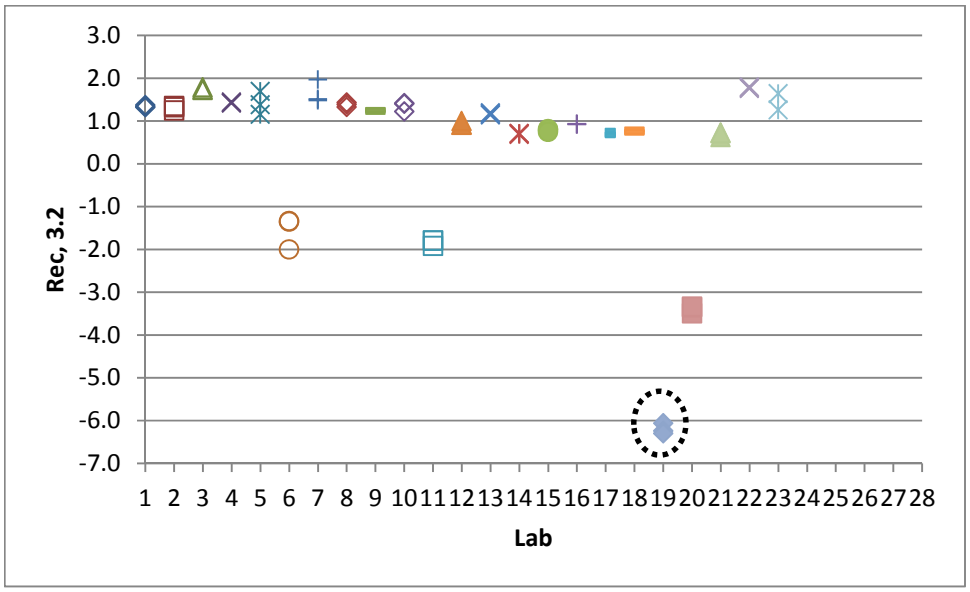

Figure 5: Rec-3.2 Data for Binder AR

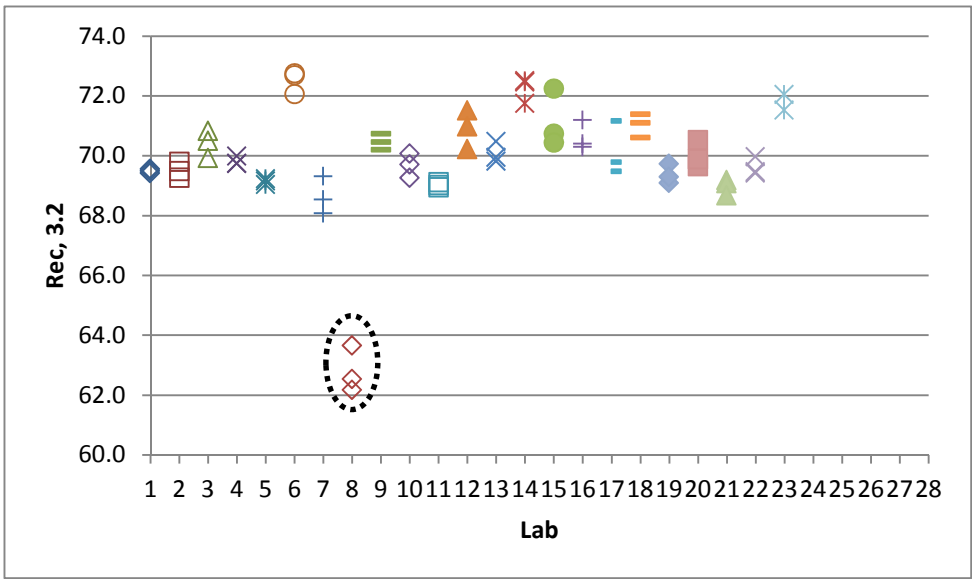

Figure 6: Rec-3.2 Data for Binder BO

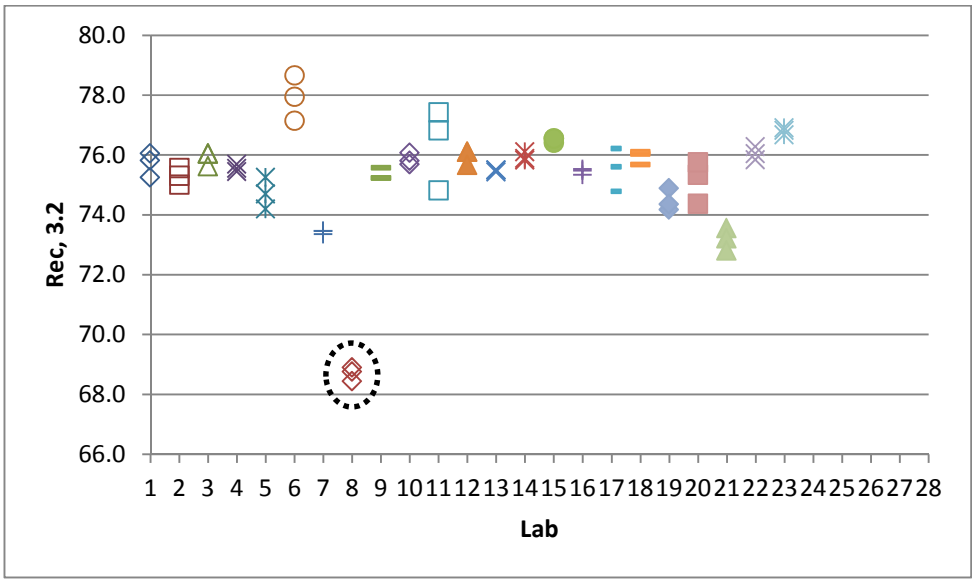

Figure 7: Rec-3.2 Data for Binder BR

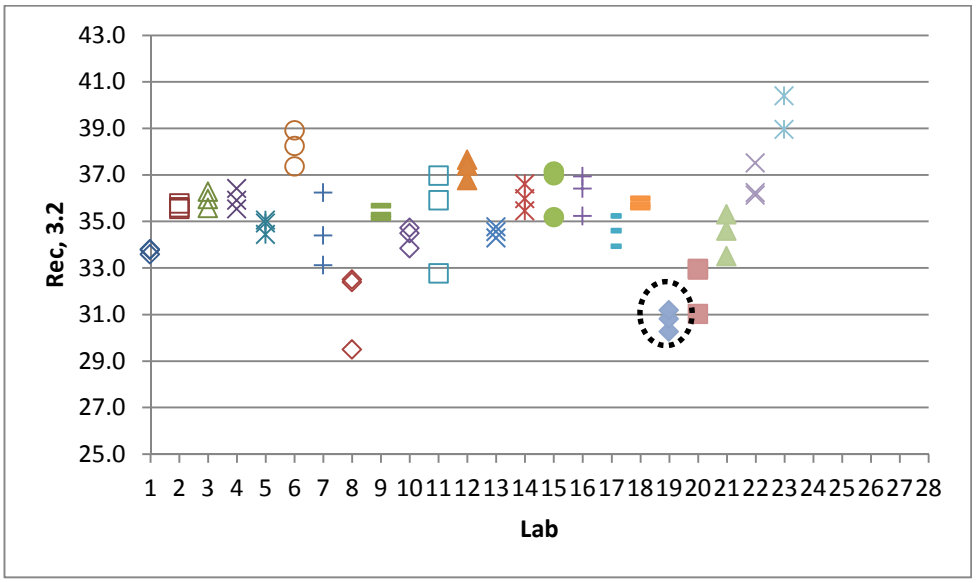

Figure 8: Rec-3.2 Data for Binder CO

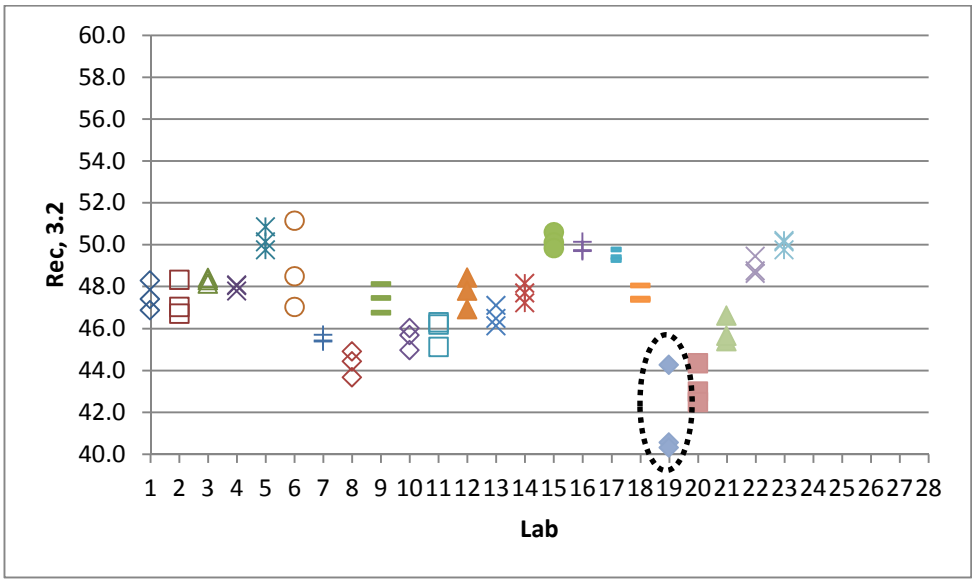

Figure 9: Rec-3.2 Data for Binder CR

As can be seen in Figures 4-7, the circled data is clearly different than the rest of the data – indicating an outlier. Based on the consistency analysis, the Rec-3.2 data from Lab 19 for Binders AO and AR (Figures 4 and 5) and from Lab 8 for Binders BO and BR (Figures 6 and 7) was eliminated from the repeatability and reproducibility calculation.

In Figures 8 and 9, while the circled data looks a little low, it is not clearly different than the rest of the data. As such, the Rec-3.2 data from Lab 19 for Binders CO and CR was left in the repeatability and reproducibility calculation.

This same analysis was conducted for each of the "flagged" data in the consistency tables. It should be noted that ASTM E691 generally does not advocate excluding data except in special instances and recommends against excluding more than 5% of the ILS data to prevent presenting precision that cannot be met in routine use. Thus, to meet this requirement, no more than 1 cell should be eliminated per binder for each MSCR parameter.

Based on the consistency analysis, the data in Table 4 was excluded from the calculation of repeatability and reproducibility.

Table 4: Data Excluded from Repeatability and Reproducibility Calculations

	Jnr-0.1	**Jnr-3.2**	**Rec-0.1**	**Rec-3.2**	**Jnr-Diff**
Binder AO	none[1]	none[1]	Lab 19	Lab 19	none
Binder AR	none	none	Lab 19	Lab 19	none
Binder BO	none	none	Lab 8	Lab 8	Lab 6
Binder BR	none	none	Lab 8	Lab 8	none
Binder CO	none	none	none	none	none
Binder CR	none	none	none	none	none

[1] although data was not eliminated from any one lab, two suspect data points where eliminated based on analysis of the "k" statistic.

After excluding the data indicated in Table 4, the repeatability and reproducibility was calculated. This data is shown in Tables 5-9.

Table 5: Repeatability and Reproducibility Calculations for Jnr-0.1

								Repeatability		Reproducibility	
ID	Binder	X-bar	$s_{X\text{-}bar}$	s_r	s_R	r	R	1s%	d2s%	1s%	d2s%
AO	PG 64-22	4.41083	0.25947	0.23554	0.32297	0.65950	0.90432	5.3%	15.0%	7.3%	20.5%
BO	PG 76-22	0.27768	0.02688	0.01240	0.02872	0.03473	0.08042	4.5%	12.5%	10.3%	29.0%
CO	PG 70-22	0.78060	0.06671	0.03584	0.07285	0.10036	0.20397	4.6%	12.9%	9.3%	26.1%
AR	PG 64-22	2.00374	0.15375	0.10094	0.17444	0.28262	0.48844	5.0%	14.1%	8.7%	24.4%
BR	PG 76-22	0.12907	0.01299	0.00662	0.01407	0.01854	0.03940	5.1%	14.4%	10.9%	30.5%
CR	PG 70-22	0.34892	0.03027	0.01380	0.03230	0.03864	0.09043	4.0%	11.1%	9.3%	25.9%

Table 6: Repeatability and Reproducibility Calculations for Jnr-3.2

								Repeatability		Reproducibility	
ID	Binder	X-bar	$s_{X\text{-}bar}$	s_r	s_R	r	R	1s%	d2s%	1s%	d2s%
AO	PG 64-22	4.69213	0.26719	0.23367	0.32832	0.65428	0.91929	5.0%	13.9%	7.0%	19.6%
BO	PG 76-22	0.30897	0.03584	0.01557	0.03803	0.04360	0.10647	5.0%	14.1%	12.3%	34.5%
CO	PG 70-22	1.07235	0.10404	0.05119	0.11212	0.14334	0.31394	4.8%	13.4%	10.5%	29.3%
AR	PG 64-22	2.15927	0.16439	0.09855	0.18302	0.27594	0.51247	4.6%	12.8%	8.5%	23.7%
BR	PG 76-22	0.13702	0.01491	0.00543	0.01555	0.01520	0.04355	4.0%	11.1%	11.4%	31.8%
CR	PG 70-22	0.42483	0.04155	0.01895	0.04434	0.05307	0.12414	4.5%	12.5%	10.4%	29.2%

Table 7: Repeatability and Reproducibility Calculations for Rec-0.1

								Repeatability		Reproducibility	
ID	Binder	X-bar	$s_{X\text{-}bar}$	s_r	s_R	r	R	1s%	d2s%	1s%	d2s%
AO	PG 64-22	0.44413	1.18720	1.31083	1.59843	3.67034	4.47559	295.1%	826.4%	359.9%	1007.7%
BO	PG 76-22	72.51327	0.78482	0.42972	0.85968	1.20321	2.40711	0.6%	1.7%	1.2%	3.3%
CO	PG 70-22	49.57870	1.66396	0.81864	1.79320	2.29220	5.02095	1.7%	4.6%	3.6%	10.1%
AR	PG 64-22	3.43658	1.51018	1.48950	1.93900	4.17059	5.42920	43.3%	121.4%	56.4%	158.0%
BR	PG 76-22	76.73073	0.83887	0.82517	1.07593	2.31048	3.01262	1.1%	3.0%	1.4%	3.9%
CR	PG 70-22	55.28762	1.82594	0.68068	1.90865	1.90592	5.34422	1.2%	3.4%	3.5%	9.7%

Table 8: Repeatability and Reproducibility Calculations for Rec-3.2

								Repeatability		Reproducibility	
ID	Binder	X-bar	$s_{X\text{-}bar}$	s_r	s_R	r	R	1s%	d2s%	1s%	d2s%
AO	PG 64-22	-0.81911	1.35128	0.33383	1.37849	0.93472	3.85978	-40.8%	-114.1%	-168.3%	-471.2%
BO	PG 76-22	70.21020	1.05104	0.45632	1.11512	1.27770	3.12234	0.6%	1.8%	1.6%	4.4%
CO	PG 70-22	35.20919	1.98739	0.89385	2.11716	2.50278	5.92806	2.5%	7.1%	6.0%	16.8%
AR	PG 64-22	0.72091	1.29715	0.13549	1.30186	0.37936	3.64522	18.8%	52.6%	180.6%	505.6%
BR	PG 76-22	75.56883	1.02004	0.45928	1.08679	1.28598	3.04301	0.6%	1.7%	1.4%	4.0%
CR	PG 70-22	47.29875	2.23660	0.82159	2.33504	2.30045	6.53811	1.7%	4.9%	4.9%	13.8%

Table 9: Repeatability and Reproducibility Calculations for Jnr-Diff

								Repeatability		Reproducibility	
ID	Binder	X-bar	$s_{X\text{-}bar}$	s_r	s_R	r	R	1s%	d2s%	1s%	d2s%
AO	PG 64-22	0.06517	0.01337	0.01931	0.02067	0.05407	0.05789	29.6%	83.0%	31.7%	88.8%
BO	PG 76-22	0.11513	0.02814	0.01316	0.03012	0.03684	0.08433	11.4%	32.0%	26.2%	73.2%
CO	PG 70-22	0.36367	0.04617	0.03197	0.05304	0.08952	0.14850	8.8%	24.6%	14.6%	40.8%
AR	PG 64-22	0.07742	0.01646	0.01864	0.02242	0.05220	0.06278	24.1%	67.4%	29.0%	81.1%
BR	PG 76-22	0.07326	0.02389	0.02335	0.03057	0.06537	0.08559	31.9%	89.2%	41.7%	116.8%
CR	PG 70-22	0.21118	0.02754	0.01614	0.03053	0.04519	0.08548	7.6%	21.4%	14.5%	40.5%

In the tables above:

- "X-bar" represents the average value from the participating labs for each binder sample
- "s_r" represents the within-lab (single operator) standard deviation, or 1s. Dividing this value by the average value generates the Repeatability coefficient of variation, or 1s%. Multiplying s_r by 2.8 generates the acceptable range of two test results under repeatability conditions, or d2s. Dividing this product by the average value results in the d2s%.
- "s_R" represents the between-lab standard deviation, or 1s. Dividing this value by the average value generates the Reproducibility coefficient of variation, or 1s%. Multiplying s_R by 2.8 generates the acceptable range of two test results under reproducibility conditions, or d2s. Dividing this product by the average value results in the d2s%.

The original MSCR ILS conducted through the Asphalt Binder Expert Task Group (ETG) resulted in the development of a tiered precision statement for J_{nr} and a regular precision statement for Recovery. The "tiers" for J_{nr} were established as follows:

- J_{nr} greater than 1.00 kPa^{-1};
- J_{nr} greater than 0.25 kPa^{-1} and less than or equal to 1.00 kPa^{-1}; and
- J_{nr} greater than 0.10 kPa^{-1} and less than or equal to 0.25 kPa^{-1}

The NEAUPG ILS did not support a tiered precision statement for J_{nr}. A review of the data in Tables 5 and 6 indicates that this ILS also does not support the tiered precision statement developed by the Asphalt Binder ETG. Repeatability and Reproducibility values appear very similar for J_{nr} for all asphalt binders. As such, average values were calculated for J_{nr} repeatability and reproducibility.

Similarly, the data in Tables 7 and 8 were used to calculate average values for Recovery repeatability and reproducibility. Note that the Recovery values for Binders AO and AR were not used in calculating the average repeatability and reproducibility. The actual Recovery value is low for both binders (expected since they are unmodified asphalt binders), leading to unreasonably high 1s% and d2s% values. The repeatability and reproducibility values for Recovery were determined by only using the data from Binders BO, BR, CO, and CR.

In some cases for Binders AO and AR negative Recovery values were reported by the participating lab. Negative Recovery values are usually only seen with unmodified asphalt binders. To address the issue, guidance from the Binder ETG suggests that negative Recovery values should be simply reported as 0%.

Jnr-Diff has not been determined in previous ILS programs so the results of this ILS cannot be compared to other data. A review of the data in Table 9 suggests that the within-lab standard

deviation (s_r) and between-lab standard deviation (s_R) are relatively unaffected by the average test value. As such, it appears that coefficient of variation is not the best way of representing this data. For Jnr-Diff, the precision data is shown in Table 10.

Table 10: Precision Estimates for Jnr-Diff from SEAUPG ILS

Condition	**Acceptable Range of Two Test Results (d2s)**
Single-Operator Precision Jnr-Diff	0.057
Multilaboratory Precision Jnr-Diff	0.085

Table 11 provides a comparison of the SEAUPG ILS with the 2010 NEAUPG ILS and the ILS previously performed by the Asphalt Binder ETG.

Table 11: Comparison of SEAUPG ILS with NEAUPG ILS and ETG ILS

	Acceptable Range of Two Test Results (d2s%)		
Condition	*SEAUPG ILS*	*NEAUPG ILS*	*ETG ILS*
Single-Operator Precision:			
$Recovery_{0.1kPa}$ (%)	3.2%	9.7%	6.7%
$Recovery_{3.2kPa}$ (%)	3.9%	7.7%	8.5%
Multilaboratory Precision:			
$Recovery_{0.1kPa}$ (%)	6.8%	14.0%	15.0%
$Recovery_{3.2kPa}$ (%)	9.8%	18.7%	18.1%
Single-Operator Precision:			
$J_{nr@0.1kPa}$ (kPa^{-1})			
>1.00	13.3%	14.5%	12.8%
0.26 - 1.00	13.3%	14.5%	15.2%
0.10 - 0.25	13.3%	14.5%	38.3%
<0.10	n/a	n/a	n/a
$J_{nr@3.2kPa}$ (kPa^{-1})			
>1.00	13.0%	14.5%	16.0%
0.26 - 1.00	13.0%	14.5%	15.3%
0.10 - 0.25	13.0%	n/a	26.6%
<0.10	n/a	n/a	n/a
Multilaboratory Precision:			
$J_{nr@0.1kPa}$ (kPa^{-1})			
>1.00	26.1%	25.6%	25.6%
0.26 - 1.00	26.1%	25.6%	35.6%
0.10 - 0.25	26.1%	25.6%	46.8%
<0.10	n/a	n/a	n/a
$J_{nr@3.2kPa}$ (kPa^{-1})			
>1.00	28.0%	33.7%	22.0%
0.26 - 1.00	28.0%	33.7%	39.0%
0.10 - 0.25	28.0%	n/a	42.6%
<0.10	n/a	n/a	n/a

The data in Table 11 indicates that the SEAUPG ILS has an equal or lower value (indicating better repeatability and/or reproducibility) in nearly all cases than was generated from the NEAUPG ILS and ETG ILS.

Summary

1. After removing potential outliers, the data indicates SEAUPG ILS has an equal or lower d2s% value, thus indicating better repeatability and/or reproducibility than generated from the NEAUPG ILS and ETG ILS.

2. The analysis of the SEAUPG ILS data did not indicate that a tiered precision statement for J_{nr} was warranted. Values for d2s% were approximately equal, regardless of the measured J_{nr} value. This finding matched the results from the NEAUPG ILS, which contradicted the ETG ILS.

3. Analysis of Jnr-Diff data indicated that the standard deviation was unaffected by the test value. As such, unlike the other parameters precision estimates are reported as d2s, not d2s% (coefficient of variation).

Acknowledgments

The information presented in this report would not have been possible without the willingness of the SEAUPG labs to provide data. Thanks to all the participating labs. Thanks in particular to Don Siler (Marathon), Andy Menapace (Paragon Technical Services), Rick Holmgreen (ConocoPhillips), Danny Gierhart (Asphalt Institute), and Bob Horan (Asphalt Institute) for coordinating sample supply and assisting with the development of the ILS program.

The analysis was conducted as part of the Asphalt Institute's Cooperative Agreements with the Federal Highway Administration through projects DTFH61-08-H-00030 and DTFH61-11-H-00033. Thanks to John Bukowski (FHWA, AOTR for DTFH61-08-H-00030) and Michael Arasteh (FHWA, AOTR for DTFH61-11-H-00033) for working with us on this project.

Finally, the support of the Member Companies of the Asphalt Institute is gratefully acknowledged. Without their interest and support, none of the work presented could have been accomplished.

Disclaimer

The analyses, conclusions, and recommendations expressed in this report are those of the author and do not necessarily reflect the views of the Federal Highway Administration, the Asphalt Institute or its individual Member Companies.

APPENDIX

SEAUPG MSCR Round Robin Participating Labs
October 2011

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ASPHALT INSTITUTE

SEAUPG Interlaboratory Study for Determining the Precision of AASHTO TP70, the Multiple Stress Creep Recovery (MSCR) Test

October 2011

To: Participating Labs

From: Mike Anderson, Asphalt Institute
859.288.4984 office
859.422.1301 FAX
manderson@asphaltinstitute.org

Thanks for agreeing to participate in the SEAUPG Interlaboratory Study (ILS) on the MSCR test. Enclosed are asphalt binder samples, a data reporting form, and appropriate MSDS. You should be receiving three different asphalt binders (labeled as A, B, and C) representing PG 64-22 and PG 76-22 binders, as well as a lab blend of the two binders. For each binder, there will be three 1-oz tins and one 6-oz tin of unaged material. Please do the following:

- The 6-oz tin includes enough unaged asphalt binder to perform RTFO-aging using two bottles. **Before conducting any testing**, heat the 6-oz tin for each asphalt binder and pour two RTFO bottles. Conduct the RTFO aging in accordance with AASHTO T240. After the RTFO aging is complete, scrape the two bottles for each asphalt binder into a single container and stir. At this point, we would recommend that the RTFO-aged binder be split into three separate 1-oz containers, if possible. Label each tin with the Sample Identification and “RTFO”.
- The 1-oz tins are replicates of unaged (“ORIG”) asphalt binder. They should only be heated once.
- Perform the MSCR test (AASHTO TP70) at 64°C on each asphalt binder sample as identified on the data form. **Please perform the testing in the order indicated on the data form.** There are a total of 18 tests to be performed (3 binders x 2 aged conditions x 3 replicates).
- Report all results and either e-mail or scan/fax the data form to me when complete.

If you have any questions, please contact me. Thanks for your participation!

SEAUPG - Interlaboratory Study for Determining the Precision of AASHTO TP70, the Multiple Stress Creep Recovery (MSCR) Test
Data Sheet - 1
October 2011 **Lab** _____

Please return this form to: manderson@asphaltinstitute.org

Please follow the testing order indicated in the table below (i.e., top to bottom).

		0.1 kPa Shear Stress		3.2 kPa Shear Stress					
Sample Cond.	Test Temp, C	J_{nr}, kPa^{-1}	%Recovery	J_{nr}, kPa^{-1}	%Recovery	Jnr Diff*	Date	Tech	DSR Make &Model
A ORIG	64								
A ORIG	64								
A RTFO	64								
B RTFO	64								
C RTFO	64								
B ORIG	64								
A ORIG	64								
C ORIG	64								
B RTFO	64								
C ORIG	64								
B ORIG	64								
C ORIG	64								
B ORIG	64								
B RTFO	64								
A RTFO	64								
A RTFO	64								
C RTFO	64								
C RTFO	64								

* calculated as (Jnr,3.2kPa - Jnr,0.1kPa)/(Jnr,0.1kPa)

SEAUPG - Interlaboratory Study for Determining the Precision of AASHTO TP70, the Multiple Stress Creep Recovery (MSCR) Test
Data Sheet - 2
October 2011 **Lab** _____

Please return this form to: manderson@asphaltinstitute.org

Please follow the testing order indicated in the table below (i.e., top to bottom).

		0.1 kPa Shear Stress		3.2 kPa Shear Stress					
Sample Cond.	Test Temp, C	J_{nr}, kPa^{-1}	%Recovery	J_{nr}, kPa^{-1}	%Recovery	Jnr Diff*	Date	Tech	DSR Make &Model
C RTFO	64								
C ORIG	64								
B RTFO	64								
A ORIG	64								
B ORIG	64								
B RTFO	64								
C ORIG	64								
B RTFO	64								
C ORIG	64								
C RTFO	64								
A ORIG	64								
C RTFO	64								
A RTFO	64								
A RTFO	64								
B ORIG	64								
A ORIG	64								
A RTFO	64								
B ORIG	64								

* calculated as (Jnr,3.2kPa - Jnr,0.1kPa)/(Jnr,0.1kPa)

SEAUPG - Interlaboratory Study for Determining the Precision of AASHTO TP70, the Multiple Stress Creep Recovery (MSCR) Test
Data Sheet - 3
October 2011 **Lab** _____

Please return this form to: manderson@asphaltinstitute.org

Please follow the testing order indicated in the table below (i.e., top to bottom).

		0.1 kPa Shear Stress		3.2 kPa Shear Stress					
Sample Cond.	Test Temp, C	J_{nr}, kPa^{-1}	%Recovery	J_{nr}, kPa^{-1}	%Recovery	Jnr Diff*	Date	Tech	DSR Make &Model
B RTFO	64								
C RTFO	64								
B ORIG	64								
A ORIG	64								
C ORIG	64								
A RTFO	64								
C RTFO	64								
B RTFO	64								
A ORIG	64								
C ORIG	64								
B ORIG	64								
B ORIG	64								
A RTFO	64								
C ORIG	64								
A RTFO	64								
A ORIG	64								
B RTFO	64								
C RTFO	64								

* calculated as (Jnr,3.2kPa - Jnr,0.1kPa)/(Jnr,0.1kPa)

Binder AO

PG 64-22

Jnr (0.1 kPa)

Lab No.	Lab Name	Results, x 1	2	3	Average	s	d	h	k
1		4.924	4.848	4.851	4.87433	0.04304	0.46350	1.79	0.18
2		4.675	4.513	4.503	4.56367	0.09655	0.15283	0.59	0.41
3		4.491	4.458	4.549	4.49933	0.04607	0.08850	0.34	0.20
4		4.316	4.327	4.338	4.32700	0.01100	-0.08383	-0.32	0.05
5		2.768	4.453	4.212	4.33270	0.17041	-0.07813	-0.30	0.72
6		4.664	4.487	3.952	4.36747	0.37087	-0.04337	-0.17	1.57
7		4.520	4.670	4.770	4.65333	0.12583	0.24250	0.93	0.53
8		4.152	4.291	4.172	4.20500	0.07515	-0.20583	-0.79	0.32
9		4.317	4.255	4.423	4.33163	0.08520	-0.07920	-0.31	0.36
10		5.269	4.870	4.781	4.97333	0.25989	0.56250	2.17	1.10
11		4.169	4.615	4.068	4.28370	0.29094	-0.12713	-0.49	1.24
12		4.194	4.323	4.283	4.26687	0.06636	-0.14397	-0.55	0.28
13		4.419	5.042	4.660	4.70700	0.31415	0.29617	1.14	1.33
14		4.726	4.671	4.772	4.72320	0.05082	0.31237	1.20	0.22
15		4.124	4.501	4.324	4.31640	0.18817	-0.09443	-0.36	0.80
16		4.244	4.250	4.267	4.25373	0.01151	-0.15710	-0.61	0.05
17		4.836	4.765	4.727	4.77600	0.05543	0.36517	1.41	0.24
18		4.198	4.138	4.126	4.15410	0.03879	-0.25673	-0.99	0.16
19		4.131	4.281	4.059	4.15710	0.11300	-0.25373	-0.98	0.48
20		4.096	4.096	3.884	4.02490	0.12246	-0.38593	-1.49	0.52
21		4.182	4.403	2.389	4.29240	0.15684	-0.11843	-0.46	0.67
22		4.236	4.112	4.414	4.25400	0.15180	-0.15683	-0.60	0.64
23		3.523	4.701		4.11200	0.83297	-0.29883	-1.15	3.54
24									
25									
26									
27									
28									

Average of Cell Averages	X-bar	4.411	
Standard Deviation of Cell Averages	$s_{X\text{-}bar}$	0.259	
Repeatability Standard Deviation	s_r	0.23554	0.323
Reproducibility Standard Deviation	s_R	0.323	

Shaded cells were removed after outlier analysis

Binder AO

PG 64-22

Jnr (3.2 kPa)

Lab No.	Lab Name	Results, x 1	2	3	Average	s	d	h	k
1		5.212	5.116	5.159	5.16233	0.04809	0.47020	1.76	0.21
2		4.935	4.854	4.848	4.87900	0.04859	0.18687	0.70	0.21
3		4.661	4.668	4.760	4.69633	0.05525	0.00420	0.02	0.24
4		4.769	4.739	4.713	4.74033	0.02802	0.04820	0.18	0.12
5		2.866	4.744	4.469	4.60630	0.19445	-0.08583	-0.32	0.83
6		4.953	4.785	4.222	4.65317	0.38269	-0.03897	-0.15	1.64
7		4.630	4.900	4.920	4.81667	0.16197	0.12453	0.47	0.69
8		4.737	4.550	4.400	4.56233	0.16884	-0.12980	-0.49	0.72
9		4.570	4.544	4.707	4.60690	0.08746	-0.08523	-0.32	0.37
10		5.706	5.254	5.167	5.37567	0.28937	0.68353	2.56	1.24
11		4.515	4.779	4.398	4.56417	0.19541	-0.12797	-0.48	0.84
12		4.490	4.572	4.541	4.53417	0.04133	-0.15797	-0.59	0.18
13		4.981	5.047	4.916	4.98133	0.06550	0.28920	1.08	0.28
14		4.998	4.960	5.057	5.00513	0.04895	0.31300	1.17	0.21
15		4.418	4.779	4.576	4.59060	0.18107	-0.10153	-0.38	0.77
16		4.565	4.542	4.557	4.55450	0.01172	-0.13763	-0.52	0.05
17		5.067	4.971	4.965	5.00100	0.05689	0.30887	1.16	0.24
18		4.529	4.419	4.463	4.47037	0.05490	-0.22177	-0.83	0.23
19		4.329	4.524	4.297	4.38303	0.12268	-0.30910	-1.16	0.53
20		4.424	4.424	4.116	4.32130	0.17823	-0.37083	-1.39	0.76
21		4.455	4.689	2.544	4.57210	0.16518	-0.12003	-0.45	0.71
22		4.546	4.112	4.762	4.47333	0.33104	-0.21880	-0.82	1.42
23		3.800	4.938		4.36900	0.80469	-0.32313	-1.21	3.44
24									
25									
26									
27									
28									

Average of Cell Averages	X-bar	4.692	
Standard Deviation of Cell Averages	$s_{X\text{-}bar}$	0.267	
Repeatability Standard Deviation	s_r	0.23367	0.328
Reproducibility Standard Deviation	s_R	0.328	

Shaded cells were removed after outlier analysis

Binder AO

PG 64-22

Recovery (0.1 kPa)

Lab No.	Lab Name	Results, x 1	2	3	Average	s	d	h	k
1		0.8	0.7	1.0	0.838	0.177	0.394	0.33	0.13
2		0.5	1.1	1.7	1.113	0.600	0.669	0.56	0.46
3		1.1	1.2	1.2	1.169	0.064	0.725	0.61	0.05
4		2.3	1.5	0.8	1.538	0.733	1.094	0.92	0.56
5		1.3	0.4	0.4	0.703	0.508	0.259	0.22	0.39
6		-2.2	-1.8	-1.4	-1.808	0.380	-2.252	-1.90	0.29
7		0.9	2.1	1.1	1.367	0.615	0.923	0.78	0.47
8		2.4	2.7	2.5	2.530	0.160	2.086	1.76	0.12
9		0.4	0.7	0.1	0.387	0.298	-0.057	-0.05	0.23
10		1.3	0.5	1.1	0.981	0.430	0.537	0.45	0.33
11		-0.4	-4.1	-0.9	-1.824	1.966	-2.268	-1.91	1.50
12		0.7	-0.1	0.0	0.198	0.454	-0.246	-0.21	0.35
13		6.2	-4.5	0.5	0.732	5.360	0.288	0.24	4.09
14		0.1	0.2	0.1	0.141	0.083	-0.303	-0.26	0.06
15		0.5	0.2	0.1	0.268	0.241	-0.176	-0.15	0.18
16		0.3	0.3	0.1	0.238	0.115	-0.206	-0.17	0.09
17		0.0	0.0	0.1	0.011	0.040	-0.433	-0.36	0.03
18		1.2	0.8	1.4	1.126	0.312	0.682	0.57	0.24
19		-6.5	-6.2	-6.2					
20		-2.3	-2.3	-3.5	-2.692	0.681	-3.137	-2.64	0.52
21		0.7	1.1	0.9	0.915	0.186	0.471	0.40	0.14
22		1.0	0.2	1.8	1.029	0.790	0.585	0.49	0.60
23		1.7	-0.1		0.810	1.299	0.365	0.31	0.99
24									
25									
26									
27									
28									

Average of Cell Averages	X-bar	0.444	
Standard Deviation of Cell Averages	$s_{X\text{-}bar}$	1.187	
Repeatability Standard Deviation	s_r	1.31083	1.598
Reproducibility Standard Deviation	s_R	1.598	

Shaded cells were removed after outlier analysis

Binder AO

PG 64-22

Recovery (3.2 kPa)

Lab No.	Lab Name	Results, x 1	2	3	Average	s	d	h	k
1		0.0	0.0	0.0	-0.04384	0.00237	0.77527	0.57	0.01
2		-0.1	0.0	0.0	-0.02097	0.04729	0.79815	0.59	0.14
3		0.3	0.3	0.3	0.31290	0.00975	1.13201	0.84	0.03
4		0.1	0.1	0.2	0.14423	0.01012	0.96335	0.71	0.03
5		0.0	-0.9	-0.8	-0.53633	0.49684	0.28278	0.21	1.49
6		-3.8	-3.7	-3.4	-3.60337	0.20005	-2.78425	-2.06	0.60
7		0.3	0.3	0.3	0.27333	0.02517	1.09245	0.81	0.08
8		0.3	0.3	0.3	0.28333	0.02082	1.10245	0.82	0.06
9		-0.9	-0.8	0.9	-0.27023	1.01528	0.54888	0.41	3.04
10		0.0	0.1	0.1	0.06274	0.03871	0.88185	0.65	0.12
11		-3.6	-3.7	-3.5	-3.58740	0.09755	-2.76829	-2.05	0.29
12		-0.8	-0.9	-0.9	-0.85617	0.01993	-0.03705	-0.03	0.06
13		0.0	0.0	0.0	-0.01247	0.01068	0.80664	0.60	0.03
14		-1.0	-1.0	-1.0	-0.98533	0.01705	-0.16622	-0.12	0.05
15		-1.0	-1.1	-1.1	-1.04173	0.07981	-0.22262	-0.16	0.24
16		-0.9	-0.9	-0.9	-0.87737	0.00768	-0.05825	-0.04	0.02
17		-1.1	-1.1	-1.0	-1.05987	0.01712	-0.24075	-0.18	0.05
18		-0.8	-0.8	-0.8	-0.80630	0.02126	0.01281	0.01	0.06
19		-7.4	-7.4	-7.3					
20		-4.6	-4.6	-4.5	-4.56860	0.04088	-3.74949	-2.77	0.12
21		-0.7	-0.8	0.2	-0.47110	0.56252	0.34801	0.26	1.69
22		0.1	0.1	0.0	0.06841	0.02323	0.88752	0.66	0.07
23		0.2	-1.1		-0.42435	0.89046	0.39476	0.29	2.67
24									
25									
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28									

Average of Cell Averages	X-bar	-0.819	
Standard Deviation of Cell Averages	$s_{X\text{-}bar}$	1.351	
Repeatability Standard Deviation	s_r	0.33383	1.378
Reproducibility Standard Deviation	s_R	1.378	

Shaded cells were removed after outlier analysis

Binder AO

PG 64-22

Jnr,Diff

Lab No.	Lab Name	Results, x 1	2	3	Average	s	d	h	k
1		0.058	0.055	0.064	0.05903	0.00425	-0.00614	-0.46	0.22
2		0.056	0.076	0.077	0.06926	0.01184	0.00409	0.31	0.61
3		0.038	0.052	0.047	0.04533	0.00699	-0.01984	-1.48	0.36
4		0.105	0.095	0.086	0.09544	0.00925	0.03027	2.26	0.48
5		0.035	0.065	0.061	0.05383	0.01617	-0.01134	-0.85	0.84
6		0.062	0.066	0.068	0.06558	0.00327	0.00041	0.03	0.17
7		0.024	0.051	0.031	0.03537	0.01369	-0.02980	-2.23	0.71
8		0.123	0.057	0.052	0.07740	0.03992	0.01223	0.91	2.07
9		0.059	0.068	0.064	0.06357	0.00462	-0.00160	-0.12	0.24
10		0.077	0.073	0.075	0.07471	0.00175	0.00954	0.71	0.09
11		0.083	0.036	0.081	0.06664	0.02680	0.00147	0.11	1.39
12		0.071	0.057	0.060	0.06272	0.00697	-0.00245	-0.18	0.36
13		0.127	0.001	0.055	0.06090	0.06334	-0.00427	-0.32	3.28
14		0.057	0.062	0.060	0.05970	0.00224	-0.00547	-0.41	0.12
15		0.071	0.062	0.058	0.06366	0.00667	-0.00150	-0.11	0.35
16		0.075	0.069	0.068	0.07071	0.00412	0.00554	0.41	0.21
17		0.048	0.048	0.055	0.05010	0.00416	-0.01507	-1.13	0.22
18		0.079	0.068	0.082	0.07613	0.00713	0.01096	0.82	0.37
19		0.048	0.057	0.059	0.05434	0.00574	-0.01083	-0.81	0.30
20		0.080	0.080	0.060	0.07341	0.01183	0.00824	0.62	0.61
21		0.066	0.065	0.065	0.06517	0.00031	0.00000	0.00	0.02
22		0.073	0.122	0.079	0.09139	0.02685	0.02622	1.96	1.39
23		0.079	0.050		0.06452	0.01995	-0.00065	-0.05	1.03
24									
25									
26									
27									
28									

Average of Cell Averages	X-bar	0.065	
Standard Deviation of Cell Averages	$s_{X\text{-}bar}$	0.013	
Repeatability Standard Deviation	s_r	0.01931	0.021
Reproducibility Standard Deviation	s_R	0.021	

Shaded cells were removed after outlier analysis

Binder AR

PG 64-22

Jnr (0.1 kPa)

Lab No.	Lab Name	Results, x 1	2	3	Average	s	d	h	k
1		2.121	2.112	2.100	2.11100	0.01054	0.10726	0.70	0.10
2		2.116	2.086	2.206	2.13600	0.06245	0.13226	0.86	0.62
3		1.928	1.941	1.906	1.92500	0.01769	-0.07874	-0.51	0.18
4		2.053	2.014	2.021	2.02933	0.02079	0.02559	0.17	0.21
5		1.604	1.846	1.712	1.72033	0.12108	-0.28341	-1.84	1.20
6		2.173	1.784	1.743	1.90000	0.23745	-0.10374	-0.67	2.35
7		1.758	2.029	2.116	1.96767	0.18671	-0.03607	-0.23	1.85
8		2.113	2.017	2.052	2.06067	0.04858	0.05693	0.37	0.48
9		1.775	1.811	1.743	1.77603	0.03373	-0.22771	-1.48	0.33
10		2.283	2.065	2.060	2.13600	0.12733	0.13226	0.86	1.26
11		1.903	1.855	2.010	1.92270	0.07960	-0.08104	-0.53	0.79
12		1.915	1.906	1.840	1.88673	0.04109	-0.11701	-0.76	0.41
13		2.155	2.337	2.415	2.30233	0.13342	0.29859	1.94	1.32
14		2.140	2.178	2.160	2.15893	0.01906	0.15519	1.01	0.19
15		1.902	1.879	1.938	1.90593	0.02968	-0.09781	-0.64	0.29
16		1.992	2.005	1.977	1.99143	0.01416	-0.01231	-0.08	0.14
17		2.010	2.099	2.130	2.07980	0.06214	0.07606	0.49	0.62
18		2.063	2.084	2.084	2.07683	0.01233	0.07309	0.48	0.12
19		2.076	2.159	2.273	2.16913	0.09896	0.16539	1.08	0.98
20		2.361	2.050	2.011	2.14057	0.19169	0.13683	0.89	1.90
21		2.134	2.170	2.090	2.13130	0.03995	0.12756	0.83	0.40
22		1.736	1.760	1.756	1.75067	0.01286	-0.25307	-1.65	0.13
23		1.918	1.697		1.80760	0.15613	-0.19614	-1.28	1.55
24									
25									
26									
27									
28									

Average of Cell Averages	X-bar	2.004	
Standard Deviation of Cell Averages	$s_{X\text{-}bar}$	0.154	
Repeatability Standard Deviation	s_r	0.10094	0.174
Reproducibility Standard Deviation	s_R	0.174	

Shaded cells were removed after outlier analysis

Binder AR

PG 64-22

Jnr (3.2 kPa)

Lab No.	Lab Name	Results, x 1	2	3	Average	s	d	h	k
1		2.292	2.279	2.268	2.27967	0.01201	0.12040	0.73	0.12
2		2.290	2.318	2.377	2.32833	0.04441	0.16907	1.03	0.45
3		2.057	2.070	2.042	2.05633	0.01401	-0.10293	-0.63	0.14
4		2.266	2.228	2.263	2.25233	0.02113	0.09307	0.57	0.21
5		1.762	1.999	1.859	1.87307	0.11886	-0.28620	-1.74	1.21
6		2.361	1.916	1.886	2.05403	0.26610	-0.10523	-0.64	2.70
7		1.854	2.129	2.210	2.06433	0.18660	-0.09493	-0.58	1.89
8		2.291	2.149	2.200	2.21333	0.07193	0.05407	0.33	0.73
9		1.915	1.957	1.892	1.92153	0.03319	-0.23773	-1.45	0.34
10		2.491	2.260	2.276	2.34233	0.12900	0.18307	1.11	1.31
11		2.065	2.078	2.236	2.12633	0.09495	-0.03293	-0.20	0.96
12		2.053	2.046	1.996	2.03160	0.03125	-0.12767	-0.78	0.32
13		2.465	2.454	2.447	2.45533	0.00907	0.29607	1.80	0.09
14		2.311	2.345	2.309	2.32153	0.01991	0.16227	0.99	0.20
15		2.037	2.015	2.080	2.04380	0.03303	-0.11547	-0.70	0.34
16		2.152	2.156	2.128	2.14533	0.01499	-0.01393	-0.08	0.15
17		2.143	2.242	2.279	2.22133	0.07044	0.06207	0.38	0.71
18		2.244	2.248	2.243	2.24520	0.00263	0.08593	0.52	0.03
19		2.221	2.315	2.424	2.32000	0.10174	0.16073	0.98	1.03
20		2.521	2.182	2.156	2.28643	0.20383	0.12717	0.77	2.07
21		2.264	2.295	2.236	2.26497	0.02957	0.10570	0.64	0.30
22		1.897	1.935	1.977	1.93633	0.04002	-0.22293	-1.36	0.41
23		1.938	1.821		1.87960	0.08259	-0.27967	-1.70	0.84
24									
25									
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28									

Average of Cell Averages	X-bar	2.159	
Standard Deviation of Cell Averages	$s_{X\text{-}bar}$	0.164	
Repeatability Standard Deviation	s_r	0.09855	0.183
Reproducibility Standard Deviation	s_R	0.183	

Shaded cells were removed after outlier analysis

Binder AR

PG 64-22

Recovery (0.1 kPa)

Lab No.	Lab Name	Results, x 1	2	3	Average	s	d	h	k
1		3.9	3.8	3.8	3.827	0.051	0.390	0.26	0.03
2		3.7	5.6	2.9	4.066	1.360	0.629	0.42	0.91
3		4.3	4.6	4.8	4.560	0.220	1.123	0.74	0.15
4		3.8	4.1	5.1	4.326	0.665	0.890	0.59	0.45
5		6.0	4.3	4.9	5.049	0.879	1.612	1.07	0.59
6		1.4	1.7	2.2	1.786	0.397	-1.651	-1.09	0.27
7		5.2	3.6	3.5	4.093	0.953	0.657	0.43	0.64
8		5.1	5.1	4.7	4.993	0.237	1.557	1.03	0.16
9		4.4	4.3	4.7	4.474	0.205	1.038	0.69	0.14
10		3.4	4.3	4.0	3.885	0.471	0.448	0.30	0.32
11		2.1	4.2	3.8	3.386	1.135	-0.051	-0.03	0.76
12		3.2	3.3	4.1	3.543	0.527	0.106	0.07	0.35
13		8.0	1.3	-2.0	2.442	5.089	-0.995	-0.66	3.42
14		3.8	3.2	3.0	3.312	0.432	-0.125	-0.08	0.29
15		3.4	3.5	3.6	3.508	0.088	0.071	0.05	0.06
16		3.6	3.5	3.4	3.456	0.103	0.020	0.01	0.07
17		3.2	3.1	3.1	3.122	0.078	-0.314	-0.21	0.05
18		4.1	3.6	3.5	3.702	0.312	0.265	0.18	0.21
19		-3.4	-3.5	-3.8					
20		-1.8	-2.0	-1.2	-1.675	0.398	-5.111	-3.38	0.27
21		2.6	2.1	3.4	2.675	0.661	-0.762	-0.50	0.44
22		4.4	5.2	6.9	5.528	1.297	2.091	1.38	0.87
23		-1.1	4.2		1.548	3.776	-1.888	-1.25	2.54
24									
25									
26									
27									
28									

Average of Cell Averages	X-bar	3.437	
Standard Deviation of Cell Averages	$s_{X\text{-}bar}$	1.510	
Repeatability Standard Deviation	s_r	1.48950	1.939
Reproducibility Standard Deviation	s_R	1.939	

Shaded cells were removed after outlier analysis

Binder AR

PG 64-22

Recovery (3.2 kPa)

Lab No.	Lab Name	Results, x 1	2	3	Average	s	d	h	k
1		1.4	1.3	1.3	1.33567	0.02730	0.61476	0.47	0.20
2		1.3	1.3	1.2	1.30100	0.05311	0.58009	0.45	0.39
3		1.7	1.7	1.8	1.74667	0.03453	1.02576	0.79	0.25
4		1.4	1.4	1.4	1.42467	0.01419	0.70376	0.54	0.10
5		1.7	1.2	1.4	1.40263	0.26793	0.68173	0.53	1.98
6		-2.0	-1.3	-1.4	-1.56900	0.37705	-2.28991	-1.77	2.78
7		2.0	1.5	1.5	1.65000	0.26889	0.92909	0.72	1.98
8		1.4	1.4	1.3	1.37667	0.05508	0.65576	0.51	0.41
9		1.3	1.2	1.2	1.23617	0.02746	0.51526	0.40	0.20
10		1.2	1.4	1.4	1.34333	0.10637	0.62243	0.48	0.79
11		-1.8	-1.8	-1.9	-1.83847	0.07356	-2.55937	-1.97	0.54
12		0.9	0.9	1.0	0.93493	0.05053	0.21403	0.16	0.37
13		1.1	1.2	1.2	1.16433	0.02654	0.44343	0.34	0.20
14		0.7	0.7	0.7	0.69507	0.01240	-0.02584	-0.02	0.09
15		0.8	0.8	0.7	0.77707	0.03095	0.05616	0.04	0.23
16		0.9	0.9	0.9	0.92330	0.00433	0.20239	0.16	0.03
17		0.8	0.7	0.7	0.70267	0.05714	-0.01824	-0.01	0.42
18		0.8	0.7	0.7	0.75343	0.03928	0.03253	0.03	0.29
19		-6.1	-6.2	-6.3					
20		-3.5	-3.4	-3.3	-3.39703	0.08560	-4.11794	-3.17	0.63
21		0.7	0.6	0.7	0.68440	0.05794	-0.03651	-0.03	0.43
22		1.8	1.8	1.8	1.76900	0.01970	1.04809	0.81	0.15
23		1.6	1.3		1.44345	0.26806	0.72254	0.56	1.98
24									
25									
26									
27									
28									

Average of Cell Averages	X-bar	0.721	
Standard Deviation of Cell Averages	$s_{X\text{-}bar}$	1.297	
Repeatability Standard Deviation	s_r	0.13549	1.302
Reproducibility Standard Deviation	s_R	1.302	

Shaded cells were removed after outlier analysis

Binder AR

PG 64-22

Jnr, Diff

Lab No.	Lab Name	Results, x 1	2	3	Average	s	d	h	k
1		0.081	0.079	0.080	0.08003	0.00063	0.00261	0.16	0.03
2		0.082	0.111	0.078	0.09039	0.01808	0.01297	0.79	0.97
3		0.067	0.067	0.072	0.06830	0.00288	-0.00911	-0.55	0.15
4		0.104	0.106	0.120	0.11000	0.00872	0.03258	1.98	0.47
5		0.099	0.083	0.086	0.08915	0.00838	0.01174	0.71	0.45
6		0.086	0.074	0.082	0.08070	0.00611	0.00328	0.20	0.33
7		0.055	0.049	0.043	0.04893	0.00606	-0.02848	-1.73	0.32
8		0.078	0.061	0.067	0.06880	0.00838	-0.00862	-0.52	0.45
9		0.079	0.081	0.085	0.08197	0.00306	0.00456	0.28	0.16
10		0.083	0.086	0.095	0.08815	0.00593	0.01073	0.65	0.32
11		0.085	0.120	0.112	0.10591	0.01848	0.02850	1.73	0.99
12		0.072	0.073	0.085	0.07688	0.00696	-0.00053	-0.03	0.37
13		0.144	0.050	0.013	0.06890	0.06741	-0.00852	-0.52	3.62
14		0.080	0.077	0.069	0.07534	0.00555	-0.00207	-0.13	0.30
15		0.071	0.072	0.073	0.07233	0.00113	-0.00509	-0.31	0.06
16		0.080	0.075	0.076	0.07728	0.00263	-0.00013	-0.01	0.14
17		0.066	0.068	0.070	0.06800	0.00201	-0.00942	-0.57	0.11
18		0.088	0.079	0.077	0.08109	0.00606	0.00368	0.22	0.33
19		0.070	0.072	0.067	0.06960	0.00298	-0.00782	-0.47	0.16
20		0.068	0.065	0.072	0.06818	0.00355	-0.00924	-0.56	0.19
21		0.061	0.058	0.070	0.06280	0.00627	-0.01462	-0.89	0.34
22		0.093	0.100	0.125	0.10607	0.01710	0.02866	1.74	0.92
23		0.010	0.073		0.04175	0.04423	-0.03567	-2.17	2.37
24									
25									
26									
27									
28									

Average of Cell Averages	X-bar	0.077	
Standard Deviation of Cell Averages	$s_{X\text{-}bar}$	0.016	
Repeatability Standard Deviation	s_r	0.01864	0.022
Reproducibility Standard Deviation	s_R	0.022	

Shaded cells were removed after outlier analysis

Binder BO

PG 76-22

Jnr (0.1 kPa)

Lab No.	Lab Name	Results, x 1	2	3	Average	s	d	h	k
1		0.306	0.312	0.306	0.30817	0.00315	0.03049	1.13	0.25
2		0.272	0.290	0.287	0.28327	0.00959	0.00559	0.21	0.77
3		0.251	0.269	0.283	0.26777	0.01604	-0.00991	-0.37	1.29
4		0.283	0.281	0.271	0.27810	0.00645	0.00042	0.02	0.52
5		0.291	0.279	0.279	0.28317	0.00696	0.00549	0.20	0.56
6		0.257	0.245	0.244	0.24853	0.00707	-0.02915	-1.08	0.57
7		0.287	0.324	0.300	0.30367	0.01877	0.02599	0.97	1.51
8		0.335	0.356	0.350	0.34700	0.01082	0.06932	2.58	0.87
9		0.306	0.270	0.273	0.28287	0.01972	0.00519	0.19	1.59
10		0.306	0.301	0.285	0.29737	0.01103	0.01969	0.73	0.89
11		0.298	0.292	0.292	0.29390	0.00312	0.01622	0.60	0.25
12		0.237	0.268	0.247	0.25037	0.01566	-0.02731	-1.02	1.26
13		0.296	0.296	0.290	0.29403	0.00335	0.01635	0.61	0.27
14		0.273	0.261	0.258	0.26410	0.00767	-0.01358	-0.51	0.62
15		0.215	0.258	0.268	0.24707	0.02845	-0.03061	-1.14	2.29
16		0.234	0.270	0.283	0.26240	0.02539	-0.01528	-0.57	2.05
17		0.301	0.302	0.288	0.29703	0.00751	0.01935	0.72	0.61
18		0.267	0.274	0.266	0.26910	0.00401	-0.00858	-0.32	0.32
19		0.275	0.270	0.280	0.27493	0.00495	-0.00275	-0.10	0.40
20		0.264	0.272	0.274	0.26993	0.00503	-0.00775	-0.29	0.41
21		0.275	0.284	0.282	0.28050	0.00493	0.00282	0.10	0.40
22		0.273	0.275	0.279	0.27567	0.00295	-0.00201	-0.07	0.24
23		0.200		0.216	0.20770	0.01117	-0.06998	-2.60	0.90
24									
25									
26									
27									
28									

Average of Cell Averages	X-bar	0.278	
Standard Deviation of Cell Averages	$s_{X\text{-}bar}$	0.027	
Repeatability Standard Deviation	s_r	0.01240	0.029
Reproducibility Standard Deviation	s_R	0.029	

Shaded cells were removed after outlier analysis

Binder BO

PG 76-22

Jnr (3.2 kPa)

Lab No.	Lab Name	Results, x 1	2	3	Average	s	d	h	k
1		0.349	0.356	0.350	0.35173	0.00399	0.04277	1.19	0.26
2		0.316	0.338	0.327	0.32673	0.01090	0.01777	0.50	0.70
3		0.279	0.301	0.317	0.29907	0.01909	-0.00990	-0.28	1.23
4		0.325	0.324	0.309	0.31943	0.00889	0.01047	0.29	0.57
5		0.331	0.320	0.316	0.32237	0.00800	0.01340	0.37	0.51
6		0.261	0.238	0.236	0.24473	0.01369	-0.06423	-1.79	0.88
7		0.320	0.359	0.331	0.33667	0.02011	0.02770	0.77	1.29
8		0.374	0.406	0.397	0.39233	0.01650	0.08337	2.33	1.06
9		0.352	0.306	0.311	0.32287	0.02515	0.01390	0.39	1.62
10		0.356	0.348	0.332	0.34510	0.01254	0.03613	1.01	0.81
11		0.315	0.315	0.316	0.31523	0.00093	0.00627	0.17	0.06
12		0.261	0.296	0.274	0.27697	0.01796	-0.03200	-0.89	1.15
13		0.340	0.331	0.315	0.32870	0.01297	0.01973	0.55	0.83
14		0.295	0.279	0.275	0.28283	0.01032	-0.02613	-0.73	0.66
15		0.236	0.289	0.301	0.27560	0.03455	-0.03337	-0.93	2.22
16		0.260	0.302	0.316	0.29253	0.02911	-0.01643	-0.46	1.87
17		0.335	0.339	0.316	0.32987	0.01244	0.02090	0.58	0.80
18		0.302	0.309	0.299	0.30320	0.00537	-0.00577	-0.16	0.34
19		0.292	0.289	0.299	0.29340	0.00492	-0.01557	-0.43	0.32
20		0.283	0.294	0.295	0.29093	0.00654	-0.01803	-0.50	0.42
21		0.313	0.323	0.322	0.31940	0.00563	0.01043	0.29	0.36
22		0.308	0.321	0.317	0.31520	0.00626	0.00623	0.17	0.40
23		0.209		0.234	0.22135	0.01789	-0.08762	-2.44	1.15
24									
25									
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27									
28									

Average of Cell Averages	X-bar	0.309	
Standard Deviation of Cell Averages	$s_{X\text{-}bar}$	0.036	
Repeatability Standard Deviation	s_r	0.01557	0.038
Reproducibility Standard Deviation	s_R	0.038	

Shaded cells were removed after outlier analysis

Binder BO

PG 76-22

Recovery (0.1 kPa)

Lab No.	Lab Name	Results, x 1	2	3	Average	s	d	h	k
1		72.4	72.4	72.5	72.437	0.055	-0.077	-0.10	0.13
2		73.1	72.7	72.2	72.650	0.405	0.137	0.17	0.94
3		73.4	73.2	72.8	73.107	0.330	0.593	0.76	0.77
4		72.4	72.4	72.7	72.453	0.170	-0.060	-0.08	0.40
5		72.2	72.2	72.1	72.169	0.088	-0.344	-0.44	0.20
6		72.1	71.9	71.7	71.911	0.213	-0.602	-0.77	0.49
7		72.0	71.2	71.8	71.663	0.417	-0.850	-1.08	0.97
8		66.3	65.7	65.9					
9		73.7	72.9	73.6	73.391	0.387	0.877	1.12	0.90
10		72.4	72.8	73.1	72.763	0.330	0.250	0.32	0.77
11		70.4	70.8	71.0	70.725	0.292	-1.788	-2.28	0.68
12		73.6	73.2	72.6	73.124	0.524	0.611	0.78	1.22
13		73.1	72.3	72.2	72.507	0.517	-0.007	-0.01	1.20
14		73.3	73.7	73.7	73.594	0.249	1.081	1.38	0.58
15		74.3	73.3	73.1	73.575	0.657	1.062	1.35	1.53
16		73.5	72.8	72.8	73.042	0.402	0.528	0.67	0.94
17		72.3	72.2	73.1	72.534	0.518	0.021	0.03	1.21
18		73.9	73.3	73.6	73.579	0.277	1.065	1.36	0.64
19		71.3	70.9	71.0	71.074	0.164	-1.439	-1.83	0.38
20		72.0	71.4	71.5	71.606	0.309	-0.907	-1.16	0.72
21		72.3	72.2	71.9	72.144	0.216	-0.370	-0.47	0.50
22		72.5	72.3	72.2	72.320	0.114	-0.193	-0.25	0.26
23		72.1		73.8	72.925	1.209	0.412	0.52	2.81
24									
25									
26									
27									
28									

Average of Cell Averages	X-bar	72.513	
Standard Deviation of Cell Averages	$s_{X\text{-}bar}$	0.785	
Repeatability Standard Deviation	s_r	0.42972	0.860
Reproducibility Standard Deviation	s_R	0.860	

Shaded cells were removed after outlier analysis

Binder BO

PG 76-22

Recovery (3.2 kPa)

Lab No.	Lab Name	Results, x 1	2	3	Average	s	d	h	k
1		69.6	69.4	69.5	69.49333	0.07024	-0.71686	-0.68	0.15
2		69.8	69.3	69.5	69.51000	0.26627	-0.70020	-0.67	0.58
3		70.8	70.5	69.9	70.41667	0.46069	0.20647	0.20	1.01
4		69.7	69.7	70.0	69.82333	0.14434	-0.38686	-0.37	0.32
5		69.2	69.0	69.2	69.14040	0.09748	-1.06980	-1.02	0.21
6		72.1	72.7	72.7	72.49543	0.38433	2.28524	2.17	0.84
7		69.3	68.1	68.5	68.64333	0.62148	-1.56686	-1.49	1.36
8		63.7	62.2	62.5					
9		70.5	70.2	70.7	70.46520	0.26682	0.25500	0.24	0.58
10		69.3	69.7	70.1	69.68000	0.40583	-0.53020	-0.50	0.89
11		69.1	69.0	68.9	69.02307	0.08548	-1.18713	-1.13	0.19
12		71.5	71.0	70.2	70.90833	0.65152	0.69814	0.66	1.43
13		69.9	69.8	70.5	70.08000	0.35157	-0.13020	-0.12	0.77
14		71.7	72.5	72.5	72.23723	0.42810	2.02704	1.93	0.94
15		72.2	70.7	70.4	71.13810	0.96660	0.92790	0.88	2.12
16		71.2	70.4	70.3	70.63097	0.49144	0.42077	0.40	1.08
17		69.8	69.5	71.2	70.14270	0.89821	-0.06750	-0.06	1.97
18		71.4	70.6	71.1	71.03350	0.39367	0.82330	0.78	0.86
19		69.7	69.1	69.3	69.37063	0.32566	-0.83956	-0.80	0.71
20		70.5	69.6	69.9	70.01333	0.45107	-0.19686	-0.19	0.99
21		69.2	69.1	68.7	68.97807	0.27142	-1.23213	-1.17	0.59
22		70.0	69.4	69.5	69.61667	0.30665	-0.59353	-0.56	0.67
23		71.5		72.0	71.78400	0.37335	1.57380	1.50	0.82
24									
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28									

Average of Cell Averages	X-bar	70.210	
Standard Deviation of Cell Averages	$s_{X\text{-}bar}$	1.051	
Repeatability Standard Deviation	s_r	0.45632	1.115
Reproducibility Standard Deviation	s_R	1.115	

Shaded cells were removed after outlier analysis

Binder BO

PG 76-22

Jnr, Diff

Lab No.	Lab Name	Results, x 1	2	3	Average	s	d	h	k
1		0.139	0.143	0.143	0.14127	0.00240	0.02613	0.93	0.18
2		0.160	0.163	0.138	0.15343	0.01393	0.03830	1.36	1.06
3		0.113	0.117	0.121	0.11673	0.00420	0.00160	0.06	0.32
4		0.151	0.152	0.142	0.14863	0.00544	0.03350	1.19	0.41
5		0.137	0.147	0.132	0.13853	0.00754	0.02340	0.83	0.57
6		0.015	0.028	0.035					
7		0.130	0.110	0.103	0.11423	0.01401	-0.00090	-0.03	1.07
8		0.105	0.125	0.117	0.11573	0.00981	0.00060	0.02	0.75
9		0.151	0.133	0.139	0.14105	0.00941	0.02592	0.92	0.72
10		0.140	0.134	0.140	0.13837	0.00352	0.02323	0.83	0.27
11		0.058	0.077	0.083	0.07264	0.01309	-0.04249	-1.51	0.99
12		0.100	0.107	0.111	0.10601	0.00523	-0.00912	-0.32	0.40
13		0.152	0.117	0.084	0.11762	0.03368	0.00248	0.09	2.56
14		0.080	0.067	0.066	0.07092	0.00794	-0.04422	-1.57	0.60
15		0.101	0.120	0.123	0.11455	0.01223	-0.00058	-0.02	0.93
16		0.111	0.115	0.117	0.11463	0.00320	-0.00050	-0.02	0.24
17		0.114	0.122	0.095	0.11027	0.01405	-0.00487	-0.17	1.07
18		0.129	0.129	0.121	0.12669	0.00468	0.01156	0.41	0.36
19		0.061	0.072	0.068	0.06715	0.00557	-0.04799	-1.71	0.42
20		0.073	0.082	0.078	0.07755	0.00468	-0.03758	-1.34	0.36
21		0.138	0.136	0.142	0.13863	0.00278	0.02350	0.84	0.21
22		0.128	0.167	0.135	0.14333	0.02103	0.02820	1.00	1.60
23		0.045		0.085	0.06494	0.02885	-0.05019	-1.78	2.19
24									
25									
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27									
28									

Average of Cell Averages	X-bar	0.115	
Standard Deviation of Cell Averages	$s_{X\text{-}bar}$	0.028	
Repeatability Standard Deviation	s_r	0.01316	0.030
Reproducibility Standard Deviation	s_R	0.030	

Shaded cells were removed after outlier analysis

Binder BR

PG 76-22

Jnr (0.1 kPa)

Lab No.	Lab Name	Results, x 1	2	3	Average	s	d	h	k
1		0.119	0.133	0.122	0.12437	0.00726	-0.00470	-0.36	1.10
2		0.124	0.128	0.134	0.12863	0.00502	-0.00043	-0.03	0.76
3		0.124	0.124	0.129	0.12570	0.00286	-0.00337	-0.26	0.43
4		0.122	0.125	0.122	0.12317	0.00159	-0.00590	-0.45	0.24
5		0.136	0.149	0.131	0.13873	0.00916	0.00967	0.74	1.38
6		0.145	0.127	0.115	0.12893	0.01525	-0.00013	-0.01	2.30
7		0.141	0.142	0.143	0.14200	0.00100	0.01293	1.00	0.15
8		0.166	0.174	0.173	0.17100	0.00436	0.04193	3.23	0.66
9		0.121	0.124	0.115	0.11983	0.00480	-0.00923	-0.71	0.72
10		0.136	0.135	0.129	0.13343	0.00395	0.00437	0.34	0.60
11		0.155	0.136	0.112	0.13437	0.02131	0.00530	0.41	3.22
12		0.124	0.122	0.127	0.12450	0.00256	-0.00457	-0.35	0.39
13		0.137	0.134	0.129	0.13333	0.00381	0.00427	0.33	0.58
14		0.137	0.138	0.133	0.13577	0.00268	0.00670	0.52	0.40
15		0.105	0.105	0.104	0.10463	0.00047	-0.02443	-1.88	0.07
16		0.121	0.125	0.126	0.12377	0.00294	-0.00530	-0.41	0.44
17		0.128	0.127	0.126	0.12723	0.00110	-0.00183	-0.14	0.17
18		0.128	0.130	0.129	0.12917	0.00110	0.00010	0.01	0.17
19		0.119	0.129	0.123	0.12387	0.00497	-0.00520	-0.40	0.75
20		0.124	0.131	0.129	0.12797	0.00357	-0.00110	-0.08	0.54
21		0.140	0.144	0.146	0.14313	0.00303	0.01407	1.08	0.46
22		0.113	0.109	0.111	0.11093	0.00191	-0.01813	-1.40	0.29
23		0.114	0.115	0.113	0.11403	0.00097	-0.01503	-1.16	0.15
24									
25									
26									
27									
28									

Average of Cell Averages	X-bar	0.129	
Standard Deviation of Cell Averages	$s_{X\text{-}bar}$	0.013	
Repeatability Standard Deviation	s_r	0.00662	0.014
Reproducibility Standard Deviation	s_R	0.014	

Shaded cells were removed after outlier analysis

Binder BR

PG 76-22

Jnr (3.2 kPa)

Lab No.	Lab Name	Results, x 1	2	3	Average	s	d	h	k
1		0.128	0.144	0.131	0.13417	0.00832	-0.00286	-0.19	1.53
2		0.132	0.137	0.143	0.13733	0.00565	0.00031	0.02	1.04
3		0.132	0.131	0.137	0.13333	0.00335	-0.00369	-0.25	0.62
4		0.134	0.138	0.135	0.13543	0.00199	-0.00159	-0.11	0.37
5		0.145	0.162	0.140	0.14923	0.01142	0.01221	0.82	2.10
6		0.125	0.113	0.100	0.11297	0.01260	-0.02406	-1.61	2.32
7		0.148	0.146	0.154	0.14933	0.00416	0.01231	0.83	0.77
8		0.177	0.187	0.184	0.18267	0.00513	0.04564	3.06	0.95
9		0.133	0.132	0.134	0.13260	0.00100	-0.00442	-0.30	0.18
10		0.150	0.146	0.144	0.14660	0.00302	0.00958	0.64	0.56
11		0.148	0.134	0.130	0.13763	0.00938	0.00061	0.04	1.73
12		0.132	0.130	0.136	0.13240	0.00321	-0.00462	-0.31	0.59
13		0.151	0.147	0.140	0.14617	0.00550	0.00914	0.61	1.01
14		0.143	0.145	0.139	0.14223	0.00283	0.00521	0.35	0.52
15		0.111	0.112	0.110	0.11100	0.00078	-0.02602	-1.75	0.14
16		0.129	0.133	0.136	0.13257	0.00349	-0.00446	-0.30	0.64
17		0.138	0.142	0.134	0.13787	0.00431	0.00084	0.06	0.79
18		0.138	0.140	0.138	0.13843	0.00095	0.00141	0.09	0.17
19		0.130	0.132	0.127	0.12970	0.00271	-0.00732	-0.49	0.50
20		0.131	0.138	0.130	0.13273	0.00423	-0.00429	-0.29	0.78
21		0.151	0.157	0.159	0.15567	0.00405	0.01864	1.25	0.75
22		0.125	0.120	0.124	0.12270	0.00267	-0.01432	-0.96	0.49
23		0.119	0.118	0.120	0.11873	0.00121	-0.01829	-1.23	0.22
24									
25									
26									
27									
28									

Average of Cell Averages	X-bar	0.137	
Standard Deviation of Cell Averages	$s_{X\text{-}bar}$	0.015	
Repeatability Standard Deviation	s_r	0.00543	0.016
Reproducibility Standard Deviation	s_R	0.016	

Shaded cells were removed after outlier analysis

Binder BR

PG 76-22

Recovery (0.1 kPa)

Lab No.	Lab Name	Results, x 1	2	3	Average	s	d	h	k
1		77.4	76.7	77.2	77.093	0.322	0.363	0.43	0.39
2		76.6	76.5	76.2	76.403	0.206	-0.327	-0.39	0.25
3		77.4	77.3	77.0	77.223	0.195	0.493	0.59	0.24
4		76.9	76.9	77.0	76.927	0.083	0.196	0.23	0.10
5		76.1	75.9	76.5	76.169	0.303	-0.562	-0.67	0.37
6		74.2	75.7	76.1	75.346	1.013	-1.385	-1.65	1.23
7		75.4	75.1	75.5	75.330	0.192	-1.401	-1.67	0.23
8		70.5	70.7	70.4					
9		77.0	76.4	78.7	77.375	1.191	0.644	0.77	1.44
10		77.4	77.2	77.5	77.377	0.167	0.646	0.77	0.20
11		74.0	76.8	80.6	77.123	3.351	0.393	0.47	4.06
12		77.2	77.3	77.0	77.142	0.145	0.412	0.49	0.18
13		77.5	77.2	77.1	77.257	0.175	0.526	0.63	0.21
14		76.8	76.7	77.0	76.815	0.143	0.084	0.10	0.17
15		77.7	77.7	77.7	77.685	0.034	0.954	1.14	0.04
16		76.9	76.8	76.8	76.825	0.028	0.095	0.11	0.03
17		77.0	76.9	77.3	77.074	0.242	0.343	0.41	0.29
18		77.4	77.3	77.0	77.237	0.201	0.506	0.60	0.24
19		75.9	75.0	75.3	75.418	0.469	-1.312	-1.56	0.57
20		76.4	75.4	75.6	75.838	0.517	-0.892	-1.06	0.63
21		75.3	75.1	74.7	75.032	0.301	-1.699	-2.03	0.36
22		77.6	78.0	78.1	77.883	0.225	1.153	1.37	0.27
23		77.6	77.1	77.8	77.503	0.393	0.773	0.92	0.48
24									
25									
26									
27									
28									

Average of Cell Averages	X-bar	76.731	
Standard Deviation of Cell Averages	$s_{X\text{-}bar}$	0.839	
Repeatability Standard Deviation	s_r	0.82517	1.076
Reproducibility Standard Deviation	s_R	1.076	

Shaded cells were removed after outlier analysis

Binder BR

PG 76-22

Recovery (3.2 kPa)

Lab No.	Lab Name	Results, x 1	2	3	Average	s	d	h	k
1		76.1	75.3	75.8	75.70667	0.41187	0.13784	0.14	0.90
2		75.6	75.3	75.0	75.29000	0.27514	-0.27883	-0.27	0.60
3		76.0	76.1	75.6	75.90333	0.24542	0.33451	0.33	0.53
4		75.6	75.4	75.7	75.56000	0.12530	-0.00883	-0.01	0.27
5		74.7	74.2	75.3	74.71527	0.52715	-0.85356	-0.84	1.15
6		77.1	77.9	78.7	77.90983	0.75886	2.34101	2.30	1.65
7		73.5	73.5	73.4	73.42333	0.06351	-2.14549	-2.10	0.14
8		68.8	68.9	68.4					
9		75.2	75.2	75.6	75.34570	0.19503	-0.22313	-0.22	0.42
10		75.8	76.1	75.7	75.85333	0.19553	0.28451	0.28	0.43
11		74.8	76.8	77.4	76.34917	1.36693	0.78034	0.77	2.98
12		76.1	76.1	75.7	75.95790	0.25582	0.38907	0.38	0.56
13		75.4	75.5	75.5	75.47667	0.04041	-0.09216	-0.09	0.09
14		75.9	75.8	76.1	75.93860	0.14580	0.36977	0.36	0.32
15		76.5	76.4	76.5	76.49980	0.08126	0.93097	0.91	0.18
16		75.5	75.5	75.3	75.44533	0.09615	-0.12349	-0.12	0.21
17		75.6	74.8	76.2	75.53087	0.71625	-0.03796	-0.04	1.56
18		76.0	76.1	75.7	75.93650	0.22842	0.36767	0.36	0.50
19		74.9	74.2	74.4	74.47273	0.37144	-1.09609	-1.07	0.81
20		75.3	74.4	75.8	75.15287	0.71005	-0.41596	-0.41	1.55
21		73.6	73.2	72.8	73.19227	0.37722	-2.37656	-2.33	0.82
22		75.8	76.3	76.0	76.05333	0.22030	0.48451	0.47	0.48
23		76.9	76.8	76.7	76.80067	0.12017	1.23184	1.21	0.26
24									
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Average of Cell Averages	X-bar	75.569	
Standard Deviation of Cell Averages	$s_{X\text{-}bar}$	1.020	
Repeatability Standard Deviation	s_r	0.45928	1.087
Reproducibility Standard Deviation	s_R	1.087	

Shaded cells were removed after outlier analysis

Binder BR

PG 76-22

Jnr, Diff

Lab No.	Lab Name	Results, x 1	2	3	Average	s	d	h	k
1		0.076	0.083	0.078	0.07887	0.00380	0.00561	0.23	0.16
2		0.063	0.072	0.068	0.06754	0.00459	-0.00572	-0.24	0.20
3		0.061	0.058	0.063	0.06073	0.00251	-0.01253	-0.52	0.11
4		0.098	0.102	0.100	0.09984	0.00220	0.02658	1.11	0.09
5		0.070	0.088	0.068	0.07557	0.01124	0.00231	0.10	0.48
6		0.136	0.107	0.127	0.12333	0.01455	0.05007	2.10	0.62
7		0.050	0.030	0.078	0.05247	0.02425	-0.02079	-0.87	1.04
8		0.063	0.067	0.061	0.06373	0.00281	-0.00953	-0.40	0.12
9		0.094	0.063	0.166	0.10776	0.05320	0.03450	1.44	2.28
10		0.092	0.074	0.103	0.08985	0.01462	0.01659	0.69	0.63
11		0.042	0.013	0.161	0.07216	0.07867	-0.00110	-0.05	3.37
12		0.060	0.061	0.068	0.06319	0.00430	-0.01007	-0.42	0.18
13		0.107	0.094	0.087	0.09583	0.01028	0.02257	0.94	0.44
14		0.047	0.048	0.047	0.04743	0.00042	-0.02583	-1.08	0.02
15		0.061	0.064	0.058	0.06084	0.00315	-0.01242	-0.52	0.13
16		0.069	0.069	0.075	0.07106	0.00365	-0.00220	-0.09	0.16
17		0.072	0.118	0.060	0.08317	0.03029	0.00991	0.41	1.30
18		0.073	0.070	0.072	0.07176	0.00180	-0.00150	-0.06	0.08
19		0.032	0.025	0.029	0.02842	0.00351	-0.04484	-1.88	0.15
20		0.054	0.053	0.004	0.03721	0.02840	-0.03605	-1.51	1.22
21		0.081	0.091	0.090	0.08730	0.00582	0.01404	0.59	0.25
22		0.107	0.099	0.112	0.10576	0.00621	0.03250	1.36	0.27
23		0.042	0.022	0.060	0.04117	0.01906	-0.03209	-1.34	0.82
24									
25									
26									
27									
28									

Average of Cell Averages	X-bar	0.073	
Standard Deviation of Cell Averages	$s_{X\text{-}bar}$	0.024	
Repeatability Standard Deviation	s_r	0.02335	0.031
Reproducibility Standard Deviation	s_R	0.031	

Shaded cells were removed after outlier analysis

Binder CO

PG 70-22

Jnr (0.1 kPa)

Lab No.	Lab Name	Results, x 1	2	3	Average	s	d	h	k
1		0.860	0.881	0.899	0.87977	0.01957	0.09917	1.49	0.55
2		0.806	0.784	0.802	0.79727	0.01132	0.01667	0.25	0.32
3		0.819	0.808	0.782	0.80290	0.01922	0.02230	0.33	0.54
4		0.783	0.739	0.760	0.76060	0.02182	-0.02000	-0.30	0.61
5		0.824	0.730	0.762	0.77173	0.04778	-0.00886	-0.13	1.33
6		0.663	0.600	0.626	0.62943	0.03165	-0.15116	-2.27	0.88
7		0.831	0.810	0.879	0.84000	0.03537	0.05940	0.89	0.99
8		0.905	0.879	0.874	0.88600	0.01664	0.10540	1.58	0.46
9		0.814	0.814	0.661	0.76303	0.08802	-0.01756	-0.26	2.46
10		0.856	0.820	0.819	0.83147	0.02108	0.05087	0.76	0.59
11		0.828	0.872	0.740	0.81343	0.06731	0.03284	0.49	1.88
12		0.738	0.755	0.700	0.73087	0.02825	-0.04973	-0.75	0.79
13		0.818	0.869	0.825	0.83713	0.02746	0.05654	0.85	0.77
14		0.801	0.799	0.766	0.78853	0.01978	0.00794	0.12	0.55
15		0.744	0.686	0.780	0.73683	0.04711	-0.04376	-0.66	1.31
16		0.793	0.731	0.746	0.75667	0.03218	-0.02393	-0.36	0.90
17		0.803	0.857	0.845	0.83510	0.02803	0.05450	0.82	0.78
18		0.781	0.771	0.770	0.77390	0.00629	-0.00670	-0.10	0.18
19		0.843	0.777	0.780	0.80003	0.03742	0.01944	0.29	1.04
20		0.776	0.831	0.763	0.79037	0.03613	0.00977	0.15	1.01
21		0.784	0.746	0.816	0.78203	0.03512	0.00144	0.02	0.98
22		0.723	0.770	0.746	0.74617	0.02345	-0.03443	-0.52	0.65
23		0.592	0.609		0.60045	0.01195	-0.18015	-2.70	0.33
24									
25									
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27									
28									

Average of Cell Averages	X-bar	0.781	
Standard Deviation of Cell Averages	$s_{X\text{-}bar}$	0.067	
Repeatability Standard Deviation	s_r	0.03584	0.073
Reproducibility Standard Deviation	s_R	0.073	

Shaded cells were removed after outlier analysis

Binder CO

PG 70-22

Jnr (3.2 kPa)

Lab No.	Lab Name	Results, x 1	2	3	Average	s	d	h	k
1		1.201	1.234	1.258	1.23100	0.02862	0.15865	1.52	0.56
2		1.094	1.137	1.122	1.11767	0.02183	0.04531	0.44	0.43
3		1.121	1.116	1.063	1.10000	0.03214	0.02765	0.27	0.63
4		1.107	1.050	1.070	1.07567	0.02892	0.00331	0.03	0.56
5		1.142	0.998	1.037	1.05907	0.07469	-0.01329	-0.13	1.46
6		0.862	0.779	0.806	0.81593	0.04245	-0.25642	-2.46	0.83
7		1.163	1.087	1.185	1.14500	0.05142	0.07265	0.70	1.00
8		1.177	1.181	1.130	1.16267	0.02836	0.09031	0.87	0.55
9		1.130	1.126	1.042	1.09920	0.05000	0.02685	0.26	0.98
10		1.246	1.175	1.163	1.19467	0.04486	0.12231	1.18	0.88
11		1.125	1.195	0.983	1.10087	0.10820	0.02851	0.27	2.11
12		1.053	1.047	0.955	1.01820	0.05518	-0.05415	-0.52	1.08
13		1.117	1.175	1.146	1.14600	0.02900	0.07365	0.71	0.57
14		1.107	1.106	1.052	1.08803	0.03164	0.01568	0.15	0.62
15		1.059	0.924	1.075	1.01900	0.08301	-0.05335	-0.51	1.62
16		1.079	0.991	1.010	1.02683	0.04621	-0.04552	-0.44	0.90
17		1.104	1.189	1.175	1.15613	0.04559	0.08378	0.81	0.89
18		1.095	1.061	1.086	1.08050	0.01759	0.00815	0.08	0.34
19		1.160	1.051	1.057	1.08940	0.06138	0.01705	0.16	1.20
20		1.046	1.132	1.034	1.07047	0.05325	-0.00189	-0.02	1.04
21		1.078	1.009	1.121	1.06923	0.05686	-0.00312	-0.03	1.11
22		0.986	1.056	1.044	1.02867	0.03743	-0.04369	-0.42	0.73
23		0.734	0.806		0.76995	0.05028	-0.30240	-2.91	0.98
24									
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28									

Average of Cell Averages	X-bar	1.072	
Standard Deviation of Cell Averages	$s_{X\text{-}bar}$	0.104	
Repeatability Standard Deviation	s_r	0.05119	0.112
Reproducibility Standard Deviation	s_R	0.112	

Shaded cells were removed after outlier analysis

Binder CO

PG 70-22

Recovery (0.1 kPa)

Lab No.	Lab Name	Results, x 1	2	3	Average	s	d	h	k
1		49.1	49.0	49.2	49.097	0.091	-0.482	-0.29	0.11
2		49.0	52.0	50.3	50.433	1.492	0.855	0.51	1.82
3		50.3	51.0	50.4	50.557	0.421	0.978	0.59	0.51
4		50.3	51.2	50.4	50.623	0.522	1.045	0.63	0.64
5		50.0	49.3	48.9	49.442	0.554	-0.137	-0.08	0.68
6		49.7	50.8	50.0	50.179	0.584	0.600	0.36	0.71
7		51.4	48.9	48.1	49.490	1.729	-0.089	-0.05	2.11
8		45.0	44.9	44.9	44.947	0.070	-4.632	-2.78	0.09
9		50.3	50.1	52.2	50.857	1.163	1.278	0.77	1.42
10		50.3	50.5	49.5	50.127	0.524	0.548	0.33	0.64
11		47.6	47.2	48.6	47.806	0.757	-1.773	-1.07	0.93
12		52.9	51.4	51.1	51.809	0.944	2.231	1.34	1.15
13		49.0	48.1	49.4	48.830	0.675	-0.749	-0.45	0.82
14		50.7	50.5	51.0	50.728	0.249	1.149	0.69	0.30
15		52.5	50.6	50.1	51.092	1.239	1.513	0.91	1.51
16		49.5	50.6	50.1	50.094	0.553	0.516	0.31	0.67
17		49.9	49.3	49.9	49.711	0.324	0.132	0.08	0.40
18		50.8	50.4	51.2	50.821	0.398	1.243	0.75	0.49
19		46.4	46.0	46.4	46.239	0.225	-3.340	-2.01	0.28
20		47.3	46.2	47.5	46.977	0.710	-2.602	-1.56	0.87
21		49.6	49.5	48.7	49.298	0.506	-0.281	-0.17	0.62
22		51.1	49.9	51.0	50.653	0.665	1.075	0.65	0.81
23		49.5	51.5		50.500	1.457	0.921	0.55	1.78
24									
25									
26									
27									
28									

Average of Cell Averages	X-bar	49.579	
Standard Deviation of Cell Averages	$s_{X\text{-}bar}$	1.664	
Repeatability Standard Deviation	s_r	0.81864	1.793
Reproducibility Standard Deviation	s_R	1.793	

Shaded cells were removed after outlier analysis

Binder CO

PG 70-22

Recovery (3.2 kPa)

Lab No.	Lab Name	Results, x 1	2	3	Average	s	d	h	k
1		33.8	33.6	33.8	33.72000	0.12166	-1.48919	-0.75	0.14
2		35.6	35.8	35.5	35.63333	0.12342	0.42414	0.21	0.14
3		35.6	36.3	36.0	35.94000	0.35043	0.73081	0.37	0.39
4		35.5	36.4	35.9	35.95000	0.44136	0.74081	0.37	0.49
5		34.9	35.0	34.4	34.80643	0.32772	-0.40276	-0.20	0.37
6		37.4	38.9	38.2	38.17013	0.78130	2.96094	1.49	0.87
7		36.2	34.4	33.1	34.58333	1.56896	-0.62586	-0.31	1.76
8		32.4	29.5	32.5	31.46000	1.70696	-3.74919	-1.89	1.91
9		35.3	35.1	35.7	35.36990	0.27368	0.16071	0.08	0.31
10		33.8	34.7	34.5	34.35000	0.45640	-0.85919	-0.43	0.51
11		35.9	37.0	32.8	35.21307	2.18167	0.00388	0.00	2.44
12		37.6	36.8	37.4	37.27383	0.45013	2.06464	1.04	0.50
13		34.8	34.6	34.3	34.53667	0.23587	-0.67252	-0.34	0.26
14		36.0	35.5	36.6	36.00970	0.57537	0.80051	0.40	0.64
15		37.1	37.0	35.2	36.43110	1.08516	1.22191	0.61	1.21
16		35.2	36.9	36.4	36.19080	0.87118	0.98161	0.49	0.97
17		35.2	33.9	34.6	34.58737	0.64850	-0.62182	-0.31	0.73
18		35.6	35.7	36.0	35.77127	0.19685	0.56208	0.28	0.22
19		30.3	30.8	31.2	30.75393	0.46610	-4.45526	-2.24	0.52
20		33.0	31.0	32.9	32.30110	1.11147	-2.90809	-1.46	1.24
21		34.6	35.3	33.5	34.46610	0.90880	-0.74309	-0.37	1.02
22		37.5	36.2	36.1	36.62333	0.76950	1.41414	0.71	0.86
23		40.4	39.0		39.67000	1.01823	4.46081	2.24	1.14
24									
25									
26									
27									
28									

Average of Cell Averages	X-bar	35.209	
Standard Deviation of Cell Averages	$s_{X\text{-}bar}$	1.987	
Repeatability Standard Deviation	s_r	0.89385	2.117
Reproducibility Standard Deviation	s_R	2.117	

Shaded cells were removed after outlier analysis

Binder CO

PG 70-22

Jnr, Diff

Lab No.	Lab Name	Results, x 1	2	3	Average	s	d	h	k
1		0.398	0.401	0.400	0.39937	0.00164	0.03570	0.77	0.05
2		0.358	0.449	0.399	0.40230	0.04552	0.03863	0.84	1.42
3		0.368	0.382	0.360	0.36970	0.01100	0.00603	0.13	0.34
4		0.414	0.421	0.409	0.41457	0.00576	0.05090	1.10	0.18
5		0.387	0.367	0.362	0.37180	0.01308	0.00813	0.18	0.41
6		0.301	0.299	0.288	0.29628	0.00709	-0.06739	-1.46	0.22
7		0.400	0.345	0.348	0.36430	0.03104	0.00063	0.01	0.97
8		0.230	0.256	0.227	0.23777	0.01589	-0.12590	-2.73	0.50
9		0.389	0.384	0.575	0.44891	0.10887	0.08524	1.85	3.41
10		0.313	0.302	0.296	0.30373	0.00854	-0.05993	-1.30	0.27
11		0.359	0.370	0.328	0.35213	0.02182	-0.01154	-0.25	0.68
12		0.428	0.386	0.364	0.39273	0.03233	0.02906	0.63	1.01
13		0.365	0.352	0.389	0.36887	0.01851	0.00520	0.11	0.58
14		0.382	0.384	0.373	0.37972	0.00561	0.01605	0.35	0.18
15		0.422	0.346	0.378	0.38205	0.03846	0.01838	0.40	1.20
16		0.361	0.355	0.354	0.35696	0.00350	-0.00671	-0.15	0.11
17		0.374	0.388	0.390	0.38427	0.00870	0.02060	0.45	0.27
18		0.402	0.376	0.411	0.39616	0.01820	0.03249	0.70	0.57
19		0.376	0.353	0.355	0.36133	0.01268	-0.00234	-0.05	0.40
20		0.348	0.361	0.354	0.35414	0.00662	-0.00953	-0.21	0.21
21		0.376	0.351	0.373	0.36683	0.01343	0.00317	0.07	0.42
22		0.364	0.372	0.400	0.37877	0.01881	0.01510	0.33	0.59
23		0.241	0.323		0.28170	0.05820	-0.08197	-1.78	1.82
24									
25									
26									
27									
28									

Average of Cell Averages	X-bar	0.364	
Standard Deviation of Cell Averages	$s_{X\text{-}bar}$	0.046	
Repeatability Standard Deviation	s_r	0.03197	0.053
Reproducibility Standard Deviation	s_R	0.053	

Shaded cells were removed after outlier analysis

Binder CR

PG 70-22

Jnr (0.1 kPa)

Lab No.	Lab Name	Results, x 1	2	3	Average	s	d	h	k
1		0.338	0.343	0.351	0.34387	0.00657	-0.00505	-0.17	0.48
2		0.351	0.363	0.369	0.36087	0.00922	0.01195	0.39	0.67
3		0.344	0.345	0.338	0.34220	0.00383	-0.00672	-0.22	0.28
4		0.335	0.339	0.336	0.33640	0.00219	-0.01252	-0.41	0.16
5		0.315	0.297	0.285	0.29913	0.01521	-0.04978	-1.64	1.10
6		0.370	0.317	0.294	0.32677	0.03875	-0.02215	-0.73	2.81
7		0.371	0.369	0.384	0.37467	0.00814	0.02575	0.85	0.59
8		0.380	0.401	0.381	0.38733	0.01185	0.03842	1.27	0.86
9		0.342	0.323	0.343	0.33597	0.01150	-0.01295	-0.43	0.83
10		0.387	0.381	0.373	0.38027	0.00731	0.03135	1.04	0.53
11		0.381	0.374	0.387	0.38073	0.00637	0.03182	1.05	0.46
12		0.333	0.344	0.354	0.34387	0.01081	-0.00505	-0.17	0.78
13		0.389	0.363	0.373	0.37497	0.01286	0.02605	0.86	0.93
14		0.366	0.352	0.353	0.35700	0.00764	0.00808	0.27	0.55
15		0.282	0.287	0.293	0.28700	0.00577	-0.06192	-2.05	0.42
16		0.326	0.331	0.316	0.32450	0.00743	-0.02442	-0.81	0.54
17		0.332	0.319	0.335	0.32860	0.00865	-0.02032	-0.67	0.63
18		0.351	0.356	0.357	0.35443	0.00317	0.00552	0.18	0.23
19		0.362	0.420	0.431	0.40437	0.03726	0.05545	1.83	2.70
20		0.377	0.379	0.394	0.38313	0.00903	0.03422	1.13	0.65
21		0.359	0.370	0.372	0.36703	0.00690	0.01812	0.60	0.50
22		0.324	0.325	0.323	0.32403	0.00086	-0.02488	-0.82	0.06
23		0.309	0.313	0.302	0.30797	0.00572	-0.04095	-1.35	0.41
24									
25									
26									
27									
28									

Average of Cell Averages	X-bar	0.349	
Standard Deviation of Cell Averages	$s_{X\text{-}bar}$	0.030	
Repeatability Standard Deviation	s_r	0.01380	0.032
Reproducibility Standard Deviation	s_R	0.032	

Shaded cells were removed after outlier analysis

Binder CR

PG 70-22

Jnr (3.2 kPa)

Lab No.	Lab Name	Results, x 1	2	3	Average	s	d	h	k
1		0.411	0.421	0.431	0.42100	0.01030	-0.00383	-0.09	0.54
2		0.446	0.459	0.451	0.45183	0.00639	0.02700	0.65	0.34
3		0.417	0.415	0.406	0.41280	0.00577	-0.01203	-0.29	0.30
4		0.416	0.421	0.418	0.41817	0.00225	-0.00666	-0.16	0.12
5		0.378	0.359	0.345	0.36020	0.01656	-0.06463	-1.56	0.87
6		0.436	0.364	0.332	0.37703	0.05323	-0.04780	-1.15	2.81
7		0.434	0.436	0.453	0.44100	0.01044	0.01617	0.39	0.55
8		0.499	0.471	0.443	0.47100	0.02800	0.04617	1.11	1.48
9		0.415	0.397	0.435	0.41570	0.01895	-0.00913	-0.22	1.00
10		0.494	0.482	0.474	0.48313	0.01032	0.05830	1.40	0.54
11		0.464	0.452	0.457	0.45740	0.00612	0.03257	0.78	0.32
12		0.404	0.420	0.436	0.41973	0.01585	-0.00510	-0.12	0.84
13		0.477	0.471	0.450	0.46613	0.01391	0.04130	0.99	0.73
14		0.450	0.431	0.433	0.43787	0.01081	0.01304	0.31	0.57
15		0.337	0.340	0.349	0.34197	0.00621	-0.08286	-1.99	0.33
16		0.393	0.398	0.381	0.39053	0.00850	-0.03430	-0.83	0.45
17		0.400	0.385	0.404	0.39627	0.01026	-0.02856	-0.69	0.54
18		0.437	0.438	0.438	0.43770	0.00062	0.01287	0.31	0.03
19		0.440	0.518	0.531	0.49607	0.04917	0.07124	1.71	2.59
20		0.455	0.466	0.485	0.46853	0.01482	0.04370	1.05	0.78
21		0.444	0.459	0.459	0.45410	0.00875	0.02927	0.70	0.46
22		0.386	0.395	0.379	0.38647	0.00778	-0.03836	-0.92	0.41
23		0.370	0.367	0.362	0.36647	0.00438	-0.05836	-1.40	0.23
24									
25									
26									
27									
28									

Average of Cell Averages	X-bar	0.425	
Standard Deviation of Cell Averages	$s_{X\text{-}bar}$	0.042	
Repeatability Standard Deviation	s_r	0.01895	0.044
Reproducibility Standard Deviation	s_R	0.044	

Shaded cells were removed after outlier analysis

Binder CR

PG 70-22

Recovery (0.1 kPa)

Lab No.	Lab Name	Results, x 1	2	3	Average	s	d	h	k
1		56.0	55.6	55.3	55.630	0.372	0.342	0.19	0.55
2		57.3	55.9	54.8	56.010	1.253	0.722	0.40	1.84
3		56.3	56.1	56.2	56.200	0.106	0.912	0.50	0.16
4		55.9	55.5	55.9	55.783	0.237	0.496	0.27	0.35
5		57.3	57.1	58.2	57.512	0.608	2.225	1.22	0.89
6		54.2	54.7	56.4	55.087	1.172	-0.201	-0.11	1.72
7		53.1	53.6	53.6	53.427	0.318	-1.861	-1.02	0.47
8		51.7	50.7	51.1	51.147	0.496	-4.141	-2.27	0.73
9		56.0	57.6	56.4	56.652	0.810	1.364	0.75	1.19
10		54.4	54.9	55.4	54.920	0.495	-0.368	-0.20	0.73
11		53.9	54.5	53.5	53.970	0.503	-1.317	-0.72	0.74
12		56.2	55.8	55.4	55.768	0.380	0.480	0.26	0.56
13		54.5	57.0	54.8	55.447	1.381	0.159	0.09	2.03
14		55.8	56.3	56.0	56.007	0.274	0.719	0.39	0.40
15		57.4	57.1	57.0	57.147	0.225	1.859	1.02	0.33
16		57.1	57.1	57.5	57.208	0.228	1.921	1.05	0.34
17		57.2	56.8	56.9	56.980	0.214	1.693	0.93	0.31
18		56.7	56.0	55.9	56.179	0.425	0.892	0.49	0.62
19		53.0	50.4	50.2	51.180	1.567	-4.108	-2.25	2.30
20		52.4	51.9	51.7	52.010	0.344	-3.278	-1.80	0.51
21		55.2	54.5	54.7	54.778	0.384	-0.510	-0.28	0.56
22		55.3	56.2	55.5	55.637	0.484	0.349	0.19	0.71
23		56.9	56.5	57.4	56.937	0.475	1.649	0.90	0.70
24									
25									
26									
27									
28									

Average of Cell Averages	X-bar	55.288	
Standard Deviation of Cell Averages	$s_{X\text{-}bar}$	1.826	
Repeatability Standard Deviation	s_r	0.68068	1.909
Reproducibility Standard Deviation	s_R	1.909	

Shaded cells were removed after outlier analysis

Binder CR

PG 70-22

Recovery (3.2 kPa)

Lab No.	Lab Name	Results, x 1	2	3	Average	s	d	h	k
1		48.3	47.4	46.9	47.52333	0.71675	0.22459	0.10	0.87
2		48.3	46.7	47.0	47.35000	0.85422	0.05125	0.02	1.04
3		48.3	48.1	48.4	48.28000	0.14107	0.98125	0.44	0.17
4		48.1	47.8	48.0	47.96333	0.15948	0.66459	0.30	0.19
5		50.1	49.7	50.9	50.24920	0.56284	2.95045	1.32	0.69
6		47.0	48.5	51.1	48.87920	2.08772	1.58045	0.71	2.54
7		45.4	45.7	45.4	45.50333	0.17214	-1.79541	-0.80	0.21
8		44.9	43.7	44.4	44.33667	0.62525	-2.96208	-1.32	0.76
9		48.1	47.5	46.8	47.44137	0.68303	0.14262	0.06	0.83
10		45.0	45.7	46.0	45.55000	0.53694	-1.74875	-0.78	0.65
11		45.1	46.3	46.2	45.86363	0.65148	-1.43511	-0.64	0.79
12		48.4	47.8	46.9	47.71747	0.75712	0.41872	0.19	0.92
13		46.1	46.5	47.1	46.56667	0.49217	-0.73208	-0.33	0.60
14		47.2	48.1	47.7	47.68563	0.46288	0.38689	0.17	0.56
15		50.6	50.1	49.8	50.17567	0.38244	2.87692	1.29	0.47
16		49.7	49.7	50.1	49.85920	0.24149	2.56045	1.14	0.29
17		49.8	49.4	49.3	49.48280	0.26203	2.18405	0.98	0.32
18		48.0	47.4	47.4	47.60833	0.38064	0.30959	0.14	0.46
19		44.3	40.6	40.3	41.70960	2.21848	-5.58915	-2.50	2.70
20		44.3	43.0	42.5	43.26430	0.96403	-4.03445	-1.80	1.17
21		46.6	45.4	45.7	45.88477	0.63985	-1.41398	-0.63	0.78
22		48.6	48.8	49.5	48.94333	0.44287	1.64459	0.74	0.54
23		49.8	50.1	50.2	50.03333	0.23861	2.73459	1.22	0.29
24									
25									
26									
27									
28									

Average of Cell Averages	X-bar	47.299	
Standard Deviation of Cell Averages	$s_{X\text{-}bar}$	2.237	
Repeatability Standard Deviation	s_r	0.82159	2.335
Reproducibility Standard Deviation	s_R	2.335	

Shaded cells were removed after outlier analysis

Binder CR

PG 70-22

Jnr, Diff

Lab No.	Lab Name	Results, x 1	2	3	Average	s	d	h	k
1		0.217	0.226	0.230	0.22417	0.00683	0.01299	0.47	0.42
2		0.271	0.263	0.223	0.25247	0.02563	0.04129	1.50	1.59
3		0.222	0.205	0.202	0.20963	0.01085	-0.00155	-0.06	0.67
4		0.244	0.241	0.244	0.24293	0.00163	0.03175	1.15	0.10
5		0.197	0.207	0.208	0.20434	0.00604	-0.00684	-0.25	0.37
6		0.179	0.148	0.128	0.15183	0.02552	-0.05935	-2.16	1.58
7		0.169	0.181	0.181	0.17683	0.00652	-0.03435	-1.25	0.40
8		0.154	0.149	0.140	0.14773	0.00712	-0.06345	-2.30	0.44
9		0.215	0.230	0.267	0.23722	0.02672	0.02604	0.95	1.66
10		0.216	0.210	0.213	0.21290	0.00310	0.00172	0.06	0.19
11		0.216	0.207	0.181	0.20156	0.01820	-0.00962	-0.35	1.13
12		0.214	0.219	0.229	0.22045	0.00791	0.00927	0.34	0.49
13		0.227	0.297	0.208	0.24383	0.04734	0.03265	1.19	2.93
14		0.231	0.224	0.225	0.22650	0.00394	0.01532	0.56	0.24
15		0.197	0.187	0.191	0.19156	0.00490	-0.01962	-0.71	0.30
16		0.204	0.202	0.205	0.20351	0.00148	-0.00767	-0.28	0.09
17		0.204	0.207	0.207	0.20600	0.00139	-0.00518	-0.19	0.09
18		0.246	0.230	0.229	0.23498	0.00933	0.02381	0.86	0.58
19		0.215	0.232	0.231	0.22624	0.00931	0.01506	0.55	0.58
20		0.208	0.229	0.231	0.22268	0.01282	0.01150	0.42	0.79
21		0.236	0.240	0.236	0.23717	0.00215	0.02599	0.94	0.13
22		0.190	0.215	0.173	0.19250	0.02076	-0.01868	-0.68	1.29
23		0.198	0.173	0.198	0.19008	0.01445	-0.02110	-0.77	0.90
24									
25									
26									
27									
28									

Average of Cell Averages	X-bar	0.211	
Standard Deviation of Cell Averages	$s_{X\text{-}bar}$	0.028	
Repeatability Standard Deviation	s_r	0.01614	0.031
Reproducibility Standard Deviation	s_R	0.031	

Shaded cells were removed after outlier analysis

h

Critical Value = 2.59		2.59	2.59	2.59	2.59	2.59	2.59

Jnr (0.1 kPa)

		Material					
Lab No.	Lab Name	Binder AO	Binder BO	Binder CO	Binder AR	Binder BR	Binder CR
1	0	1.79	1.13	1.49	0.70	-0.36	-0.17
2	0	0.59	0.21	0.25	0.86	-0.03	0.39
3	0	0.34	-0.37	0.33	-0.51	-0.26	-0.22
4	0	-0.32	0.02	-0.30	0.17	-0.45	-0.41
5	0	-0.30	0.20	-0.13	-1.84	0.74	-1.64
6	0	-0.17	-1.08	-2.27	-0.67	-0.01	-0.73
7	0	0.93	0.97	0.89	-0.23	1.00	0.85
8	0	-0.79	2.58	1.58	0.37	3.23	1.27
9	0	-0.31	0.19	-0.26	-1.48	-0.71	-0.43
10	0	2.17	0.73	0.76	0.86	0.34	1.04
11	0	-0.49	0.60	0.49	-0.53	0.41	1.05
12	0	-0.55	-1.02	-0.75	-0.76	-0.35	-0.17
13	0	1.14	0.61	0.85	1.94	0.33	0.86
14	0	1.20	-0.51	0.12	1.01	0.52	0.27
15	0	-0.36	-1.14	-0.66	-0.64	-1.88	-2.05
16	0	-0.61	-0.57	-0.36	-0.08	-0.41	-0.81
17	0	1.41	0.72	0.82	0.49	-0.14	-0.67
18	0	-0.99	-0.32	-0.10	0.48	0.01	0.18
19	0	-0.98	-0.10	0.29	1.08	-0.40	1.83
20	0	-1.49	-0.29	0.15	0.89	-0.08	1.13
21	0	-0.46	0.10	0.02	0.83	1.08	0.60
22	0	-0.60	-0.07	-0.52	-1.65	-1.40	-0.82
23	0	-1.15	-2.60	-2.70	-1.28	-1.16	-1.35
24	0	0.00	0.00	0.00	0.00	0.00	0.00
25	0	0.00	0.00	0.00	0.00	0.00	0.00
26	0	0.00	0.00	0.00	0.00	0.00	0.00
27	0	0.00	0.00	0.00	0.00	0.00	0.00
28	0	0.00	0.00	0.00	0.00	0.00	0.00

exceeds h before removal of outliers
exceeds h-0.5 before removal of outliers
exceeds h after removal of outliers
exceeds h-0.5 after removal of outliers

h

Critical Value = 2.59		2.59	2.59	2.59	2.59	2.59	2.59

Jnr (3.2 kPa)

Lab No.	Lab Name	Material Binder AO	Binder BO	Binder CO	Binder AR	Binder BR	Binder CR
1	0	1.76	1.19	1.52	0.73	-0.19	-0.09
2	0	0.70	0.50	0.44	1.03	0.02	0.65
3	0	0.02	-0.28	0.27	-0.63	-0.25	-0.29
4	0	0.18	0.29	0.03	0.57	-0.11	-0.16
5	0	-0.32	0.37	-0.13	-1.74	0.82	-1.56
6	0	-0.15	-1.79	-2.46	-0.64	-1.61	-1.15
7	0	0.47	0.77	0.70	-0.58	0.83	0.39
8	0	-0.49	2.33	0.87	0.33	3.06	1.11
9	0	-0.32	0.39	0.26	-1.45	-0.30	-0.22
10	0	2.56	1.01	1.18	1.11	0.64	1.40
11	0	-0.48	0.17	0.27	-0.20	0.04	0.78
12	0	-0.59	-0.89	-0.52	-0.78	-0.31	-0.12
13	0	1.08	0.55	0.71	1.80	0.61	0.99
14	0	1.17	-0.73	0.15	0.99	0.35	0.31
15	0	-0.38	-0.93	-0.51	-0.70	-1.75	-1.99
16	0	-0.52	-0.46	-0.44	-0.08	-0.30	-0.83
17	0	1.16	0.58	0.81	0.38	0.06	-0.69
18	0	-0.83	-0.16	0.08	0.52	0.09	0.31
19	0	-1.16	-0.43	0.16	0.98	-0.49	1.71
20	0	-1.39	-0.50	-0.02	0.77	-0.29	1.05
21	0	-0.45	0.29	-0.03	0.64	1.25	0.70
22	0	-0.82	0.17	-0.42	-1.36	-0.96	-0.92
23	0	-1.21	-2.44	-2.91	-1.70	-1.23	-1.40
24	0	0.00	0.00	0.00	0.00	0.00	0.00
25	0	0.00	0.00	0.00	0.00	0.00	0.00
26	0	0.00	0.00	0.00	0.00	0.00	0.00
27	0	0.00	0.00	0.00	0.00	0.00	0.00
28	0	0.00	0.00	0.00	0.00	0.00	0.00

exceeds h before removal of outliers
exceeds h-0.5 before removal of outliers
exceeds h after removal of outliers
exceeds h-0.5 after removal of outliers

h

Critical Value = 2.59		2.59	2.59	2.59	2.59	2.59	2.59

Recovery (0.1 kPa)

Lab No.	Lab Name	Material Binder AO	Binder BO	Binder CO	Binder AR	Binder BR	Binder CR
1	0	0.33	-0.10	-0.29	0.26	0.43	0.19
2	0	0.56	0.17	0.51	0.42	-0.39	0.40
3	0	0.61	0.76	0.59	0.74	0.59	0.50
4	0	0.92	-0.08	0.63	0.59	0.23	0.27
5	0	0.22	-0.44	-0.08	1.07	-0.67	1.22
6	0	-1.90	-0.77	0.36	-1.09	-1.65	-0.11
7	0	0.78	-1.08	-0.05	0.43	-1.67	-1.02
8	0	1.76	0.00	-2.78	1.03	0.00	-2.27
9	0	-0.05	1.12	0.77	0.69	0.77	0.75
10	0	0.45	0.32	0.33	0.30	0.77	-0.20
11	0	-1.91	-2.28	-1.07	-0.03	0.47	-0.72
12	0	-0.21	0.78	1.34	0.07	0.49	0.26
13	0	0.24	-0.01	-0.45	-0.66	0.63	0.09
14	0	-0.26	1.38	0.69	-0.08	0.10	0.39
15	0	-0.15	1.35	0.91	0.05	1.14	1.02
16	0	-0.17	0.67	0.31	0.01	0.11	1.05
17	0	-0.36	0.03	0.08	-0.21	0.41	0.93
18	0	0.57	1.36	0.75	0.18	0.60	0.49
19	0	0.00	-1.83	-2.01	0.00	-1.56	-2.25
20	0	-2.64	-1.16	-1.56	-3.38	-1.06	-1.80
21	0	0.40	-0.47	-0.17	-0.50	-2.03	-0.28
22	0	0.49	-0.25	0.65	1.38	1.37	0.19
23	0	0.31	0.52	0.55	-1.25	0.92	0.90
24	0	0.00	0.00	0.00	0.00	0.00	0.00
25	0	0.00	0.00	0.00	0.00	0.00	0.00
26	0	0.00	0.00	0.00	0.00	0.00	0.00
27	0	0.00	0.00	0.00	0.00	0.00	0.00
28	0	0.00	0.00	0.00	0.00	0.00	0.00

exceeds h before removal of outliers
exceeds h-0.5 before removal of outliers
exceeds h after removal of outliers
exceeds h-0.5 after removal of outliers

h

Critical Value = 2.59		2.59	2.59	2.59	2.59	2.59	2.59

Recovery (3.2 kPa)

Lab No.	Lab Name	Material Binder AO	Binder BO	Binder CO	Binder AR	Binder BR	Binder CR
1	0	0.57	-0.68	-0.75	0.47	0.14	0.10
2	0	0.59	-0.67	0.21	0.45	-0.27	0.02
3	0	0.84	0.20	0.37	0.79	0.33	0.44
4	0	0.71	-0.37	0.37	0.54	-0.01	0.30
5	0	0.21	-1.02	-0.20	0.53	-0.84	1.32
6	0	-2.06	2.17	1.49	-1.77	2.30	0.71
7	0	0.81	-1.49	-0.31	0.72	-2.10	-0.80
8	0	0.82	0.00	-1.89	0.51	0.00	-1.32
9	0	0.41	0.24	0.08	0.40	-0.22	0.06
10	0	0.65	-0.50	-0.43	0.48	0.28	-0.78
11	0	-2.05	-1.13	0.00	-1.97	0.77	-0.64
12	0	-0.03	0.66	1.04	0.16	0.38	0.19
13	0	0.60	-0.12	-0.34	0.34	-0.09	-0.33
14	0	-0.12	1.93	0.40	-0.02	0.36	0.17
15	0	-0.16	0.88	0.61	0.04	0.91	1.29
16	0	-0.04	0.40	0.49	0.16	-0.12	1.14
17	0	-0.18	-0.06	-0.31	-0.01	-0.04	0.98
18	0	0.01	0.78	0.28	0.03	0.36	0.14
19	0	0.00	-0.80	-2.24	0.00	-1.07	-2.50
20	0	-2.77	-0.19	-1.46	-3.17	-0.41	-1.80
21	0	0.26	-1.17	-0.37	-0.03	-2.33	-0.63
22	0	0.66	-0.56	0.71	0.81	0.47	0.74
23	0	0.29	1.50	2.24	0.56	1.21	1.22
24	0	0.00	0.00	0.00	0.00	0.00	0.00
25	0	0.00	0.00	0.00	0.00	0.00	0.00
26	0	0.00	0.00	0.00	0.00	0.00	0.00
27	0	0.00	0.00	0.00	0.00	0.00	0.00
28	0	0.00	0.00	0.00	0.00	0.00	0.00

exceeds h before removal of outliers
exceeds h-0.5 before removal of outliers
exceeds h after removal of outliers
exceeds h-0.5 after removal of outliers

h

Critical Value = 2.59		2.59	2.59	2.59	2.59	2.59	2.59

Jnr, Diff

Lab No.	Lab Name	Material Binder AO	Binder BO	Binder CO	Binder AR	Binder BR	Binder CR
1	0	-0.46	0.93	0.77	0.16	0.23	0.47
2	0	0.31	1.36	0.84	0.79	-0.24	1.50
3	0	-1.48	0.06	0.13	-0.55	-0.52	-0.06
4	0	2.26	1.19	1.10	1.98	1.11	1.15
5	0	-0.85	0.83	0.18	0.71	0.10	-0.25
6	0	0.03	0.00	-1.46	0.20	2.10	-2.16
7	0	-2.23	-0.03	0.01	-1.73	-0.87	-1.25
8	0	0.91	0.02	-2.73	-0.52	-0.40	-2.30
9	0	-0.12	0.92	1.85	0.28	1.44	0.95
10	0	0.71	0.83	-1.30	0.65	0.69	0.06
11	0	0.11	-1.51	-0.25	1.73	-0.05	-0.35
12	0	-0.18	-0.32	0.63	-0.03	-0.42	0.34
13	0	-0.32	0.09	0.11	-0.52	0.94	1.19
14	0	-0.41	-1.57	0.35	-0.13	-1.08	0.56
15	0	-0.11	-0.02	0.40	-0.31	-0.52	-0.71
16	0	0.41	-0.02	-0.15	-0.01	-0.09	-0.28
17	0	-1.13	-0.17	0.45	-0.57	0.41	-0.19
18	0	0.82	0.41	0.70	0.22	-0.06	0.86
19	0	-0.81	-1.71	-0.05	-0.47	-1.88	0.55
20	0	0.62	-1.34	-0.21	-0.56	-1.51	0.42
21	0	0.00	0.84	0.07	-0.89	0.59	0.94
22	0	1.96	1.00	0.33	1.74	1.36	-0.68
23	0	-0.05	-1.78	-1.78	-2.17	-1.34	-0.77
24	0	0.00	0.00	0.00	0.00	0.00	0.00
25	0	0.00	0.00	0.00	0.00	0.00	0.00
26	0	0.00	0.00	0.00	0.00	0.00	0.00
27	0	0.00	0.00	0.00	0.00	0.00	0.00
28	0	0.00	0.00	0.00	0.00	0.00	0.00

exceeds h before removal of outliers
exceeds h-0.5 before removal of outliers
exceeds h after removal of outliers
exceeds h-0.5 after removal of outliers

k

Critical Value = 2.22		2.22	2.22	2.22	2.22	2.22	2.22

Jnr (0.1 kPa)

		Material					
Lab No.	Lab Name	Binder AO	Binder BO	Binder CO	Binder AR	Binder BR	Binder CR
1	0	0.18	0.25	0.55	0.10	1.10	0.48
2	0	0.41	0.77	0.32	0.62	0.76	0.67
3	0	0.20	1.29	0.54	0.18	0.43	0.28
4	0	0.05	0.52	0.61	0.21	0.24	0.16
5	0	0.72	0.56	1.33	1.20	1.38	1.10
6	0	1.57	0.57	0.88	2.35	2.30	2.81
7	0	0.53	1.51	0.99	1.85	0.15	0.59
8	0	0.32	0.87	0.46	0.48	0.66	0.86
9	0	0.36	1.59	2.46	0.33	0.72	0.83
10	0	1.10	0.89	0.59	1.26	0.60	0.53
11	0	1.24	0.25	1.88	0.79	3.22	0.46
12	0	0.28	1.26	0.79	0.41	0.39	0.78
13	0	1.33	0.27	0.77	1.32	0.58	0.93
14	0	0.22	0.62	0.55	0.19	0.40	0.55
15	0	0.80	2.29	1.31	0.29	0.07	0.42
16	0	0.05	2.05	0.90	0.14	0.44	0.54
17	0	0.24	0.61	0.78	0.62	0.17	0.63
18	0	0.16	0.32	0.18	0.12	0.17	0.23
19	0	0.48	0.40	1.04	0.98	0.75	2.70
20	0	0.52	0.41	1.01	1.90	0.54	0.65
21	0	0.67	0.40	0.98	0.40	0.46	0.50
22	0	0.64	0.24	0.65	0.13	0.29	0.06
23	0	3.54	0.90	0.33	1.55	0.15	0.41
24	0	0.00	0.00	0.00	0.00	0.00	0.00
25	0	0.00	0.00	0.00	0.00	0.00	0.00
26	0	0.00	0.00	0.00	0.00	0.00	0.00
27	0	0.00	0.00	0.00	0.00	0.00	0.00
28	0	0.00	0.00	0.00	0.00	0.00	0.00

exceeds k before removal of outliers
exceeds k-0.5 before removal of outliers
exceeds k after removal of outliers
exceeds k-0.5 after removal of outliers

k

Critical Value = 2.22

		2.22	2.22	2.22	2.22	2.22	2.22

Jnr (3.2 kPa)

Lab No.	Lab Name	Material Binder AO	Binder BO	Binder CO	Binder AR	Binder BR	Binder CR
1	0	0.21	0.26	0.56	0.12	1.53	0.54
2	0	0.21	0.70	0.43	0.45	1.04	0.34
3	0	0.24	1.23	0.63	0.14	0.62	0.30
4	0	0.12	0.57	0.56	0.21	0.37	0.12
5	0	0.83	0.51	1.46	1.21	2.10	0.87
6	0	1.64	0.88	0.83	2.70	2.32	2.81
7	0	0.69	1.29	1.00	1.89	0.77	0.55
8	0	0.72	1.06	0.55	0.73	0.95	1.48
9	0	0.37	1.62	0.98	0.34	0.18	1.00
10	0	1.24	0.81	0.88	1.31	0.56	0.54
11	0	0.84	0.06	2.11	0.96	1.73	0.32
12	0	0.18	1.15	1.08	0.32	0.59	0.84
13	0	0.28	0.83	0.57	0.09	1.01	0.73
14	0	0.21	0.66	0.62	0.20	0.52	0.57
15	0	0.77	2.22	1.62	0.34	0.14	0.33
16	0	0.05	1.87	0.90	0.15	0.64	0.45
17	0	0.24	0.80	0.89	0.71	0.79	0.54
18	0	0.23	0.34	0.34	0.03	0.17	0.03
19	0	0.53	0.32	1.20	1.03	0.50	2.59
20	0	0.76	0.42	1.04	2.07	0.78	0.78
21	0	0.71	0.36	1.11	0.30	0.75	0.46
22	0	1.42	0.40	0.73	0.41	0.49	0.41
23	0	3.44	1.15	0.98	0.84	0.22	0.23
24	0	0.00	0.00	0.00	0.00	0.00	0.00
25	0	0.00	0.00	0.00	0.00	0.00	0.00
26	0	0.00	0.00	0.00	0.00	0.00	0.00
27	0	0.00	0.00	0.00	0.00	0.00	0.00
28	0	0.00	0.00	0.00	0.00	0.00	0.00

exceeds k before removal of outliers
exceeds k-0.5 before removal of outliers
exceeds k after removal of outliers
exceeds k-0.5 after removal of outliers

k

Critical Value = 2.22

		2.22	2.22	2.22	2.22	2.22	2.22

Recovery (0.1 kPa)

Lab No.	Lab Name	Material Binder AO	Binder BO	Binder CO	Binder AR	Binder BR	Binder CR
1	0	0.13	0.13	0.11	0.03	0.39	0.55
2	0	0.46	0.94	1.82	0.91	0.25	1.84
3	0	0.05	0.77	0.51	0.15	0.24	0.16
4	0	0.56	0.40	0.64	0.45	0.10	0.35
5	0	0.39	0.20	0.68	0.59	0.37	0.89
6	0	0.29	0.49	0.71	0.27	1.23	1.72
7	0	0.47	0.97	2.11	0.64	0.23	0.47
8	0	0.12	0.00	0.09	0.16	0.00	0.73
9	0	0.23	0.90	1.42	0.14	1.44	1.19
10	0	0.33	0.77	0.64	0.32	0.20	0.73
11	0	1.50	0.68	0.93	0.76	4.06	0.74
12	0	0.35	1.22	1.15	0.35	0.18	0.56
13	0	4.09	1.20	0.82	3.42	0.21	2.03
14	0	0.06	0.58	0.30	0.29	0.17	0.40
15	0	0.18	1.53	1.51	0.06	0.04	0.33
16	0	0.09	0.94	0.67	0.07	0.03	0.34
17	0	0.03	1.21	0.40	0.05	0.29	0.31
18	0	0.24	0.64	0.49	0.21	0.24	0.62
19	0	0.00	0.38	0.28	0.00	0.57	2.30
20	0	0.52	0.72	0.87	0.27	0.63	0.51
21	0	0.14	0.50	0.62	0.44	0.36	0.56
22	0	0.60	0.26	0.81	0.87	0.27	0.71
23	0	0.99	2.81	1.78	2.54	0.48	0.70
24	0	0.00	0.00	0.00	0.00	0.00	0.00
25	0	0.00	0.00	0.00	0.00	0.00	0.00
26	0	0.00	0.00	0.00	0.00	0.00	0.00
27	0	0.00	0.00	0.00	0.00	0.00	0.00
28	0	0.00	0.00	0.00	0.00	0.00	0.00

exceeds k before removal of outliers
exceeds k-0.5 before removal of outliers
exceeds k after removal of outliers
exceeds k-0.5 after removal of outliers

k

Critical Value = 2.22

		2.22	2.22	2.22	2.22	2.22	2.22

Recovery (3.2 kPa)

Lab No.	Lab Name	Material Binder AO	Binder BO	Binder CO	Binder AR	Binder BR	Binder CR
1	0	0.01	0.15	0.14	0.20	0.90	0.87
2	0	0.14	0.58	0.14	0.39	0.60	1.04
3	0	0.03	1.01	0.39	0.25	0.53	0.17
4	0	0.03	0.32	0.49	0.10	0.27	0.19
5	0	1.49	0.21	0.37	1.98	1.15	0.69
6	0	0.60	0.84	0.87	2.78	1.65	2.54
7	0	0.08	1.36	1.76	1.98	0.14	0.21
8	0	0.06	0.00	1.91	0.41	0.00	0.76
9	0	3.04	0.58	0.31	0.20	0.42	0.83
10	0	0.12	0.89	0.51	0.79	0.43	0.65
11	0	0.29	0.19	2.44	0.54	2.98	0.79
12	0	0.06	1.43	0.50	0.37	0.56	0.92
13	0	0.03	0.77	0.26	0.20	0.09	0.60
14	0	0.05	0.94	0.64	0.09	0.32	0.56
15	0	0.24	2.12	1.21	0.23	0.18	0.47
16	0	0.02	1.08	0.97	0.03	0.21	0.29
17	0	0.05	1.97	0.73	0.42	1.56	0.32
18	0	0.06	0.86	0.22	0.29	0.50	0.46
19	0	0.00	0.71	0.52	0.00	0.81	2.70
20	0	0.12	0.99	1.24	0.63	1.55	1.17
21	0	1.69	0.59	1.02	0.43	0.82	0.78
22	0	0.07	0.67	0.86	0.15	0.48	0.54
23	0	2.67	0.82	1.14	1.98	0.26	0.29
24	0	0.00	0.00	0.00	0.00	0.00	0.00
25	0	0.00	0.00	0.00	0.00	0.00	0.00
26	0	0.00	0.00	0.00	0.00	0.00	0.00
27	0	0.00	0.00	0.00	0.00	0.00	0.00
28	0	0.00	0.00	0.00	0.00	0.00	0.00

exceeds k before removal of outliers
exceeds k-0.5 before removal of outliers
exceeds k after removal of outliers
exceeds k-0.5 after removal of outliers

k

Critical Value = 2.22

		2.22	2.22	2.22	2.22	2.22	2.22

Jnr, Diff

		Material					
Lab No.	Lab Name	Binder AO	Binder BO	Binder CO	Binder AR	Binder BR	Binder CR
1	0	0.22	0.18	0.05	0.03	0.16	0.42
2	0	0.61	1.06	1.42	0.97	0.20	1.59
3	0	0.36	0.32	0.34	0.15	0.11	0.67
4	0	0.48	0.41	0.18	0.47	0.09	0.10
5	0	0.84	0.57	0.41	0.45	0.48	0.37
6	0	0.17	0.00	0.22	0.33	0.62	1.58
7	0	0.71	1.07	0.97	0.32	1.04	0.40
8	0	2.07	0.75	0.50	0.45	0.12	0.44
9	0	0.24	0.72	3.41	0.16	2.28	1.66
10	0	0.09	0.27	0.27	0.32	0.63	0.19
11	0	1.39	0.99	0.68	0.99	3.37	1.13
12	0	0.36	0.40	1.01	0.37	0.18	0.49
13	0	3.28	2.56	0.58	3.62	0.44	2.93
14	0	0.12	0.60	0.18	0.30	0.02	0.24
15	0	0.35	0.93	1.20	0.06	0.13	0.30
16	0	0.21	0.24	0.11	0.14	0.16	0.09
17	0	0.22	1.07	0.27	0.11	1.30	0.09
18	0	0.37	0.36	0.57	0.33	0.08	0.58
19	0	0.30	0.42	0.40	0.16	0.15	0.58
20	0	0.61	0.36	0.21	0.19	1.22	0.79
21	0	0.02	0.21	0.42	0.34	0.25	0.13
22	0	1.39	1.60	0.59	0.92	0.27	1.29
23	0	1.03	2.19	1.82	2.37	0.82	0.90
24	0	0.00	0.00	0.00	0.00	0.00	0.00
25	0	0.00	0.00	0.00	0.00	0.00	0.00
26	0	0.00	0.00	0.00	0.00	0.00	0.00
27	0	0.00	0.00	0.00	0.00	0.00	0.00
28	0	0.00	0.00	0.00	0.00	0.00	0.00

exceeds k before removal of outliers
exceeds k-0.5 before removal of outliers
exceeds k after removal of outliers
exceeds k-0.5 after removal of outliers

Jnr (0.1 kPa)

								Repeatability		Reproducibility	
ID	Binder	X-bar	$s_{X\text{-}bar}$	s_r	s_R	r	R	1s%	d2s%	1s%	d2s%
AO	PG 64-22	4.41083	0.25947	0.23554	0.32297	0.65950	0.90432	5.3%	15.0%	7.3%	20.5%
BO	PG 76-22	0.27768	0.02688	0.01240	0.02872	0.03473	0.08042	4.5%	12.5%	10.3%	29.0%
CO	PG 70-22	0.78060	0.06671	0.03584	0.07285	0.10036	0.20397	4.6%	12.9%	9.3%	26.1%
AR	PG 64-22	2.00374	0.15375	0.10094	0.17444	0.28262	0.48844	5.0%	14.1%	8.7%	24.4%
BR	PG 76-22	0.12907	0.01299	0.00662	0.01407	0.01854	0.03940	5.1%	14.4%	10.9%	30.5%
CR	PG 70-22	0.34892	0.03027	0.01380	0.03230	0.03864	0.09043	4.0%	11.1%	9.3%	25.9%

Jnr (3.2 kPa) @ 64°C

								Repeatability		Reproducibility	
ID	Binder	X-bar	$s_{X\text{-}bar}$	s_r	s_R	r	R	1s%	d2s%	1s%	d2s%
AO	PG 64-22	4.69213	0.26719	0.23367	0.32832	0.65428	0.91929	5.0%	13.9%	7.0%	19.6%
BO	PG 76-22	0.30897	0.03584	0.01557	0.03803	0.04360	0.10647	5.0%	14.1%	12.3%	34.5%
CO	PG 70-22	1.07235	0.10404	0.05119	0.11212	0.14334	0.31394	4.8%	13.4%	10.5%	29.3%
AR	PG 64-22	2.15927	0.16439	0.09855	0.18302	0.27594	0.51247	4.6%	12.8%	8.5%	23.7%
BR	PG 76-22	0.13702	0.01491	0.00543	0.01555	0.01520	0.04355	4.0%	11.1%	11.4%	31.8%
CR	PG 70-22	0.42483	0.04155	0.01895	0.04434	0.05307	0.12414	4.5%	12.5%	10.4%	29.2%

Recovery (0.1 kPa)

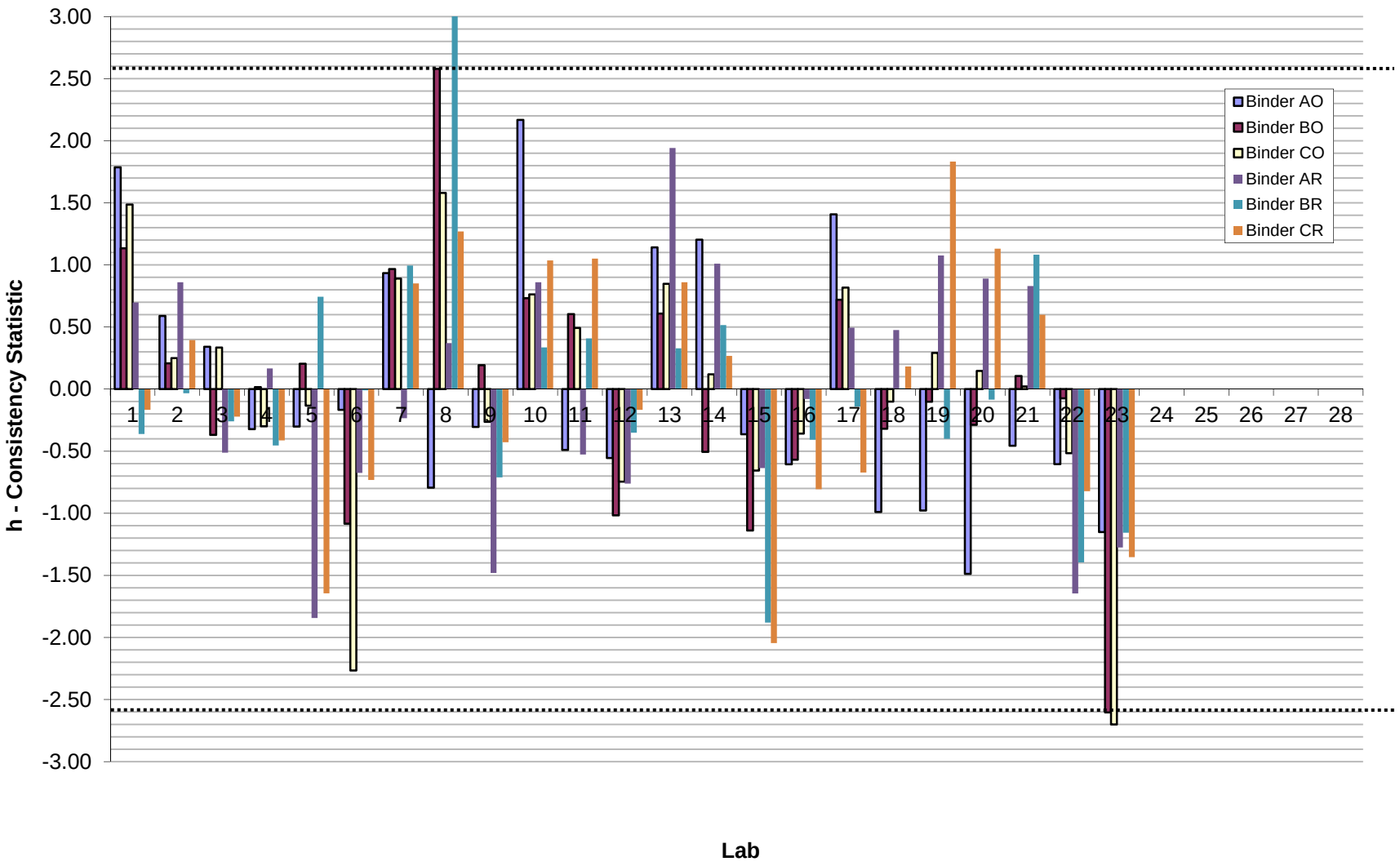
								Repeatability		Reproducibility	
ID	Binder	X-bar	$s_{X\text{-}bar}$	s_r	s_R	r	R	1s%	d2s%	1s%	d2s%
AO	PG 64-22	0.44413	1.18720	1.31083	1.59843	3.67034	4.47559	295.1%	826.4%	359.9%	1007.7%
BO	PG 76-22	72.51327	0.78482	0.42972	0.85968	1.20321	2.40711	0.6%	1.7%	1.2%	3.3%
CO	PG 70-22	49.57870	1.66396	0.81864	1.79320	2.29220	5.02095	1.7%	4.6%	3.6%	10.1%
AR	PG 64-22	3.43658	1.51018	1.48950	1.93900	4.17059	5.42920	43.3%	121.4%	56.4%	158.0%
BR	PG 76-22	76.73073	0.83887	0.82517	1.07593	2.31048	3.01262	1.1%	3.0%	1.4%	3.9%
CR	PG 70-22	55.28762	1.82594	0.68068	1.90865	1.90592	5.34422	1.2%	3.4%	3.5%	9.7%

Recovery (3.2 kPa) @ 64°C

								Repeatability		Reproducibility	
ID	Binder	X-bar	$s_{X\text{-}bar}$	s_r	s_R	r	R	1s%	d2s%	1s%	d2s%
AO	PG 64-22	-0.81911	1.35128	0.33383	1.37849	0.93472	3.85978	-40.8%	-114.1%	-168.3%	-471.2%
BO	PG 76-22	70.21020	1.05104	0.45632	1.11512	1.27770	3.12234	0.6%	1.8%	1.6%	4.4%
CO	PG 70-22	35.20919	1.98739	0.89385	2.11716	2.50278	5.92806	2.5%	7.1%	6.0%	16.8%
AR	PG 64-22	0.72091	1.29715	0.13549	1.30186	0.37936	3.64522	18.8%	52.6%	180.6%	505.6%
BR	PG 76-22	75.56883	1.02004	0.45928	1.08679	1.28598	3.04301	0.6%	1.7%	1.4%	4.0%
CR	PG 70-22	47.29875	2.23660	0.82159	2.33504	2.30045	6.53811	1.7%	4.9%	4.9%	13.8%

Jnr, Diff

								Repeatability		Reproducibility	
ID	Binder	X-bar	$s_{X\text{-}bar}$	s_r	s_R	r	R	1s%	d2s%	1s%	d2s%
AO	PG 64-22	0.06517	0.01337	0.01931	0.02067	0.05407	0.05789	29.6%	83.0%	31.7%	88.8%
BO	PG 76-22	0.11513	0.02814	0.01316	0.03012	0.03684	0.08433	11.4%	32.0%	26.2%	73.2%
CO	PG 70-22	0.36367	0.04617	0.03197	0.05304	0.08952	0.14850	8.8%	24.6%	14.6%	40.8%
AR	PG 64-22	0.07742	0.01646	0.01864	0.02242	0.05220	0.06278	24.1%	67.4%	29.0%	81.1%
BR	PG 76-22	0.07326	0.02389	0.02335	0.03057	0.06537	0.08559	31.9%	89.2%	41.7%	116.8%
CR	PG 70-22	0.21118	0.02754	0.01614	0.03053	0.04519	0.08548	7.6%	21.4%	14.5%	40.5%


Jnr (0.1 kPa): h - Materials within Laboratories
h - Consistency Statistic
Lab
3.00
2.50
2.00
1.50
1.00
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Binder AO
Binder BO
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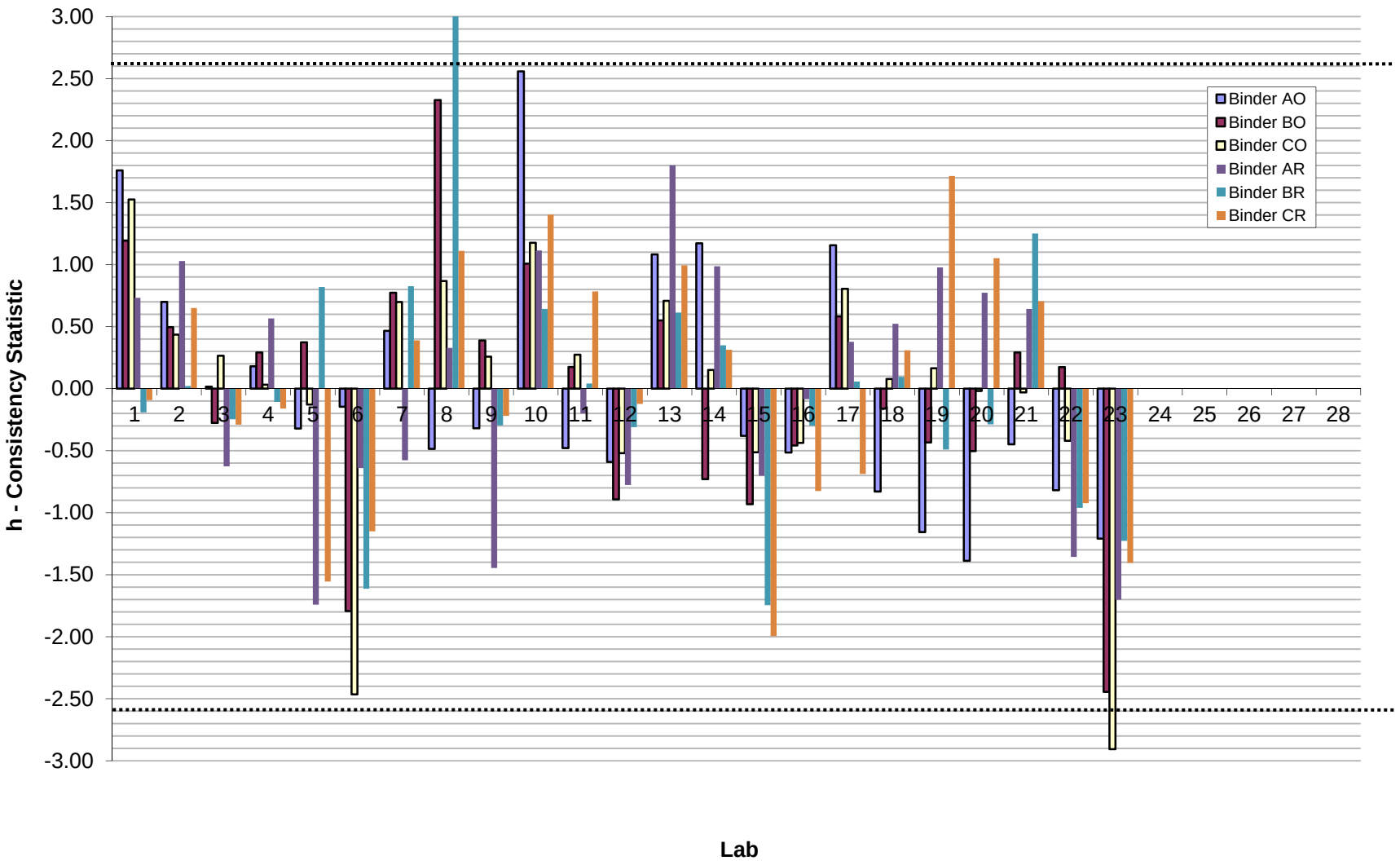
Binder AR
Binder BR
Binder CR


Jnr (3.2 kPa): h - Materials within Laboratories
h - Consistency Statistic
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2.50
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Binder AO
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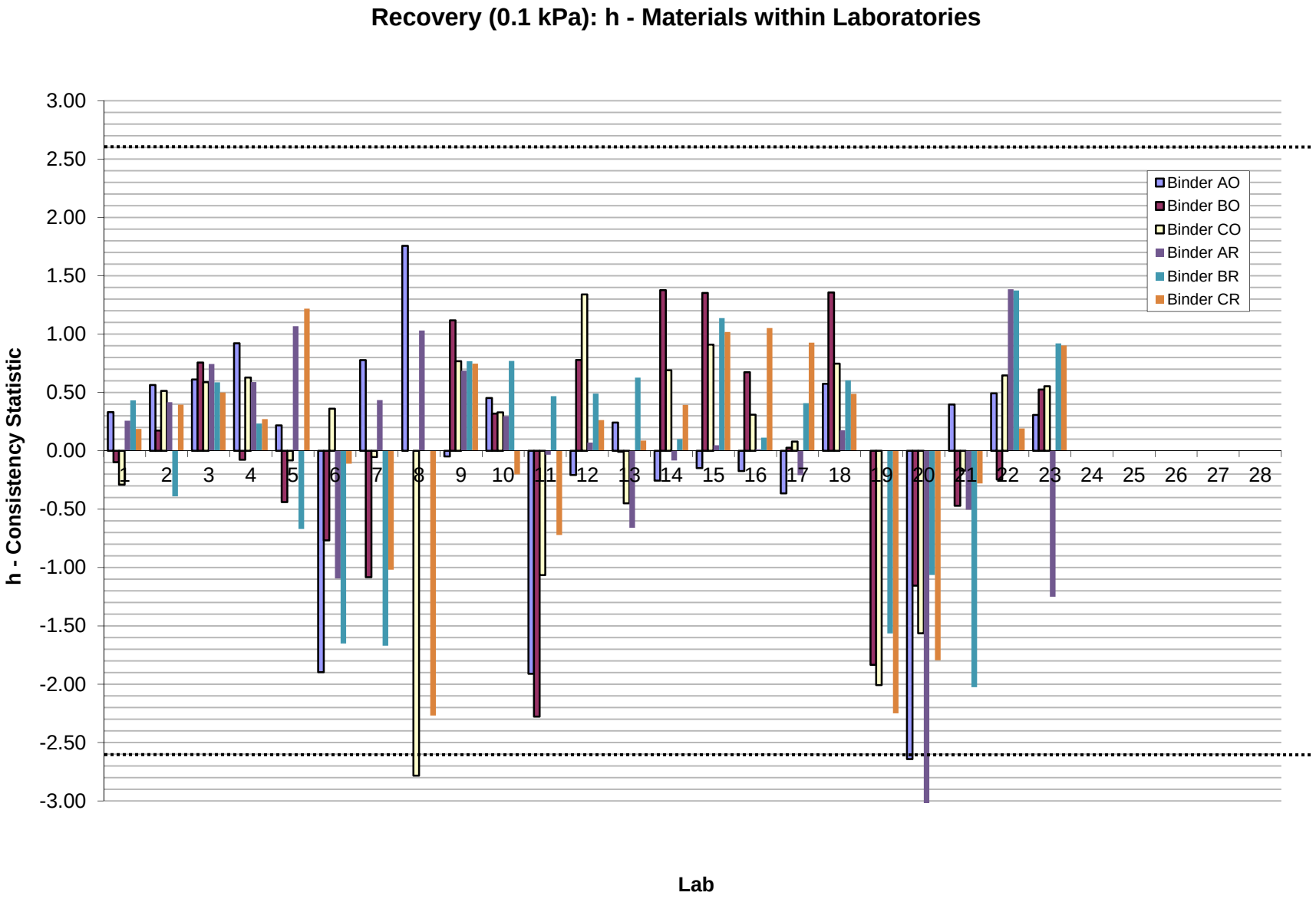
Recovery (0.1 kPa): h - Materials within Laboratories
h - Consistency Statistic
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2.50
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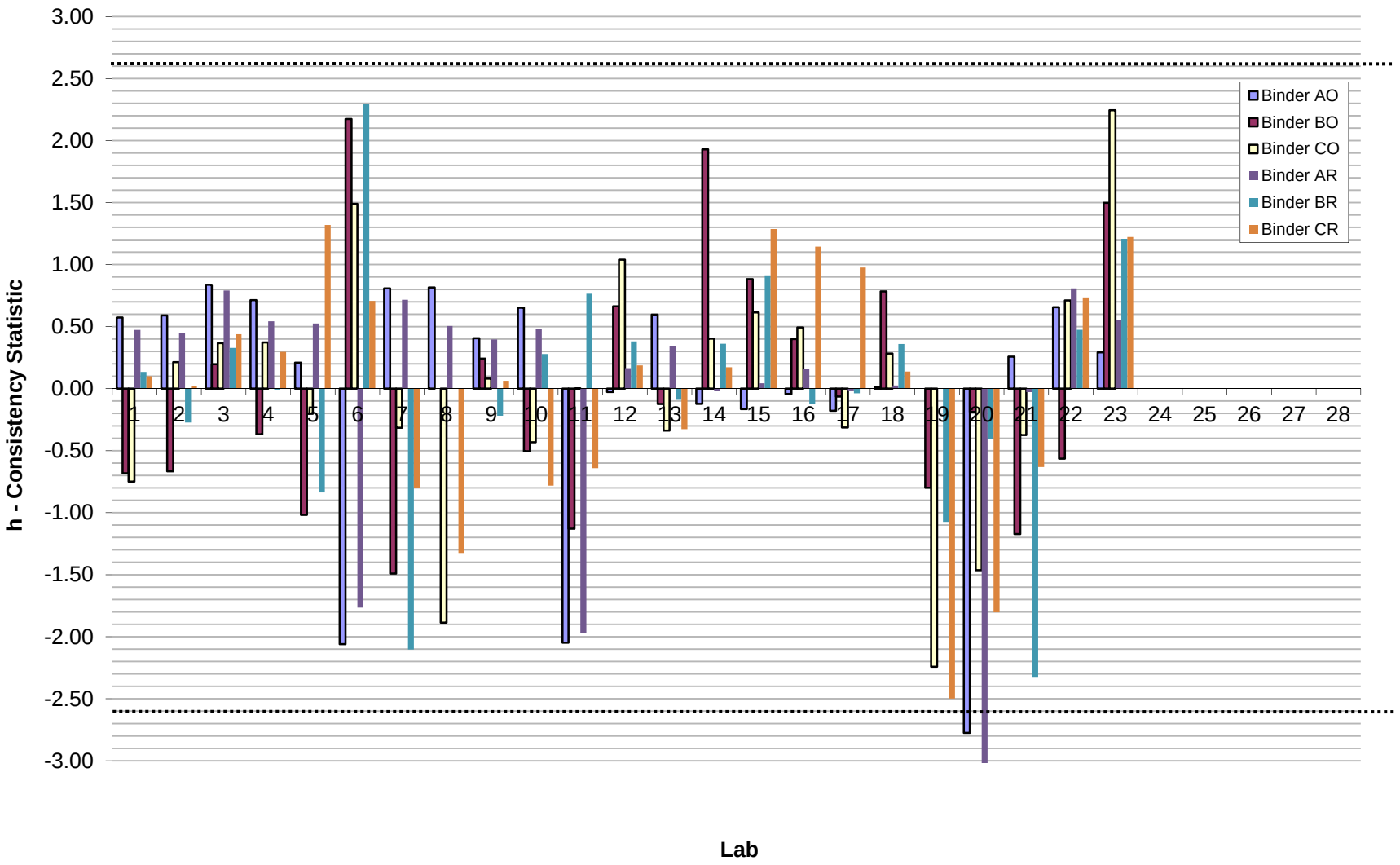
Recovery (3.2 kPa): h - Materials within Laboratories
h - Consistency Statistic
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Binder AO
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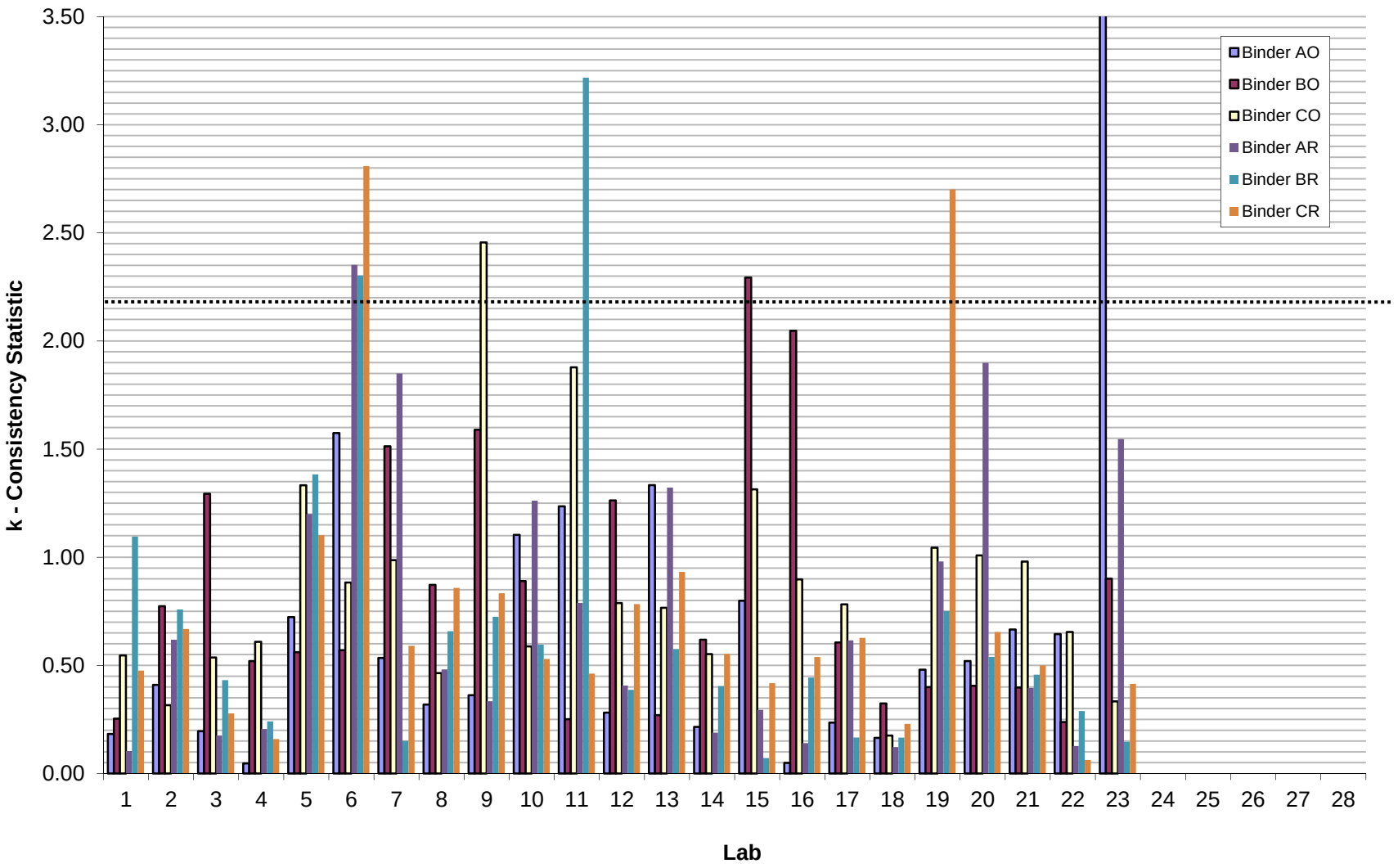
Jnr (0.1 kPa): k - Materials within Laboratories
k - Consistency Statistic
3.50
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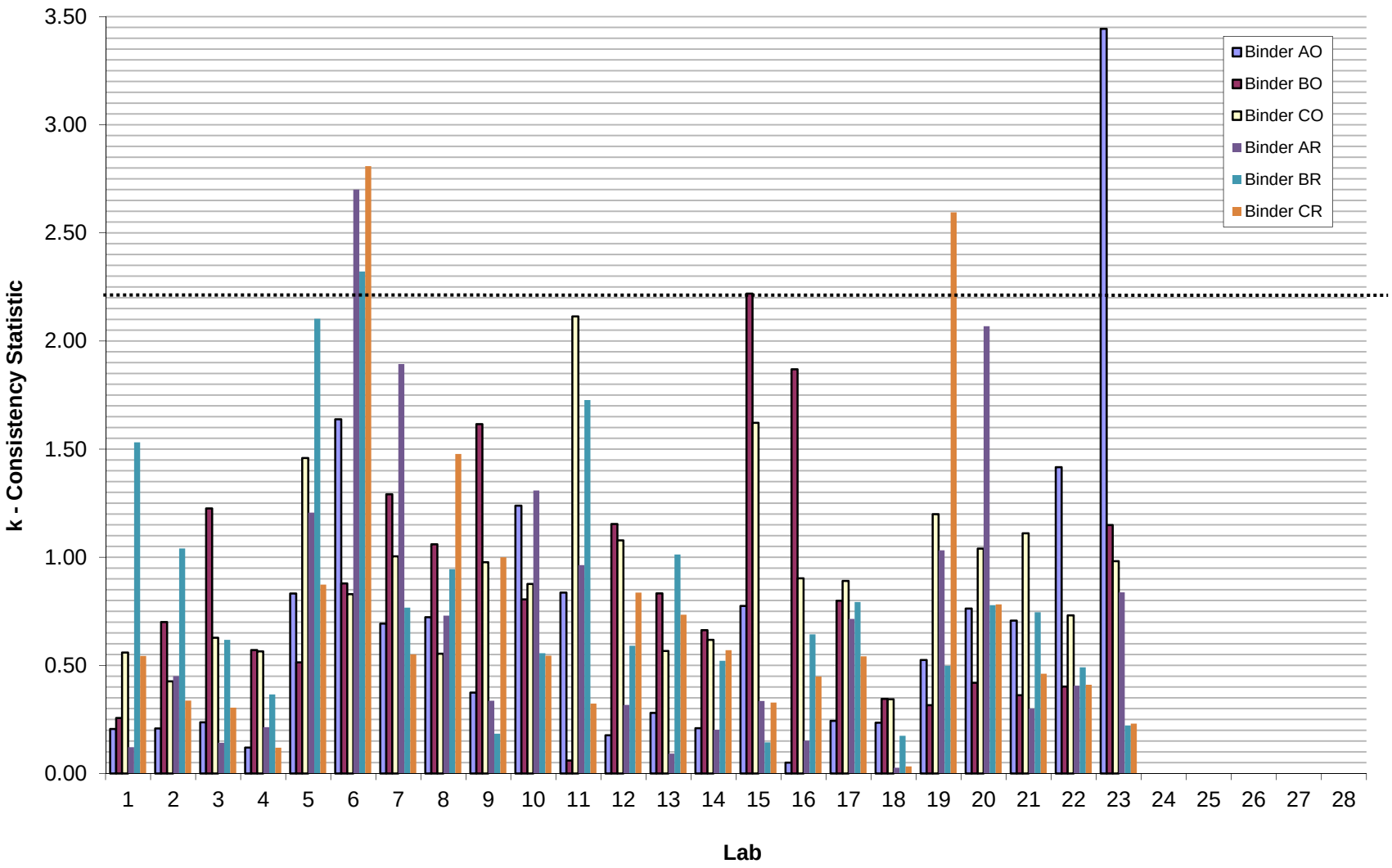
Jnr (3.2 kPa): k - Materials within Laboratories
k - Consistency Statistic
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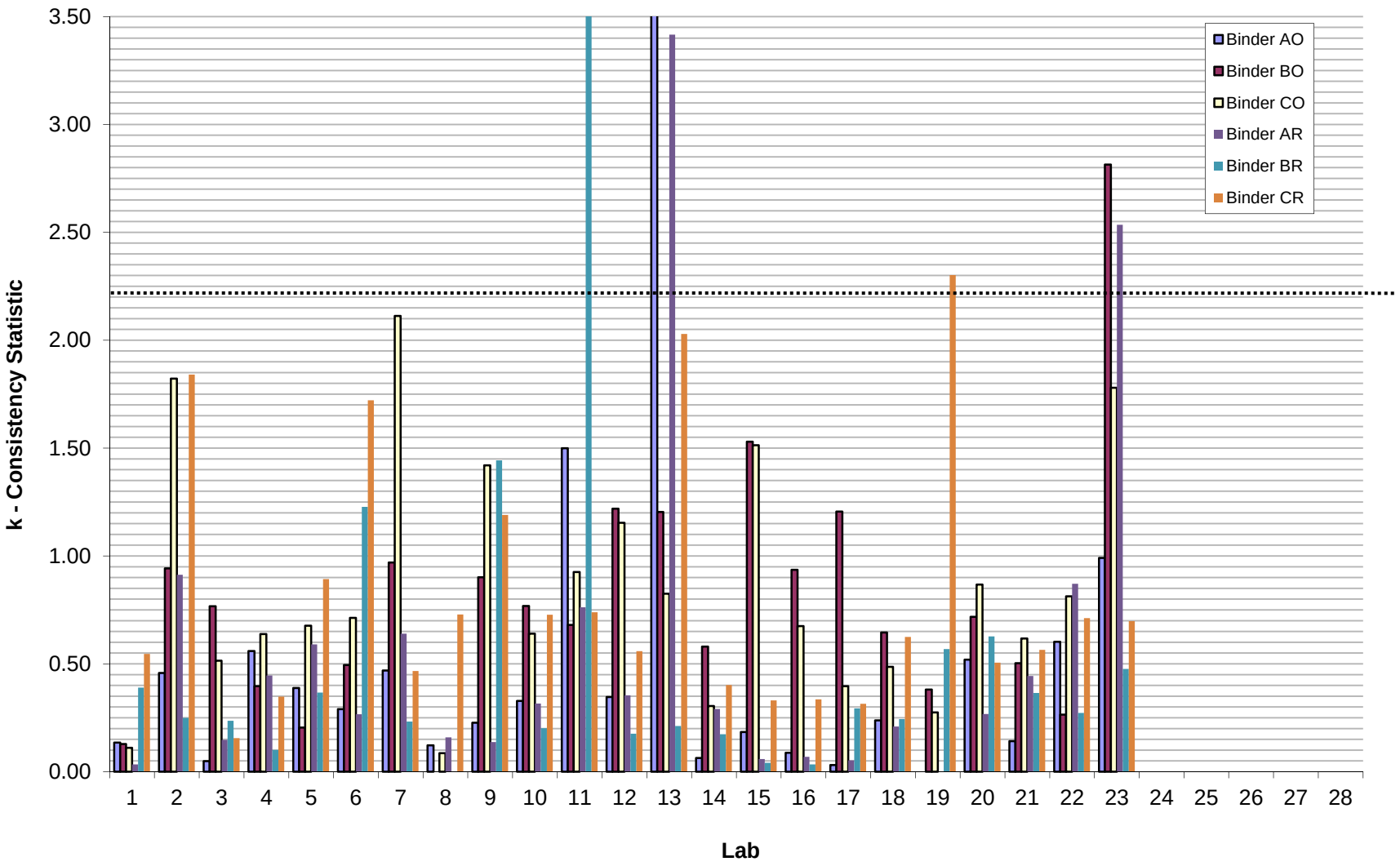
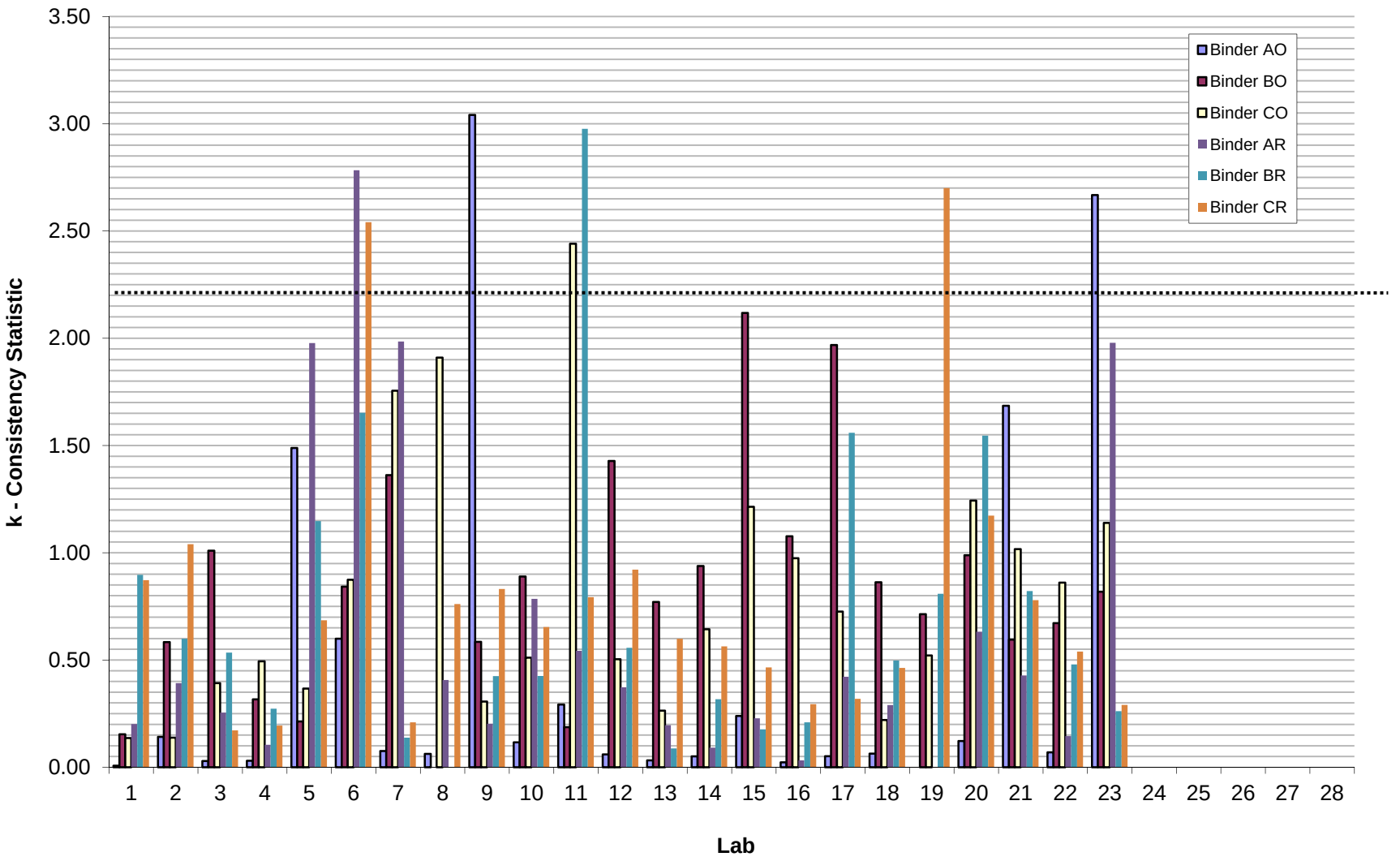
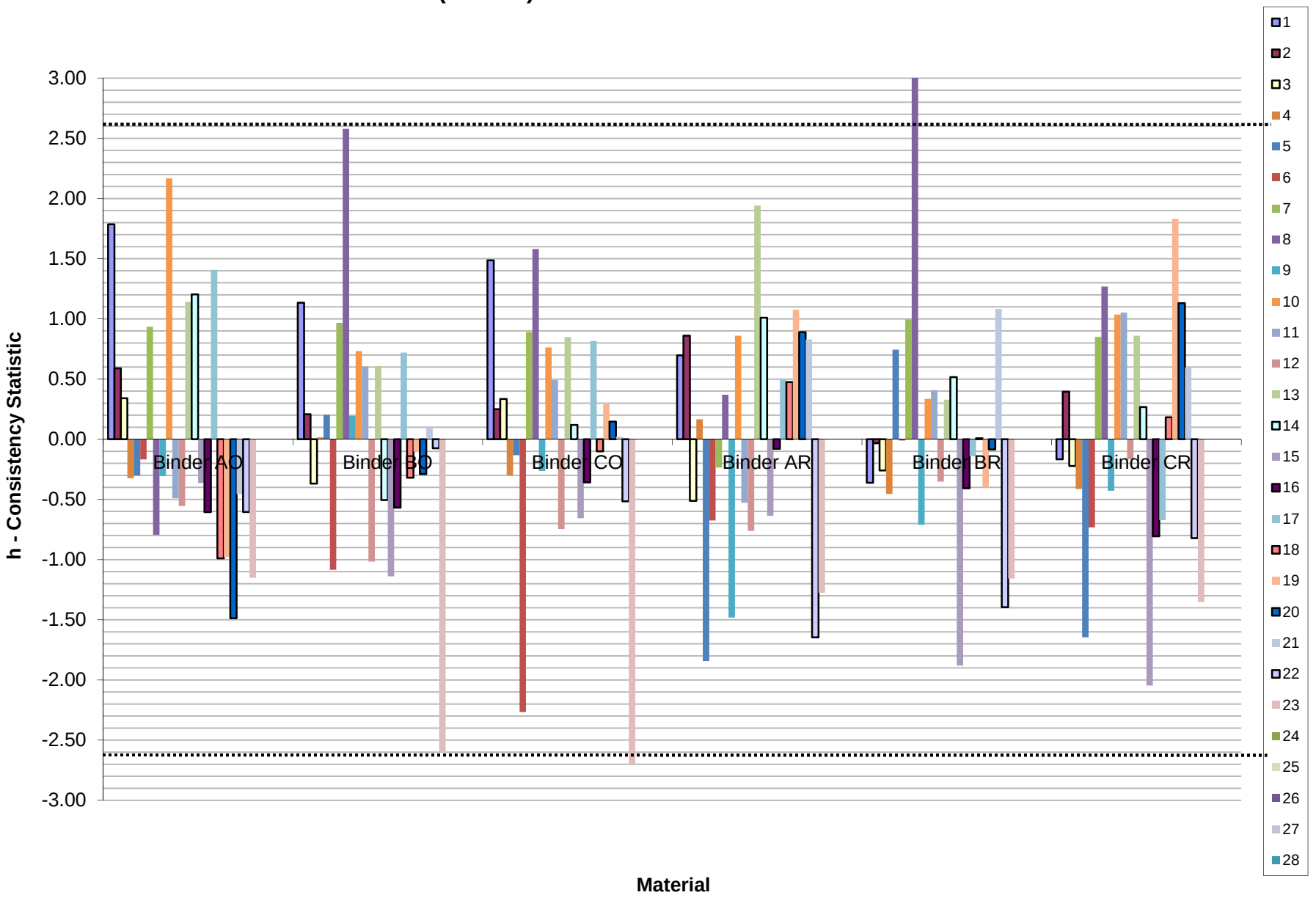
Recovery (0.1 kPa): k - Materials within Laboratories



Recovery (3.2 kPa): k - Materials within Laboratories




Jnr (0.1 kPa): h - Laboratories within Materials
h - Consistency Statistic
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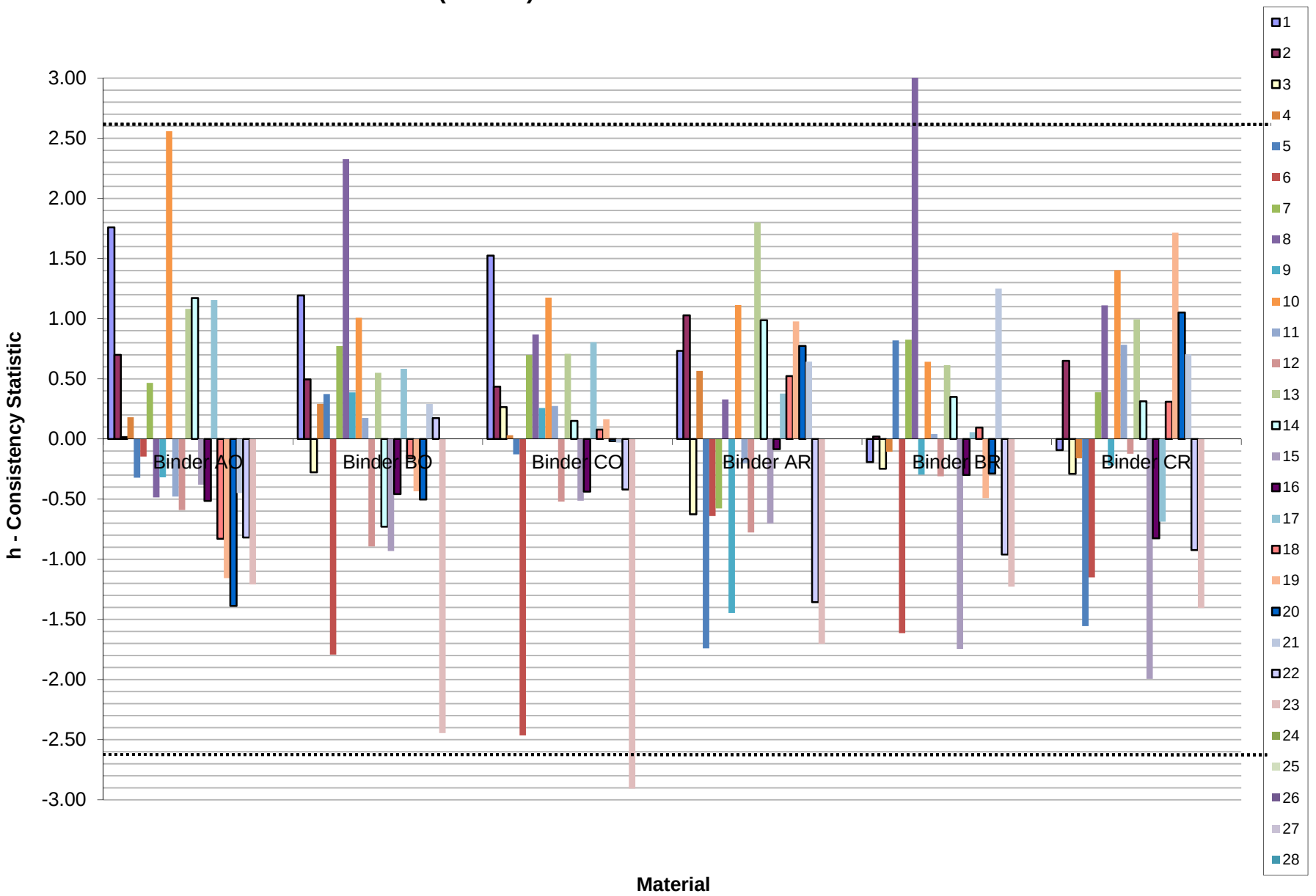
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h - Consistency Statistic
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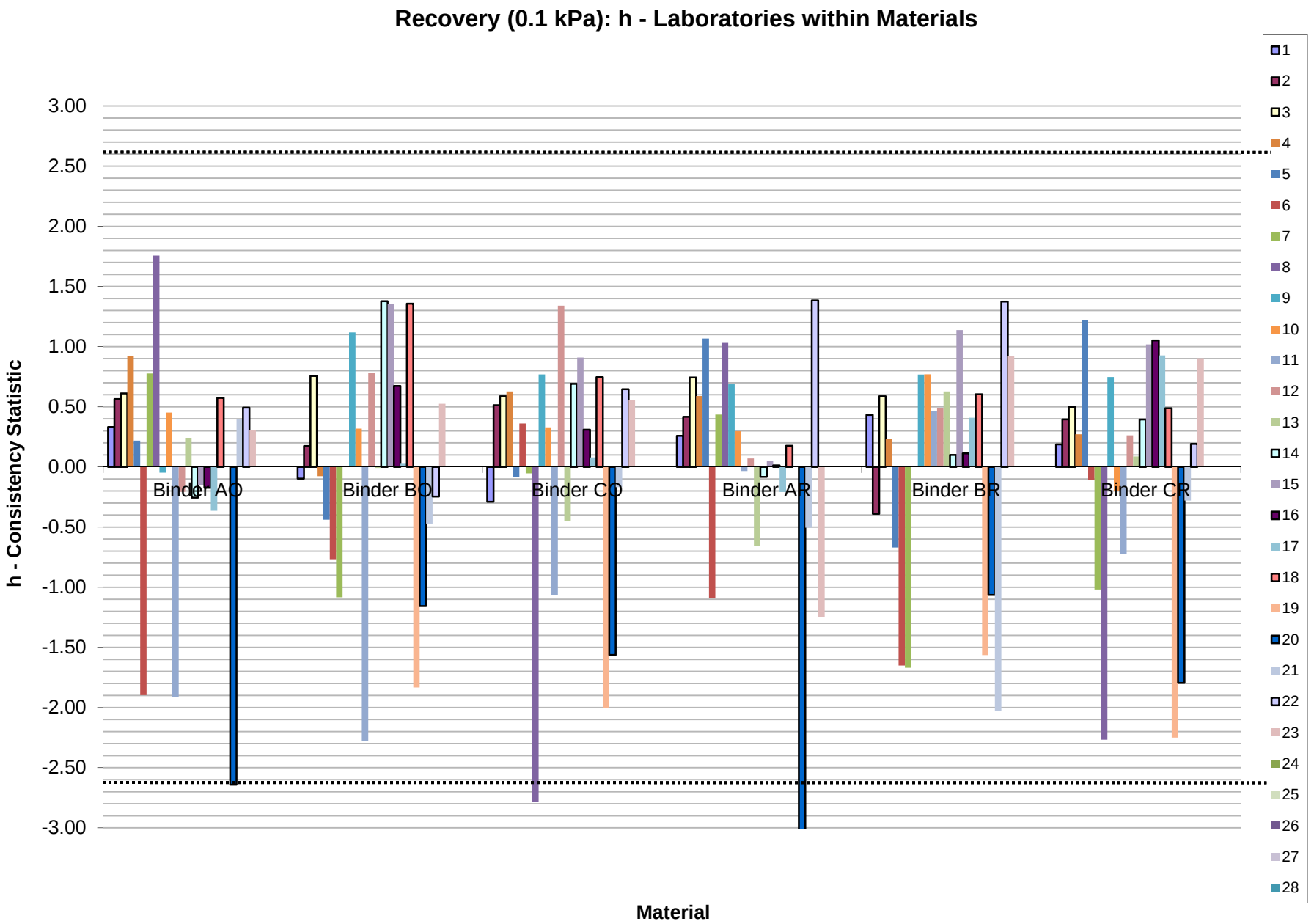
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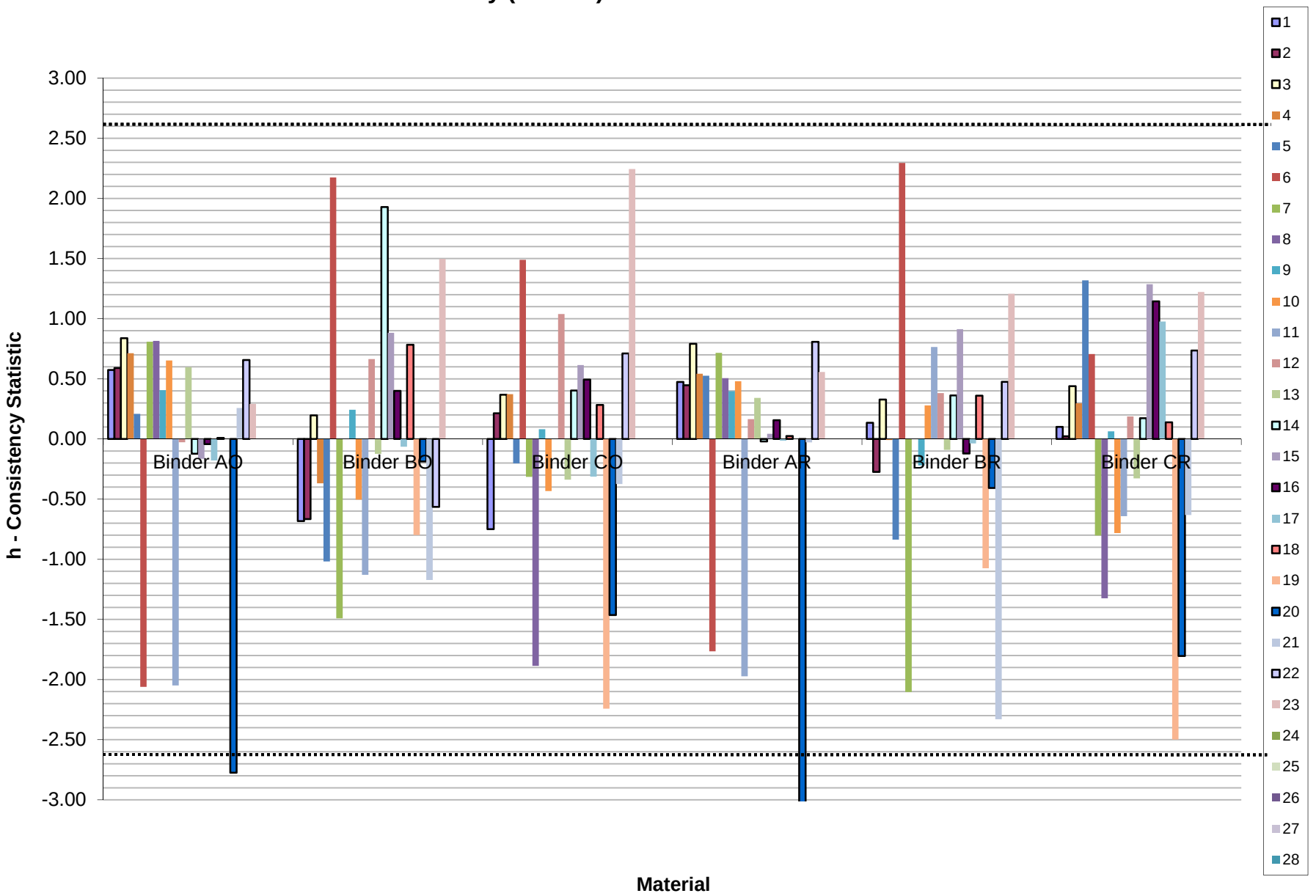
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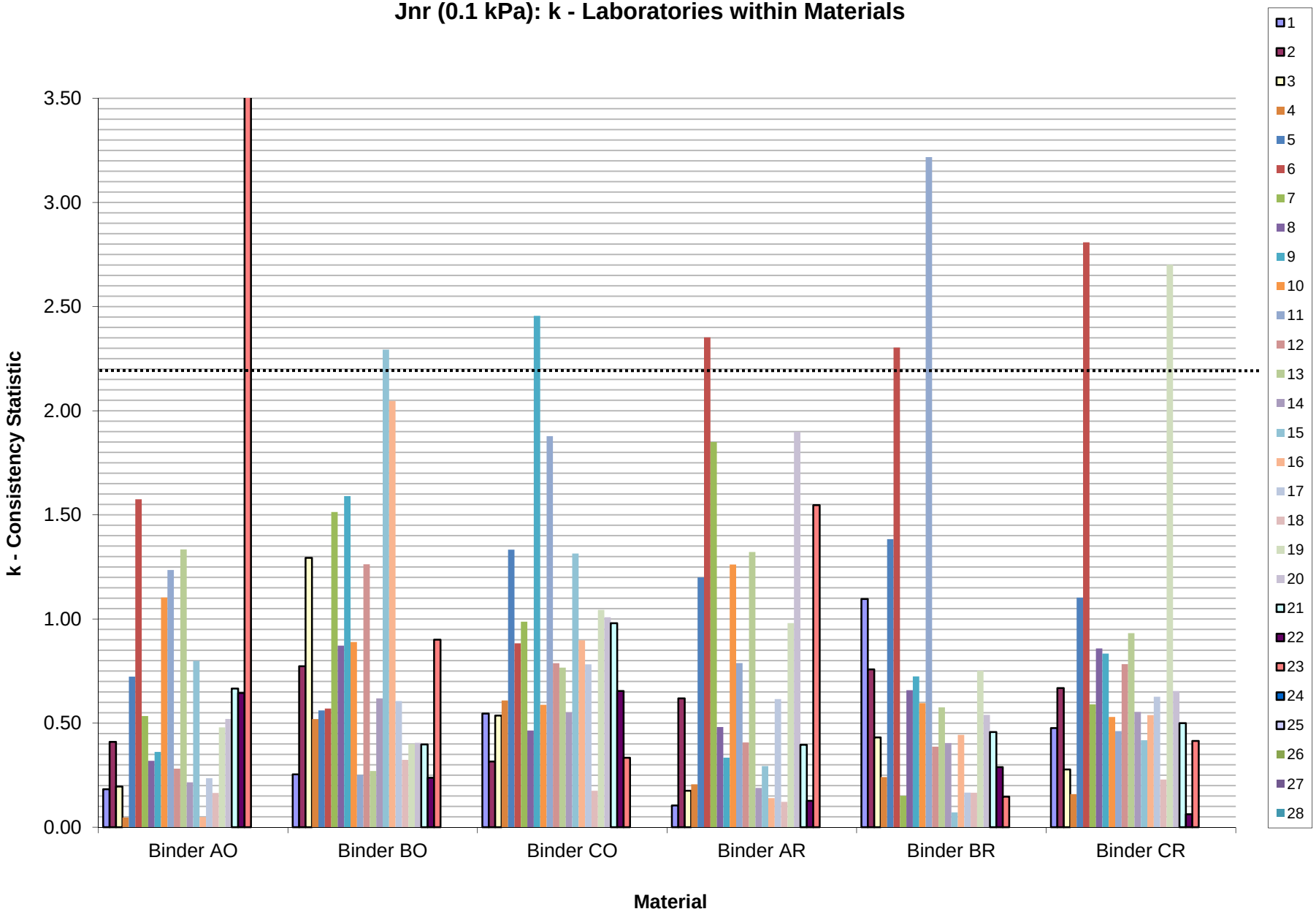
Jnr (0.1 kPa): k - Laboratories within Materials
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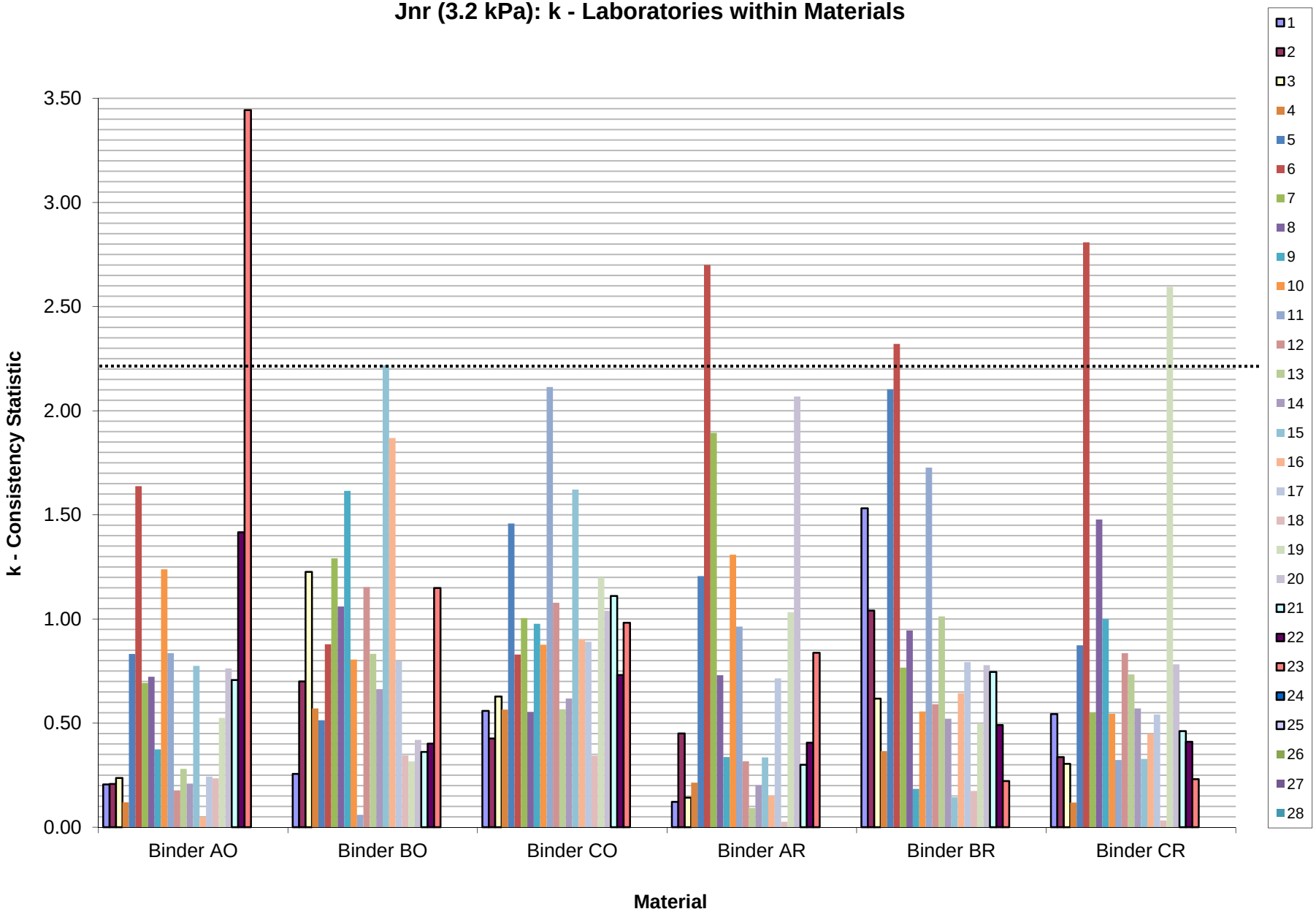
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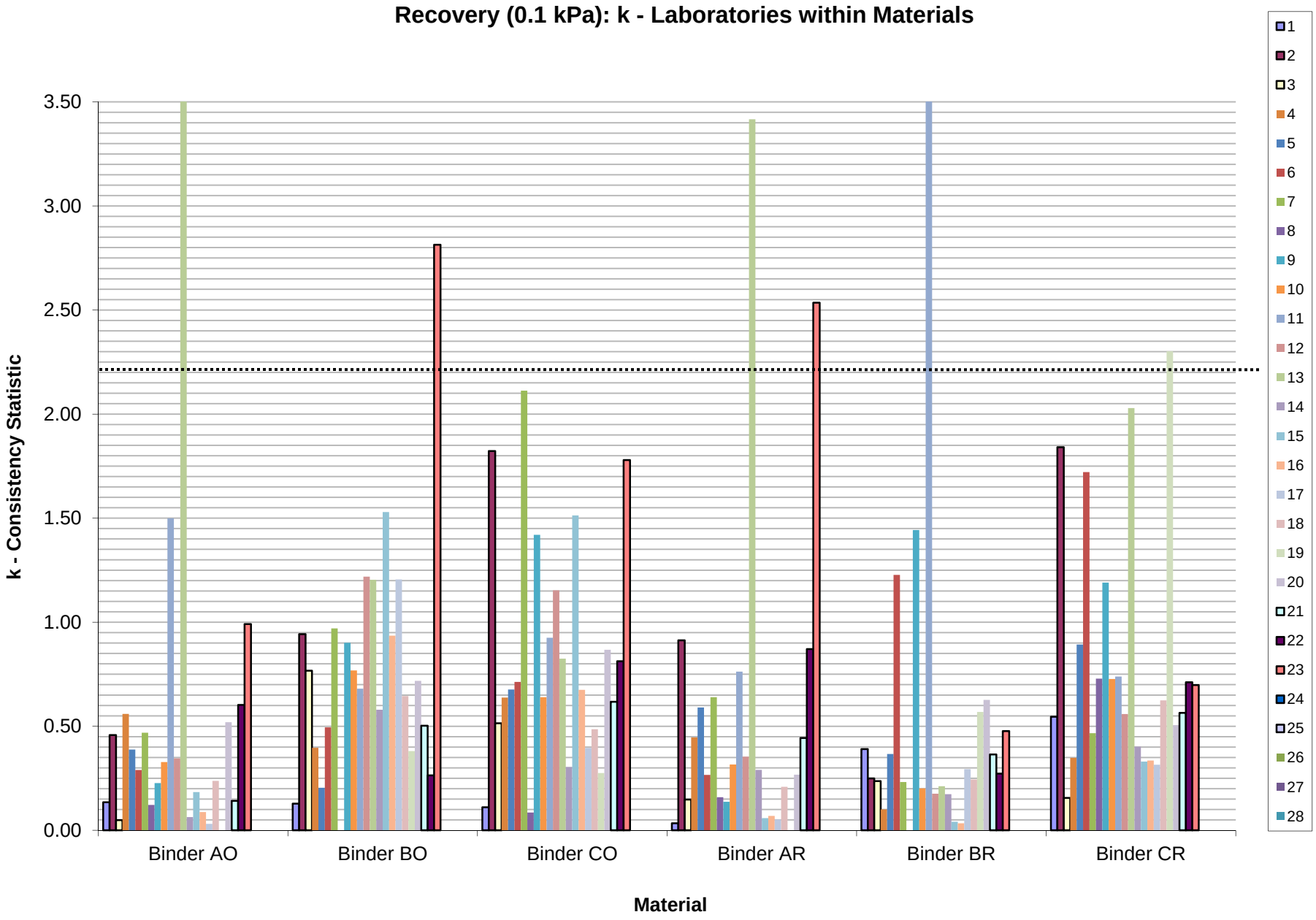
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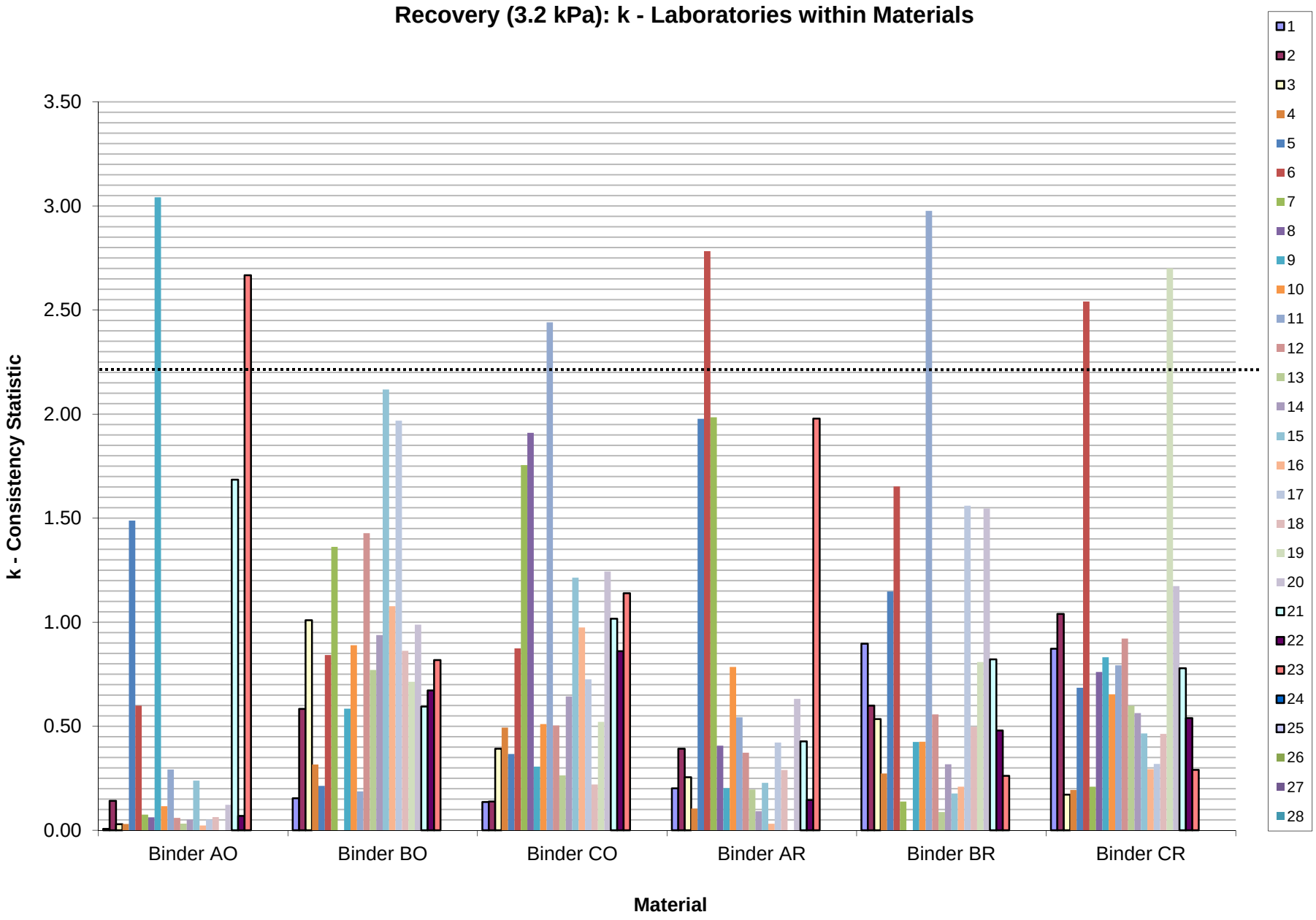
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k - Consistency Statistic
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