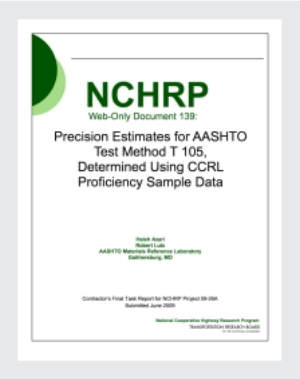

Precision Estimates for AASHTO Test Method T 105, Determined Using CCRL Proficiency Sample Data

DETAILS

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CHAPTER 1. INTRODUCTION AND RESEARCH APPROACH

1.1 INTRODUCTION

Under National Cooperative Highway Research Programs (NCHRP) Project 9-26, the AASHTO Materials Reference Laboratory (AMRL) is conducting a multi-phase research project to improve estimates of precision in AASHTO test methods for various highway construction materials. The report from Phase 1 of Project 9-26 includes precision estimates of selected volumetric properties of HMA using non-absorptive aggregates [1]. The report from Phase 2 discusses the results of an investigation into the cause of variations in HMA bulk specific gravity test results using non-absorptive aggregates [2]. The report from Phase 3 includes a robust technique developed by AMRL for analyzing proficiency sample data for the purpose of obtaining reliable single-operator and multilaboratory estimates of precision [3]. The report from phase 4 includes two parts. Part one covers the precision estimates of selected volumetric properties of HMA using absorptive aggregates. Part two of the report investigates the effect of aging period on the volumetric properties of the absorptive aggregates [4]. The report from Phase 5 includes update of precision estimates for AASHTO Standard Test Method T 269 [5].

This report includes the results for Part 3 of the 3 in Task 1 of NCHRP 9-26 where data from the CCRL Proficiency Sample Program (PSP) collected from the state laboratories are used to update precision estimates for AASHTO Standard Test Method T 105, "Chemical Analysis of Hydraulic Cement" [6].

Data used in this study are from the chemical analysis of hydraulic cement samples that were sent to the state laboratories participating in the CCRL Proficiency Program. The laboratories receive annual or biannual shipments of CCRL paired proficiency samples, which are tested according to specified ASTM test methods [7]. The hydraulic cement samples for the chemical analysis were prepared and tested according to the methods explained in ASTM C 114 [8]. The data from 14 chemical components were analyzed and are provided in this report. The proficiency samples included in these programs cover a wide range of test values and cement types.

The technique developed by AMRL in Phase 3 was utilized for analyzing proficiency sample data. This technique is a four step methodology for shaving off extraneous results and analyzing the core data of a paired data set. The results of the analysis of the "core data" can then be used to obtain reliable single-operator and multilaboratory estimates of precision.

The precision statement for Chemical Analysis of Hydraulic Cement Test Method in this study resulted from analysis of 107 paired data sets from 14 chemical tests on seven shipments of CCRL paired proficiency samples. Only the most recent proficiency samples were used in order to account for changes in test precision resulting from recent improvements in the test methods.

1.1.1 Problem Statement

AASHTO Standard Test Methods applicable to highway materials require periodic studies to determine estimates of precision. Some precision estimates become outdated as a result of improvements in the methods while other estimates need to be verified to see if they are still accurate. Some test methods need to be expanded to take into account a wider range of materials while other newer test methods may not have precision estimates of any kind.

AASHTO T 105 covers the test methods for chemical analysis of hydraulic cements. Although a set of specific chemical test methods are suggested in T 105, any test method of demonstrated acceptable precision and bias may be used for the analysis of hydraulic cements. To ensure the reliability of the user selected test methods, it is important that the precision estimates of T 105 are updated. The precision estimates also need to be expanded to include chemical components that are not included in AASHTO T 105-06 but are frequently measured by in state and private laboratories.

1.1.2 Research Objectives

The objective of this study as Part 3 of the 3 in task 1 of NCHRP 9-26A study is to verify, update, and expand single-operator and multilaboratory precision estimates for the AASHTO T 105, "Standard Method of Test for Chemical Analysis of Hydraulic Cement." Only the most recent CCRL proficiency cement samples that were tested according to the latest version of the test method will be analyzed.

1.2 SCOPE OF STUDY

This work is limited to an evaluation of the data collected from the laboratories participating in the chemical analysis of hydraulic cement for the CCRL proficiency sample program. There are a total of 107 data sets analyzed and included in this report. The resulting precision estimates will reflect a wide range of test values and cement types that are included in the scope of the CCRL Proficiency Sample Program.

1.3 PROFICIENCY SAMPLES USED IN STUDY

Included in the study are the most recent CCRL proficiency samples that were tested in accordance to AASHTO T 105-06 (ASTM C 114-05), "Standard Test Method for Chemical Analysis of Hydraulic Cement." The various cement types included in the study are Type I and Type I/II with and without limestone and Type V with limestone. Table 1-1 provides the sample designation and sample type of the CCRL cement samples and the date of the final report on the chemical analysis of the samples.

Table 1-1- Sample Designation and Date of Final Report of Proficiency Samples

Sample Designation	Cement Type	Date of Final Report
147 & 148	Type I/II	March-03
149 & 150	Type I	September-03
151 & 152	Type I	April-04
153 & 154	Type I	October-04
155 & 156	Type I	April -05
157 & 158	Type V w/ limestone (157) & Type I/II w/ limestone (158)	October-05
159 & 160	Type I w/ limestone (159) & Type I/II w/ limestone (160)	April-06
161 & 162	Type I (161) & Type I w/ limestone (162)	October-06
163 & 164	Type I (163) & Type I / II (164)	April-07
165 & 166	Type I /II w/ limestone	September-07

CHAPTER 2. RESULTS OF ANALYSIS AND ESTIMATES OF PRECISION

2.1 TEST DATA

The test data analyzed in this study are the percentages of 14 chemical components of hydraulic cement. Table 2-1 provides the list of components and the number of data sets used for precision estimate determination of each component. To capture the recent advancement in chemical analysis of hydraulic cement, only the most recent sets of CCRL data were analyzed. As indicated from the table, in most cases 8 sets of data were available for each component. The number of data sets that have been analyzed comes to a total of 107. The results of analysis of each data set can be found in Appendices A through N. This chapter includes summaries of the data and the resulting precision estimates.

Table 2-1- Chemical Components and Number of Data Sets Analyzed

Number	Chemical Components	Number of Data Sets Analyzed
1	SiO_2 (silicon dioxide)	8
2	Al_2O_3 (aluminum oxide)	8
3	Fe_2O_3 (ferric oxide)	8
4	CaO (calcium oxide)	8
5	MgO (magnesium oxide)	8
6	SO_3 (sulfur trioxide)	8
7	LOI (loss on ignition)	8
8	Na_2O (sodium oxide)	10
9	K_2O (potassium oxide)	8
10	TiO_2 (titanium dioxide)	8
11	Cl (chloride)	8
12	IR (insoluble residue)	8
13	Cx (free calcium oxide)	6
14	CO_2 (carbon dioxide)	3

2.2 ANALYSIS OF THE DATA

Several sets of chemical analysis data of 14 chemical components of hydraulic cement were included in the precision estimate determination for AASHTO T 105. Table 2-2 through Table 2-15 provide the results of the analyses. Precision estimates are based, where appropriate, on either the coefficients of variation (CV%) or the pooled standard deviation (1s) values.

2.2.1 Silicon Dioxide (SiO_2)

There were 8 sets of percent Silicon Dioxide (SiO_2) data included in the precision estimate determination of AASHTO T 105. The results from analyzing the data are found in Table 2-2 and Appendix A. A review of the data shown in Table 2-2 indicates that there are no specific trends between the averages and standard deviations of SiO_2 measurements; therefore, the form of the precision estimates should be based on the sample standard deviation. The pooled repeatability sample standard deviation for the eight pairs of samples analyzed is 0.119 percent. The corresponding pooled reproducibility sample standard deviation is 0.196 percent. The pooled estimates are derived using the following equation from Ku [9]:

$$s_p = \sqrt{\frac{(n_1 - 1)s_1^2 + (n_2 - 1)s_2^2 + ... + (n_k - 1)s_k^2}{n_1 + n_2 + ... + n_k - k}} \qquad \text{(Equation 1)}$$

Where:

s_p = pooled standard deviation

s_k = k^{th} standard deviation

n_k = number of laboratories analyzed resulting in k^{th} standard deviation

Table 2-2- Summary of Statistics for % Silicon Dioxide (SiO_2)

Sample Number	No. of Labs	Average Results		Repeatability			Reproducibility		Reproducibility	
		Odd Samples	Even Samples	1s	Odd Samples	Even Samples	Odd Samples	Odd Samples	Even Samples	Even Samples
					CV%	CV%	1s	CV%	1s	CV%
147 & 148	141	19.66	20.24	0.100	0.5	0.5	0.180	0.9	0.140	0.7
149 & 150	154	20.15	20.70	0.090	0.4	0.4	0.200	1.0	0.170	0.8
153 & 154	207	20.87	22.13	0.100	0.5	0.4	0.160	0.8	0.190	0.8
157 & 158	208	21.11	20.84	0.130	0.6	0.6	0.210	1.0	0.220	1.1
159 & 160	209	20.02	20.51	0.100	0.5	0.5	0.210	1.1	0.210	1.0
161 & 162	218	20.38	20.34	0.100	0.5	0.5	0.180	0.9	0.190	0.9
163 & 164	212	20.58	20.20	0.131	0.6	0.6	0.217	1.1	0.182	0.9
165 & 166	221	20.63	19.03	0.164	0.8	0.9	0.201	1.0	0.230	1.2

2.2.2 Aluminum Oxide (Al_2O_3)

There were 8 sets of percent Aluminum Oxide (Al_2O_3) data included in the precision estimate determination of AASHTO T 105. The results from analyzing the data are found in Table 2-3 and Appendix B. A review of the data shown in Table 2-3 indicates that there are no specific trends between the averages and standard deviations of Al_2O_3 measurements; therefore, the form of the precision estimates should be based on the

sample standard deviation. The pooled repeatability sample standard deviation for the eight pairs of samples analyzed is 0.073 percent. The corresponding pooled reproducibility sample standard deviation is 0.110 percent. The pooled estimates are derived using Equation 1.

Table 2-3- Summary of Statistics for % Aluminum Oxide (Al_2O_3)

Sample Number	No. of Labs	Average Results		Repeatability			Reproducibility		Reproducibility	
		Odd Samples	Even Samples	1s	Odd Samples CV%	Even Samples CV%	Odd Samples 1s	Odd Samples CV%	Even Samples 1s	Even Samples CV%
147 & 148	126	4.32	4.79	0.060	1.4	1.3	0.130	2.9	0.130	2.6
149 & 150	144	4.98	4.64	0.050	1.0	1.0	0.160	3.3	0.140	3.1
153 & 154	199	5.02	3.46	0.070	1.3	1.9	0.100	2.1	0.100	3.0
157 & 158	210	3.73	3.99	0.080	2.0	1.9	0.100	2.6	0.130	3.4
159 & 160	196	5.11	5.12	0.050	1.0	1.0	0.100	1.9	0.100	1.9
161 & 162	203	5.18	4.75	0.040	0.9	0.9	0.080	1.6	0.070	1.5
163 & 164	208	4.93	5.13	0.077	1.6	1.5	0.108	2.2	0.092	1.8
165 & 166	218	4.49	5.26	0.114	2.54	2.2	0.082	1.8	0.141	2.7

2.2.3 Ferric Oxide (Fe_2O_3)

There were 8 sets of percent Ferric Oxide (Fe_2O_3) data included in the precision estimate determination of AASHTO T 105. The results from analyzing the data are found in Table 2-4 and Appendix C. A review of the data shown in Table 2-4 indicates that there are no trends between the averages and standard deviations of Fe_2O_3 measurements; therefore, the form of the precision estimates should be based on the sample standard deviation. The pooled repeatability sample standard deviation for the eight pairs of samples analyzed is 0.029 percent. The corresponding pooled reproducibility sample standard deviation is 0.051 percent. The pooled estimates are derived using Equation 1.

Table 2-4- Summary of Statistics for % Ferric Oxide (Fe_2O_3)

Sample Number	No. of Labs	Average Results		Repeatability			Reproducibility		Reproducibility	
		Odd Samples	Even Samples	1s	Odd Samples CV%	Even Samples CV%	Odd Samples 1s	Odd Samples CV%	Even Samples 1s	Even Samples CV%
147 & 148	143	3.26	3.16	0.027	0.8	0.9	0.051	1.6	0.050	1.6
149 & 150	156	3.03	3.19	0.029	0.9	0.9	0.047	1.6	0.050	1.6
153 & 154	194	3.45	2.91	0.020	0.6	0.7	0.044	1.3	0.039	1.3
157 & 158	211	3.37	3.00	0.022	0.7	0.7	0.065	1.9	0.060	2.0
159 & 160	198	1.99	3.62	0.031	1.6	0.9	0.039	2.0	0.053	1.5
161 & 162	217	3.66	3.53	0.032	0.9	0.9	0.057	1.6	0.055	1.6
163 & 164	208	2.75	4.24	0.037	1.4	0.9	0.041	1.5	0.066	1.5
165 & 166	219	2.90	2.38	0.026	0.89	1.1	0.042	1.5	0.046	1.9

2.2.4 Calcium Oxide (CaO)

There were 8 sets of percent Calcium Oxide (CaO) data included in the precision estimate determination of AASHTO T 105. The results from analyzing the data are found in Table 2-5 and Appendix D. A review of the data shown in Table 2-5 indicates that there are no trends between the averages and standard deviations of CaO measurements; therefore, the form of the precision estimates should be based on the sample standard deviation. The pooled repeatability sample standard deviation for the eight pairs of samples analyzed is 0.199 percent. The corresponding pooled reproducibility sample standard deviation is 0.384 percent. The pooled estimates are derived using Equation 1.

Table 2-5- Summary of Statistics for % Calcium Oxide (CaO)

Sample Number	No. of Labs	Average Results		Repeatability			Reproducibility		Reproducibility	
		Odd Samples	Even Samples	1s	Odd Samples	Even Samples	Odd Samples	Odd Samples	Even Samples	Even Samples
					CV%	CV%	1s	CV%	1s	CV%
147 & 148	147	63.88	64.28	0.190	0.3	0.3	0.330	0.5	0.360	0.6
149 & 150	153	62.23	63.99	0.230	0.4	0.4	0.370	0.6	0.350	0.5
153 & 154	208	63.71	63.57	0.170	0.3	0.3	0.330	0.5	0.330	0.5
157 & 158	205	63.49	64.96	0.160	0.3	0.2	0.520	0.8	0.490	0.8
159 & 160	203	64.34	62.90	0.160	0.3	0.3	0.390	0.6	0.390	0.6
161 & 162	215	63.91	61.88	0.220	0.4	0.4	0.370	0.6	0.430	0.7
163 & 164	210	63.98	63.68	0.212	0.3	0.3	0.337	0.5	0.345	0.5
165 & 166	217	62.63	63.47	0.236	0.4	0.4	0.327	0.5	0.390	0.6

2.2.5 Magnesium Oxide (MgO)

There were 8 sets of percent Magnesium Oxide (MgO) data included in the precision estimate determination of AASHTO T 105. The results from analyzing of hydraulic cement are found in Table 2-6 and Appendix E. A review of the data shown in Table 2-6 indicates that there are no trends between the averages and standard deviations of MgO measurements; therefore, the form of the precision estimates should be based on the sample standard deviation. The pooled repeatability sample standard deviation for the eight pairs of samples analyzed is 0.049 percent. The corresponding pooled reproducibility sample standard deviation is 0.070 percent. The pooled estimates are derived using Equation 1.

Table 2-6- Summary of Statistics for % Magnesium Oxide (MgO)

Sample Number	No. of Labs	Average Results		Repeatability			Reproducibility		Reproducibility	
		Odd Samples	Even Samples	1s	Odd Samples CV%	Even Samples CV%	Odd Samples 1s	Odd Samples CV%	Even Samples 1s	Even Samples CV%
147 & 148	140	3.50	1.35	0.070	2.0	5.2	0.090	2.7	0.070	5.5
149 & 150	160	2.46	2.21	0.040	1.5	1.7	0.110	4.3	0.090	4.3
153 & 154	198	1.18	2.37	0.040	3.4	1.7	0.050	3.9	0.060	2.4
157 & 158	200	2.53	1.66	0.050	2.0	3.1	0.090	3.5	0.060	3.8
159 & 160	197	1.27	0.92	0.020	2.0	2.7	0.050	4.0	0.060	6.0
161 & 162	206	1.17	3.55	0.060	5.5	1.8	0.050	4.0	0.090	2.4
163 & 164	203	1.87	1.07	0.038	2.0	3.6	0.052	2.8	0.053	4.9
165 & 166	210	2.60	2.08	0.058	2.23	2.8	0.071	2.7	0.054	2.6

2.2.6 Sulfur Trioxide (SO_3)

There were 8 sets of percent Sulfur Trioxide (SO_3) data included in the precision estimate determination of AASHTO T 105. The results from analyzing the data are found in Table 2-7 and Appendix F. A review of the data shown in Table 2-7 indicates that there are no trends between the averages and standard deviations of SO_3 measurements; therefore, the form of the precision estimates should be based on the sample standard deviation. The pooled repeatability sample standard deviation for the eight pairs of samples analyzed is 0.047 percent. The corresponding pooled reproducibility sample standard deviation is 0.076 percent. The pooled estimates are derived using Equation 1.

Table 2-7- Summary of Statistics for % Sulfur Trioxide (SO_3)

Sample Number	No. of Labs	Average Results		Repeatability			Reproducibility		Reproducibility	
		Odd Samples	Even Samples	1s	Odd Samples CV%	Even Samples CV%	Odd Samples 1s	Odd Samples CV%	Even Samples 1s	Even Samples CV%
147 & 148	153	2.60	2.90	0.050	2.0	1.8	0.070	2.9	0.080	2.8
149 & 150	160	3.48	2.37	0.040	1.3	1.8	0.080	2.3	0.060	2.7
153 & 154	206	2.78	2.73	0.050	1.6	1.7	0.070	2.7	0.070	2.6
157 & 158	200	2.22	2.35	0.030	1.2	1.1	0.070	3.0	0.070	3.1
159 & 160	199	3.68	3.16	0.040	1.2	1.4	0.100	2.6	0.070	2.3
161 & 162	213	2.73	3.00	0.050	1.8	1.7	0.060	2.3	0.080	2.5
163 & 164	211	2.88	3.58	0.051	1.8	1.4	0.070	2.4	0.082	2.3
165 & 166	213	3.23	3.68	0.055	1.69	1.5	0.080	2.5	0.091	2.5

2.2.7 Loss on Ignition (LOI)

There were 8 sets of percent Loss on Ignition (LOI) data included in the precision estimate determination of AASHTO T 105. The results from analyzing the data are found in Table 2-8 and Appendix G. A review of the data shown in Table 2-8 indicates that there are no trends between the averages and standard deviations of LOI measurements; therefore, the form of the precision estimates should be based on the sample standard deviation. The pooled repeatability sample standard deviation for the eight pairs of samples analyzed is 0.055 percent. The corresponding pooled reproducibility sample standard deviation is 0.085 percent. The pooled estimates are derived using Equation 1.

Table 2-8- Summary of Statistics for % Loss on Ignition (LOI)

Sample Number	No. of Labs	Average Results		Repeatability			Reproducibility		Reproducibility	
		Odd Samples	Even Samples	1s	Odd Samples	Even Samples	Odd Samples	Odd Samples	Even Samples	Even Samples
					CV%	CV%	1s	CV%	1s	CV%
147 & 148	177	1.61	1.63	0.040	2.2	2.2	0.060	3.9	0.060	3.9
149 & 150	179	1.98	1.66	0.070	3.4	4.1	0.090	4.4	0.080	4.7
153 & 154	199	2.00	1.80	0.050	2.7	3.0	0.080	4.2	0.090	5.0
157 & 158	209	2.91	2.70	0.070	2.3	2.5	0.110	3.8	0.110	4.1
159 & 160	204	2.65	2.48	0.040	1.6	1.7	0.070	2.5	0.070	3.0
161 & 162	213	1.67	2.00	0.060	3.6	3.0	0.080	4.8	0.090	4.4
163 & 164	204	1.43	1.08	0.040	2.8	3.7	0.063	4.4	0.057	5.3
165 & 166	220	2.13	2.39	0.056	2.63	2.4	0.097	4.5	0.110	4.6

2.2.8 Sodium Oxide (Na_2O)

There were 10 sets of percent sodium oxide (Na_2O) data included in the precision estimate determination of AASHTO T 105. The results from analyzing the data are found in Table 2-9 and Appendix H. A review of the data shown in Table 2-9 indicates that there are no trends between the averages and standard deviations of Na_2O measurements; therefore, the form of the precision estimates should be based on the sample standard deviation. The pooled repeatability sample standard deviation for the ten pairs of samples analyzed is 0.013 percent. The corresponding pooled reproducibility sample standard deviation is 0.024 percent. The pooled estimates are derived using Equation 1.

Table 2-9- Summary of Statistics for % Sodium Oxide (Na_2O)

Sample Number	No. of Labs	Average Results		Repeatability			Reproducibility		Reproducibility	
		Odd Samples	Even Samples	1s	Odd Samples	Even Samples	Odd Samples	Odd Samples	Even Samples	Even Samples
					CV%	CV%	1s	CV%	1s	CV%
147 & 148	120	0.13	0.13	0.015	11.49	11.6	0.020	15.7	0.018	13.8
149 & 150	132	0.32	0.07	0.022	6.94	33.7	0.031	9.8	0.024	35.6
151 & 152	141	0.27	0.19	0.012	4.53	6.5	0.025	9.2	0.022	11.5
153 & 154	191	0.11	0.11	0.009	7.77	7.8	0.022	19.8	0.024	21.3
155 & 156	200	0.08	0.14	0.012	15.00	8.9	0.025	29.7	0.026	18.9
157 & 158	195	0.21	0.11	0.014	6.65	12.5	0.031	14.3	0.026	22.8
159 & 160	184	0.12	0.06	0.008	7.04	13.6	0.021	17.8	0.021	34.6
161 & 162	193	0.09	0.13	0.012	12.45	9.1	0.023	24.4	0.022	17.5
163 & 164	199	0.20	0.06	0.015	7.78	27.0	0.021	10.9	0.019	34.2
165 & 166	205	0.16	0.16	0.007	4.60	4.7	0.023	14.6	0.024	15.4

2.2.9 Potassium Oxide (K_2O)

There were 8 sets of percent Potassium Oxide (K_2O) data included in the precision estimate determination of AASHTO T 105. The results from analyzing the data are found in Table 2-10 and Appendix I. A review of the data shown in Table 2-10 indicates that there are no trends between the averages and standard deviations of K_2O measurements; therefore, the form of the precision estimates should be based on the sample standard deviation. The pooled repeatability sample standard deviation for the eight pairs of samples analyzed is 0.009 percent. The corresponding pooled reproducibility sample standard deviation is 0.016 percent. The pooled estimates are derived using Equation 1.

Table 2-10- Summary of Statistics for % Potassium Oxide (K_2O)

Sample Number	No. of Labs	Average Results		Repeatability			Reproducibility		Reproducibility	
		Odd Samples	Even Samples	1s	Odd Samples	Even Samples	Odd Samples	Odd Samples	Even Samples	Even Samples
					CV%	CV%	1s	CV%	1s	CV%
147 & 148	114	0.69	0.82	0.008	1.2	1.0	0.016	2.4	0.017	2.1
149 & 150	128	0.83	0.69	0.009	1.2	1.4	0.019	2.3	0.019	2.7
153 & 154	195	0.42	0.69	0.010	3.1	1.9	0.015	3.5	0.021	3.0
157 & 158	186	0.47	0.31	0.000	1.5	2.2	0.014	3.0	0.012	4.0
159 & 160	188	0.51	0.75	0.007	1.3	0.9	0.012	2.4	0.015	2.0
161 & 162	180	0.63	0.53	0.007	1.1	1.3	0.011	1.7	0.011	2.1
163 & 164	195	0.68	0.38	0.009	1.3	2.3	0.015	2.2	0.013	3.3
165 & 166	197	0.73	1.17	0.014	2.0	1.22	0.017	2.3	0.025	2.1

2.2.10 Titanium Dioxide (TiO_2)

There were 8 sets of percent Titanium Dioxide (TiO_2) data included in the precision estimate determination of AASHTO T 105. The results from analyzing the data are found in Table 2-11 and Appendix J. A review of the data shown in Table 2-11 indicates that there are no trends between the averages and standard deviations of TiO_2 measurements; therefore, the form of the precision estimates should be based on the sample standard deviation. The pooled repeatability sample standard deviation for the eight pairs of samples analyzed is 0.005 percent. The corresponding pooled reproducibility sample standard deviation is 0.007 percent. The pooled estimates are derived using Equation 1.

Table 2-11- Summary of Statistics for % Titanium Dioxide (TiO_2)

Sample Number	No. of Labs	Average Results		Repeatability			Reproducibility		Reproducibility	
		Odd Samples	Even Samples	1s	Odd Samples	Even Samples	Odd Samples	Odd Samples	Even Samples	Even Samples
					CV%	CV%	1s	CV%	1s	CV%
147 & 148	71	0.25	0.23	0.003	1.3	1.4	0.008	3.3	0.008	3.4
149 & 150	88	0.21	0.30	0.008	3.7	2.6	0.006	3.0	0.009	3.1
153 & 154	139	0.26	0.16	0.006	2.4	3.9	0.008	3.1	0.007	4.1
157 & 158	116	0.17	0.22	0.005	2.7	2.1	0.007	3.9	0.004	1.9
159 & 160	143	0.26	0.23	0.006	2.2	2.5	0.009	3.4	0.007	3.1
161 & 162	116	0.23	0.25	0.003	1.2	1.1	0.005	2.0	0.005	2.1
163 & 164	126	0.30	0.33	0.004	1.2	1.1	0.009	3.1	0.010	2.9
165 & 166	143	0.23	0.22	0.003	1.40	1.44	0.006	2.7	0.006	2.9

2.2.11 Chloride (Cl)

There were 5 sets of percent Chloride (Cl) data included in the precision estimate determination of AASHTO T 105. The results from analyzing the data are found in Table 2-12 and Appendix K. A review of the data shown in Table 2-12 indicates that there are no trends between the averages and standard deviations of Cl measurements; therefore, the form of the precision estimates should be based on the sample standard deviation. The pooled repeatability sample standard deviation for the five pairs of samples analyzed is 0.002 percent. The corresponding pooled reproducibility sample standard deviation is 0.004 percent. The pooled estimates are derived using Equation 1.

Table 2-12- Summary of Statistics for % Chloride (Cl)

Sample Number	No. of Labs	Average Results		Repeatability			Reproducibility		Reproducibility	
		Odd Samples	Even Samples	1s	Odd Samples	Even Samples	Odd Samples	Odd Samples	Even Samples	Even Samples
					CV%	CV%	1s	CV%	1s	CV%
157 & 158	66	0.009	0.003	0.003	33.39	105.2	0.004	52.3	0.003	116.8
159 & 160	76	0.004	0.005	0.002	42.27	28.8	0.003	82.0	0.003	61.1
161 & 162	90	0.017	0.009	0.003	20.29	39.9	0.007	43.9	0.005	58.7
163 & 164	80	0.005	0.004	0.001	24.18	30.6	0.003	48.5	0.003	60.9
165 & 166	82	0.011	0.009	0.001	13.75	16.5	0.005	42.9	0.004	40.6

2.2.12 Insoluble Residue (IR)

There were 8 sets of Insoluble Residue (IR) data included in the precision estimate determination of AASHTO T 105. The results from analyzing the data are found in Table 2-13 and Appendix L. A review of the data shown in Table 2-13 indicates that there are no trends between the averages and standard deviations of IR measurements; therefore, the form of the precision estimates should be based on the sample standard deviation. The pooled repeatability sample standard deviation for the eight pairs of samples analyzed is 0.048 percent. The corresponding pooled reproducibility sample standard deviation is 0.080 percent. The pooled estimates are derived using Equation 1.

Table 2-13- Summary of Statistics for % Insoluble Residue (IR)

Sample Number	No. of Labs	Average Results		Repeatability			Reproducibility		Reproducibility	
		Odd Samples	Even Samples	1s	Odd Samples	Even Samples	Odd Samples	Odd Samples	Even Samples	Even Samples
					CV%	CV%	1s	CV%	1s	CV%
147 & 148	160	0.20	0.33	0.040	19.1	11.7	0.060	28.4	0.070	20.5
149 & 150	166	0.19	0.17	0.040	20.3	22.4	0.068	35.5	0.071	40.9
153 & 154	175	0.23	0.54	0.060	25.4	11.1	0.080	33.3	0.090	17.0
157 & 158	179	0.50	0.31	0.050	10.0	16.4	0.090	18.5	0.090	28.5
159 & 160	189	0.23	0.23	0.040	19.0	18.9	0.070	32.5	0.080	35.7
161 & 162	197	0.52	0.47	0.051	9.9	10.9	0.096	18.7	0.088	18.8
163 & 164	198	0.23	0.18	0.042	18.4	23.6	0.078	34.2	0.075	42.2
165 & 166	202	0.45	0.16	0.055	12.19	33.7	0.086	19.0	0.075	45.6

2.2.13 Free Calcium Oxide

There were 8 sets of percent Free Calcium Oxide data included in the precision estimate determination of AASHTO T 105. The results from analyzing the data are found in Table 2-14 and Appendix M. A review of the data shown in Table 2-14 indicates that there are no trends between the averages and standard deviations of Free CaO measurements; therefore, form of the precision estimates should be based on the sample standard

deviation. The pooled repeatability sample standard deviation for the eight pairs of samples analyzed is 0.125 percent. The corresponding pooled reproducibility sample standard deviation is 0.214 percent. The pooled estimates are derived using Equation 1.

Table 2-14- Summary of Statistics for % Free Calcium Oxide (Free CaO)

Sample Number	No. of Labs	Average Results		Repeatability			Reproducibility		Reproducibility	
		Odd Samples	Even Samples	1s	Odd Samples	Even Samples	Odd Samples	Odd Samples	Even Samples	Even Samples
					CV%	CV%	1s	CV%	1s	CV%
147 & 148	147	1.22	1.84	0.200	17.4	11.5	0.260	21.2	0.440	24.1
149 & 150	140	0.64	1.45	0.130	20.4	9.0	0.140	22.5	0.240	16.6
153 & 154	160	1.15	0.76	0.100	8.4	12.8	0.220	19.2	0.160	21.5
157 & 158	162	1.12	0.46	0.140	12.2	29.4	0.220	19.7	0.150	31.7
159 & 160	159	1.07	1.13	0.080	7.6	7.2	0.170	15.7	0.190	16.7
161 & 162	167	1.43	0.50	0.150	10.5	30.1	0.250	17.7	0.160	31.4
163 & 164	170	0.64	0.60	0.070	10.9	11.6	0.134	20.9	0.147	24.5
165 & 166	180	0.77	0.97	0.088	11.54	9.08	0.174	22.7	0.217	22.2

2.2.14 Carbon Dioxide (CO_2)

There were 3 sets of percent Carbon Dioxide (CO_2) data included in the precision estimate determination of AASHTO T 105. The results from analyzing the data are found in Table 2-15 and Appendix N. A review of the data shown in Table 2-15 indicates that there are no trends between the averages and standard deviations of CO_2 measurements; therefore, the form of the precision estimates should be based on the sample standard deviation. The pooled repeatability sample standard deviation for three available pairs of samples analyzed is 0.083 percent. The corresponding pooled reproducibility sample standard deviation is 0.219 percent. The pooled estimates are derived using Equation 1.

Table 2-15- Summary of Statistics for % Carbon Dioxide (CO_2)

Sample Number	No. of Labs	Average Results		Repeatability			Reproducibility		Reproducibility	
		Odd Samples	Even Samples	1s	Odd Samples	Even Samples	Odd Samples	Odd Samples	Even Samples	Even Samples
					CV%	CV%	1s	CV%	1s	CV%
157 & 158	136	1.82	1.93	0.115	6.33	6.0	0.304	16.7	0.223	11.6
159 & 160	141	1.34	1.33	0.064	4.81	4.8	0.175	13.1	0.166	12.5
165 & 166	155	1.48	1.78	0.062	4.16	3.5	0.209	14.1	0.216	12.1

2.2.15 Comparison of the Existing and Developed Precision Estimates

Table 2-16 shows the table of precision estimates in AASHTO T 105-06, with the current precisions crossed out and the new precisions underlined. As indicated from the table, the precision estimates of 6 out of 13 chemical components have been changed significantly, which could be due to the changes in chemical analysis procedure. In addition, precision estimate for CO2 has been added to the table since it is being frequently measured in the state and private laboratories.

Table 2-16- Comparison of the Existing and Proposed Precision Estimates

(Column 1) Component	(Column 2) Maximum Difference between Duplicates[d]	(Column 3) Maximum Difference of the Average of Duplicates from CRM Certificate Values[bcd]	(Column 4) Maximum Difference between Two Laboratories[g]
SiO_2 (silicon dioxide)	~~0.16~~ 0.34	± 0.20	0.56
Al_2O_3 (aluminum oxide)	~~0.20~~ 0.21	± 0.20	0.31
Fe_2O_3 (ferric oxide)	~~0.10~~ 0.08	± 0.10	0.15
CaO (calcium oxide)	~~0.20~~ 0.56	± 0.30	1.09
MgO (magnesium oxide)	~~0.16~~ 0.14	± 0.20	0.20
SO_3 (sulfur trioxide)	~~0.10~~ 0.13	± 0.10	0.22
LOI (loss on ignition)	~~0.10~~ 0.16	± 0.10	0.24
Na_2O (sodium oxide)	~~0.03~~ 0.04	± 0.05	0.07
K_2O (potassium oxide)	~~0.03~~ 0.03	± 0.05	0.05
TiO_2 (titanium dioxide)	~~0.02~~ 0.01	± 0.03	0.02
P_2O_5 (phosphorus pentoxide)	0.03	± 0.03	
ZnO (zinc oxide)	0.03	± 0.03	
Mn_2O_3 (manganic oxide)	0.03	± 0.03	
S (sulfide sulfur)	0.01	*f*	
Cl (chloride)	~~0.02~~ 0.01	*f*	0.01
IR (insoluble residue)	~~0.10~~ 0.14	*f*	0.23
Cx (free calcium oxide)	~~0.20~~ 0.35	*f*	0.61
~~Alk_{wsl}~~ (water-soluble alkali)[e]	0.75/*w*	*f*	
~~Chl_{wsl}~~ (chloroform-soluble organic substances)	0.004		
CO2 (carbon dioxide)	0.24	*f*	0.62

CHAPTER 3. CONCLUSIONS AND RECOMMENDATIONS

3.1 COMMENTARY

This study was conducted to update and expand the precision estimates for AASHTO Standard Test Method T 105, "Chemical Analysis of Hydraulic Cement." The data analyzed in this study are from the most recent data sets collected from the laboratories participating in the CCRL Proficiency Sample Program. The data reflect wide range of test values and cement types. In most cases the data sets used to derive the precision estimate included well over 150 laboratories.

3.2 CONCLUSION

AASHTO T 105 covers the test methods for chemical analysis of hydraulic cements. Although a set of specific chemical test methods are suggested in T 105-03, any test method of demonstrated acceptable precision and bias may be used for analysis of hydraulic cements. Since reliability of the user selected chemical analysis test methods are determined by T 105 precision and bias estimates, the verification and update of the precision estimates are of particular importance. To update and expand T 105 precision estimates, the most recent chemical analysis data that have been collected from the laboratories participating in the CCRL Proficiency Sample Program were analyzed. To capture the advancement in some of the chemical analysis methods only the most recent sets of CCRL data were analyzed. Also, only 14 of the most frequently measured chemical components by the state and private laboratories were included in the analysis. The comparison of the precision estimates developed in this study and the existing precisions in AASHTO T 105-06 indicated significant change in precisions of a number of chemical analysis.

3.3 RECOMMENDATIONS

In order for the precision estimates of AASHTO T 105 to reflect the recent advancement in chemical testing of hydraulic cement, it is recommended that the updated precision and bias statement in Section 3.4 be adopted for AASHTO T 105.

3.4 PRECISION STATEMENT FOR AASHTO T 105, "CHEMICAL ANALYSIS OF HYDRAULIC CEMENT"

X. Precision and Bias

X.1 Precision - Criteria for judging the acceptability of percentages of chemical components that are obtained using AASHTO T 105 for hydraulic cement are:

X.1.1 Single-Operator Precision (Repeatability) – The figures in Column 2 of Table X are the standard deviations that have been found to be appropriate for the chemical components in Column 1. Two results obtained in the same laboratory, by the same operator using the same equipment, in the shortest practical period of time, should not be considered suspect unless the difference in the two results exceeds the values given in Table X, Column 3.

X.1.2 Multilaboratory Precision (Reproducibility) – The figures in Column 4 of Table X are the standard deviations that have been found to be appropriate for the chemical components in Column 1. Two results submitted by two different operators testing the same material in different laboratories shall not be considered suspect unless the difference in the two results exceeds the values given in Table X, Column 5.

Table X – Precision Estimates

Chemical Components	Standard Deviation (1s)[a]	Acceptable Range of Two Test Results (d2s)[a]	Standard Deviation (1s)[a]	Acceptable Range of Two Test Results (d2s)[a]
	Single Operator Precision:		Multilaboratory Precision:	
SiO_2 (silicon dioxide)	0.119	0.333	0.196	0.549
Al_2O_3 (aluminum oxide)	0.073	0.204	0.110	0.308
Fe_2O_3 (ferric oxide)	0.029	0.081	0.051	0.143
CaO (calcium oxide)	0.199	0.557	0.384	1.075
MgO (magnesium oxide)	0.049	0.137	0.070	0.196
SO_3 (sulfur trioxide)	0.047	0.132	0.076	0.213
LOI (loss on ignition)	0.055	0.154	0.085	0.238
Na_2O (sodium oxide)	0.013	0.036	0.024	0.067
K_2O (potassium oxide)	0.009	0.025	0.016	0.045
TiO_2 (titanium dioxide)	0.005	0.014	0.007	0.020
Cl (chloride)	0.002	0.006	0.004	0.011
IR (insoluble residue)	0.048	0.134	0.080	0.224
Cx (free calcium oxide)	0.125	0.350	0.214	0.599
CO2 (carbon dioxide)	0.083	0.232	0.219	0.613

[a] These values represent the 1s and d2s limits described in ASTM Practice C670.

Note – The precision estimates given in Table X are based on the analysis of test results from 107 pairs of CCRL proficiency samples. The data analyzed consisted of results from 66 to 221 laboratories for each of the pairs of samples. The analysis included five cement types: Type I and Type I/II with and without limestone and Type V with limestone.

X.2 Bias – No information can be presented on the bias of the procedure because no comparison with the material having an accepted reference value was conducted.

REFERENCES

[1] Spellerberg, P.A., Savage, D.A., and Pielert, J.H., "Precision Estimates of Selected Volumetric Properties of HMA Using Non-Absorptive Aggregate," NCHRP Web Document 54, 2003.

[2] Spellerberg, P.A. and Savage, D.A., "An Investigation of the Cause of Variation in HMA Bulk Specific Gravity Test Results Using Non-Absorptive Aggregates," NCHRP Web Document 66, 2004.

[3] Holsinger, R.E., Fisher, A., and Spellerberg, P.A., "Precision Estimates for AASHTO Test Method T308 and the Test Methods for Performance-Graded Asphalt Binder in AASHTO Specification M320," NCHRP Web Document 71, 2005.

[4] Azari, H., Lutz, R., and Spellerberg, P., "Precision Estimates of Selected Volumetric Properties of HMA Using Absorptive Aggregate," Submitted for Approval by the NCHRP 9-26 Panel

[5] Azari, H., Lutz, R., and Spellerberg, P., "Precision Estimates for AASHTO Test Method T269 Determined Using AMRL Proficiency Sample data," Submitted for Approval by the NCHRP 9-26 Panel

[6] AASHTO, Designation T 105, "Chemical Analysis of Hydraulic Cement" Standard Specifications for Transportation Materials and Methods of Sampling and Testing, 27th Edition, AASHTO, Washington, DC, 2007, CD-ROM.

[7] CCRL Web Site: http://www.ccrl.us

[8] ASTM, Designation D114-06, "Chemical Analysis of Hydraulic Cement," Annual Book of ASTM Standards, Volume 04.01, ASTM, West Conshohocken, PA, 2007.

[9] Ku, Harry H., "Statistical Concepts in Metrology," NIST Special Publication 300, Volume 1, 1969: p 316-40.

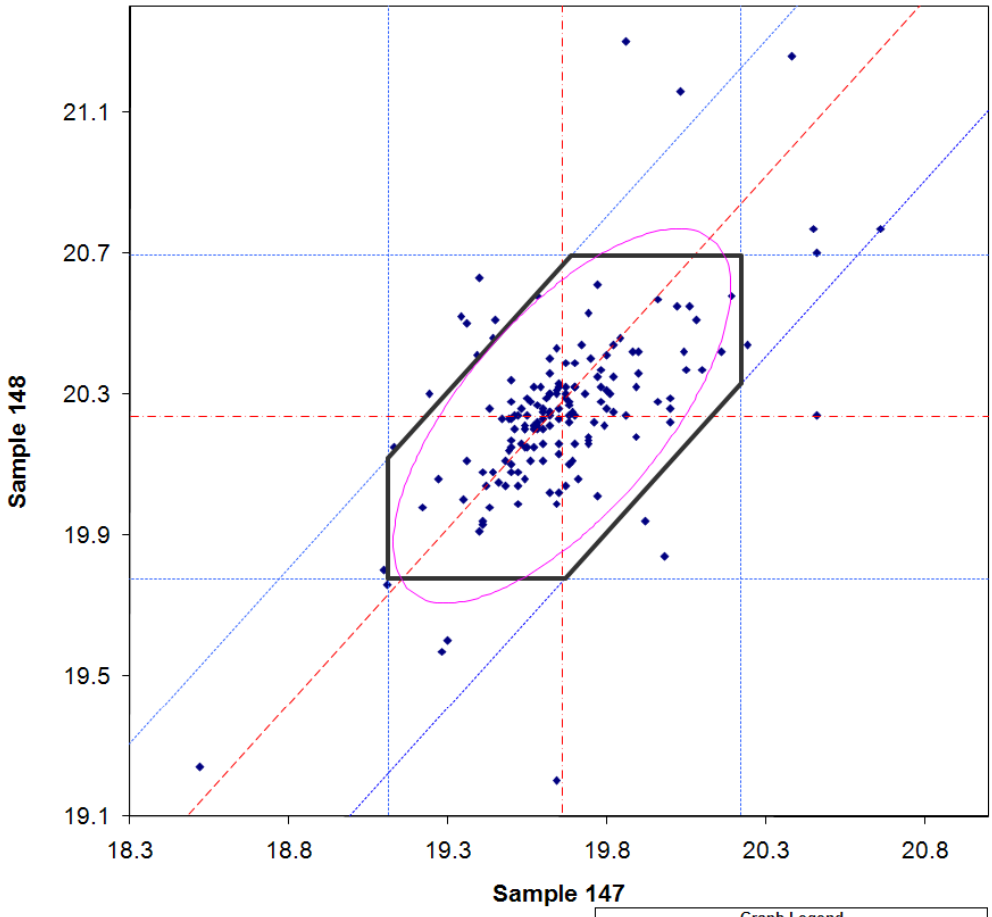
APPENDIX A: SILICON DIOXIDE (SiO_2)

Graph and Analysis Results for AASHTO T 105

Chemical Analysis of Hydraulic Cement

CCRL Samples 147 and 148

Test Property: % Silicon Dioxide (SiO2) , Type I / II Cement



Graph Legend
Lines With Small Dash Marks - Sample Outlier Boundaries
Lines With Alternating Dash Marks - Sample Medians
Line With Large Dash Marks - Center Diagonal
Black Hexagon - Data Within is Used for Analysis
Ellipse - 2 Std Dev for Within and Between Lab Variation

Source of Data: AASHTO Materials Reference Laboratory Proficiency Sample Program
CCRL Samples 147 and 148
Final Report Issued March 2003

Participation:

165	Total Laboratories
5	Laboratories Determined to be Invalid
19	Laboratories Determined to be Outliers
141	Total Laboratorires Included in Analysis

Average Results	
Sample 147 Average	Sample 148 Average
19.66	20.24

Repeatability			
1s	d2s	CV% (147)	CV% (148)
0.10	0.28	0.50	0.49

Reproducability (Sample 147)		
1s	d2s	CV%
0.18	0.51	0.91

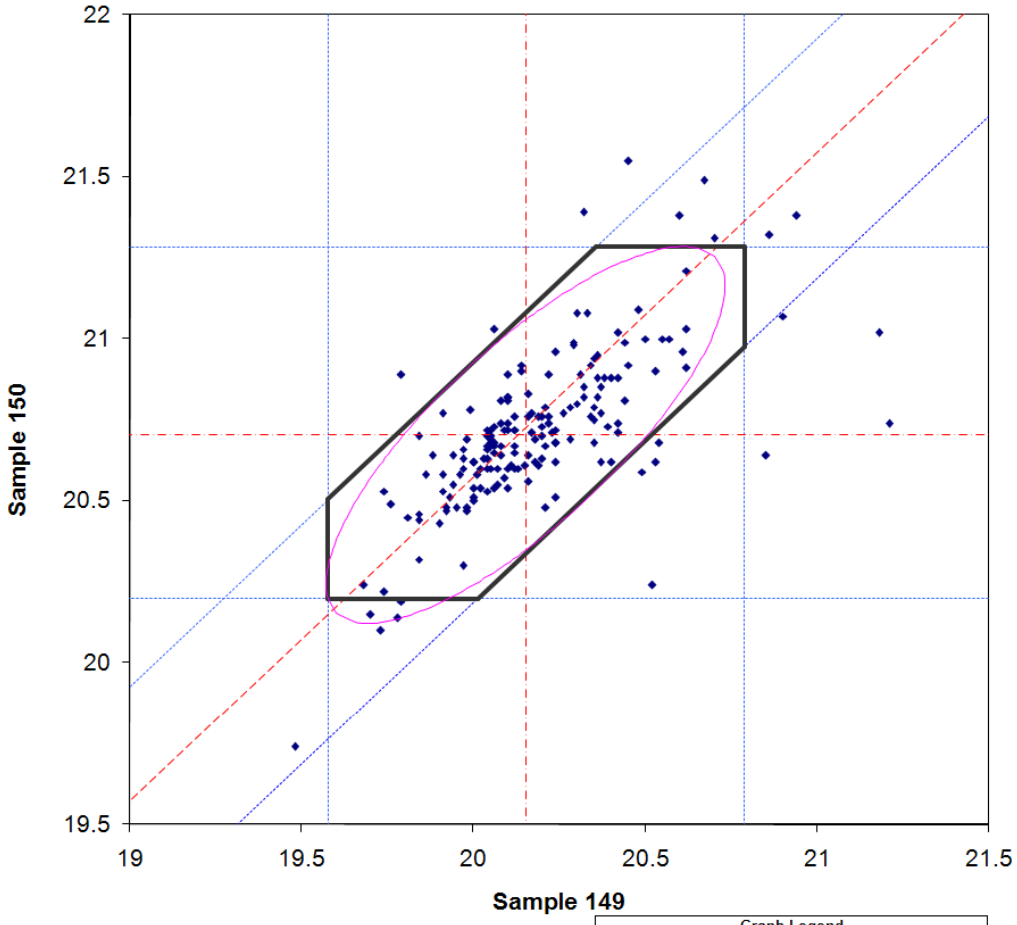
Reproducability (Sample 148)		
1s	d2s	CV%
0.14	0.41	0.71

Graph and Analysis Results for AASHTO T 105

Chemical Analysis of Hydraulic Cement

CCRL Samples 149 and 150

Test Property: % Silicon Dioxide (SiO2) , Type I Cement



Graph Legend
Lines With Small Dash Marks - Sample Outlier Boundaries
Lines With Alternating Dash Marks - Sample Medians
Line With Large Dash Marks - Center Diagonal
Black Hexagon - Data Within is Used for Analysis
Ellipse - 2 Std Dev for Within and Between Lab Variation

Source of Data: AASHTO Materials Reference Laboratory Proficiency Sample Program
CCRL Samples 149 and 150
Final Report Issued Sept. 2003

Participation:

178	Total Laboratories
6	Laboratories Determined to be Invalid
18	Laboratories Determined to be Outliers
154	Total Laboratorires Included in Analysis

Average Results	
Sample 149 Average	Sample 150 Average
20.15	20.70

Repeatability			
1s	d2s	CV% (149)	CV% (150)
0.09	0.25	0.44	0.43

Reproducability (Sample 149)		
1s	d2s	CV%
0.20	0.55	0.97

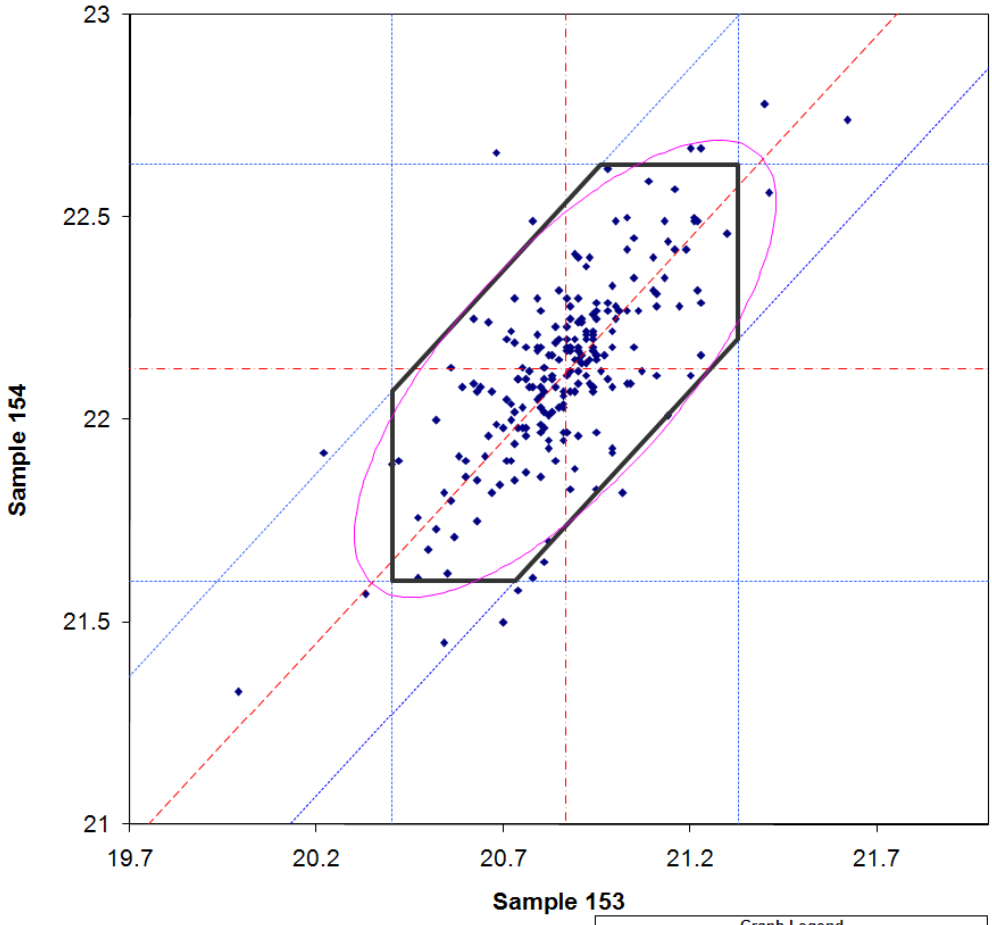
Reproducability (Sample 150)		
1s	d2s	CV%
0.17	0.48	0.82

Graph and Analysis Results for AASHTO T 105

Chemical Analysis of Hydraulic Cement

CCRL Samples 153 and 154

Test Property: % Silicon Dioxide (SiO2) , Type I / II Cement



Graph Legend
Lines With Small Dash Marks - Sample Outlier Boundaries
Lines With Alternating Dash Marks - Sample Medians
Line With Large Dash Marks - Center Diagonal
Black Hexagon - Data Within is Used for Analysis
Ellipse - 2 Std Dev for Within and Between Lab Variation

Source of Data: AASHTO Materials Reference Laboratory Proficiency Sample Program
CCRL Samples 153 and 154
Final Report Issued Oct. 2004

Participation:

230	Total Laboratories
7	Laboratories Determined to be Invalid
16	Laboratories Determined to be Outliers
207	Total Laboratorires Included in Analysis

Average Results	
Sample 153 Average	Sample 154 Average
20.87	22.13

Repeatability			
1s	d2s	CV% (153)	CV% (154)
0.10	0.28	0.47	0.44

Reproducability (Sample 153)		
1s	d2s	CV%
0.16	0.46	0.79

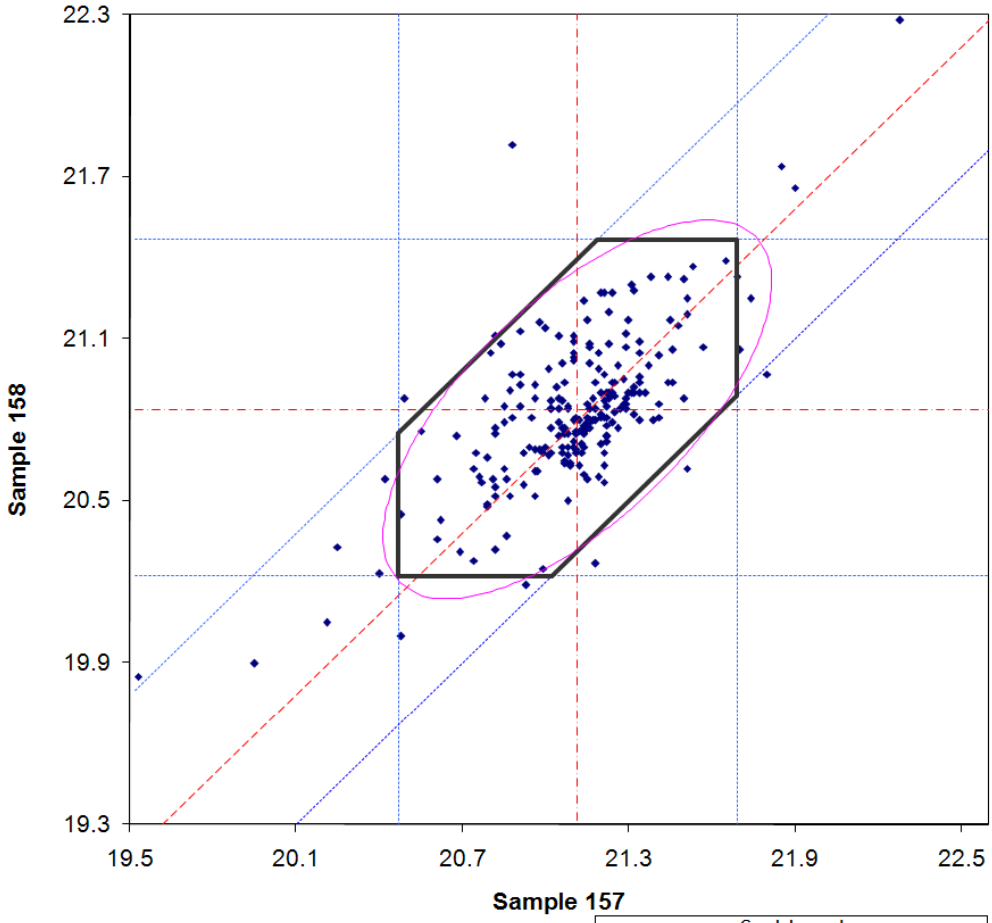
Reproducability (Sample 154)		
1s	d2s	CV%
0.19	0.52	0.84

Graph and Analysis Results for AASHTO T 105

Chemical Analysis of Hydraulic Cement

CCRL Samples 157 and 158

% Silicon Dioxide (SiO2) , Type V Cement w/ Limestone (157) & Type I/II w/ Limestone (158)



Graph Legend
Lines With Small Dash Marks - Sample Outlier Boundaries
Lines With Alternating Dash Marks - Sample Medians
Line With Large Dash Marks - Center Diagonal
Black Hexagon - Data Within is Used for Analysis
Ellipse - 2 Std Dev for Within and Between Lab Variation

Source of Data: AASHTO Materials Reference Laboratory Proficiency Sample Program
CCRL Samples 157 and 158
Final Report Issued Oct. 2005

Participation:

231	Total Laboratories
8	Laboratories Determined to be Invalid
15	Laboratories Determined to be Outliers
208	Total Laboratorires Included in Analysis

Average Results	
Sample 157 Average	Sample 158 Average
21.11	20.84

Repeatability			
1s	d2s	CV% (157)	CV% (158)
0.13	0.38	0.63	0.64

Reproducability (Sample 157)		
1s	d2s	CV%
0.21	0.59	0.99

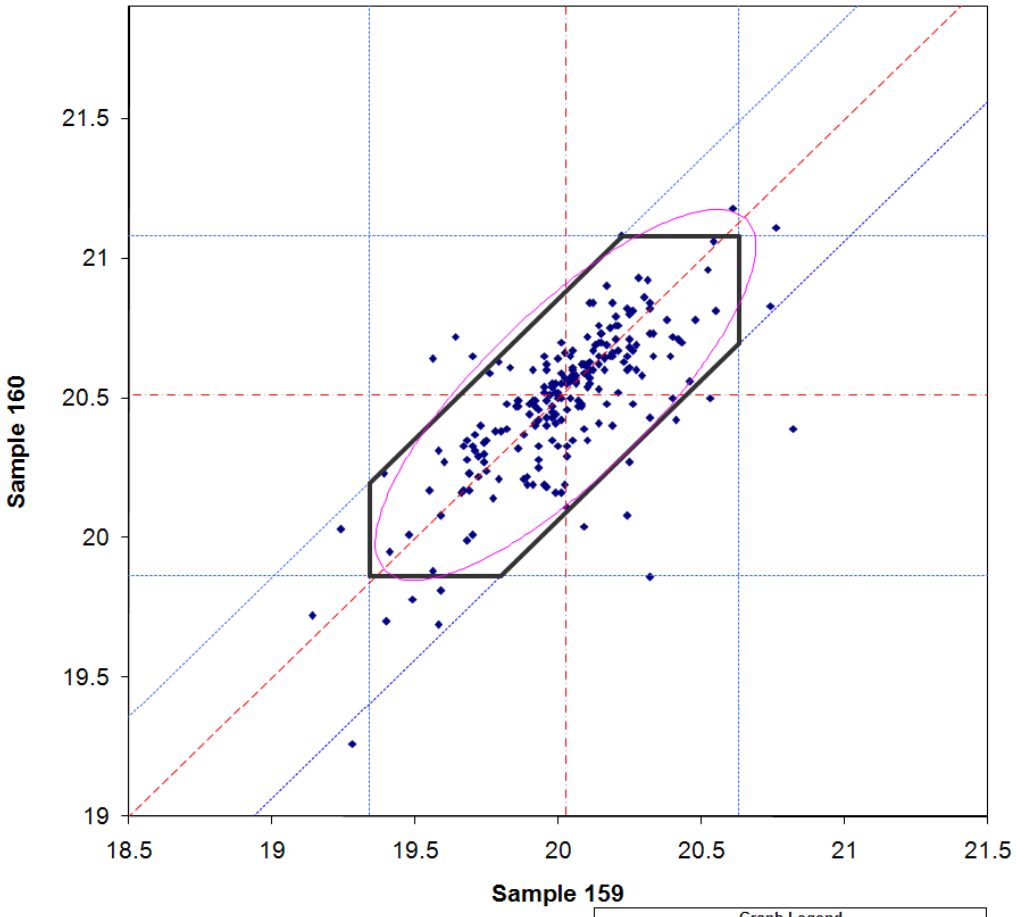
Reproducability (Sample 158)		
1s	d2s	CV%
0.22	0.62	1.05

Graph and Analysis Results for AASHTO T 105

Chemical Analysis of Hydraulic Cement

CCRL Samples 159 and 160

% Silicon Dioxide (SiO2), Type I Cement w/ Limestone (159) & Type I / II w/ Limestone (160)



Graph Legend
Lines With Small Dash Marks - Sample Outlier Boundaries
Lines With Alternating Dash Marks - Sample Medians
Line With Large Dash Marks - Center Diagonal
Black Hexagon - Data Within is Used for Analysis
Ellipse - 2 Std Dev for Within and Between Lab Variation

Source of Data: AASHTO Materials Reference Laboratory Proficiency Sample Program
CCRL Samples 159 and 160
Final Report Issued April 2006

Participation:

233	Total Laboratories
6	Laboratories Determined to be Invalid
18	Laboratories Determined to be Outliers
209	Total Laboratorires Included in Analysis

Average Results	
Sample 159 Average	Sample 160 Average
20.02	20.51

Repeatability			
1s	d2s	CV% (159)	CV% (160)
0.10	0.28	0.49	0.48

Reproducability (Sample 159)		
1s	d2s	CV%
0.21	0.60	1.07

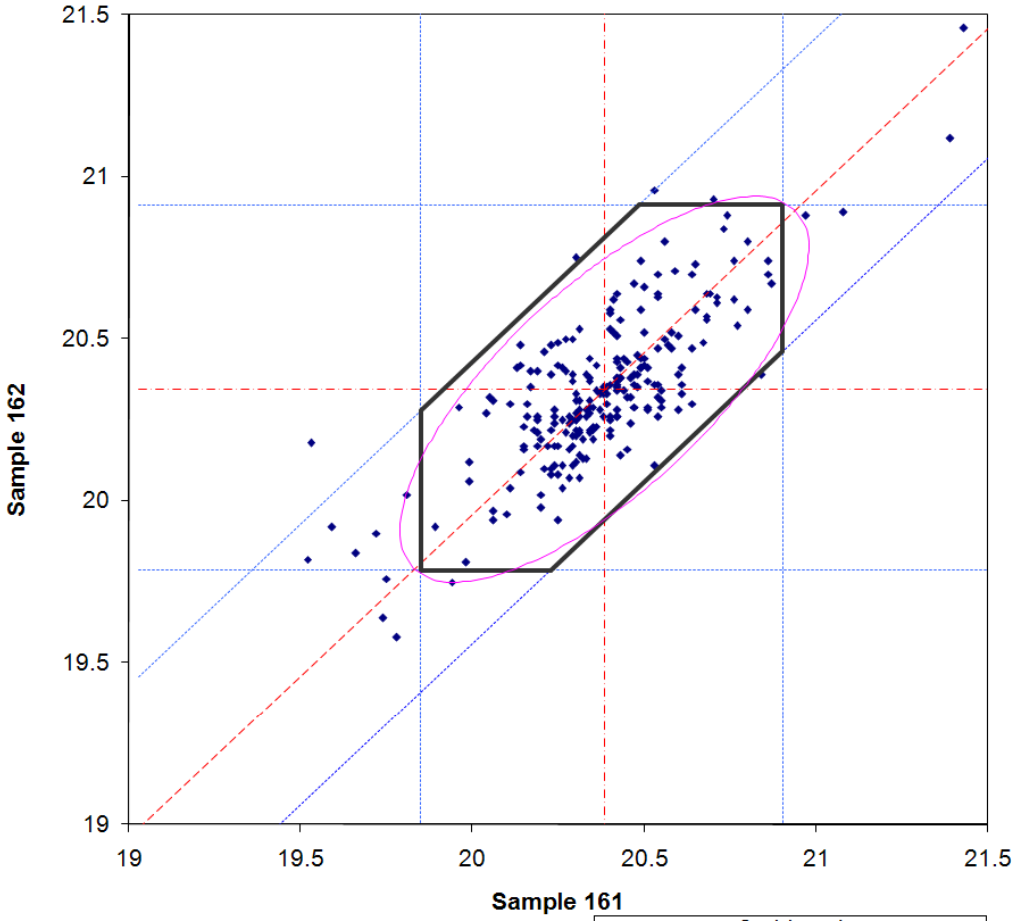
Reproducability (Sample 160)		
1s	d2s	CV%
0.21	0.58	1.01

Graph and Analysis Results for AASHTO T 105

Chemical Analysis of Hydraulic Cement

CCRL Samples 161 and 162

% Silicon Dioxide (SiO2), Type I Cement (161) & Type I Cement w/ Limestone (162)



Graph Legend
Lines With Small Dash Marks - Sample Outlier Boundaries
Lines With Alternating Dash Marks - Sample Medians
Line With Large Dash Marks - Center Diagonal
Black Hexagon - Data Within is Used for Analysis
Ellipse - 2 Std Dev for Within and Between Lab Variation

Source of Data: AASHTO Materials Reference Laboratory Proficiency Sample Program
CCRL Samples 161 and 162
Final Report Issued Oct 2006

Participation:

238	Total Laboratories
4	Laboratories Determined to be Invalid
16	Laboratories Determined to be Outliers
218	Total Laboratorires Included in Analysis

Average Results	
Sample 161 Average	Sample 162 Average
20.38	20.34

Repeatability			
1s	d2s	CV% (161)	CV% (162)
0.10	0.29	0.50	0.50

Reproducability (Sample 161)		
1s	d2s	CV%
0.18	0.51	0.89

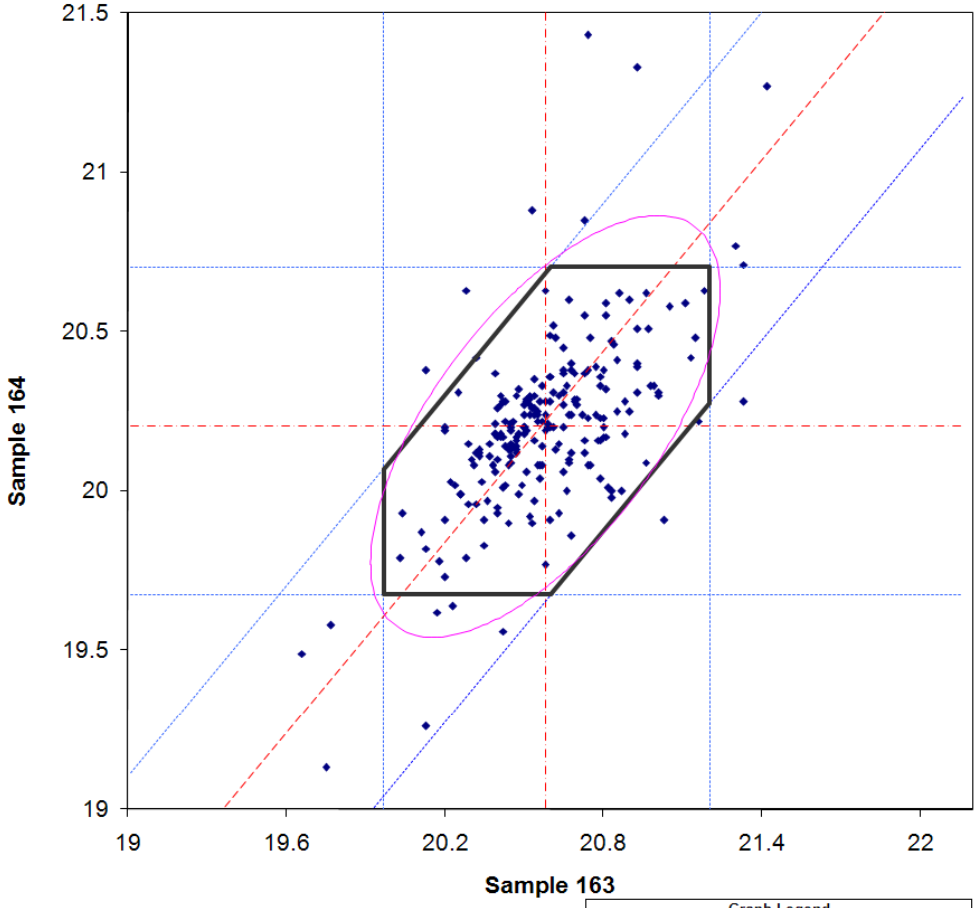
Reproducability (Sample 162)		
1s	d2s	CV%
0.19	0.53	0.92

Graph and Analysis Results for AASHTO T 105

Chemical Analysis of Hydraulic Cement

CCRL Samples 163 and 164

% Silicon Dioxide (SiO2), Type I / II Cement



Graph Legend
Lines With Small Dash Marks - Sample Outlier Boundaries
Lines With Alternating Dash Marks - Sample Medians
Line With Large Dash Marks - Center Diagonal
Black Hexagon - Data Within is Used for Analysis
Ellipse - 2 Std Dev for Within and Between Lab Variation

Source of Data: AASHTO Materials Reference Laboratory Proficiency Sample Program
CCRL Samples 163 and 164
Final Report Issued April 2007

Participation:

235	Total Laboratories
8	Laboratories Determined to be Invalid
15	Laboratories Determined to be Outliers
212	Total Laboratorires Included in Analysis

Average Results	
Sample 163 Average	Sample 164 Average
20.58	20.20

Repeatability			
1s	d2s	CV% (163)	CV% (164)
0.13	0.37	0.64	0.65

Reproducability (Sample 163)		
1s	d2s	CV%
0.22	0.61	1.05

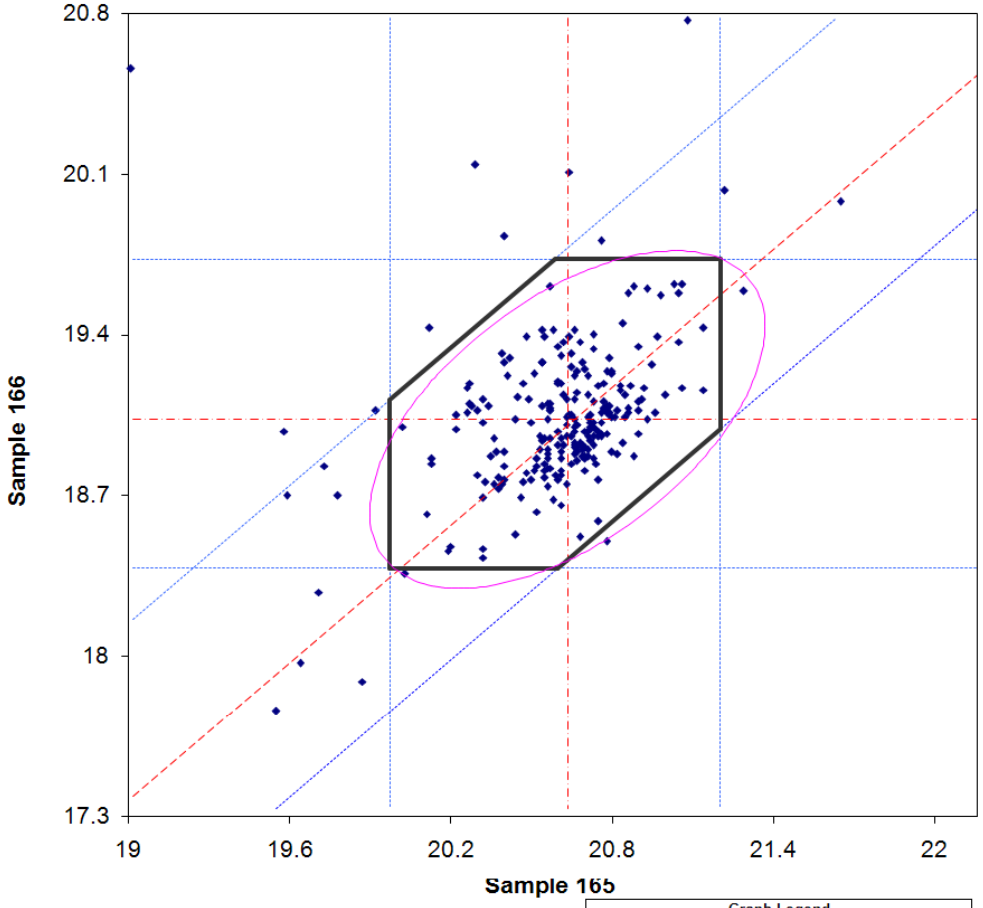
Reproducability (Sample 164)		
1s	d2s	CV%
0.18	0.51	0.90

Graph and Analysis Results for AASHTO T 105

Chemical Analysis of Hydraulic Cement

CCRL Samples 165 and 166

% Silicon Dioxide (SiO2), Type I /II Cement w/ Limestone



Graph Legend
Lines With Small Dash Marks - Sample Outlier Boundaries
Lines With Alternating Dash Marks - Sample Medians
Line With Large Dash Marks - Center Diagonal
Black Hexagon - Data Within is Used for Analysis
Ellipse - 2 Std Dev for Within and Between Lab Variation

Source of Data: AASHTO Materials Reference Laboratory Proficiency Sample Program
CCRL Samples 165 and 166
Final Report Issued September 2007

Participation:

244	Total Laboratories
6	Laboratories Determined to be Invalid
17	Laboratories Determined to be Outliers
221	Total Laboratorires Included in Analysis

Average Results	
Sample 165 Average	Sample 166 Average
20.63	19.03

Repeatability			
1s	d2s	CV% (165)	CV% (166)
0.16	0.47	0.80	0.86

Reproducability (Sample 165)		
1s	d2s	CV%
0.20	0.57	0.97

Reproducability (Sample 166)		
1s	d2s	CV%
0.23	0.65	1.21

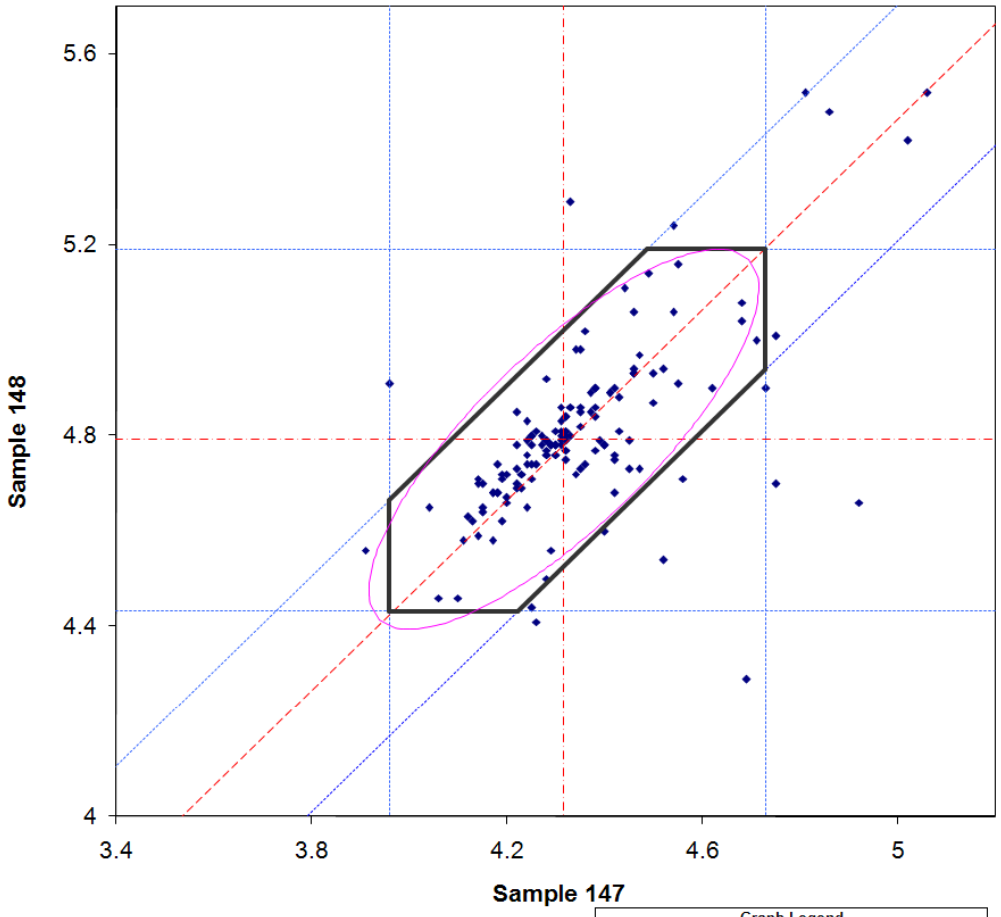
APPENDIX B: ALUMINUM OXIDE (AL_2O_3)

Graph and Analysis Results for AASHTO T 105

Chemical Analysis of Hydraulic Cement

CCRL Samples 147 and 148

Test Property: Aluminium Oxide (Al2O3) %, Type I / II Cement



Graph Legend
Lines With Small Dash Marks - Sample Outlier Boundaries
Lines With Alternating Dash Marks - Sample Medians
Line With Large Dash Marks - Center Diagonal
Black Hexagon - Data Within is Used for Analysis
Ellipse - 2 Std Dev for Within and Between Lab Variation

Source of Data: AASHTO Materials Reference Laboratory Proficiency Sample Program
CCRL Samples 147 and 148
Final Report Issued March 2003

Participation:

148	Total Laboratories
6	Laboratories Determined to be Invalid
16	Laboratories Determined to be Outliers
126	Total Laboratorires Included in Analysis

Average Results	
Sample 147 Average	Sample 148 Average
4.32	4.79

Repeatability			
1s	d2s	CV% (147)	CV% (148)
0.06	0.17	1.40	1.26

Reproducability (Sample 147)		
1s	d2s	CV%
0.13	0.35	2.91

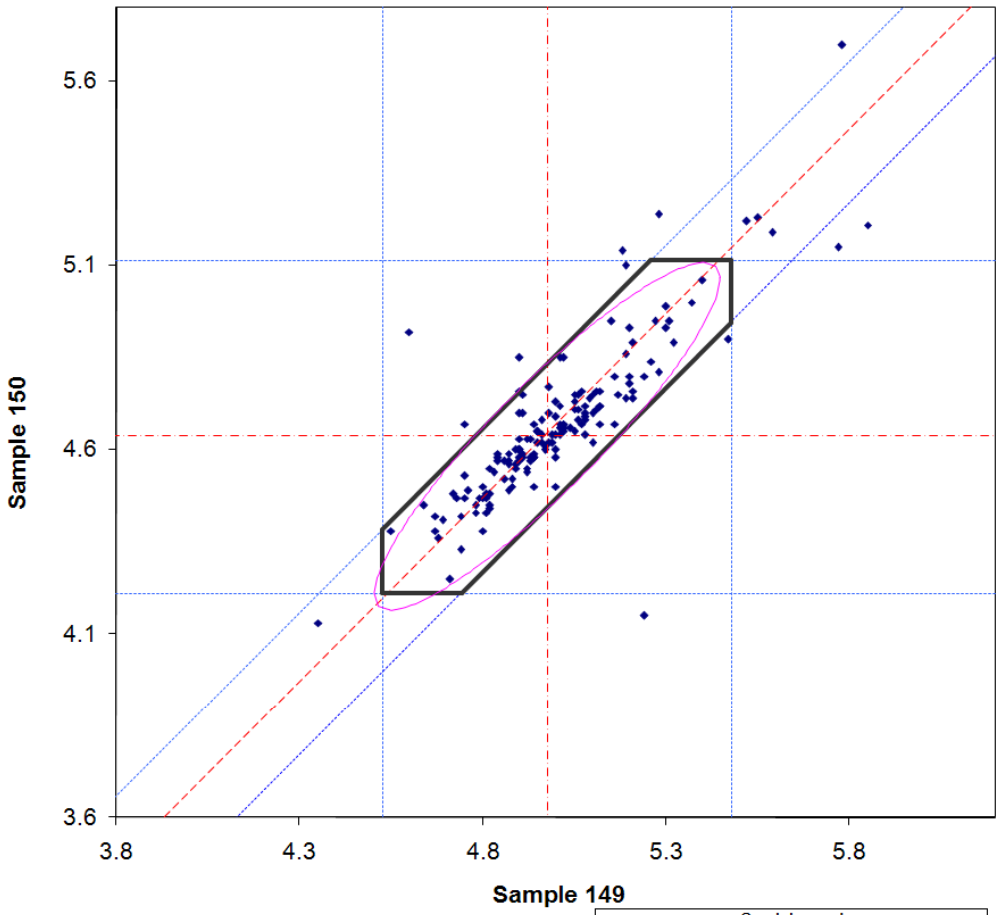
Reproducability (Sample 148)		
1s	d2s	CV%
0.13	0.36	2.64

Graph and Analysis Results for AASHTO T 105

Chemical Analysis of Hydraulic Cement

CCRL Samples 149 and 150

Test Property: Aluminium Oxide (Al2O3) %, Type I Cement



Graph Legend
Lines With Small Dash Marks - Sample Outlier Boundaries
Lines With Alternating Dash Marks - Sample Medians
Line With Large Dash Marks - Center Diagonal
Black Hexagon - Data Within is Used for Analysis
Ellipse - 2 Std Dev for Within and Between Lab Variation

Source of Data: AASHTO Materials Reference Laboratory Proficiency Sample Program
CCRL Samples 149 and 150
Final Report Issued Sept. 2003

Participation:

162	Total Laboratories
5	Laboratories Determined to be Invalid
13	Laboratories Determined to be Outliers
144	Total Laboratorires Included in Analysis

Average Results	
Sample 149 Average	Sample 150 Average
4.98	4.64

Repeatability			
1s	d2s	CV% (149)	CV% (150)
0.05	0.14	0.96	1.03

Reproducability (Sample 149)		
1s	d2s	CV%
0.16	0.46	3.25

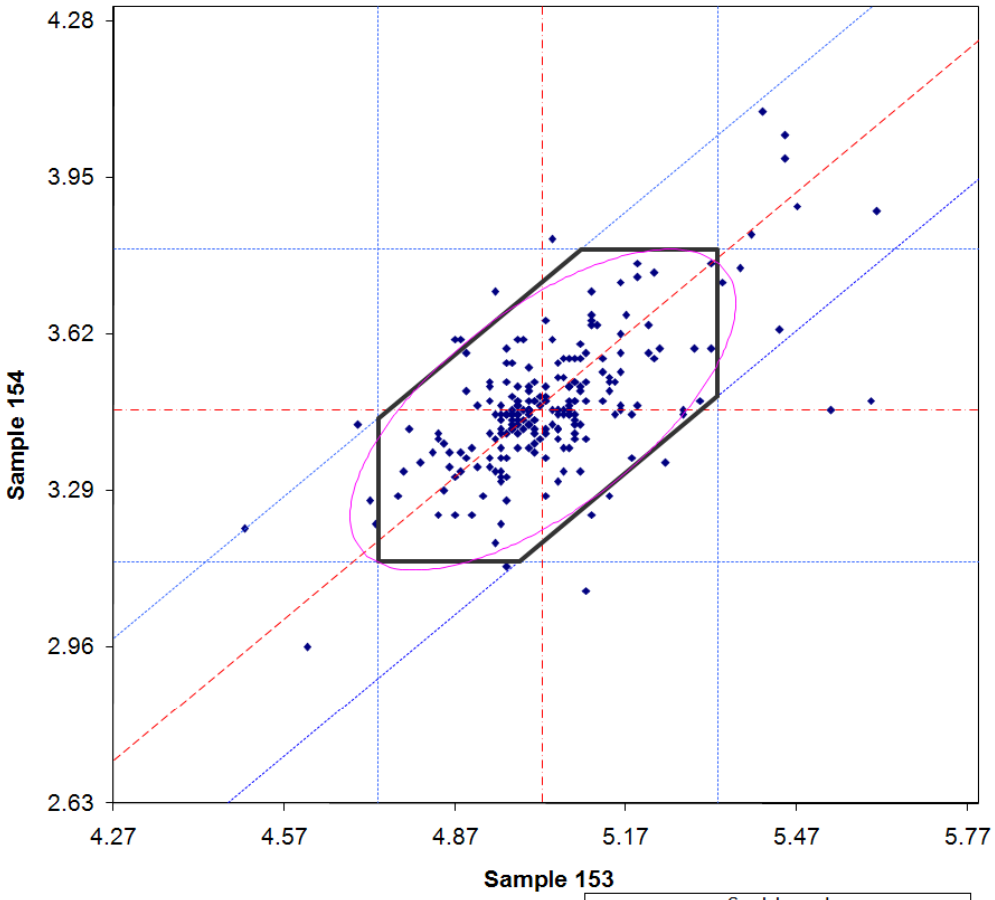
Reproducability (Sample 150)		
1s	d2s	CV%
0.14	0.41	3.12

Graph and Analysis Results for AASHTO T 105

Chemical Analysis of Hydraulic Cement

CCRL Samples 153 and 154

Test Property: Aliminum Oxide (AL2O3) %, Type I / II Cement



Graph Legend
Lines With Small Dash Marks - Sample Outlier Boundaries
Lines With Alternating Dash Marks - Sample Medians
Line With Large Dash Marks - Center Diagonal
Black Hexagon - Data Within is Used for Analysis
Ellipse - 2 Std Dev for Within and Between Lab Variation

Source of Data: AASHTO Materials Reference Laboratory Proficiency Sample Program
CCRL Samples 153 and 154
Final Report Issued Oct. 2004

Participation:

228	Total Laboratories
6	Laboratories Determined to be Invalid
23	Laboratories Determined to be Outliers
199	Total Laboratorires Included in Analysis

Average Results	
Sample 153 Average	Sample 154 Average
5.02	3.46

Repeatability			
1s	d2s	CV% (153)	CV% (154)
0.07	0.19	1.30	1.89

Reproducability (Sample 153)		
1s	d2s	CV%
0.10	0.29	2.05

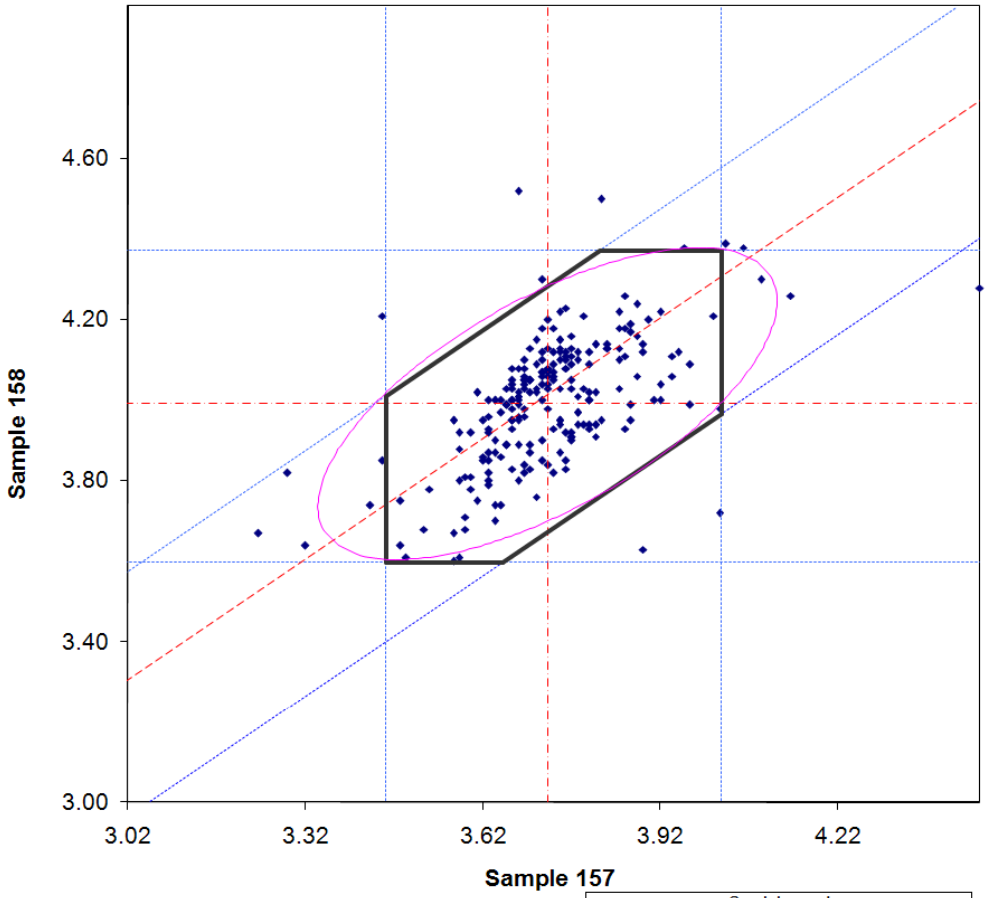
Reproducability (Sample 154)		
1s	d2s	CV%
0.10	0.29	2.97

Graph and Analysis Results for AASHTO T 105

Chemical Analysis of Hydraulic Cement

CCRL Samples 157 and 158

Aliminum Oxide (AL2O3) %, Type V w/ Limestone (157) & Type I / II w/ Limestone (158)



Graph Legend
Lines With Small Dash Marks - Sample Outlier Boundaries
Lines With Alternating Dash Marks - Sample Medians
Line With Large Dash Marks - Center Diagonal
Black Hexagon - Data Within is Used for Analysis
Ellipse - 2 Std Dev for Within and Between Lab Variation

Source of Data: AASHTO Materials Reference Laboratory Proficiency Sample Program
CCRL Samples 157 and 158
Final Report Issued Oct. 2005

Participation:

229	Total Laboratories
5	Laboratories Determined to be Invalid
14	Laboratories Determined to be Outliers
210	Total Laboratorires Included in Analysis

Average Results	
Sample 157 Average	Sample 158 Average
3.73	3.99

Repeatability			
1s	d2s	CV% (157)	CV% (158)
0.08	0.21	2.03	1.89

Reproducability (Sample 157)		
1s	d2s	CV%
0.10	0.28	2.64

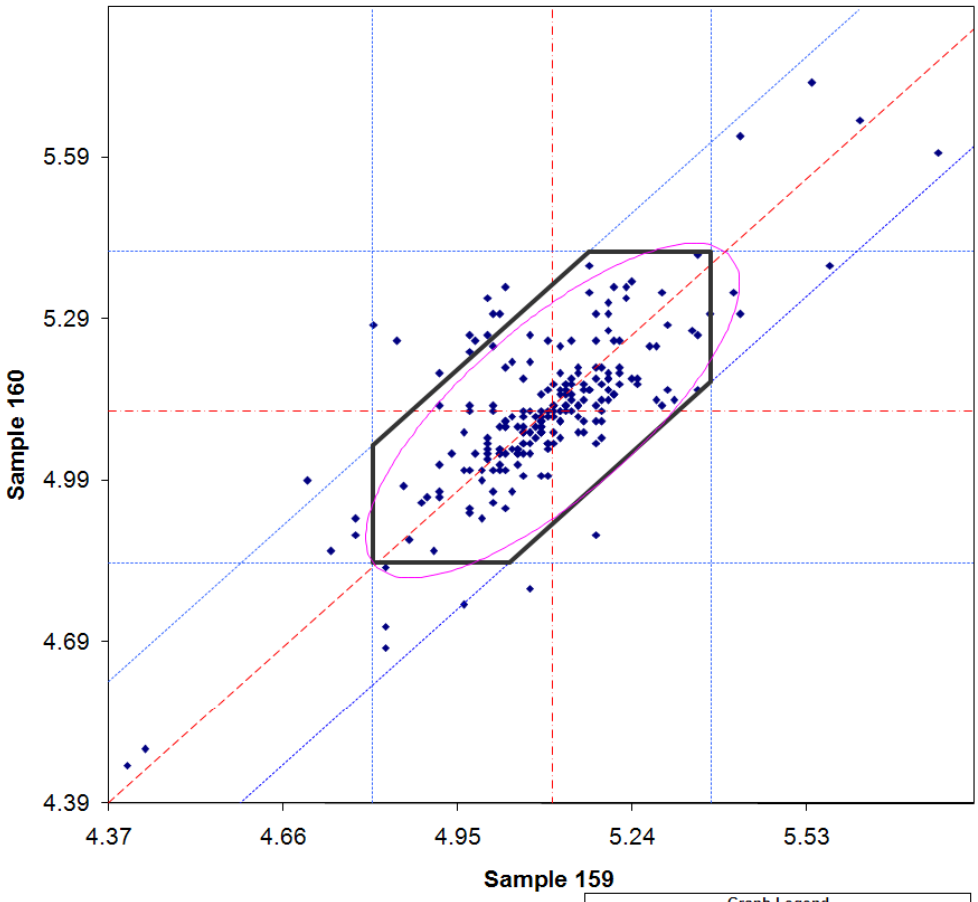
Reproducability (Sample 158)		
1s	d2s	CV%
0.13	0.38	3.37

Graph and Analysis Results for AASHTO T 105

Chemical Analysis of Hydraulic Cement

CCRL Samples 159 and 160

Aliminum Oxide (AL2O3) %, Type I w/ Limestone (159) & Type I / II w/ limestone (160)



Graph Legend
Lines With Small Dash Marks - Sample Outlier Boundaries
Lines With Alternating Dash Marks - Sample Medians
Line With Large Dash Marks - Center Diagonal
Black Hexagon - Data Within is Used for Analysis
Ellipse - 2 Std Dev for Within and Between Lab Variation

Source of Data: AASHTO Materials Reference Laboratory Proficiency Sample Program
CCRL Samples 159 and 160
Final Report Issued April 2006

Participation:

230	Total Laboratories
10	Laboratories Determined to be Invalid
24	Laboratories Determined to be Outliers
196	Total Laboratorires Included in Analysis

Average Results	
Sample 159 Average	Sample 160 Average
5.11	5.12

Repeatability			
1s	d2s	CV% (159)	CV% (160)
0.05	0.14	0.99	0.99

Reproducability (Sample 159)		
1s	d2s	CV%
0.10	0.28	1.93

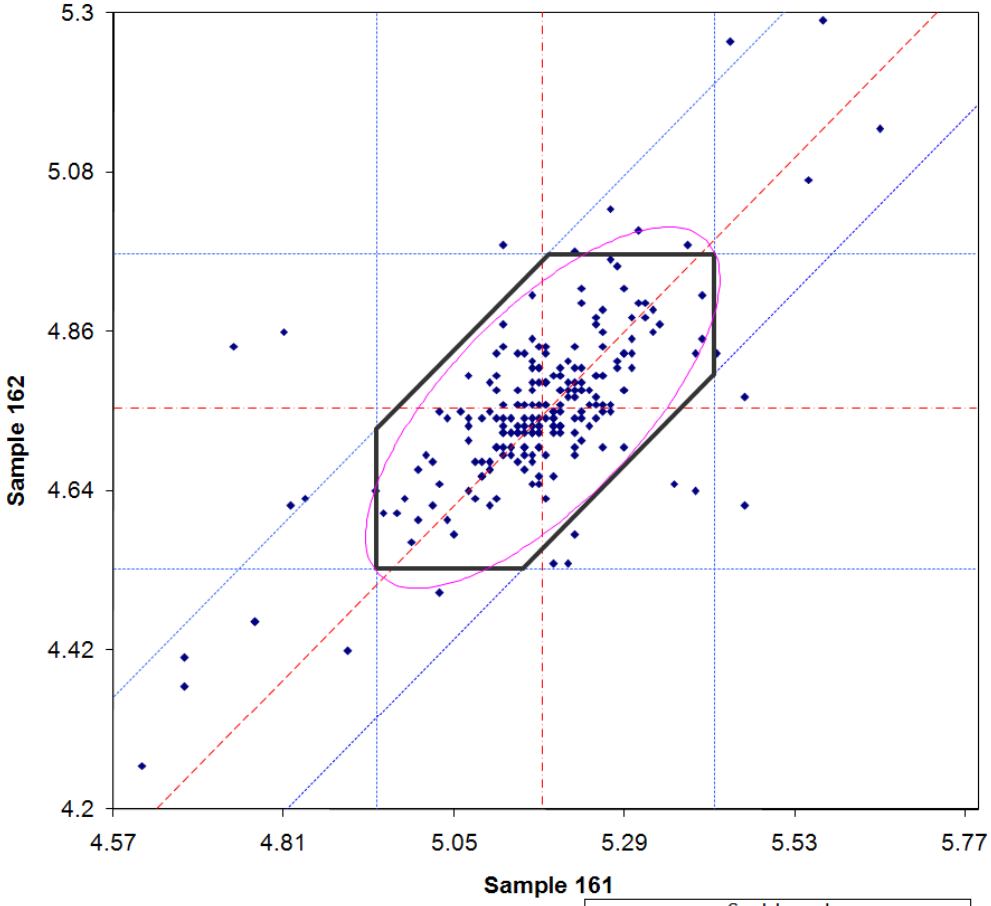
Reproducability (Sample 160)		
1s	d2s	CV%
0.10	0.27	1.87

Graph and Analysis Results for AASHTO T 105

Chemical Analysis of Hydraulic Cement

CCRL Samples 161 and 162

Aluminium Oxide (Al_2O_3) %, Type I Cement (161) & Type I w/ Limestone (162)



Graph Legend
Lines With Small Dash Marks - Sample Outlier Boundaries
Lines With Alternating Dash Marks - Sample Medians
Line With Large Dash Marks - Center Diagonal
Black Hexagon - Data Within is Used for Analysis
Ellipse - 2 Std Dev for Within and Between Lab Variation

Source of Data: AASHTO Materials Reference Laboratory Proficiency Sample Program
CCRL Samples 161 and 162
Final Report Issued Oct. 2006

Participation:

236	Total Laboratories
13	Laboratories Determined to be Invalid
20	Laboratories Determined to be Outliers
203	Total Laboratorires Included in Analysis

Average Results	
Sample 161 Average	Sample 162 Average
5.18	4.75

Repeatability			
1s	d2s	CV% (161)	CV% (162)
0.04	0.13	0.86	0.94

Reproducability (Sample 161)		
1s	d2s	CV%
0.08	0.23	1.55

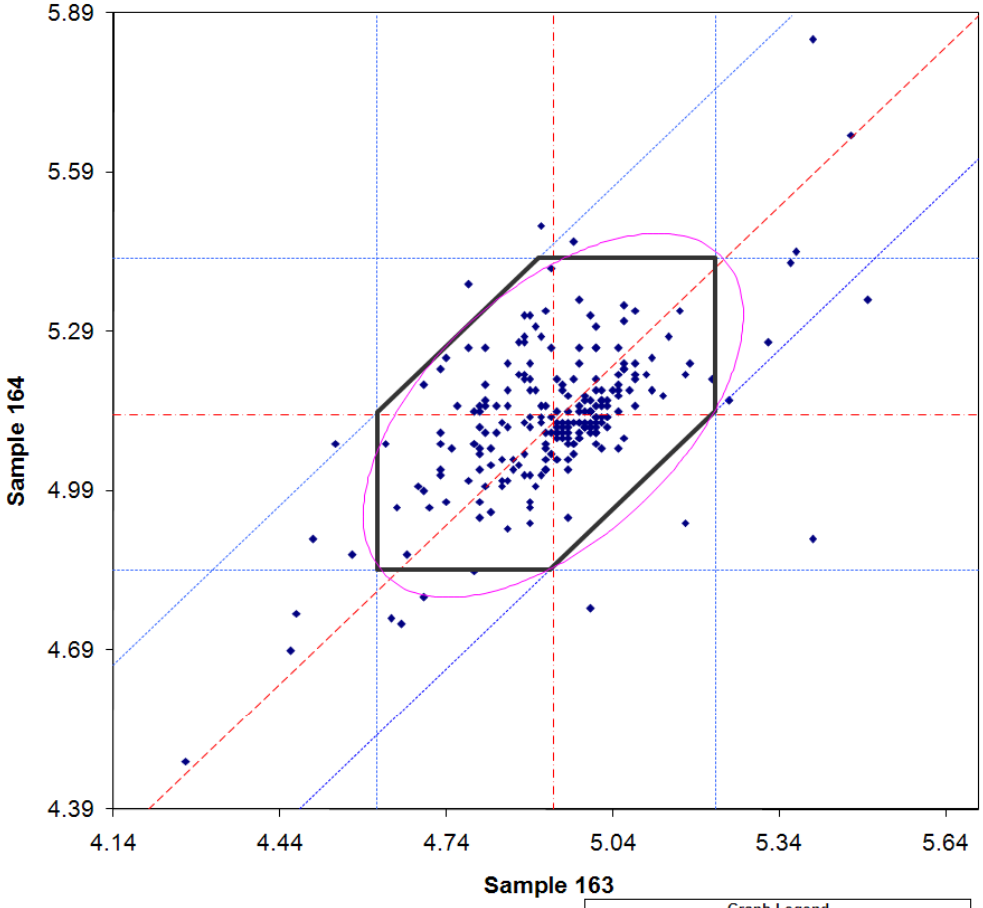
Reproducability (Sample 162)		
1s	d2s	CV%
0.07	0.21	1.54

Graph and Analysis Results for AASHTO T 105

Chemical Analysis of Hydraulic Cement

CCRL Samples 163 and 164

Aluminium Oxide (Al2O3) %, Type I / II Cement



Graph Legend
Lines With Small Dash Marks - Sample Outlier Boundaries
Lines With Alternating Dash Marks - Sample Medians
Line With Large Dash Marks - Center Diagonal
Black Hexagon - Data Within is Used for Analysis
Ellipse - 2 Std Dev for Within and Between Lab Variation

Source of Data: AASHTO Materials Reference Laboratory Proficiency Sample Program
CCRL Samples 163 and 164
Final Report Issued Oct. 2006

Participation:

235	Total Laboratories
9	Laboratories Determined to be Invalid
18	Laboratories Determined to be Outliers
208	Total Laboratorires Included in Analysis

Average Results	
Sample 163 Average	Sample 164 Average
4.93	5.13

Repeatability			
1s	d2s	CV% (163)	CV% (164)
0.08	0.22	1.55	1.49

Reproducability (Sample 163)		
1s	d2s	CV%
0.11	0.31	2.19

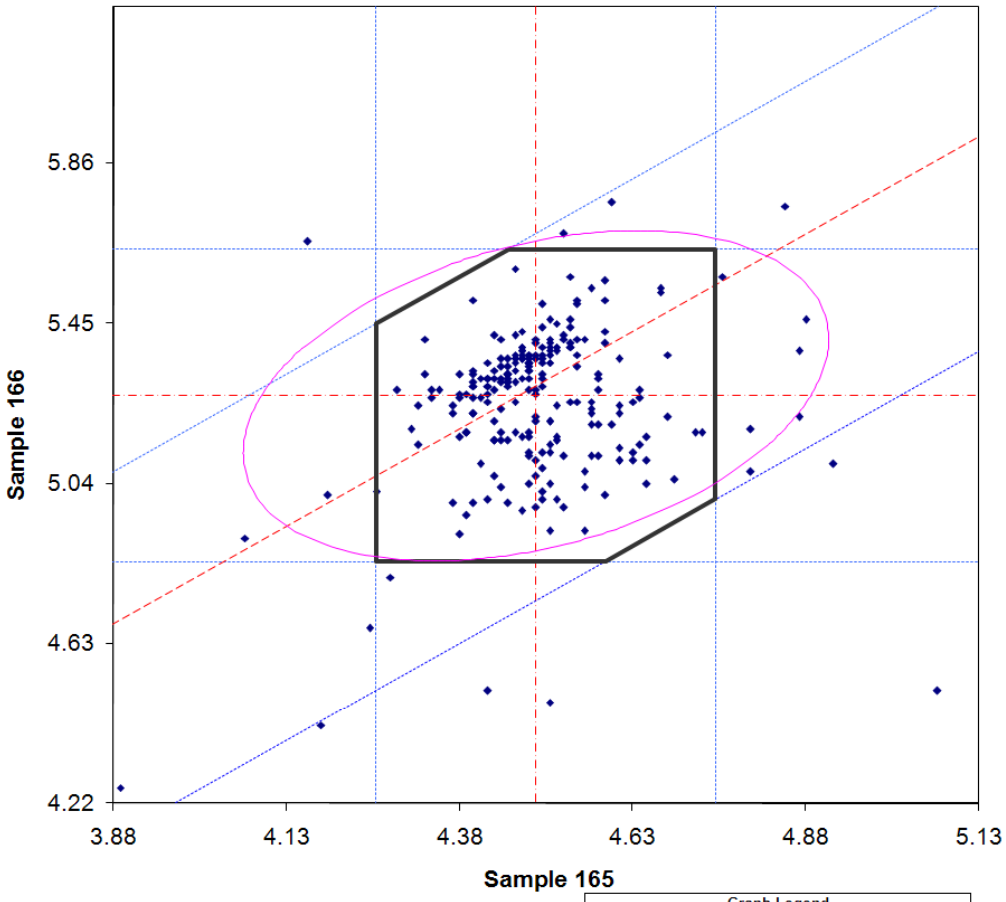
Reproducability (Sample 164)		
1s	d2s	CV%
0.09	0.26	1.80

Graph and Analysis Results for AASHTO T 105

Chemical Analysis of Hydraulic Cement

CCRL Samples 165 and 166

Aluminium Oxide (Al_2O_3) %, Type I / II Cement w/ Limestone



Graph Legend
Lines With Small Dash Marks - Sample Outlier Boundaries
Lines With Alternating Dash Marks - Sample Medians
Line With Large Dash Marks - Center Diagonal
Black Hexagon - Data Within is Used for Analysis
Ellipse - 2 Std Dev for Within and Between Lab Variation

Source of Data: AASHTO Materials Reference Laboratory Proficiency Sample Program
CCRL Samples 165 and 166
Final Report Issued Sept. 2007

Participation:

241	Total Laboratories
7	Laboratories Determined to be Invalid
16	Laboratories Determined to be Outliers
218	Total Laboratorires Included in Analysis

Average Results	
Sample 165 Average	Sample 166 Average
4.49	5.26

Repeatability			
1s	d2s	CV% (165)	CV% (166)
0.11	0.32	2.54	2.16

Reproducability (Sample 165)		
1s	d2s	CV%
0.08	0.23	1.83

Reproducability (Sample 166)		
1s	d2s	CV%
0.14	0.40	2.68

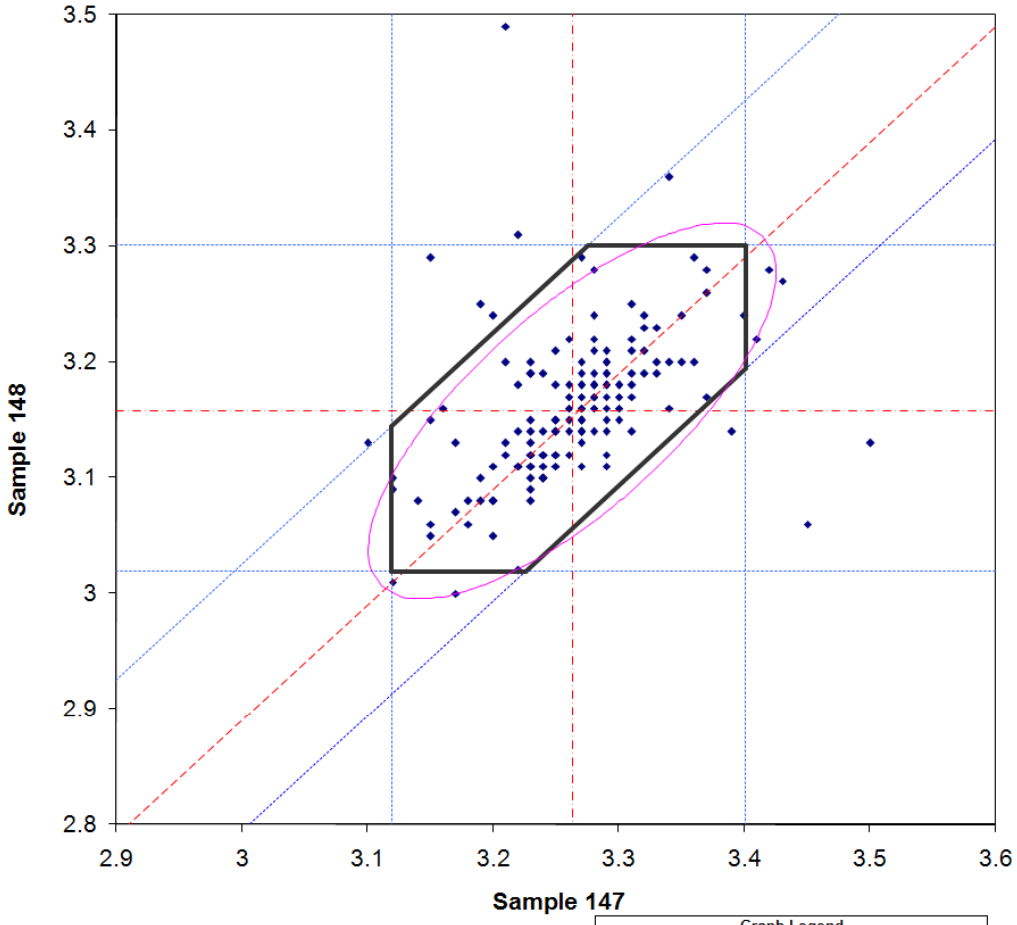
APPENDIX C: FERRIC OXIDE (FE_2O_3)

Graph and Analysis Results for AASHTO T 105

Chemical Analysis of Hydraulic Cement

CCRL Samples 147 and 148

Test Property: % Ferric Oxide (Fe2O3), Type I / II Cement



Graph Legend
Lines With Small Dash Marks - Sample Outlier Boundaries
Lines With Alternating Dash Marks - Sample Medians
Line With Large Dash Marks - Center Diagonal
Black Hexagon - Data Within is Used for Analysis
Ellipse - 2 Std Dev for Within and Between Lab Variation

Source of Data: AASHTO Materials Reference Laboratory Proficiency Sample Program
CCRL Samples 147 and 148
Final Report Issued March 2003

Participation:

160	Total Laboratories
6	Laboratories Determined to be Invalid
11	Laboratories Determined to be Outliers
143	Total Laboratorires Included in Analysis

Average Results	
Sample 147 Average	Sample 148 Average
3.26	3.16

Repeatability			
1s	d2s	CV% (147)	CV% (148)
0.027	0.078	0.84	0.87

Reproducability (Sample 147)		
1s	d2s	CV%
0.051	0.144	1.56

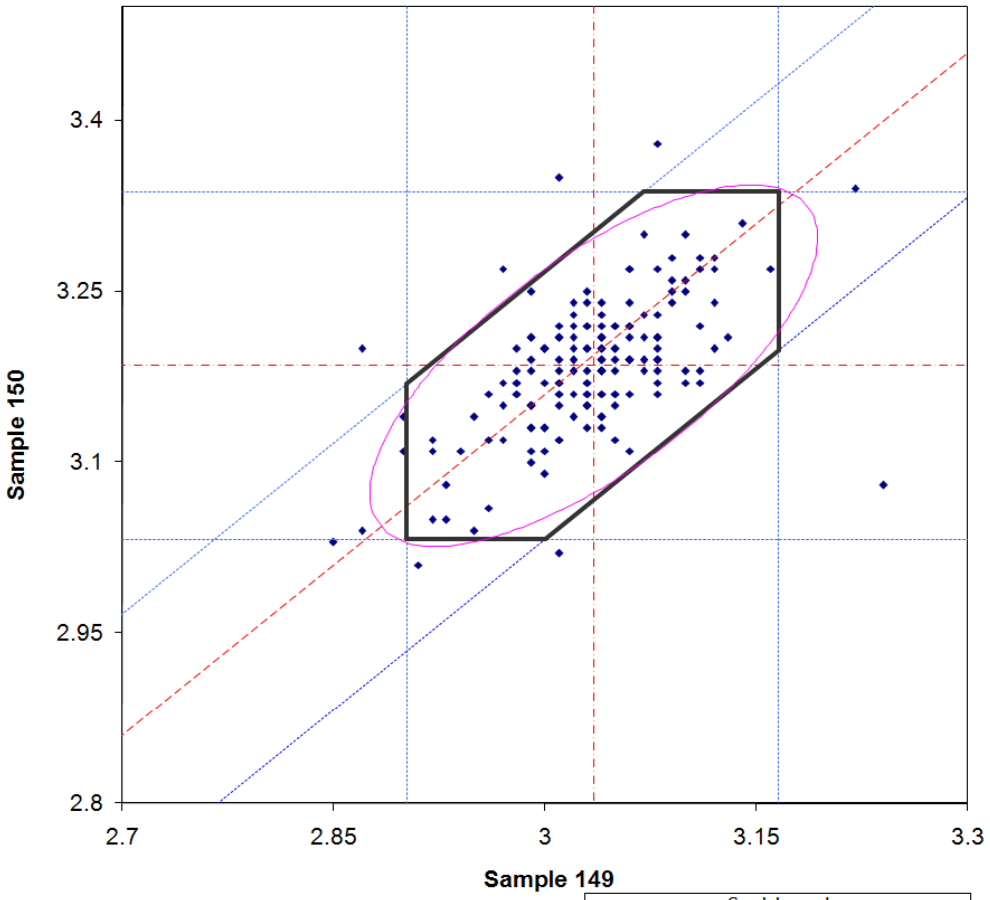
Reproducability (Sample 148)		
1s	d2s	CV%
0.050	0.142	1.59

Graph and Analysis Results for AASHTO T 105

Chemical Analysis of Hydraulic Cement

CCRL Samples 149 and 150

Test Property: % Ferric Oxide (Fe_2O_3), Type I Cement



Graph Legend
Lines With Small Dash Marks - Sample Outlier Boundaries
Lines With Alternating Dash Marks - Sample Medians
Line With Large Dash Marks - Center Diagonal
Black Hexagon - Data Within is Used for Analysis
Ellipse - 2 Std Dev for Within and Between Lab Variation

Source of Data: AASHTO Materials Reference Laboratory Proficiency Sample Program
CCRL Samples 149 and 150
Final Report Issued Sept. 2003

Participation:

174	Total Laboratories
7	Laboratories Determined to be Invalid
11	Laboratories Determined to be Outliers
156	Total Laboratorires Included in Analysis

Average Results	
Sample 149 Average	Sample 150 Average
3.03	3.19

Repeatability			
1s	d2s	CV% (149)	CV% (150)
0.029	0.081	0.94	0.90

Reproducability (Sample 149)		
1s	d2s	CV%
0.047	0.134	1.56

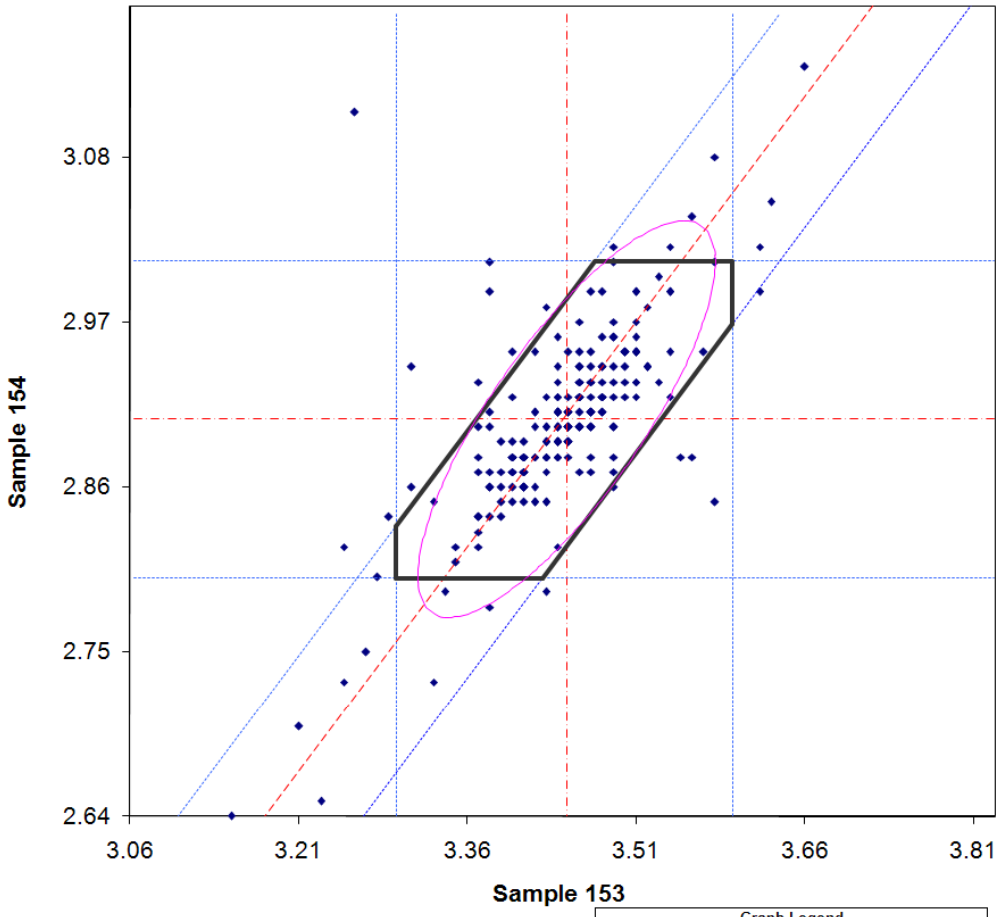
Reproducability (Sample 150)		
1s	d2s	CV%
0.050	0.143	1.58

Graph and Analysis Results for AASHTO T 105

Chemical Analysis of Hydraulic Cement

CCRL Samples 153 and 154

Test Property: % Ferric Oxide (Fe2O3), Type I / II Cement



Graph Legend
Lines With Small Dash Marks - Sample Outlier Boundaries
Lines With Alternating Dash Marks - Sample Medians
Line With Large Dash Marks - Center Diagonal
Black Hexagon - Data Within is Used for Analysis
Ellipse - 2 Std Dev for Within and Between Lab Variation

Source of Data: AASHTO Materials Reference Laboratory Proficiency Sample Program
CCRL Samples 153 and 154
Final Report Issued Oct. 2004

Participation:

231	Total Laboratories
12	Laboratories Determined to be Invalid
25	Laboratories Determined to be Outliers
194	Total Laboratorires Included in Analysis

Average Results	
Sample 153 Average	Sample 154 Average
3.45	2.91

Repeatability			
1s	d2s	CV% (153)	CV% (154)
0.020	0.057	0.58	0.69

Reproducability (Sample 153)		
1s	d2s	CV%
0.044	0.126	1.29

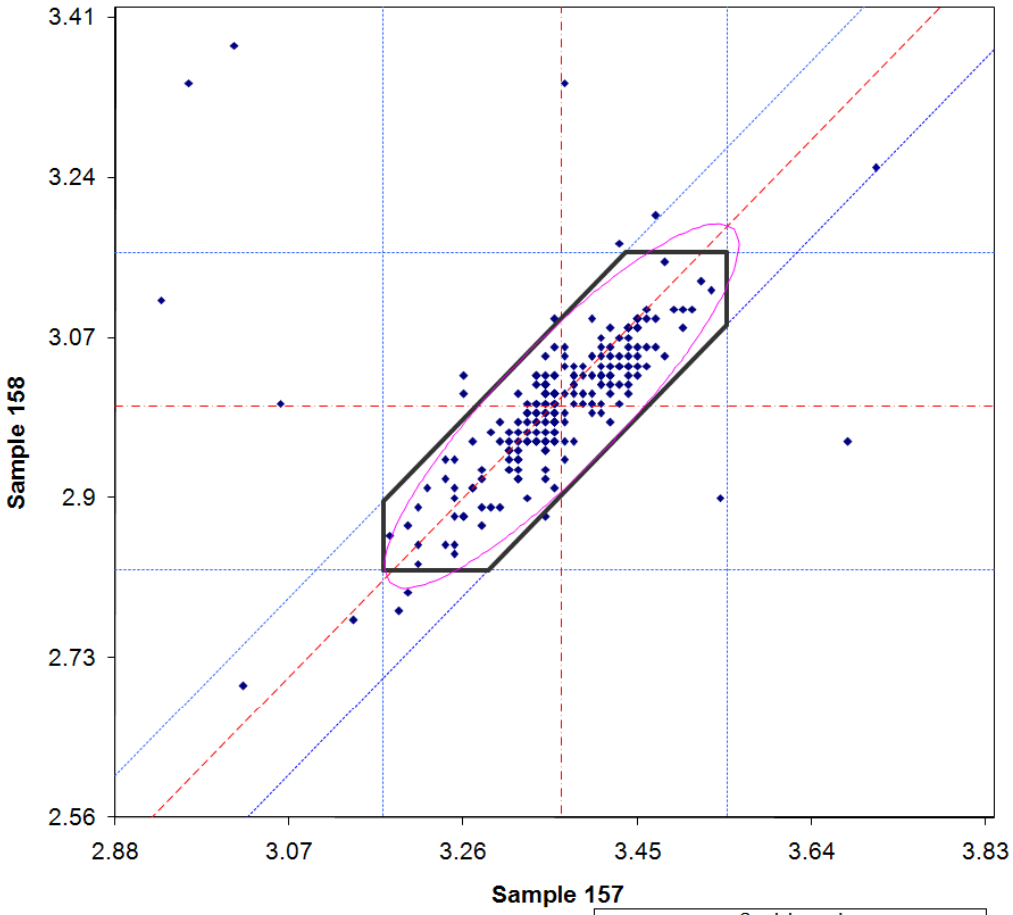
Reproducability (Sample 154)		
1s	d2s	CV%
0.039	0.110	1.34

Graph and Analysis Results for AASHTO T 105

Chemical Analysis of Hydraulic Cement

CCRL Samples 157 and 158

% Ferric Oxide (Fe2O3), Type V Cement w/ limestone & Type I / II Cement w/ Limestone



Graph Legend
Lines With Small Dash Marks - Sample Outlier Boundaries
Lines With Alternating Dash Marks - Sample Medians
Line With Large Dash Marks - Center Diagonal
Black Hexagon - Data Within is Used for Analysis
Ellipse - 2 Std Dev for Within and Between Lab Variation

Source of Data: AASHTO Materials Reference Laboratory Proficiency Sample Program
CCRL Samples 157 and 158
Final Report Issued Oct. 2005

Participation:

232	Total Laboratories
10	Laboratories Determined to be Invalid
11	Laboratories Determined to be Outliers
211	Total Laboratorires Included in Analysis

Average Results	
Sample 157 Average	Sample 158 Average
3.37	3.00

Repeatability			
1s	d2s	CV% (157)	CV% (158)
0.022	0.062	0.65	0.73

Reproducability (Sample 157)		
1s	d2s	CV%
0.065	0.184	1.93

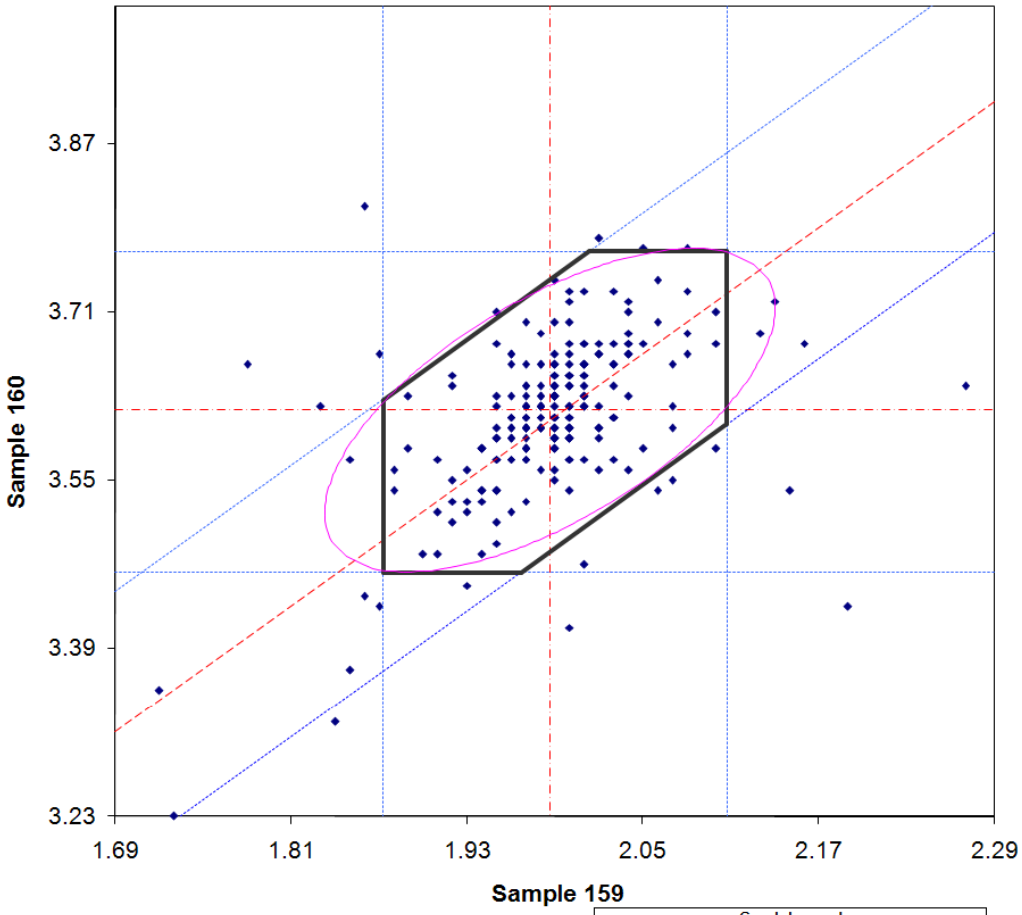
Reproducability (Sample 158)		
1s	d2s	CV%
0.060	0.170	2.00

Graph and Analysis Results for AASHTO T 105

Chemical Analysis of Hydraulic Cement

CCRL Samples 159 and 160

% Ferric Oxide (Fe2O3), Type I Cement w/ Limestone (159) & Type I / II w/ Limestone (160)



Graph Legend
Lines With Small Dash Marks - Sample Outlier Boundaries
Lines With Alternating Dash Marks - Sample Medians
Line With Large Dash Marks - Center Diagonal
Black Hexagon - Data Within is Used for Analysis
Ellipse - 2 Std Dev for Within and Between Lab Variation

Source of Data: AASHTO Materials Reference Laboratory Proficiency Sample Program
CCRL Samples 159 and 160
Final Report Issued April 2006

Participation:

231	Total Laboratories
13	Laboratories Determined to be Invalid
20	Laboratories Determined to be Outliers
198	Total Laboratorires Included in Analysis

Average Results	
Sample 159 Average	Sample 160 Average
1.99	3.62

Repeatability			
1s	d2s	CV% (159)	CV% (160)
0.031	0.087	1.55	0.85

Reproducability (Sample 159)		
1s	d2s	CV%
0.039	0.111	1.97

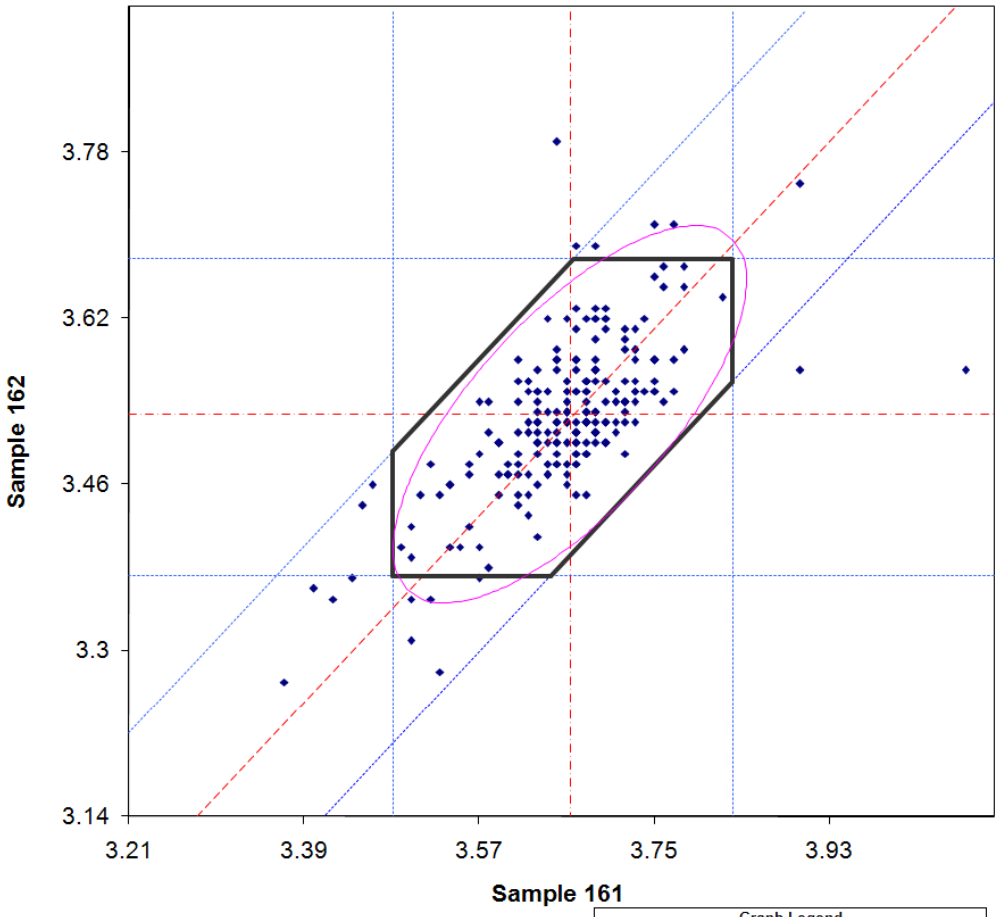
Reproducability (Sample 160)		
1s	d2s	CV%
0.053	0.149	1.45

Graph and Analysis Results for AASHTO T 105

Chemical Analysis of Hydraulic Cement

CCRL Samples 161 and 162

% Ferric Oxide (Fe2O3), Type I Cement (161) & Type I Cement w/ Limestone (162)



Graph Legend
Lines With Small Dash Marks - Sample Outlier Boundaries
Lines With Alternating Dash Marks - Sample Medians
Line With Large Dash Marks - Center Diagonal
Black Hexagon - Data Within is Used for Analysis
Ellipse - 2 Std Dev for Within and Between Lab Variation

Source of Data: AASHTO Materials Reference Laboratory Proficiency Sample Program
CCRL Samples 161 and 162
Final Report Issued Oct 2006

Participation:

239	Total Laboratories
5	Laboratories Determined to be Invalid
17	Laboratories Determined to be Outliers
217	Total Laboratorires Included in Analysis

Average Results	
Sample 161 Average	Sample 162 Average
3.66	3.53

Repeatability			
1s	d2s	CV% (161)	CV% (162)
0.032	0.092	0.88	0.92

Reproducability (Sample 161)		
1s	d2s	CV%
0.057	0.162	1.56

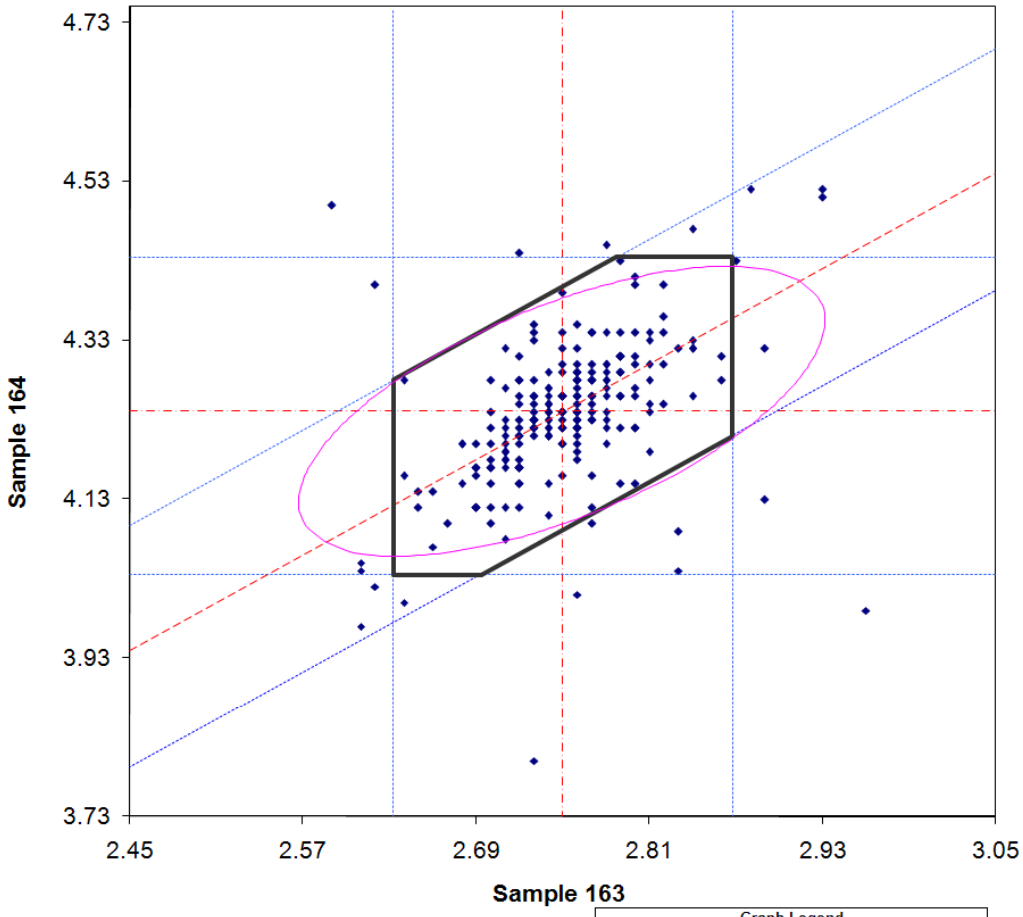
Reproducability (Sample 162)		
1s	d2s	CV%
0.055	0.155	1.55

Graph and Analysis Results for AASHTO T 105

Chemical Analysis of Hydraulic Cement

CCRL Samples 163 and 164

% Ferric Oxide (Fe_2O_3), Type I / II Cement



Graph Legend
Lines With Small Dash Marks - Sample Outlier Boundaries
Lines With Alternating Dash Marks - Sample Medians
Line With Large Dash Marks - Center Diagonal
Black Hexagon - Data Within is Used for Analysis
Ellipse - 2 Std Dev for Within and Between Lab Variation

Source of Data: AASHTO Materials Reference Laboratory Proficiency Sample Program
CCRL Samples 163 and 164
Final Report Issued April 2007

Participation:

238	Total Laboratories
11	Laboratories Determined to be Invalid
19	Laboratories Determined to be Outliers
208	Total Laboratorires Included in Analysis

Average Results	
Sample 163 Average	Sample 164 Average
2.75	4.24

Repeatability			
1s	d2s	CV% (163)	CV% (164)
0.037	0.105	1.35	0.88

Reproducability (Sample 163)		
1s	d2s	CV%
0.041	0.117	1.51

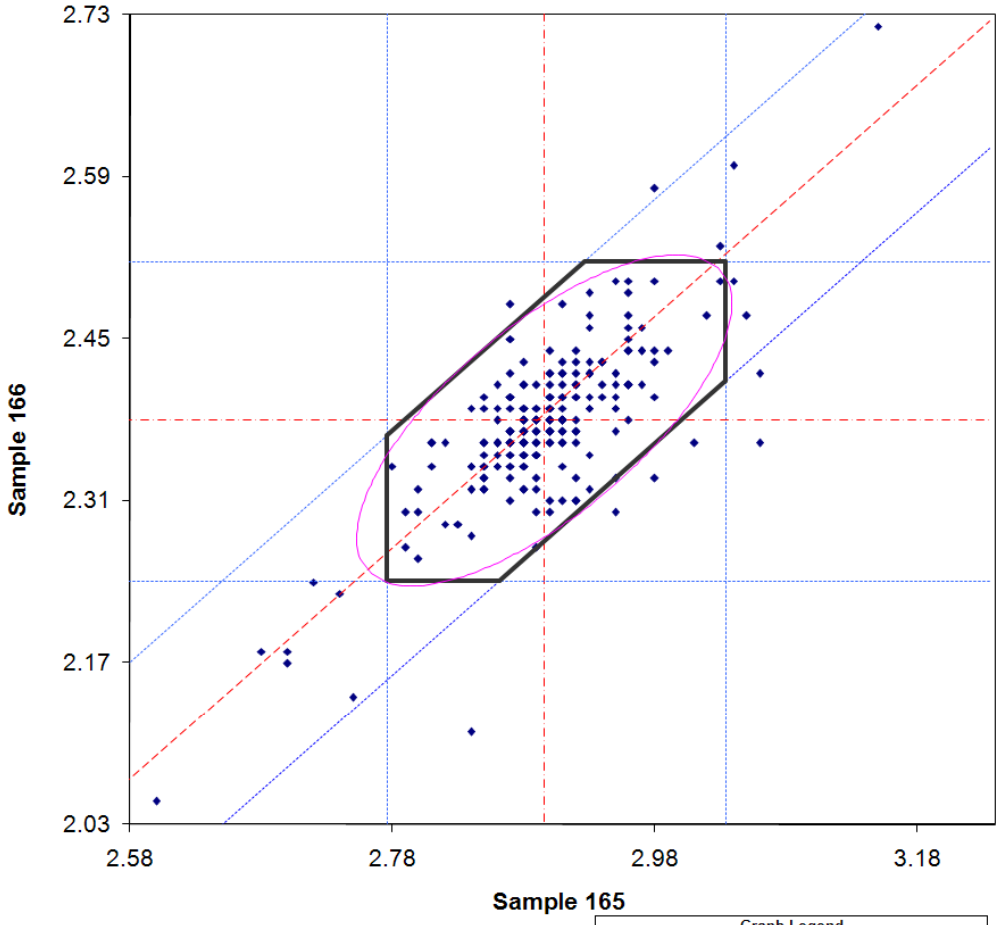
Reproducability (Sample 164)		
1s	d2s	CV%
0.066	0.185	1.55

Graph and Analysis Results for AASHTO T 105

Chemical Analysis of Hydraulic Cement

CCRL Samples 165 and 166

% Ferric Oxide (Fe2O3), Type I / II Cement w/ Limestone



Graph Legend
Lines With Small Dash Marks - Sample Outlier Boundaries
Lines With Alternating Dash Marks - Sample Medians
Line With Large Dash Marks - Center Diagonal
Black Hexagon - Data Within is Used for Analysis
Ellipse - 2 Std Dev for Within and Between Lab Variation

Source of Data: AASHTO Materials Reference Laboratory Proficiency Sample Program
CCRL Samples 165 and 166
Final Report Issued Sept. 2007

Participation:

243	Total Laboratories
8	Laboratories Determined to be Invalid
16	Laboratories Determined to be Outliers
219	Total Laboratorires Included in Analysis

Average Results	
Sample 165 Average	Sample 166 Average
2.90	2.38

Repeatability			
1s	d2s	CV% (165)	CV% (166)
0.026	0.073	0.89	1.08

Reproducability (Sample 165)		
1s	d2s	CV%
0.042	0.120	1.46

Reproducability (Sample 166)		
1s	d2s	CV%
0.046	0.129	1.92

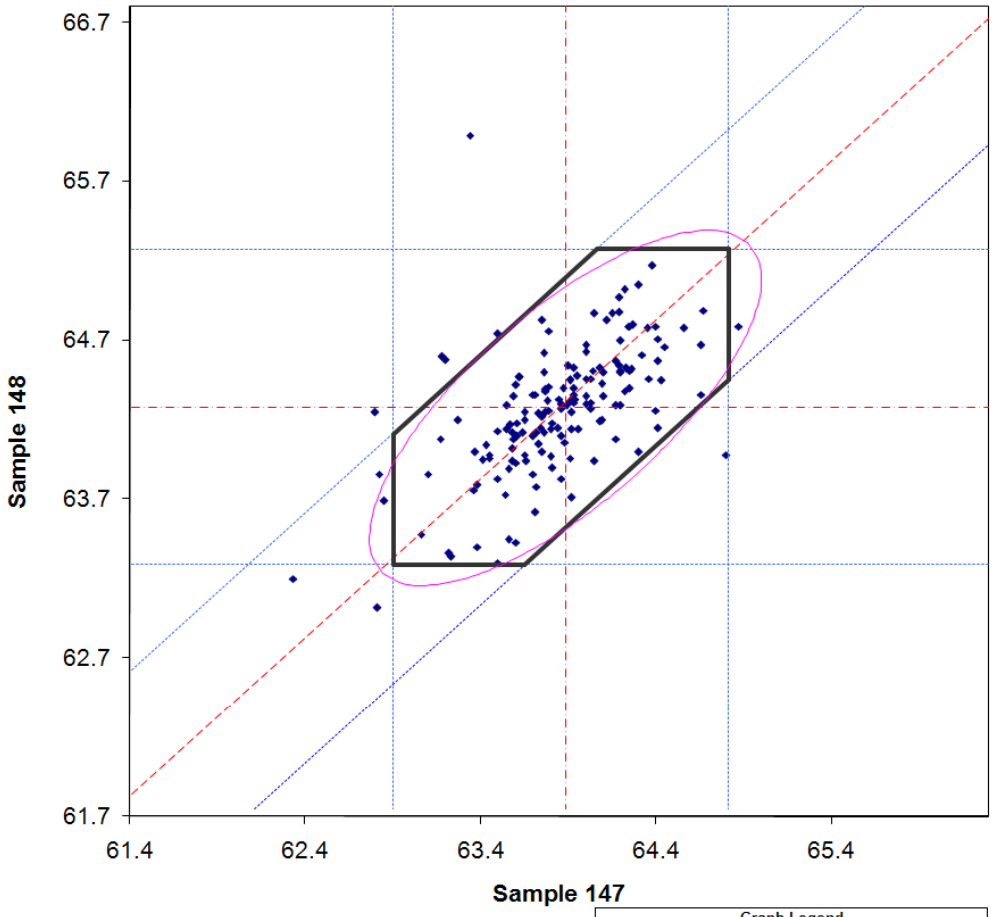
APPENDIX D: CALCIUM OXIDE (CAO)

Graph and Analysis Results for AASHTO T 105

Chemical Analysis of Hydraulic Cement

CCRL Samples 147 and 148

Test Property: % Calcium Oxide (CaO), Type I / II Cement



Graph Legend
Lines With Small Dash Marks - Sample Outlier Boundaries
Lines With Alternating Dash Marks - Sample Medians
Line With Large Dash Marks - Center Diagonal
Black Hexagon - Data Within is Used for Analysis
Ellipse - 2 Std Dev for Within and Between Lab Variation

Source of Data: AASHTO Materials Reference Laboratory Proficiency Sample Program
CCRL Samples 147 and 148
Final Report Issued March 2003

Participation:

160	Total Laboratories
3	Laboratories Determined to be Invalid
10	Laboratories Determined to be Outliers
147	Total Laboratorires Included in Analysis

Average Results	
Sample 147 Average	Sample 148 Average
63.88	64.28

Repeatability			
1s	d2s	CV% (147)	CV% (148)
0.19	0.55	0.30	0.30

Reproducability (Sample 147)		
1s	d2s	CV%
0.33	0.93	0.52

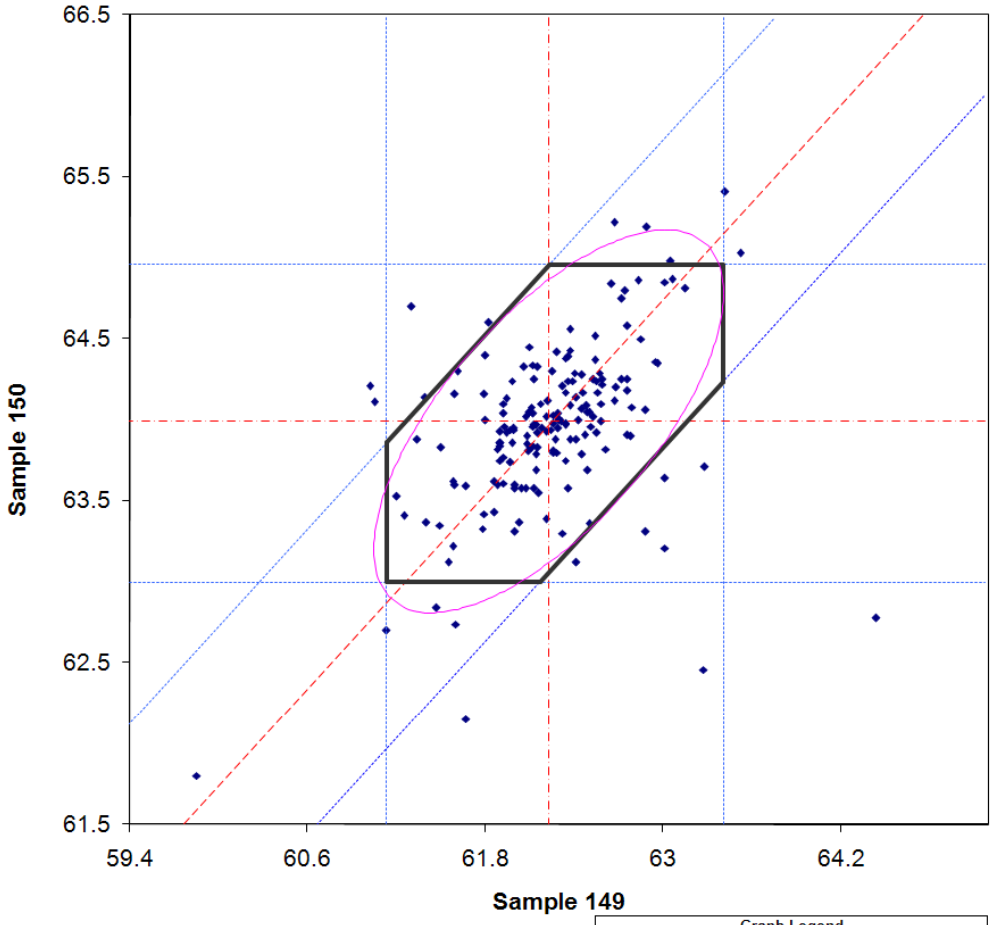
Reproducability (Sample 148)		
1s	d2s	CV%
0.36	1.02	0.56

Graph and Analysis Results for AASHTO T 105

Chemical Analysis of Hydraulic Cement

CCRL Samples 149 and 150

Test Property: % Calcium Oxide (CaO), Type I Cement



Graph Legend
Lines With Small Dash Marks - Sample Outlier Boundaries
Lines With Alternating Dash Marks - Sample Medians
Line With Large Dash Marks - Center Diagonal
Black Hexagon - Data Within is Used for Analysis
Ellipse - 2 Std Dev for Within and Between Lab Variation

Source of Data: AASHTO Materials Reference Laboratory Proficiency Sample Program
CCRL Samples 149 and 150
Final Report Issued Sept. 2003

Participation:

175	Total Laboratories
3	Laboratories Determined to be Invalid
19	Laboratories Determined to be Outliers
153	Total Laboratorires Included in Analysis

Average Results	
Sample 149 Average	Sample 150 Average
62.23	63.99

Repeatability			
1s	d2s	CV% (149)	CV% (150)
0.23	0.64	0.36	0.35

Reproducability (Sample 149)		
1s	d2s	CV%
0.37	1.05	0.60

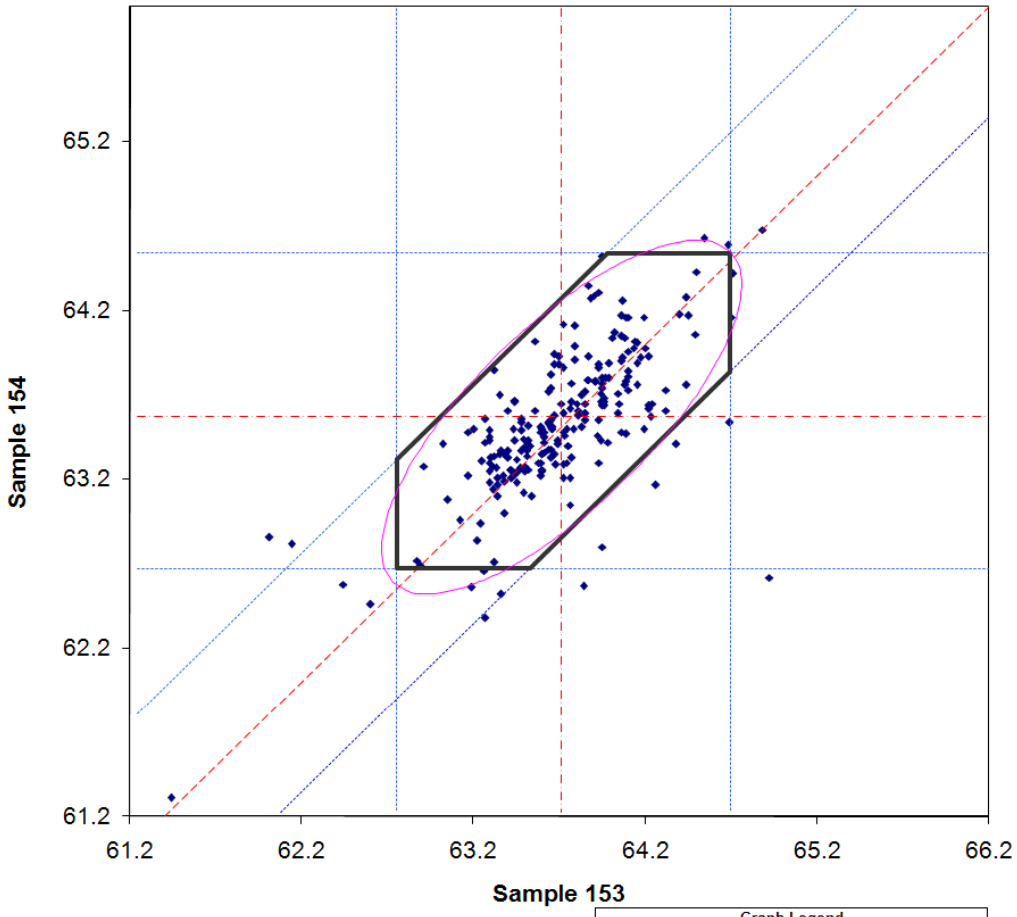
Reproducability (Sample 150)		
1s	d2s	CV%
0.35	0.98	0.54

Graph and Analysis Results for AASHTO T 105

Chemical Analysis of Hydraulic Cement

CCRL Samples 153 and 154

Test Property: % Calcium Oxide (CaO), Type I / II Cement



Graph Legend
Lines With Small Dash Marks - Sample Outlier Boundaries
Lines With Alternating Dash Marks - Sample Medians
Line With Large Dash Marks - Center Diagonal
Black Hexagon - Data Within is Used for Analysis
Ellipse - 2 Std Dev for Within and Between Lab Variation

Source of Data: AASHTO Materials Reference Laboratory Proficiency Sample Program
CCRL Samples 153 and 154
Final Report Issued Oct. 2004

Participation:

230	Total Laboratories
3	Laboratories Determined to be Invalid
19	Laboratories Determined to be Outliers
208	Total Laboratorires Included in Analysis

Average Results	
Sample 153 Average	Sample 154 Average
63.71	63.57

Repeatability			
1s	d2s	CV% (153)	CV% (154)
0.17	0.49	0.27	0.27

Reproducability (Sample 153)		
1s	d2s	CV%
0.33	0.93	0.52

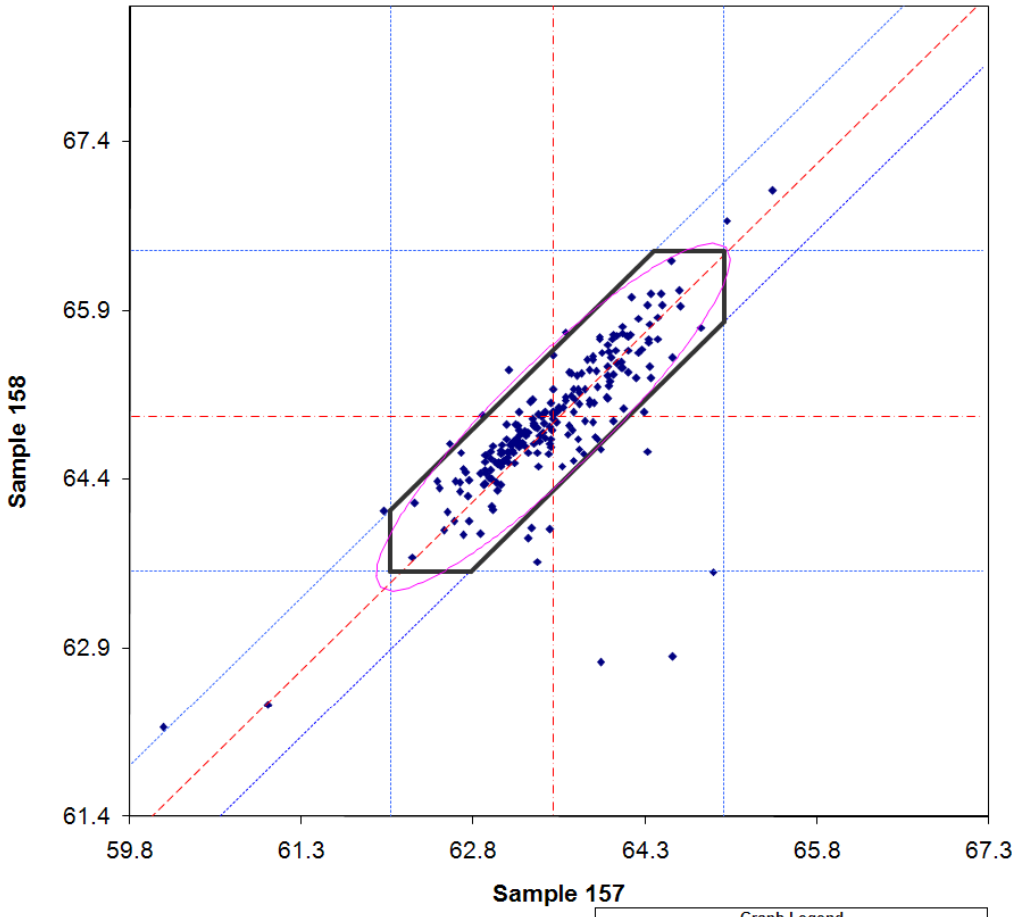
Reproducability (Sample 154)		
1s	d2s	CV%
0.33	0.92	0.51

Graph and Analysis Results for AASHTO T 105

Chemical Analysis of Hydraulic Cement

CCRL Samples 157 and 158

% Calcium Oxide (CaO), Type V Cement w/ Limestone (157) & Type I / II w/ Limestone (158)



Graph Legend
Lines With Small Dash Marks - Sample Outlier Boundaries
Lines With Alternating Dash Marks - Sample Medians
Line With Large Dash Marks - Center Diagonal
Black Hexagon - Data Within is Used for Analysis
Ellipse - 2 Std Dev for Within and Between Lab Variation

Source of Data: AASHTO Materials Reference Laboratory Proficiency Sample Program
CCRL Samples 157 and 158
Final Report Issued Oct. 2005

Participation:

229	Total Laboratories
10	Laboratories Determined to be Invalid
14	Laboratories Determined to be Outliers
205	Total Laboratorires Included in Analysis

Average Results	
Sample 157 Average	Sample 158 Average
63.49	64.96

Repeatability			
1s	d2s	CV% (157)	CV% (158)
0.16	0.44	0.25	0.24

Reproducability (Sample 157)		
1s	d2s	CV%
0.52	1.46	0.82

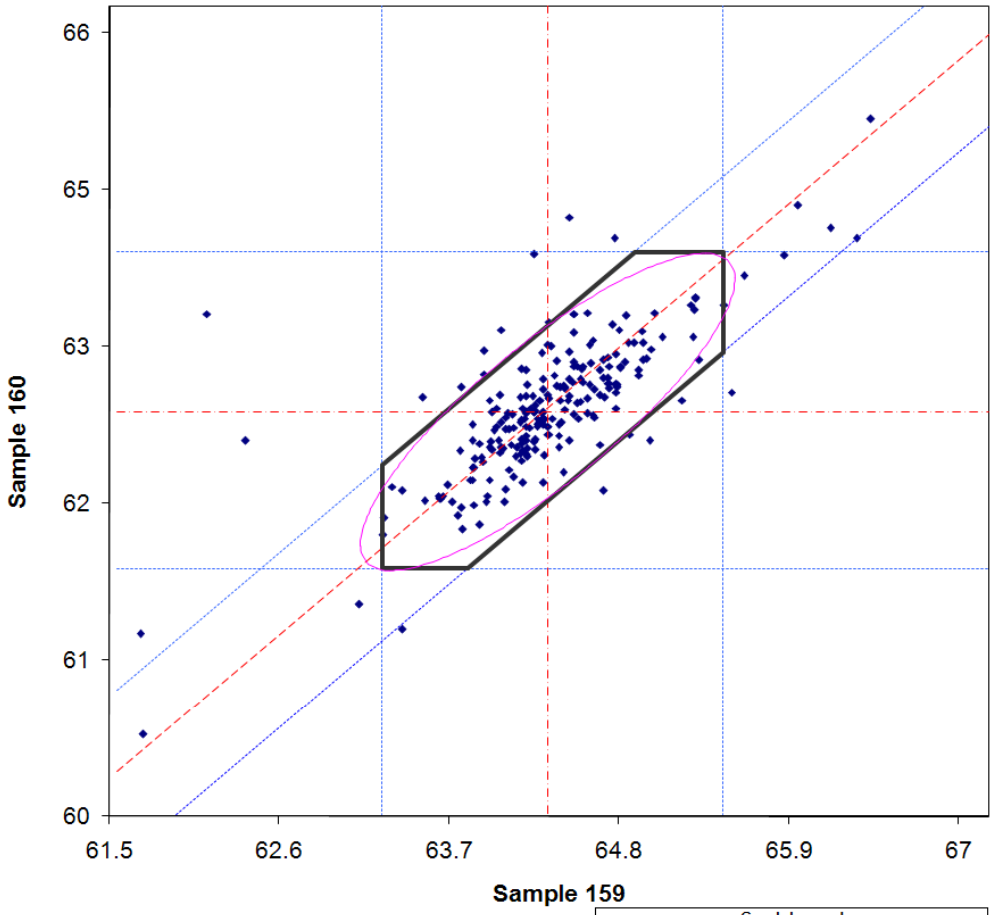
Reproducability (Sample 158)		
1s	d2s	CV%
0.49	1.38	0.75

Graph and Analysis Results for AASHTO T 105

Chemical Analysis of Hydraulic Cement

CCRL Samples 159 and 160

% Calcium Oxide (CaO) , Type I Cement w/ Limestone (159) & Type I / II w/ Limestone (160)



Graph Legend
Lines With Small Dash Marks - Sample Outlier Boundaries
Lines With Alternating Dash Marks - Sample Medians
Line With Large Dash Marks - Center Diagonal
Black Hexagon - Data Within is Used for Analysis
Ellipse - 2 Std Dev for Within and Between Lab Variation

Source of Data: AASHTO Materials Reference Laboratory Proficiency Sample Program
CCRL Samples 159 and 160
Final Report Issued April 2006

Participation:

232	Total Laboratories
8	Laboratories Determined to be Invalid
21	Laboratories Determined to be Outliers
203	Total Laboratorires Included in Analysis

Average Results	
Sample 159 Average	Sample 160 Average
64.34	62.90

Repeatability			
1s	d2s	CV% (159)	CV% (160)
0.16	0.46	0.25	0.26

Reproducability (Sample 159)		
1s	d2s	CV%
0.39	1.10	0.61

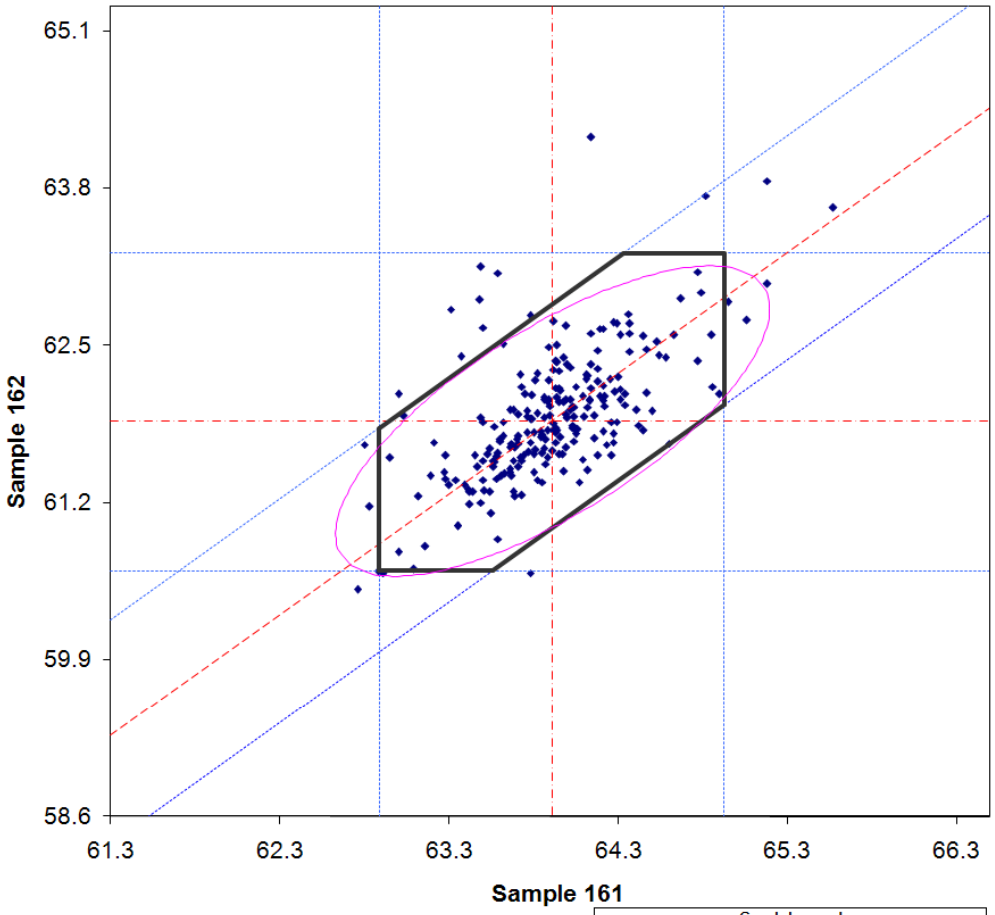
Reproducability (Sample 160)		
1s	d2s	CV%
0.39	1.09	0.61

Graph and Analysis Results for AASHTO T 105

Chemical Analysis of Hydraulic Cement

CCRL Samples 161 and 162

Test Property: % Calcium Oxide (CaO), Type I Cement (161) & Type I w/ Limestone (162)



Graph Legend
Lines With Small Dash Marks - Sample Outlier Boundaries
Lines With Alternating Dash Marks - Sample Medians
Line With Large Dash Marks - Center Diagonal
Black Hexagon - Data Within is Used for Analysis
Ellipse - 2 Std Dev for Within and Between Lab Variation

Source of Data: AASHTO Materials Reference Laboratory Proficiency Sample Program
CCRL Samples 161 and 162
Final Report Issued Oct. 2006

Participation:

236	Total Laboratories
2	Laboratories Determined to be Invalid
19	Laboratories Determined to be Outliers
215	Total Laboratorires Included in Analysis

Average Results	
Sample 161 Average	Sample 162 Average
63.91	61.88

Repeatability			
1s	d2s	CV% (161)	CV% (162)
0.22	0.63	0.35	0.36

Reproducability (Sample 161)		
1s	d2s	CV%
0.37	1.04	0.58

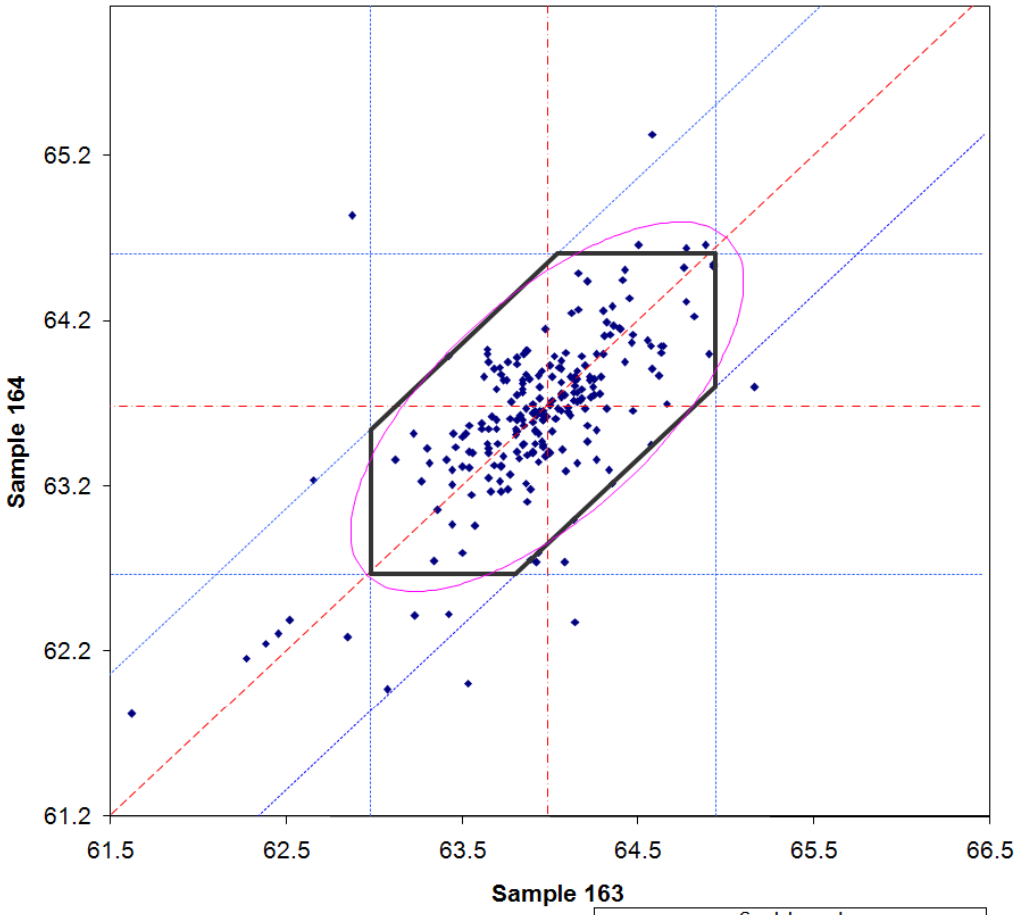
Reproducability (Sample 162)		
1s	d2s	CV%
0.43	1.20	0.69

Graph and Analysis Results for AASHTO T 105

Chemical Analysis of Hydraulic Cement

CCRL Samples 163 and 164

Test Property: % Calcium Oxide (CaO), Type I / II Cement



Graph Legend
Lines With Small Dash Marks - Sample Outlier Boundaries
Lines With Alternating Dash Marks - Sample Medians
Line With Large Dash Marks - Center Diagonal
Black Hexagon - Data Within is Used for Analysis
Ellipse - 2 Std Dev for Within and Between Lab Variation

Source of Data: AASHTO Materials Reference Laboratory Proficiency Sample Program
CCRL Samples 163 and 164
Final Report Issued April 2007

Participation:

235	Total Laboratories
6	Laboratories Determined to be Invalid
19	Laboratories Determined to be Outliers
210	Total Laboratorires Included in Analysis

Average Results	
Sample 163 Average	Sample 164 Average
63.98	63.68

Repeatability			
1s	d2s	CV% (163)	CV% (164)
0.21	0.60	0.33	0.33

Reproducability (Sample 163)		
1s	d2s	CV%
0.34	0.95	0.53

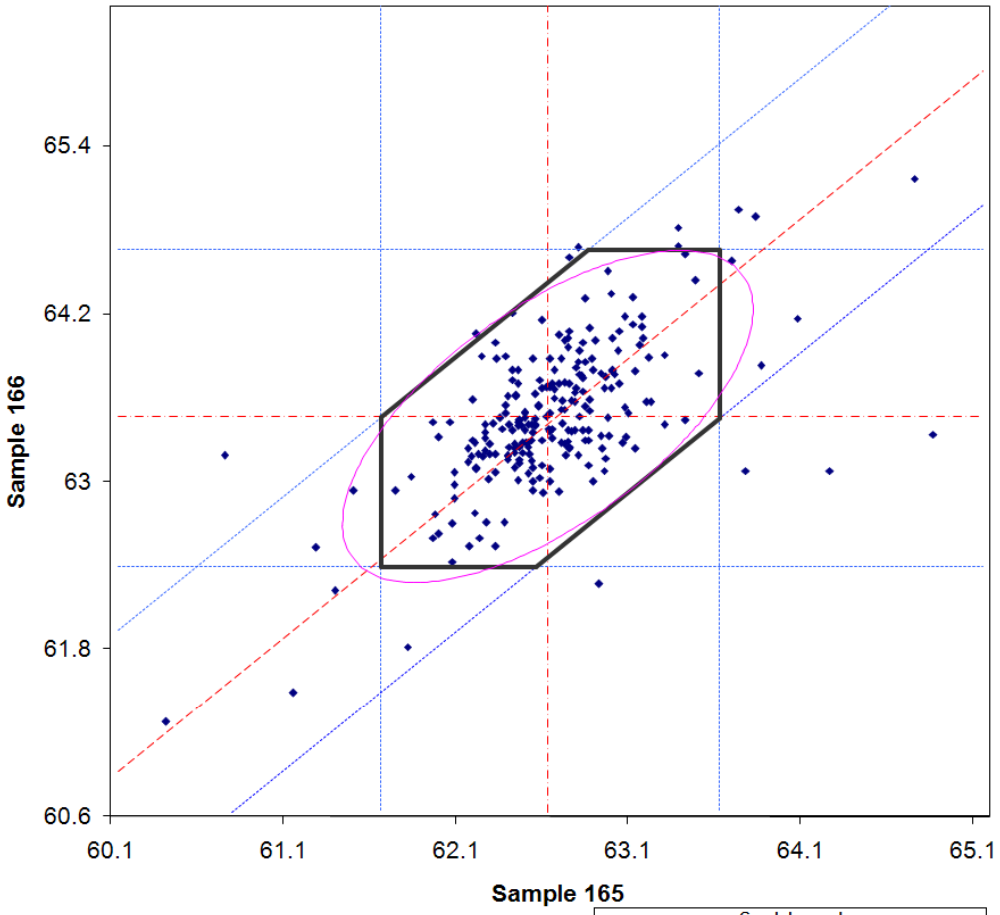
Reproducability (Sample 164)		
1s	d2s	CV%
0.34	0.97	0.54

Graph and Analysis Results for AASHTO T 105

Chemical Analysis of Hydraulic Cement

CCRL Samples 165 and 166

Test Property: % Calcium Oxide (CaO), Type I / II Cement w/ Limestone



Graph Legend
Lines With Small Dash Marks - Sample Outlier Boundaries
Lines With Alternating Dash Marks - Sample Medians
Line With Large Dash Marks - Center Diagonal
Black Hexagon - Data Within is Used for Analysis
Ellipse - 2 Std Dev for Within and Between Lab Variation

Source of Data: AASHTO Materials Reference Laboratory Proficiency Sample Program
CCRL Samples 165 and 166
Final Report Issued September 2007

Participation:

242	Total Laboratories
8	Laboratories Determined to be Invalid
17	Laboratories Determined to be Outliers
217	Total Laboratorires Included in Analysis

Average Results	
Sample 165 Average	Sample 166 Average
62.63	63.47

Repeatability			
1s	d2s	CV% (165)	CV% (166)
0.24	0.67	0.38	0.37

Reproducability (Sample 165)		
1s	d2s	CV%
0.33	0.92	0.52

Reproducability (Sample 166)		
1s	d2s	CV%
0.39	1.10	0.61

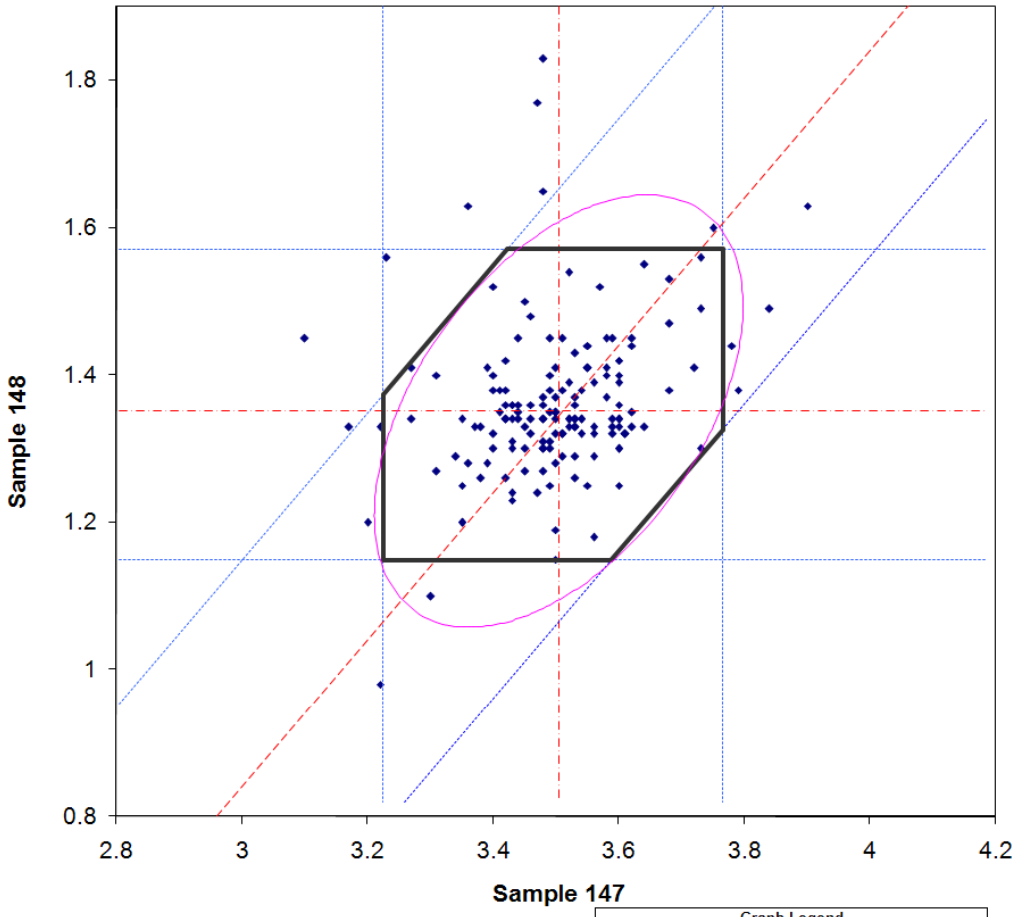
APPENDIX E: MAGNESIUM OXIDE (MGO)

Graph and Analysis Results for AASHTO T 105

Chemical Analysis of Hydraulic Cement

CCRL Samples 147 and 148

Test Property: % Magnisium Oxide (MgO), Type I / II Cement



Graph Legend
Lines With Small Dash Marks - Sample Outlier Boundaries
Lines With Alternating Dash Marks - Sample Medians
Line With Large Dash Marks - Center Diagonal
Black Hexagon - Data Within is Used for Analysis
Ellipse - 2 Std Dev for Within and Between Lab Variation

Source of Data: AASHTO Materials Reference Laboratory Proficiency Sample Program
CCRL Samples 147 and 148
Final Report Issued March 2003

Participation:

159	Total Laboratories
6	Laboratories Determined to be Invalid
13	Laboratories Determined to be Outliers
140	Total Laboratorires Included in Analysis

Average Results	
Sample 147 Average	Sample 148 Average
3.50	1.35

Repeatability			
1s	d2s	CV% (147)	CV% (148)
0.07	0.20	2.01	5.20

Reproducability (Sample 147)		
1s	d2s	CV%
0.09	0.26	2.65

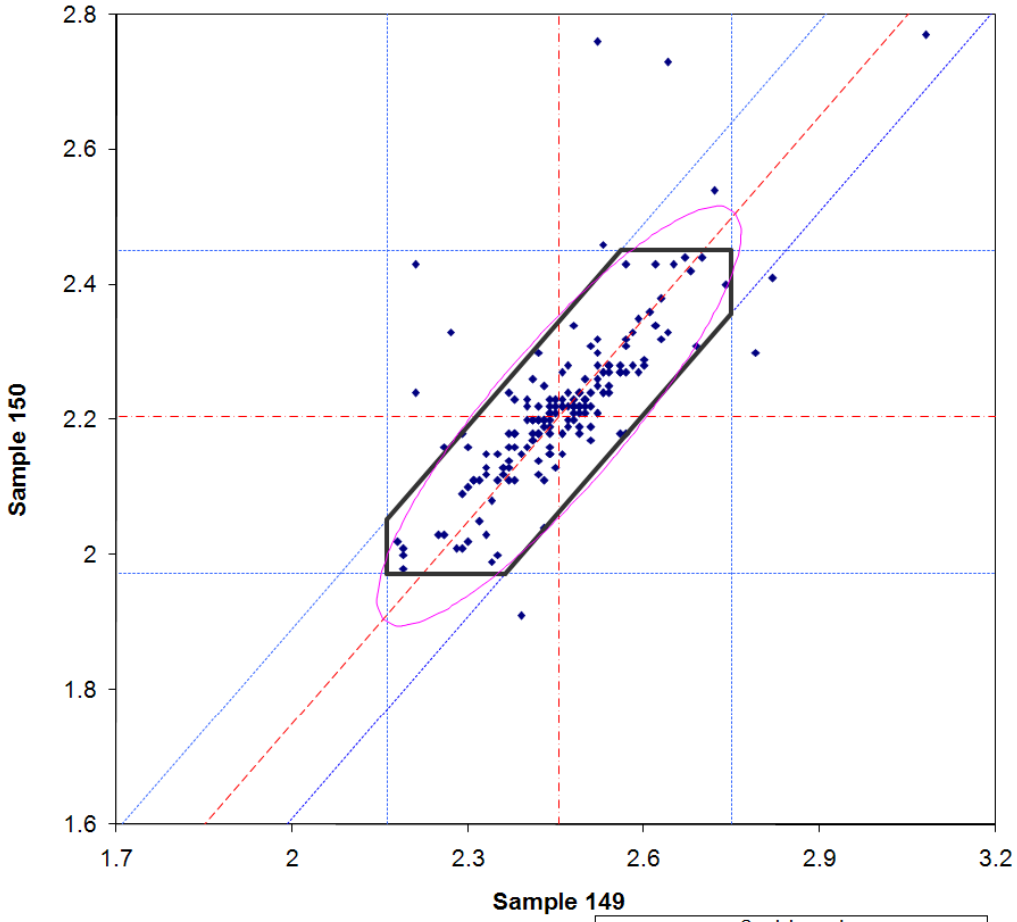
Reproducability (Sample 148)		
1s	d2s	CV%
0.07	0.21	5.52

Graph and Analysis Results for AASHTO T 105

Chemical Analysis of Hydraulic Cement

CCRL Samples 149 and 150

Test Property: % Calcium Oxide (CaO), Type I Cement



Graph Legend
Lines With Small Dash Marks - Sample Outlier Boundaries
Lines With Alternating Dash Marks - Sample Medians
Line With Large Dash Marks - Center Diagonal
Black Hexagon - Data Within is Used for Analysis
Ellipse - 2 Std Dev for Within and Between Lab Variation

Source of Data: AASHTO Materials Reference Laboratory Proficiency Sample Program
CCRL Samples 149 and 150
Final Report Issued Sept. 2003

Participation:

175	Total Laboratories
9	Laboratories Determined to be Invalid
6	Laboratories Determined to be Outliers
160	Total Laboratorires Included in Analysis

Average Results	
Sample 149 Average	Sample 150 Average
2.46	2.21

Repeatability			
1s	d2s	CV% (149)	CV% (150)
0.04	0.10	1.48	1.65

Reproducability (Sample 149)		
1s	d2s	CV%
0.11	0.30	4.30

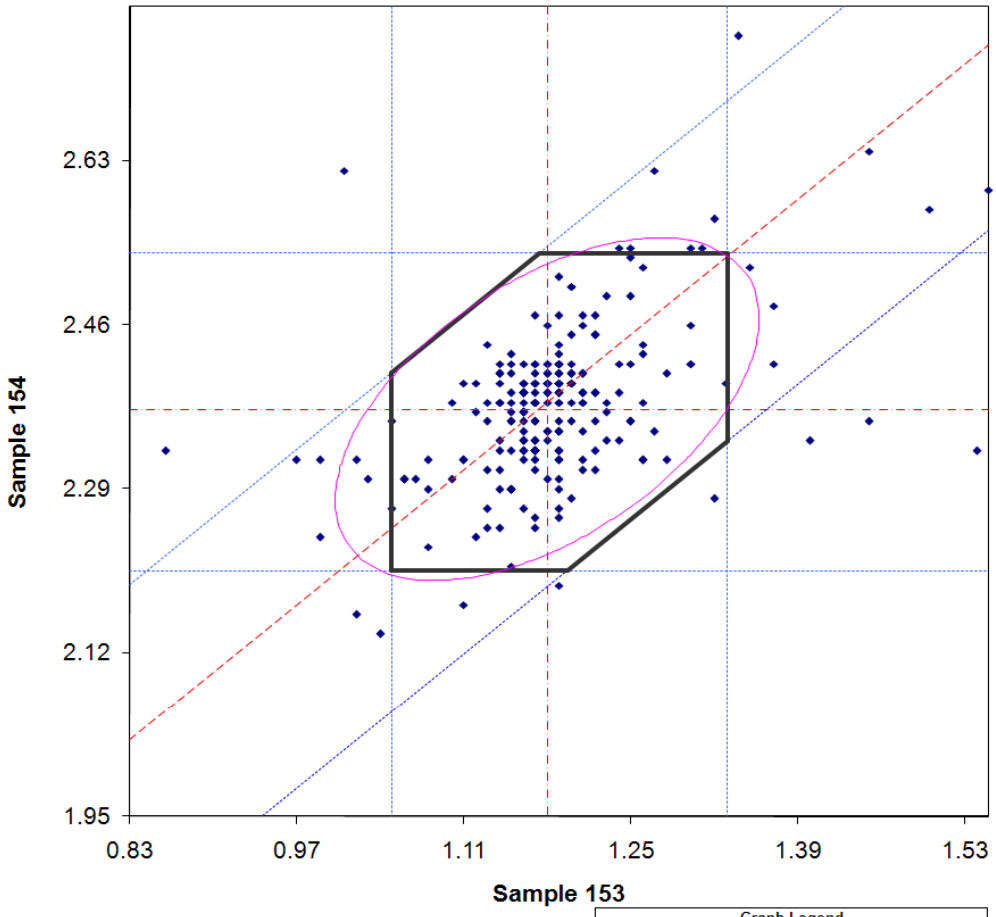
Reproducability (Sample 150)		
1s	d2s	CV%
0.09	0.27	4.29

Graph and Analysis Results for AASHTO T 105

Chemical Analysis of Hydraulic Cement

CCRL Samples 153 and 154

Test Property: % Magnisium Oxide (MgO), Type I / II Cement



Graph Legend
Lines With Small Dash Marks - Sample Outlier Boundaries
Lines With Alternating Dash Marks - Sample Medians
Line With Large Dash Marks - Center Diagonal
Black Hexagon - Data Within is Used for Analysis
Ellipse - 2 Std Dev for Within and Between Lab Variation

Source of Data: AASHTO Materials Reference Laboratory Proficiency Sample Program
CCRL Samples 153 and 154
Final Report Issued Oct. 2004

Participation:

232	Total Laboratories
12	Laboratories Determined to be Invalid
22	Laboratories Determined to be Outliers
198	Total Laboratorires Included in Analysis

Average Results	
Sample 153 Average	Sample 154 Average
1.18	2.37

Repeatability			
1s	d2s	CV% (153)	CV% (154)
0.04	0.11	3.44	1.71

Reproducability (Sample 153)		
1s	d2s	CV%
0.05	0.13	3.86

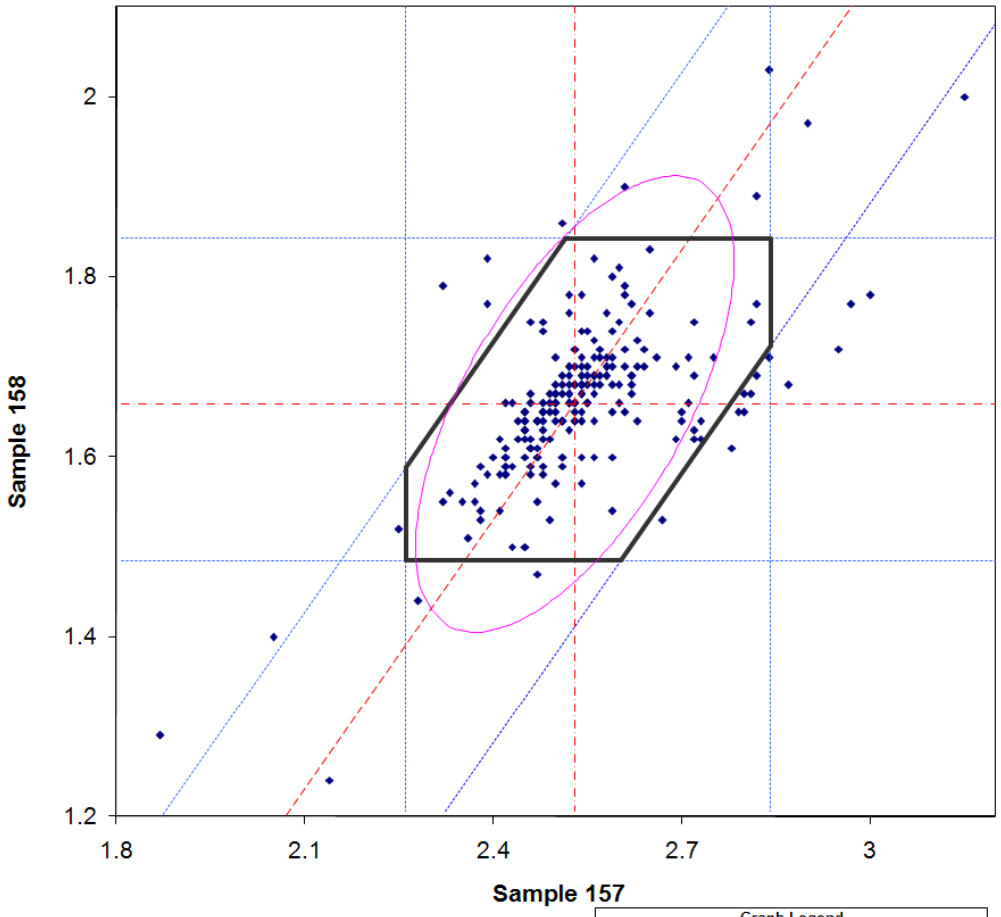
Reproducability (Sample 154)		
1s	d2s	CV%
0.06	0.16	2.42

Graph and Analysis Results for AASHTO T 105

Chemical Analysis of Hydraulic Cement

CCRL Samples 157 and 158

% Magnisium Oxide (MgO), Type V w/ Limestone (157) & Type I / II w/ Limestone (158)



Graph Legend
Lines With Small Dash Marks - Sample Outlier Boundaries
Lines With Alternating Dash Marks - Sample Medians
Line With Large Dash Marks - Center Diagonal
Black Hexagon - Data Within is Used for Analysis
Ellipse - 2 Std Dev for Within and Between Lab Variation

Source of Data: AASHTO Materials Reference Laboratory Proficiency Sample Program
CCRL Samples 157 and 158
Final Report Issued Oct. 2005

Participation:

232	Total Laboratories
9	Laboratories Determined to be Invalid
23	Laboratories Determined to be Outliers
200	Total Laboratorires Included in Analysis

Average Results	
Sample 157 Average	Sample 158 Average
2.53	1.66

Repeatability			
1s	d2s	CV% (157)	CV% (158)
0.05	0.15	2.04	3.11

Reproducability (Sample 157)		
1s	d2s	CV%
0.09	0.25	3.47

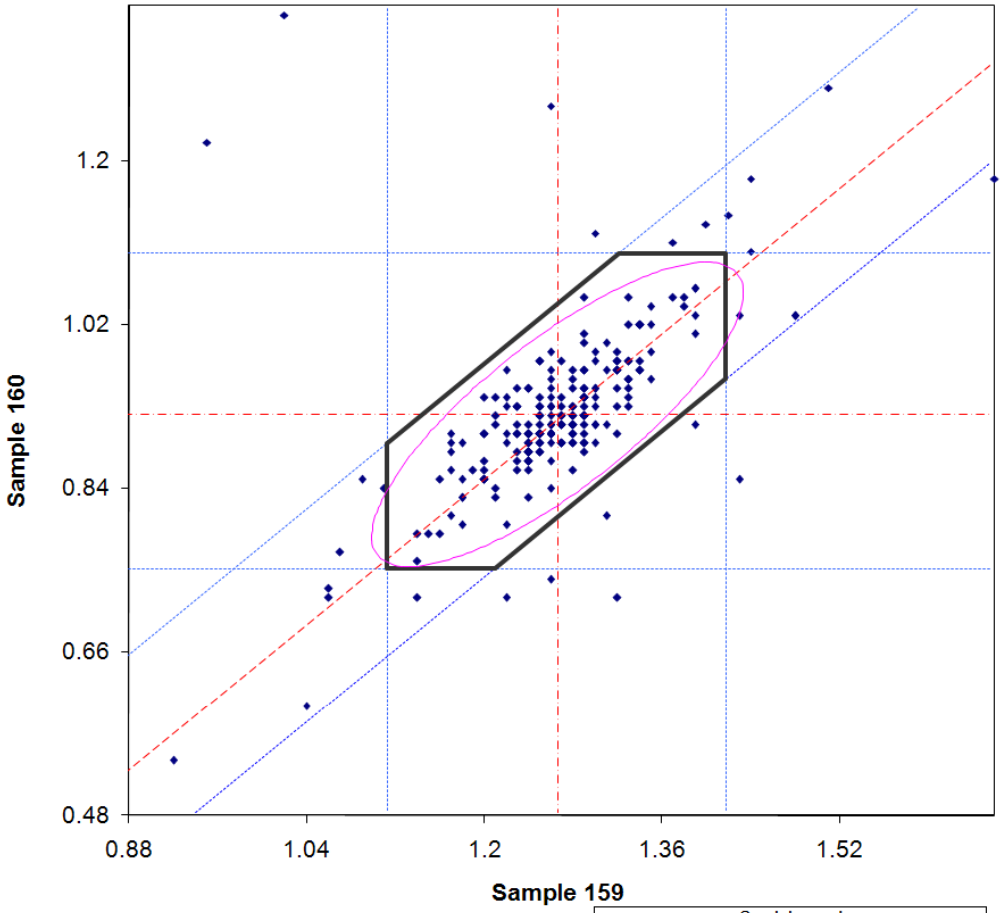
Reproducability (Sample 158)		
1s	d2s	CV%
0.06	0.18	3.77

Graph and Analysis Results for AASHTO T 105

Chemical Analysis of Hydraulic Cement

CCRL Samples 159 and 160

% Magnisium Oxide (MgO), Type I w/ Limestone (159) & Type I / II w/ Limestone (160)



Graph Legend
Lines With Small Dash Marks - Sample Outlier Boundaries
Lines With Alternating Dash Marks - Sample Medians
Line With Large Dash Marks - Center Diagonal
Black Hexagon - Data Within is Used for Analysis
Ellipse - 2 Std Dev for Within and Between Lab Variation

Source of Data: AASHTO Materials Reference Laboratory Proficiency Sample Program
CCRL Samples 159 and 160
Final Report Issued April 2006

Participation:

232	Total Laboratories
14	Laboratories Determined to be Invalid
21	Laboratories Determined to be Outliers
197	Total Laboratorires Included in Analysis

Average Results	
Sample 159 Average	Sample 160 Average
1.27	0.92

Repeatability			
1s	d2s	CV% (159)	CV% (160)
0.02	0.07	1.96	2.69

Reproducability (Sample 159)		
1s	d2s	CV%
0.05	0.14	4.00

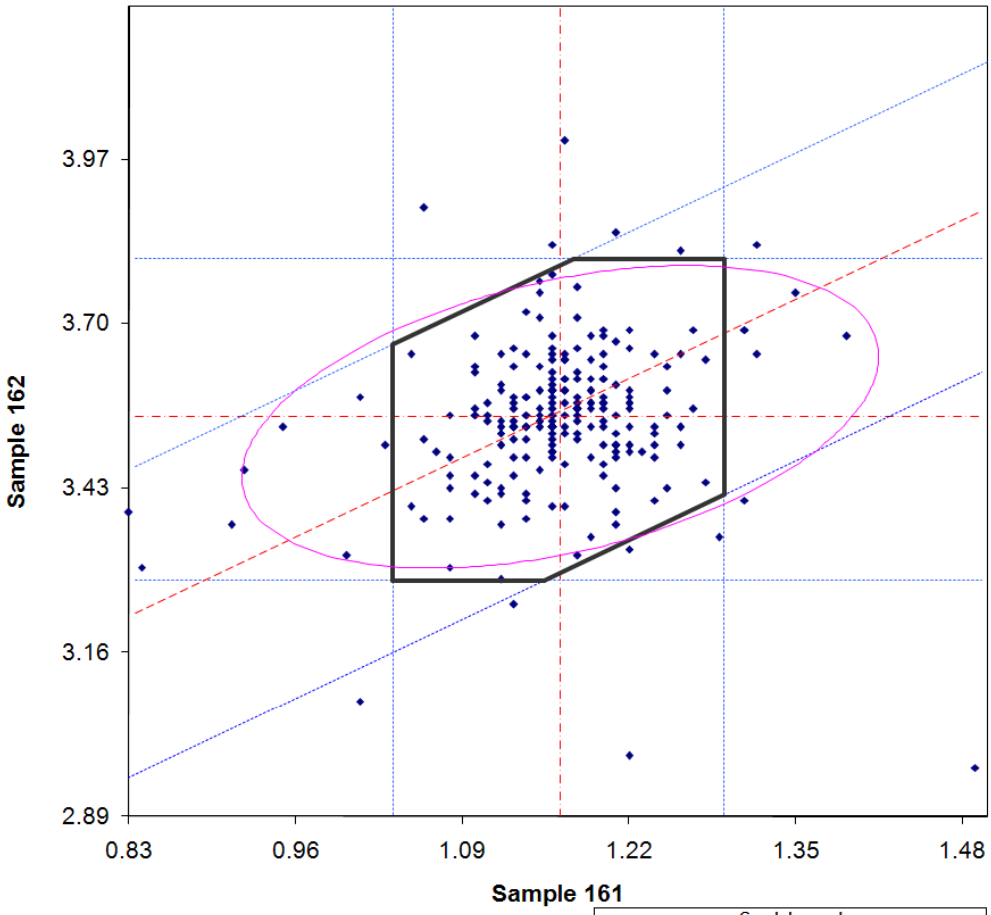
Reproducability (Sample 160)		
1s	d2s	CV%
0.06	0.16	5.99

Graph and Analysis Results for AASHTO T 105

Chemical Analysis of Hydraulic Cement

CCRL Samples 161 and 162

% Magnisium Oxide (MgO), Type I Cement (161) & Type I Cement w/ Limestone (162)



Graph Legend
Lines With Small Dash Marks - Sample Outlier Boundaries
Lines With Alternating Dash Marks - Sample Medians
Line With Large Dash Marks - Center Diagonal
Black Hexagon - Data Within is Used for Analysis
Ellipse - 2 Std Dev for Within and Between Lab Variation

Source of Data: AASHTO Materials Reference Laboratory Proficiency Sample Program
CCRL Samples 161 and 162
Final Report Issued Oct. 2006

Participation:

237	Total Laboratories
8	Laboratories Determined to be Invalid
23	Laboratories Determined to be Outliers
206	Total Laboratorires Included in Analysis

Average Results	
Sample 161 Average	Sample 162 Average
1.17	3.55

Repeatability			
1s	d2s	CV% (161)	CV% (162)
0.06	0.18	5.49	1.81

Reproducability (Sample 161)		
1s	d2s	CV%
0.05	0.13	3.99

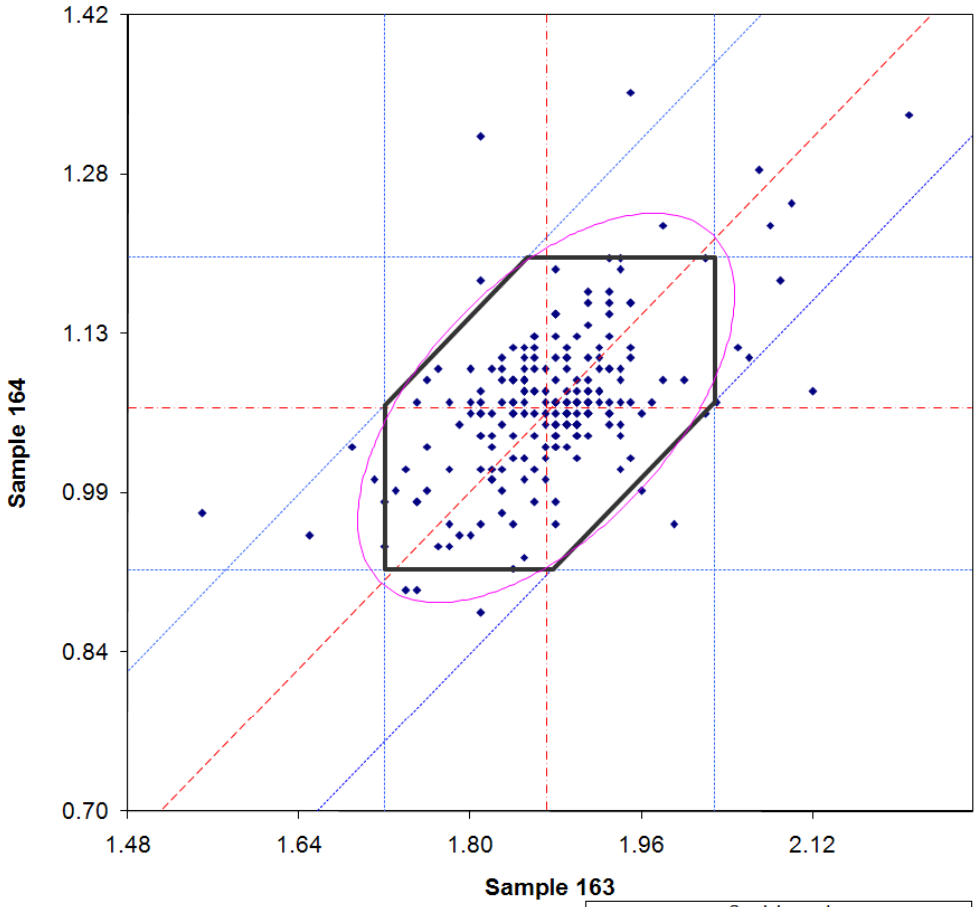
Reproducability (Sample 162)		
1s	d2s	CV%
0.09	0.24	2.43

Graph and Analysis Results for AASHTO T 105

Chemical Analysis of Hydraulic Cement

CCRL Samples 163 and 164

% Magnisium Oxide (MgO), Type I / II Cement



Graph Legend
Lines With Small Dash Marks - Sample Outlier Boundaries
Lines With Alternating Dash Marks - Sample Medians
Line With Large Dash Marks - Center Diagonal
Black Hexagon - Data Within is Used for Analysis
Ellipse - 2 Std Dev for Within and Between Lab Variation

Source of Data: AASHTO Materials Reference Laboratory Proficiency Sample Program
CCRL Samples 163 and 164
Final Report Issued April 2007

Participation:

237	Total Laboratories
13	Laboratories Determined to be Invalid
21	Laboratories Determined to be Outliers
203	Total Laboratorires Included in Analysis

Average Results	
Sample 163 Average	Sample 164 Average
1.87	1.07

Repeatability			
1s	d2s	CV% (163)	CV% (164)
0.04	0.11	2.05	3.60

Reproducability (Sample 163)		
1s	d2s	CV%
0.05	0.15	2.75

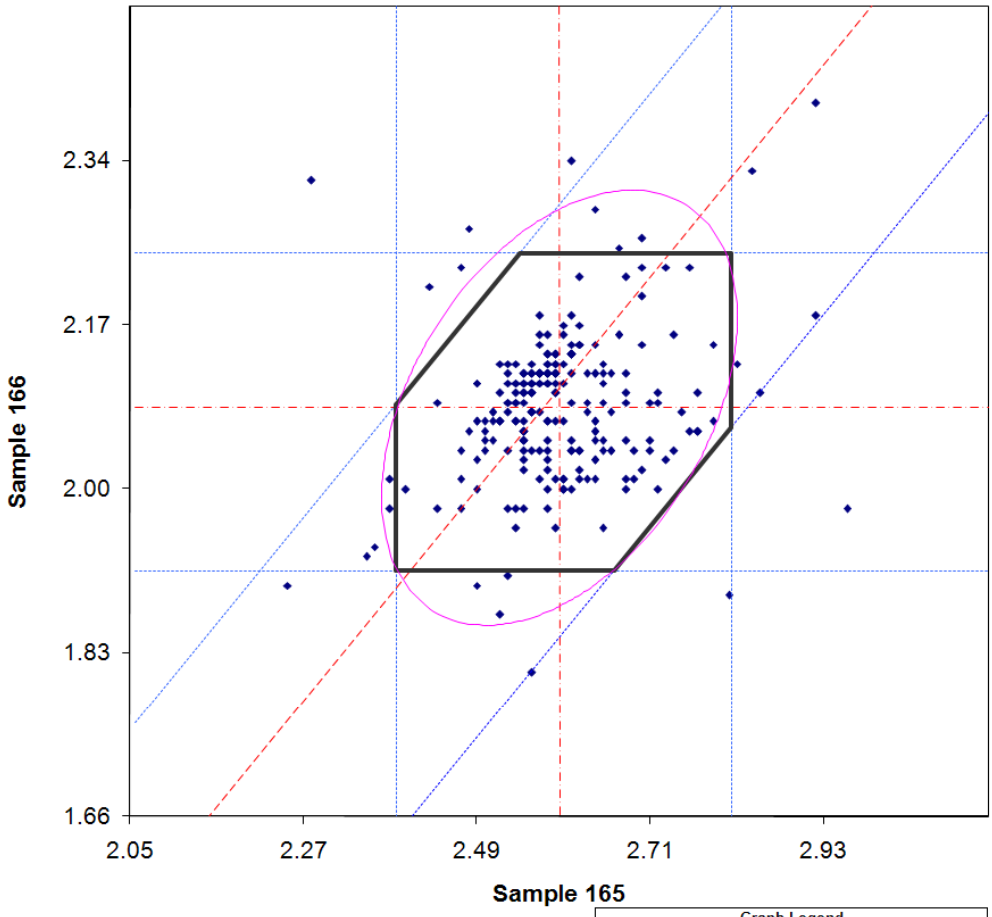
Reproducability (Sample 164)		
1s	d2s	CV%
0.05	0.15	4.93

Graph and Analysis Results for AASHTO T 105

Chemical Analysis of Hydraulic Cement

CCRL Samples 165 and 166

% Magnisium Oxide (MgO), Type I/II Cement w/ Limestone



Graph Legend
Lines With Small Dash Marks - Sample Outlier Boundaries
Lines With Alternating Dash Marks - Sample Medians
Line With Large Dash Marks - Center Diagonal
Black Hexagon - Data Within is Used for Analysis
Ellipse - 2 Std Dev for Within and Between Lab Variation

Source of Data: AASHTO Materials Reference Laboratory Proficiency Sample Program
CCRL Samples 165 and 166
Final Report Issued September 2007

Participation:

243	Total Laboratories
11	Laboratories Determined to be Invalid
22	Laboratories Determined to be Outliers
210	Total Laboratorires Included in Analysis

Average Results	
Sample 165 Average	Sample 166 Average
2.60	2.08

Repeatability			
1s	d2s	CV% (165)	CV% (166)
0.06	0.16	2.23	2.77

Reproducability (Sample 165)		
1s	d2s	CV%
0.07	0.20	2.72

Reproducability (Sample 166)		
1s	d2s	CV%
0.05	0.15	2.61

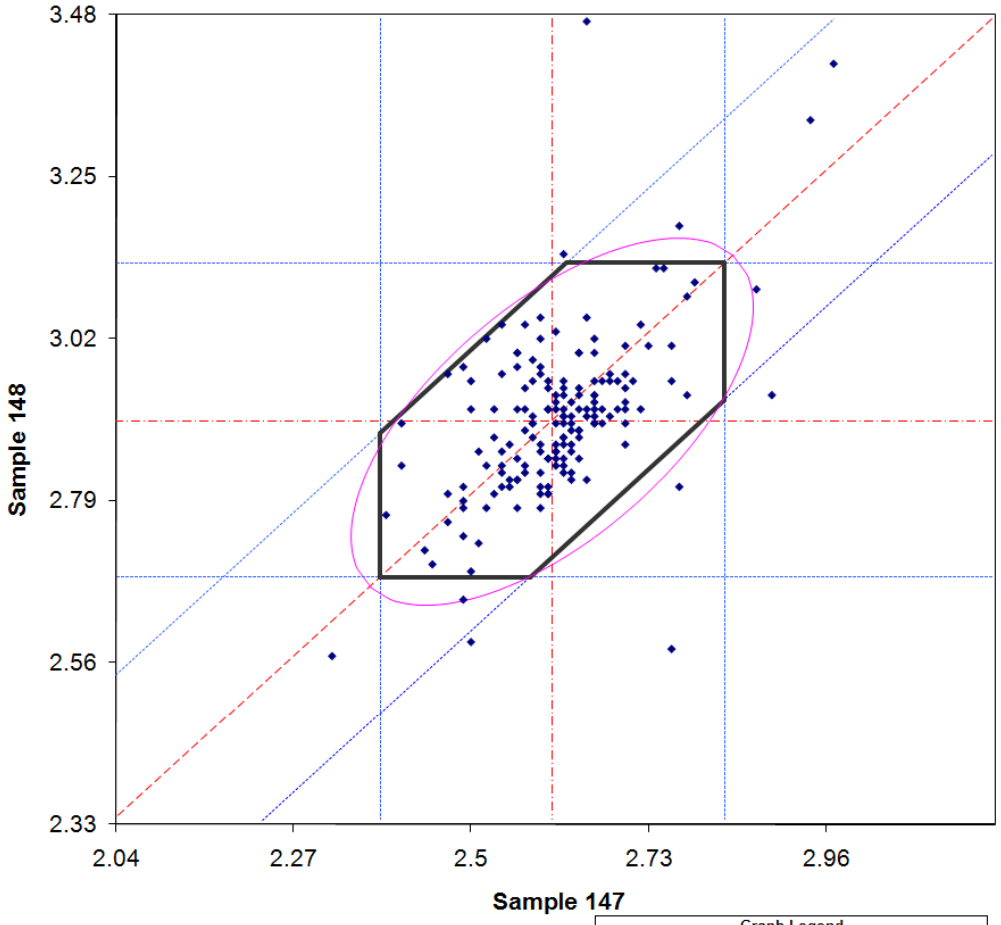
APPENDIX F: SULFUR TRIOXIDE (SO_3)

Graph and Analysis Results for AASHTO T 105

Chemical Analysis of Hydraulic Cement

CCRL Samples 147 and 148

Test Property: % Sulfur Trioxide (SO3), Type I / II Cement



Graph Legend
Lines With Small Dash Marks - Sample Outlier Boundaries
Lines With Alternating Dash Marks - Sample Medians
Line With Large Dash Marks - Center Diagonal
Black Hexagon - Data Within is Used for Analysis
Ellipse - 2 Std Dev for Within and Between Lab Variation

Source of Data: AASHTO Materials Reference Laboratory Proficiency Sample Program
CCRL Samples 147 and 148
Final Report Issued March 2003

Participation:

166	Total Laboratories
5	Laboratories Determined to be Invalid
8	Laboratories Determined to be Outliers
153	Total Laboratorires Included in Analysis

Average Results	
Sample 147 Average	Sample 148 Average
2.60	2.90

Repeatability			
1s	d2s	CV% (147)	CV% (148)
0.05	0.15	2.04	1.83

Reproducability (Sample 147)		
1s	d2s	CV%
0.07	0.21	2.87

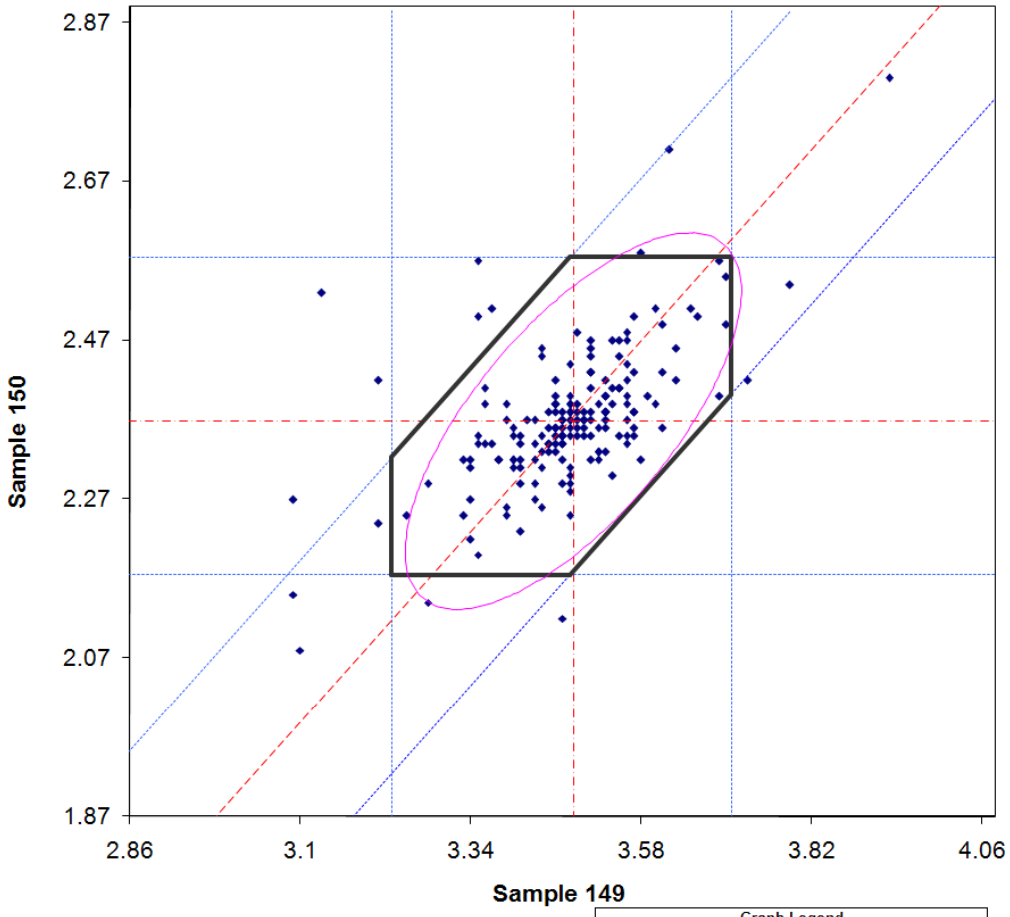
Reproducability (Sample 148)		
1s	d2s	CV%
0.08	0.23	2.82

Graph and Analysis Results for AASHTO T 105

Chemical Analysis of Hydraulic Cement

CCRL Samples 149 and 150

Test Property: % Sulfur Trioxide (SO3), Type I Cement



Graph Legend
Lines With Small Dash Marks - Sample Outlier Boundaries
Lines With Alternating Dash Marks - Sample Medians
Line With Large Dash Marks - Center Diagonal
Black Hexagon - Data Within is Used for Analysis
Ellipse - 2 Std Dev for Within and Between Lab Variation

Source of Data: AASHTO Materials Reference Laboratory Proficiency Sample Program
CCRL Samples 149 and 150
Final Report Issued Sept. 2003

Participation:

179	Total Laboratories
5	Laboratories Determined to be Invalid
14	Laboratories Determined to be Outliers
160	Total Laboratorires Included in Analysis

Average Results	
Sample 149 Average	Sample 150 Average
3.48	2.37

Repeatability			
1s	d2s	CV% (149)	CV% (150)
0.04	0.12	1.25	1.84

Reproducability (Sample 149)		
1s	d2s	CV%
0.08	0.23	2.33

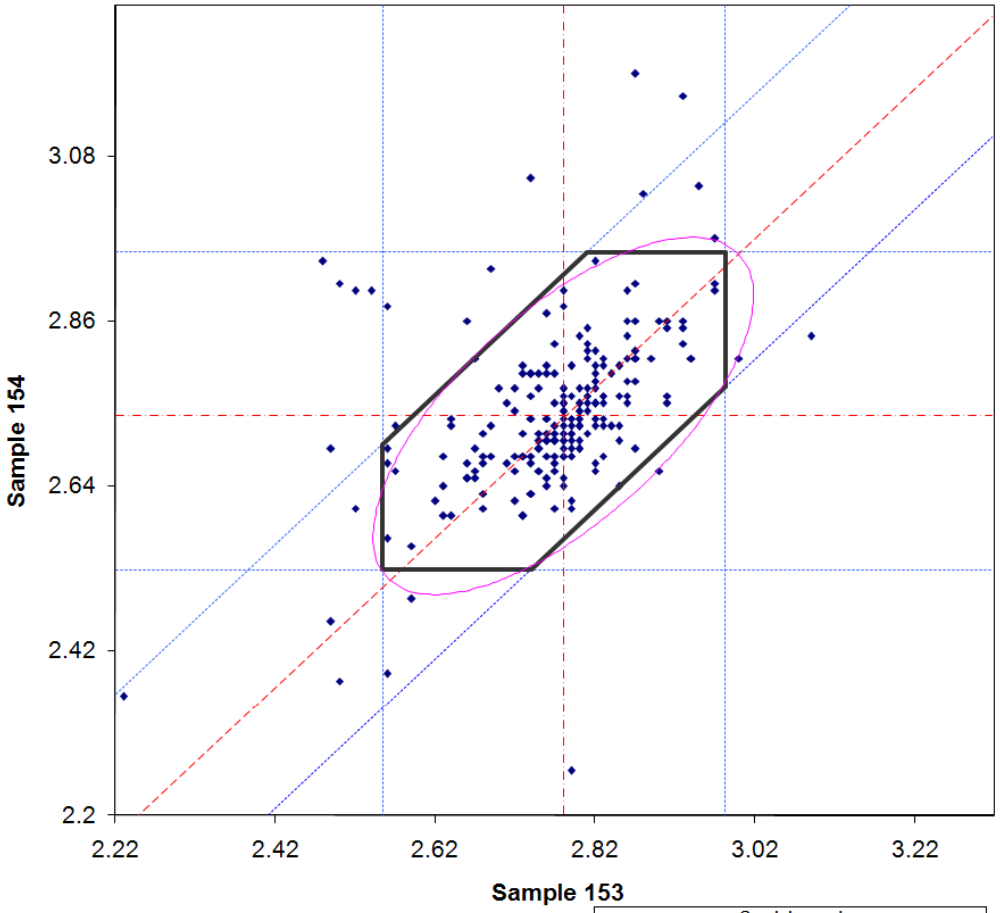
Reproducability (Sample 150)		
1s	d2s	CV%
0.06	0.18	2.66

Graph and Analysis Results for AASHTO T 105

Chemical Analysis of Hydraulic Cement

CCRL Samples 153 and 154

Test Property: % Sulfur Trioxide (SO3), Type I / II Cement



Graph Legend
Lines With Small Dash Marks - Sample Outlier Boundaries
Lines With Alternating Dash Marks - Sample Medians
Line With Large Dash Marks - Center Diagonal
Black Hexagon - Data Within is Used for Analysis
Ellipse - 2 Std Dev for Within and Between Lab Variation

Source of Data: AASHTO Materials Reference Laboratory Proficiency Sample Program
CCRL Samples 153 and 154
Final Report Issued Oct. 2004

Participation:

233	Total Laboratories
10	Laboratories Determined to be Invalid
17	Laboratories Determined to be Outliers
206	Total Laboratorires Included in Analysis

Average Results	
Sample 153 Average	Sample 154 Average
2.78	2.73

Repeatability			
1s	d2s	CV% (153)	CV% (154)
0.05	0.13	1.62	1.65

Reproducability (Sample 153)		
1s	d2s	CV%
0.07	0.21	2.65

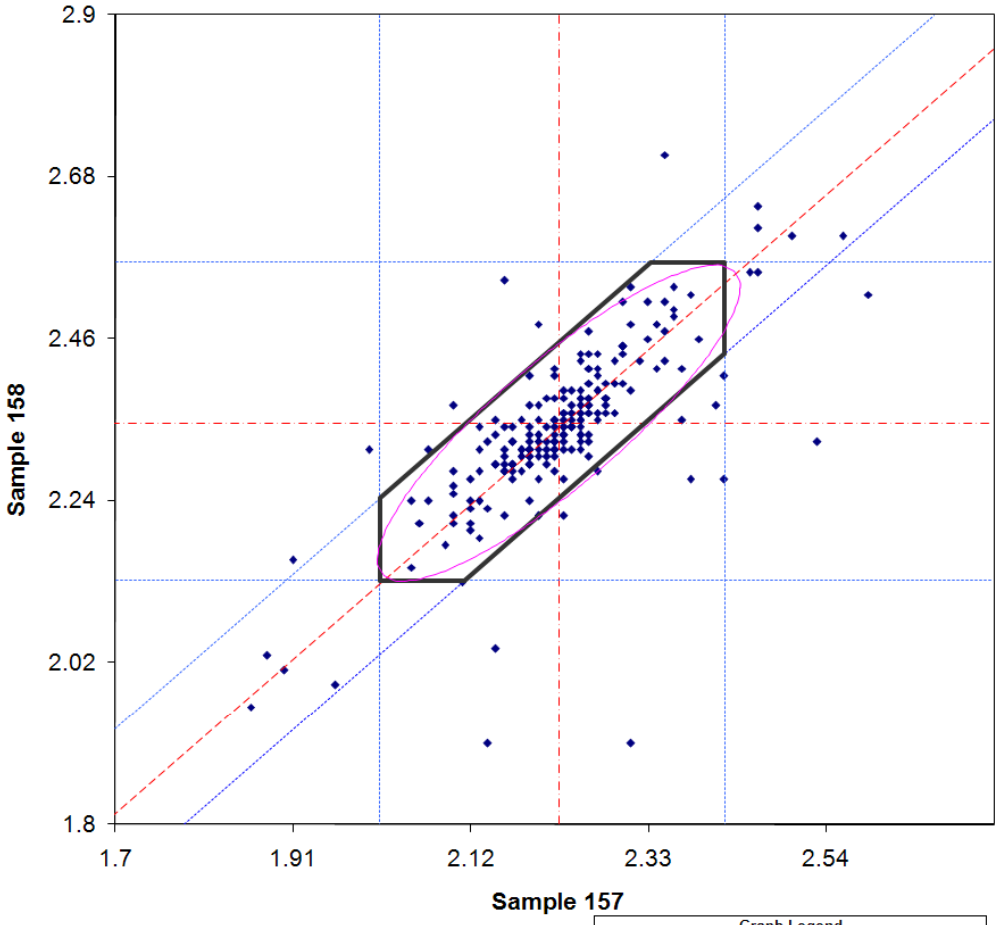
Reproducability (Sample 154)		
1s	d2s	CV%
0.07	0.20	2.62

Graph and Analysis Results for AASHTO T 105

Chemical Analysis of Hydraulic Cement

CCRL Samples 157 and 158

% Sulfur Trioxide (SO3), Type V Cement w/ Limestone (157) & Type I / II w/ Limestone (158)



Graph Legend
Lines With Small Dash Marks - Sample Outlier Boundaries
Lines With Alternating Dash Marks - Sample Medians
Line With Large Dash Marks - Center Diagonal
Black Hexagon - Data Within is Used for Analysis
Ellipse - 2 Std Dev for Within and Between Lab Variation

Source of Data: AASHTO Materials Reference Laboratory Proficiency Sample Program
CCRL Samples 157 and 158
Final Report Issued Oct. 2005

Participation:

232	Total Laboratories
10	Laboratories Determined to be Invalid
22	Laboratories Determined to be Outliers
200	Total Laboratorires Included in Analysis

Average Results	
Sample 157 Average	Sample 158 Average
2.22	2.35

Repeatability			
1s	d2s	CV% (157)	CV% (158)
0.03	0.07	1.18	1.12

Reproducability (Sample 157)		
1s	d2s	CV%
0.07	0.19	2.98

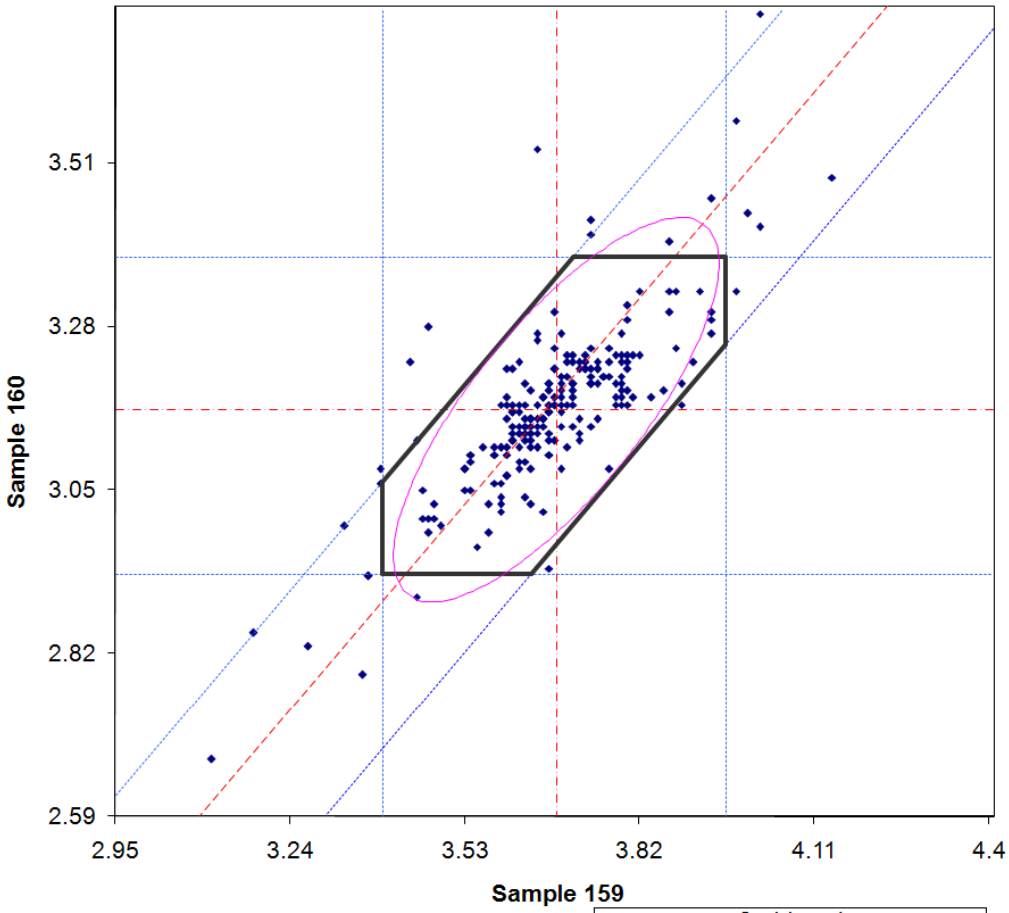
Reproducability (Sample 158)		
1s	d2s	CV%
0.07	0.20	3.05

Graph and Analysis Results for AASHTO T 105

Chemical Analysis of Hydraulic Cement

CCRL Samples 159 and 160

% Sulfur Trioxide (SO3), Type I Cement w/ Limestone (159) & Type I / II w/ Limestone (160)



Graph Legend
Lines With Small Dash Marks - Sample Outlier Boundaries
Lines With Alternating Dash Marks - Sample Medians
Line With Large Dash Marks - Center Diagonal
Black Hexagon - Data Within is Used for Analysis
Ellipse - 2 Std Dev for Within and Between Lab Variation

Source of Data: AASHTO Materials Reference Laboratory Proficiency Sample Program
CCRL Samples 159 and 160
Final Report Issued April 2006

Participation:

232	Total Laboratories
9	Laboratories Determined to be Invalid
24	Laboratories Determined to be Outliers
199	Total Laboratorires Included in Analysis

Average Results	
Sample 159 Average	Sample 160 Average
3.68	3.16

Repeatability			
1s	d2s	CV% (159)	CV% (160)
0.04	0.12	1.18	1.37

Reproducability (Sample 159)		
1s	d2s	CV%
0.10	0.27	2.59

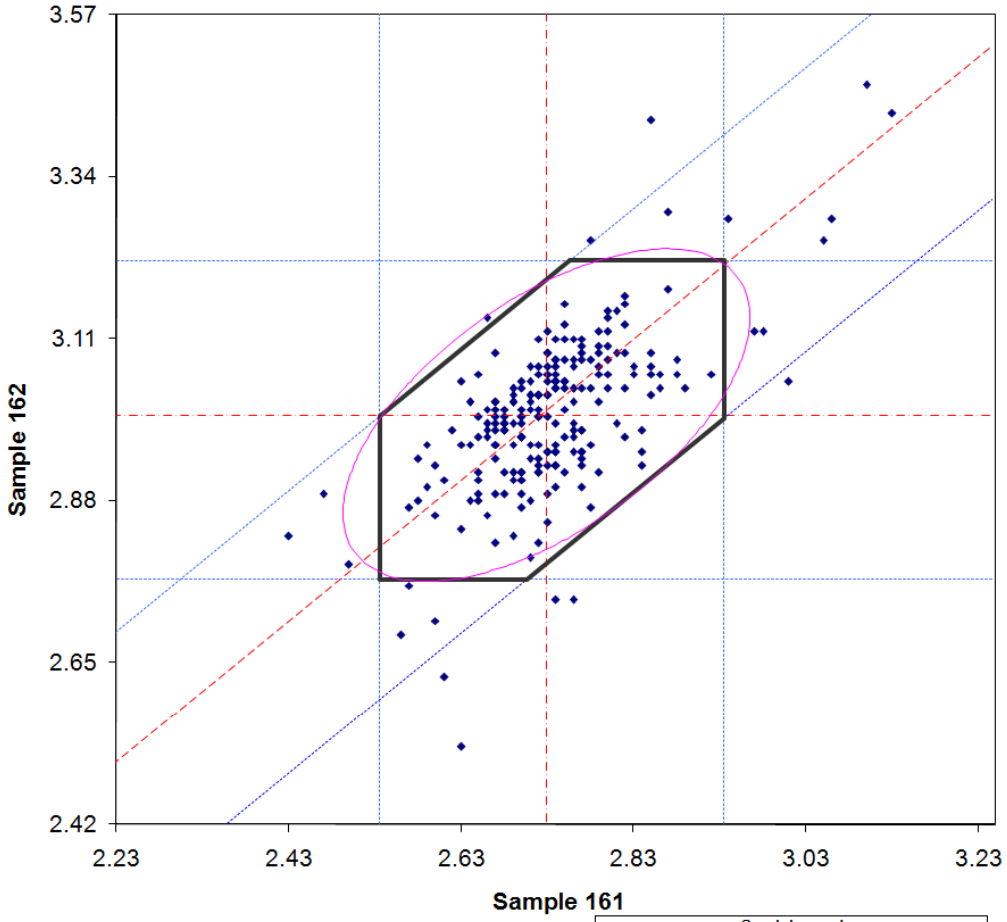
Reproducability (Sample 160)		
1s	d2s	CV%
0.07	0.21	2.29

Graph and Analysis Results for AASHTO T 105

Chemical Analysis of Hydraulic Cement

CCRL Samples 161 and 162

Test Property: % Sulfur Trioxide (SO3), Type I Cement (161) & Type I w/ Limestone (162)



Graph Legend
Lines With Small Dash Marks - Sample Outlier Boundaries
Lines With Alternating Dash Marks - Sample Medians
Line With Large Dash Marks - Center Diagonal
Black Hexagon - Data Within is Used for Analysis
Ellipse - 2 Std Dev for Within and Between Lab Variation

Source of Data: AASHTO Materials Reference Laboratory Proficiency Sample Program
CCRL Samples 161 and 162
Final Report Issued Oct 2006

Participation:

240	Total Laboratories
8	Laboratories Determined to be Invalid
19	Laboratories Determined to be Outliers
213	Total Laboratorires Included in Analysis

Average Results	
Sample 161 Average	Sample 162 Average
2.73	3.00

Repeatability			
1s	d2s	CV% (161)	CV% (162)
0.05	0.14	1.84	1.67

Reproducability (Sample 161)		
1s	d2s	CV%
0.06	0.18	2.33

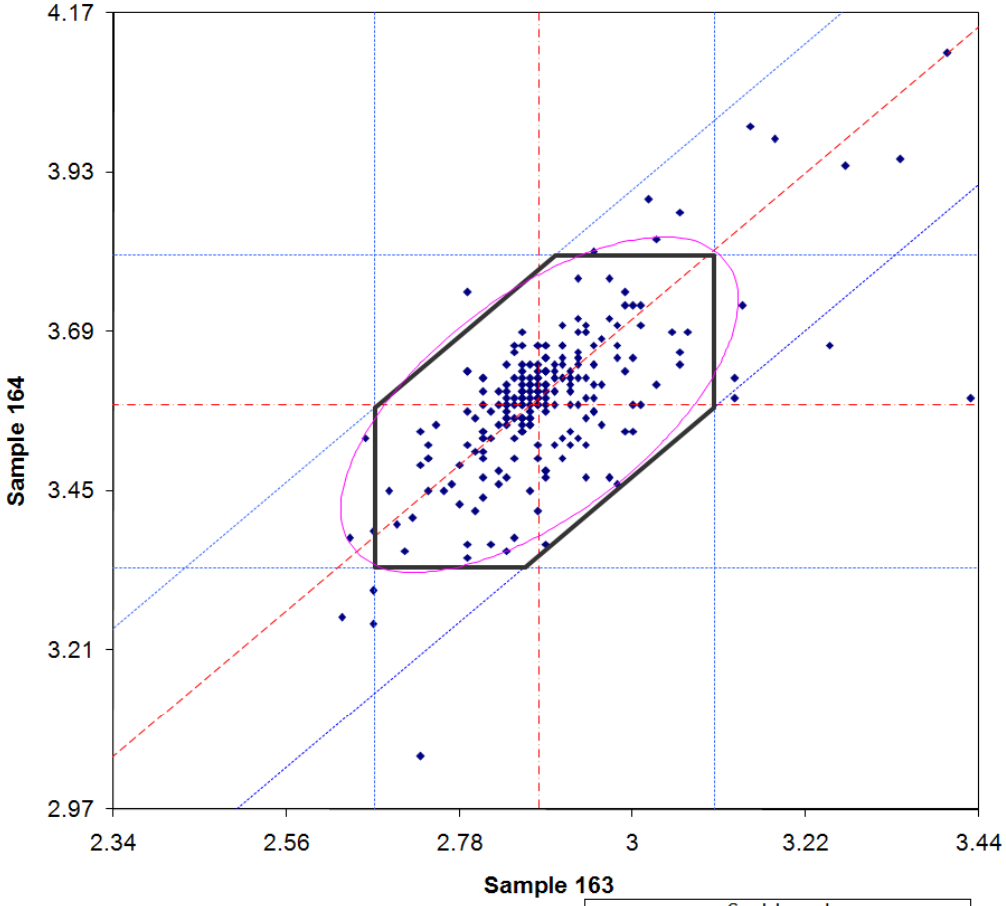
Reproducability (Sample 162)		
1s	d2s	CV%
0.08	0.22	2.54

Graph and Analysis Results for AASHTO T 105

Chemical Analysis of Hydraulic Cement

CCRL Samples 163 and 164

Test Property: % Sulfur Trioxide (SO3), Type I / II Cement



Graph Legend
Lines With Small Dash Marks - Sample Outlier Boundaries
Lines With Alternating Dash Marks - Sample Medians
Line With Large Dash Marks - Center Diagonal
Black Hexagon - Data Within is Used for Analysis
Ellipse - 2 Std Dev for Within and Between Lab Variation

Source of Data: AASHTO Materials Reference Laboratory Proficiency Sample Program
CCRL Samples 163 and 164
Final Report Issued April 2007

Participation:

239	Total Laboratories
9	Laboratories Determined to be Invalid
19	Laboratories Determined to be Outliers
211	Total Laboratorires Included in Analysis

Average Results	
Sample 163 Average	Sample 164 Average
2.88	3.58

Repeatability			
1s	d2s	CV% (163)	CV% (164)
0.05	0.15	1.78	1.43

Reproducability (Sample 163)		
1s	d2s	CV%
0.07	0.20	2.42

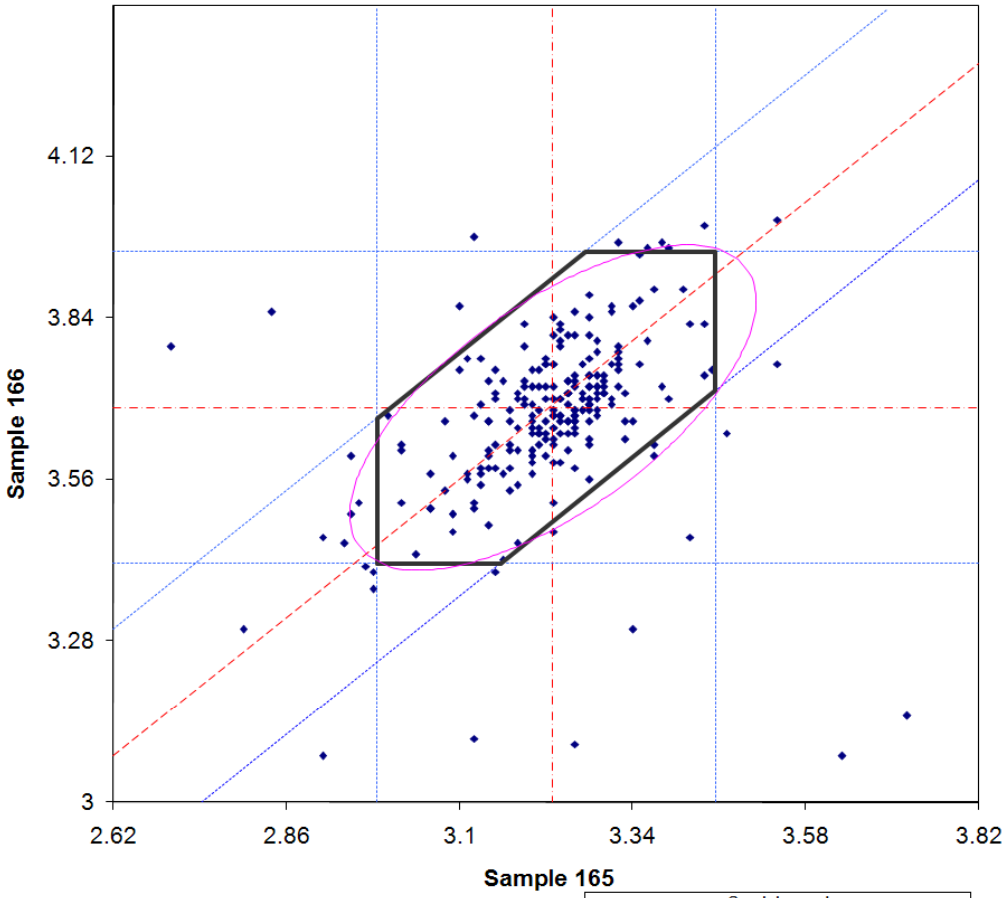
Reproducability (Sample 164)		
1s	d2s	CV%
0.08	0.23	2.28

Graph and Analysis Results for AASHTO T 105

Chemical Analysis of Hydraulic Cement

CCRL Samples 165 and 166

Test Property: % Sulfur Trioxide (SO3), Type I/II Cement w/ Limestone



Graph Legend
Lines With Small Dash Marks - Sample Outlier Boundaries
Lines With Alternating Dash Marks - Sample Medians
Line With Large Dash Marks - Center Diagonal
Black Hexagon - Data Within is Used for Analysis
Ellipse - 2 Std Dev for Within and Between Lab Variation

Source of Data: AASHTO Materials Reference Laboratory Proficiency Sample Program
CCRL Samples 165 and 166
Final Report Issued September 2007

Participation:

247	Total Laboratories
11	Laboratories Determined to be Invalid
23	Laboratories Determined to be Outliers
213	Total Laboratorires Included in Analysis

Average Results	
Sample 165 Average	Sample 166 Average
3.23	3.68

Repeatability			
1s	d2s	CV% (165)	CV% (166)
0.05	0.15	1.69	1.48

Reproducability (Sample 165)		
1s	d2s	CV%
0.08	0.23	2.48

Reproducability (Sample 166)		
1s	d2s	CV%
0.09	0.26	2.47

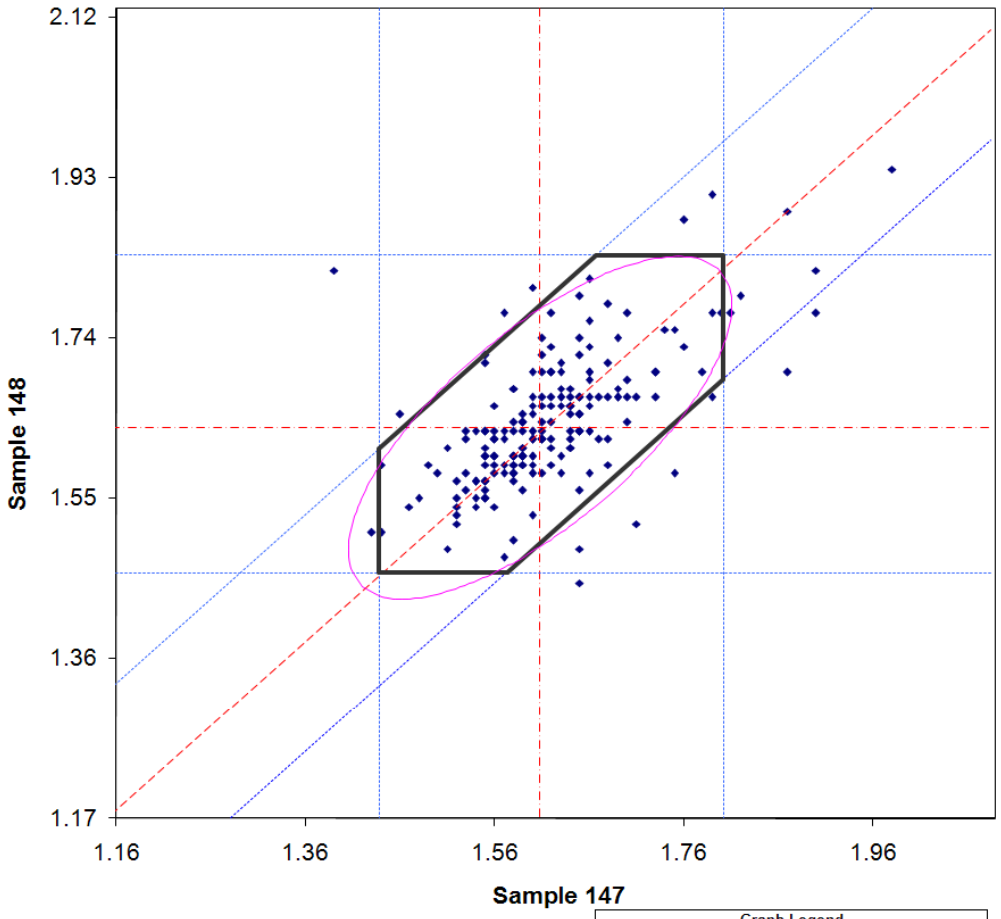
APPENDIX G: LOSS ON IGNITION

Graph and Analysis Results for AASHTO T 105

Chemical Analysis of Hydraulic Cement

CCRL Samples 147 and 148

Test Property: Loss on Ignition (%), Type I / II Cement



Graph Legend
Lines With Small Dash Marks - Sample Outlier Boundaries
Lines With Alternating Dash Marks - Sample Medians
Line With Large Dash Marks - Center Diagonal
Black Hexagon - Data Within is Used for Analysis
Ellipse - 2 Std Dev for Within and Between Lab Variation

Source of Data: AASHTO Materials Reference Laboratory Proficiency Sample Program
CCRL Samples 147 and 148
Final Report Issued March 2003

Participation:

199	Total Laboratories
4	Laboratories Determined to be Invalid
18	Laboratories Determined to be Outliers
177	Total Laboratorires Included in Analysis

Average Results	
Sample 147 Average	Sample 148 Average
1.61	1.63

Repeatability			
1s	d2s	CV% (147)	CV% (148)
0.04	0.10	2.23	2.19

Reproducability (Sample 147)		
1s	d2s	CV%
0.06	0.18	3.89

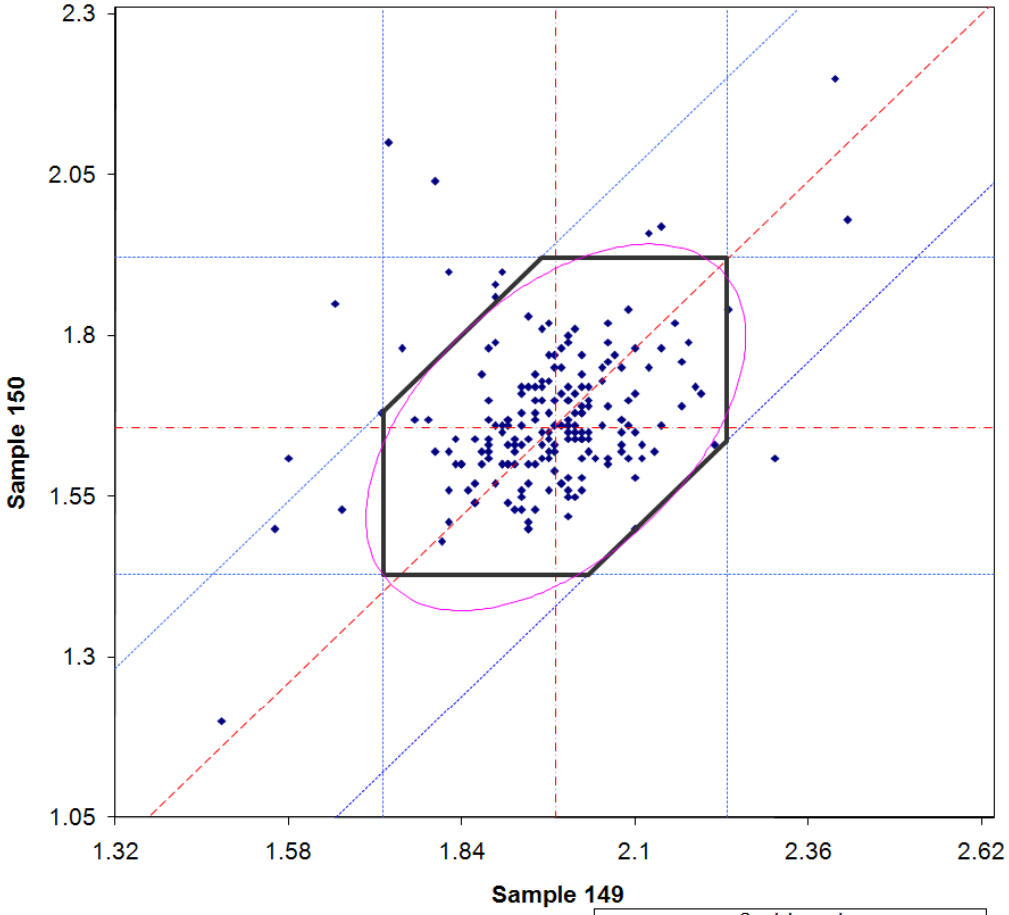
Reproducability (Sample 148)		
1s	d2s	CV%
0.06	0.18	3.85

Graph and Analysis Results for AASHTO T 105

Chemical Analysis of Hydraulic Cement

CCRL Samples 149 and 150

Test Property: Loss on Ignition (%), Type I Cement



Graph Legend
Lines With Small Dash Marks - Sample Outlier Boundaries
Lines With Alternating Dash Marks - Sample Medians
Line With Large Dash Marks - Center Diagonal
Black Hexagon - Data Within is Used for Analysis
Ellipse - 2 Std Dev for Within and Between Lab Variation

Source of Data: AASHTO Materials Reference Laboratory Proficiency Sample Program
CCRL Samples 149 and 150
Final Report Issued Sept. 2003

Participation:

203	Total Laboratories
9	Laboratories Determined to be Invalid
15	Laboratories Determined to be Outliers
179	Total Laboratorires Included in Analysis

Average Results	
Sample 149 Average	Sample 150 Average
1.98	1.66

Repeatability			
1s	d2s	CV% (149)	CV% (150)
0.07	0.19	3.40	4.06

Reproducability (Sample 149)		
1s	d2s	CV%
0.09	0.25	4.39

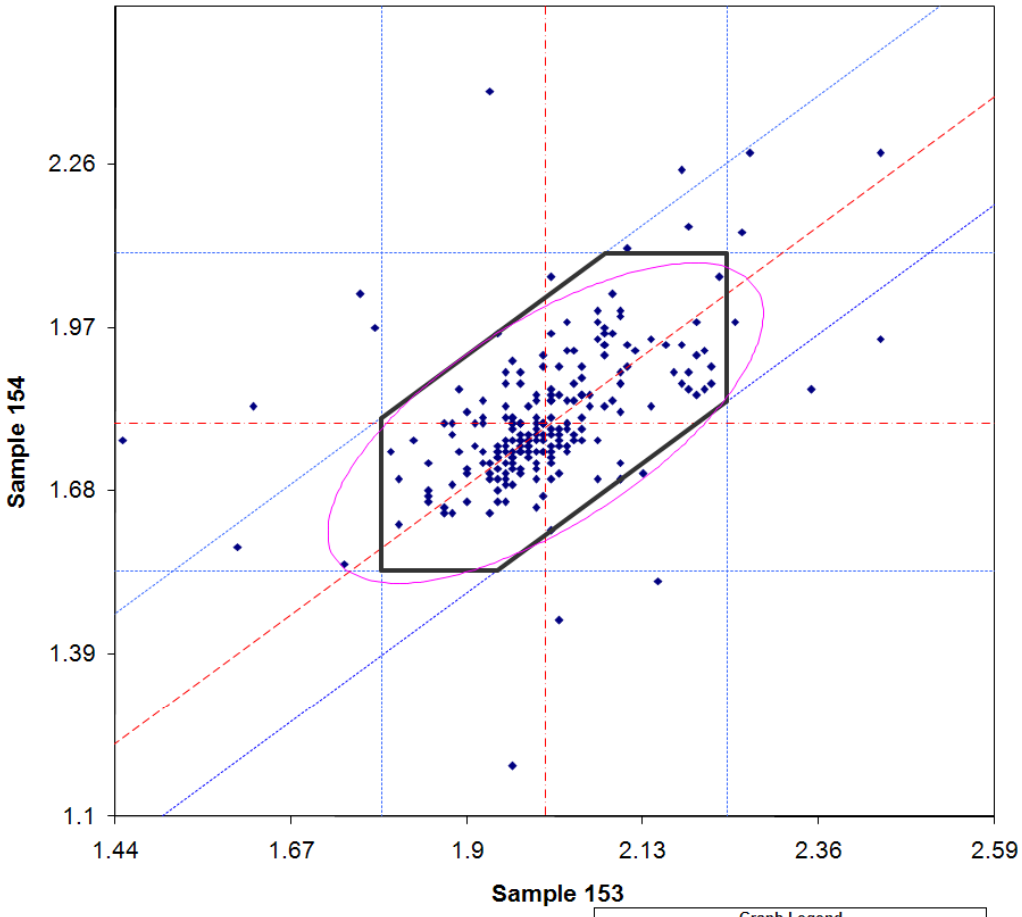
Reproducability (Sample 150)		
1s	d2s	CV%
0.08	0.22	4.65

Graph and Analysis Results for AASHTO T 105

Chemical Analysis of Hydraulic Cement

CCRL Samples 153 and 154

Test Property: Loss on Ignition (%), Type I / II Cement



Graph Legend
Lines With Small Dash Marks - Sample Outlier Boundaries
Lines With Alternating Dash Marks - Sample Medians
Line With Large Dash Marks - Center Diagonal
Black Hexagon - Data Within is Used for Analysis
Ellipse - 2 Std Dev for Within and Between Lab Variation

Source of Data: AASHTO Materials Reference Laboratory Proficiency Sample Program
CCRL Samples 153 and 154
Final Report Issued Oct. 2004

Participation:

227	Total Laboratories
12	Laboratories Determined to be Invalid
16	Laboratories Determined to be Outliers
199	Total Laboratorires Included in Analysis

Average Results	
Sample 153 Average	Sample 154 Average
2.00	1.80

Repeatability			
1s	d2s	CV% (153)	CV% (154)
0.05	0.15	2.67	2.97

Reproducability (Sample 153)		
1s	d2s	CV%
0.08	0.24	4.24

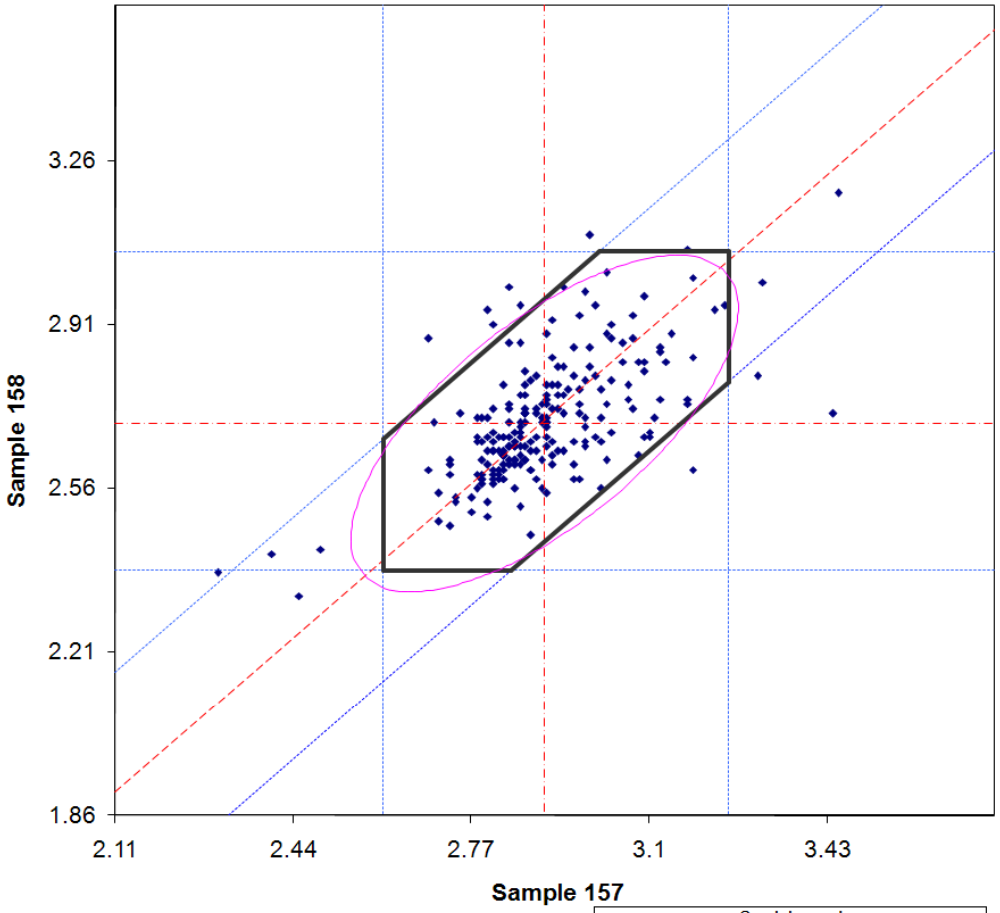
Reproducability (Sample 154)		
1s	d2s	CV%
0.09	0.25	4.96

Graph and Analysis Results for AASHTO T 105

Chemical Analysis of Hydraulic Cement

CCRL Samples 157 and 158

Loss on Ignition (%), Type V Cement w/ Limestone (157) & Type I / II w/ Limestone (158)



Graph Legend
Lines With Small Dash Marks - Sample Outlier Boundaries
Lines With Alternating Dash Marks - Sample Medians
Line With Large Dash Marks - Center Diagonal
Black Hexagon - Data Within is Used for Analysis
Ellipse - 2 Std Dev for Within and Between Lab Variation

Source of Data: AASHTO Materials Reference Laboratory Proficiency Sample Program
CCRL Samples 157 and 158
Final Report Issued Oct. 2005

Participation:

229	Total Laboratories
6	Laboratories Determined to be Invalid
14	Laboratories Determined to be Outliers
209	Total Laboratorires Included in Analysis

Average Results	
Sample 157 Average	Sample 158 Average
2.91	2.70

Repeatability			
1s	d2s	CV% (157)	CV% (158)
0.07	0.19	2.31	2.48

Reproducability (Sample 157)		
1s	d2s	CV%
0.11	0.31	3.75

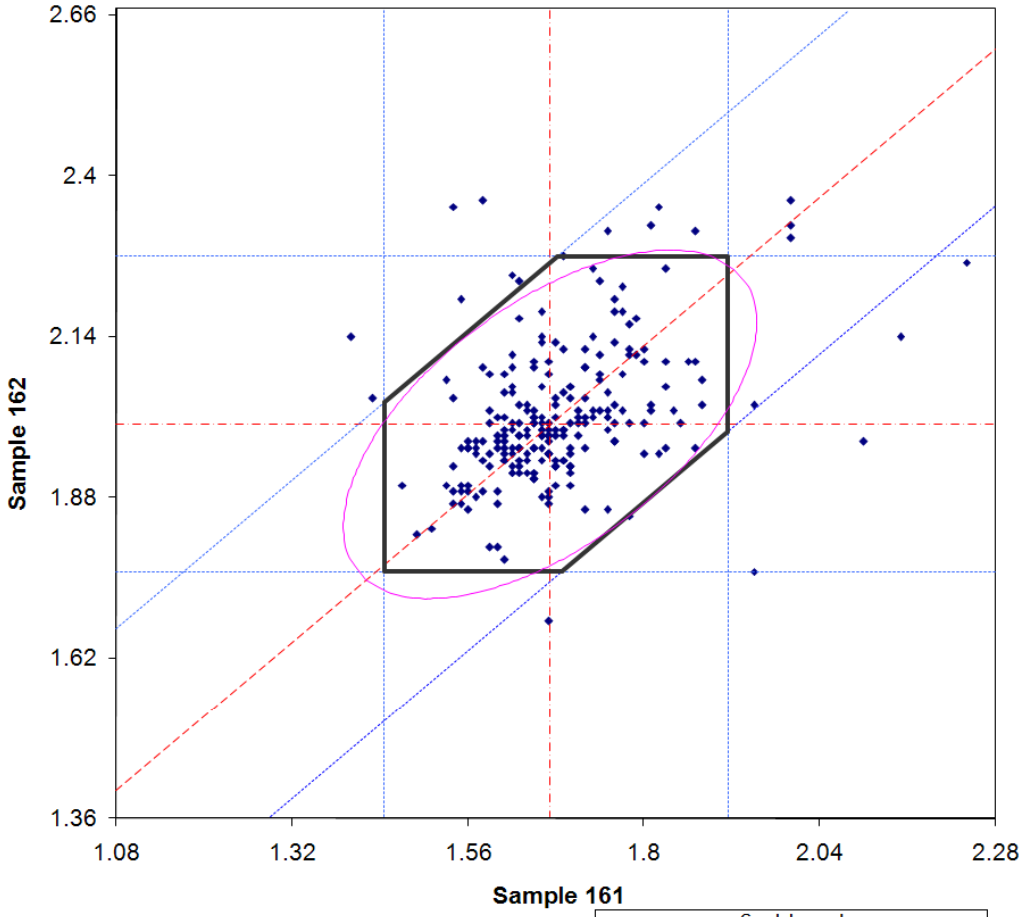
Reproducability (Sample 158)		
1s	d2s	CV%
0.11	0.31	4.11

Graph and Analysis Results for AASHTO T 105

Chemical Analysis of Hydraulic Cement

CCRL Samples 161 and 162

Test Property: Loss on Ignition (%), Type I Cement (161) & Type I w/ Limestone (162)



Graph Legend
Lines With Small Dash Marks - Sample Outlier Boundaries
Lines With Alternating Dash Marks - Sample Medians
Line With Large Dash Marks - Center Diagonal
Black Hexagon - Data Within is Used for Analysis
Ellipse - 2 Std Dev for Within and Between Lab Variation

Source of Data: AASHTO Materials Reference Laboratory Proficiency Sample Program
CCRL Samples 161 and 162
Final Report Issued Oct 2006

Participation:

240	Total Laboratories
10	Laboratories Determined to be Invalid
17	Laboratories Determined to be Outliers
213	Total Laboratorires Included in Analysis

Average Results	
Sample 161 Average	Sample 162 Average
1.67	2.00

Repeatability			
1s	d2s	CV% (161)	CV% (162)
0.06	0.17	3.62	3.03

Reproducability (Sample 161)		
1s	d2s	CV%
0.08	0.23	4.80

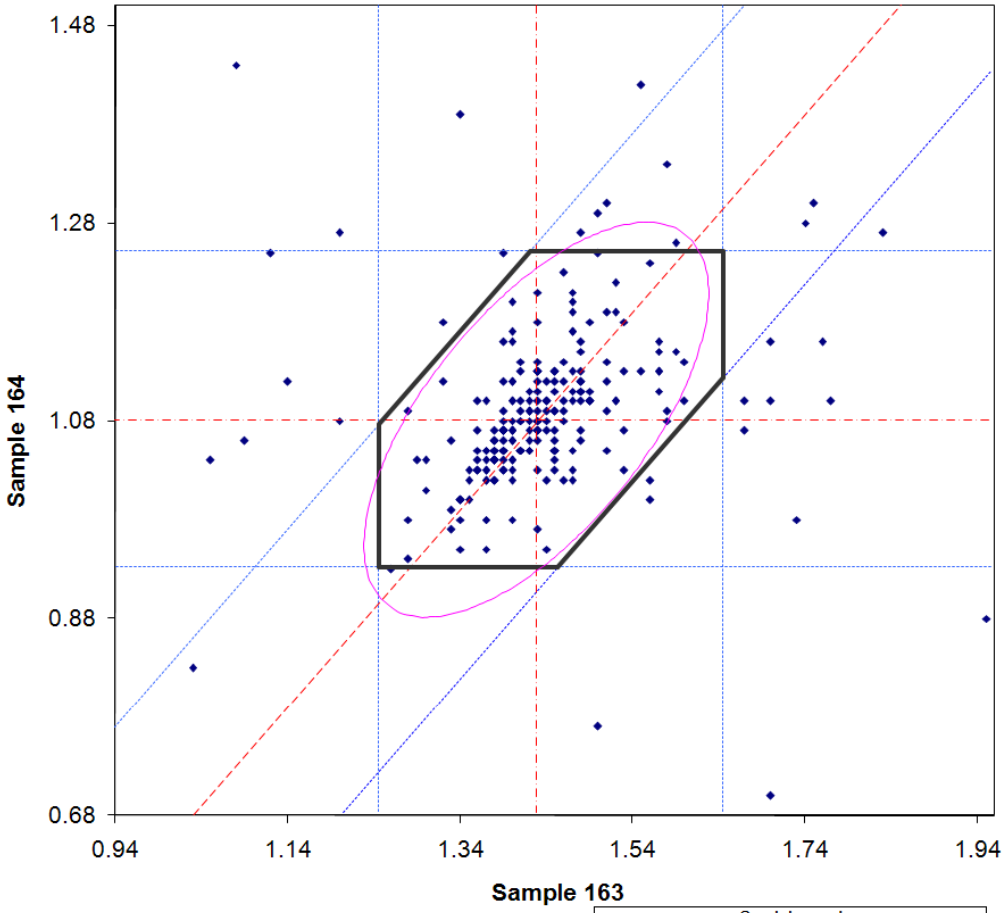
Reproducability (Sample 162)		
1s	d2s	CV%
0.09	0.25	4.35

Graph and Analysis Results for AASHTO T 105

Chemical Analysis of Hydraulic Cement

CCRL Samples 163 and 164

Test Property: Loss on Ignition (%), Type I / II Cement



Graph Legend
Lines With Small Dash Marks - Sample Outlier Boundaries
Lines With Alternating Dash Marks - Sample Medians
Line With Large Dash Marks - Center Diagonal
Black Hexagon - Data Within is Used for Analysis
Ellipse - 2 Std Dev for Within and Between Lab Variation

Source of Data: AASHTO Materials Reference Laboratory Proficiency Sample Program
CCRL Samples 163 and 164
Final Report Issued April 2007

Participation:

242	Total Laboratories
14	Laboratories Determined to be Invalid
24	Laboratories Determined to be Outliers
204	Total Laboratorires Included in Analysis

Average Results	
Sample 163 Average	Sample 164 Average
1.43	1.08

Repeatability			
1s	d2s	CV% (163)	CV% (164)
0.04	0.11	2.79	3.69

Reproducability (Sample 163)		
1s	d2s	CV%
0.06	0.18	4.44

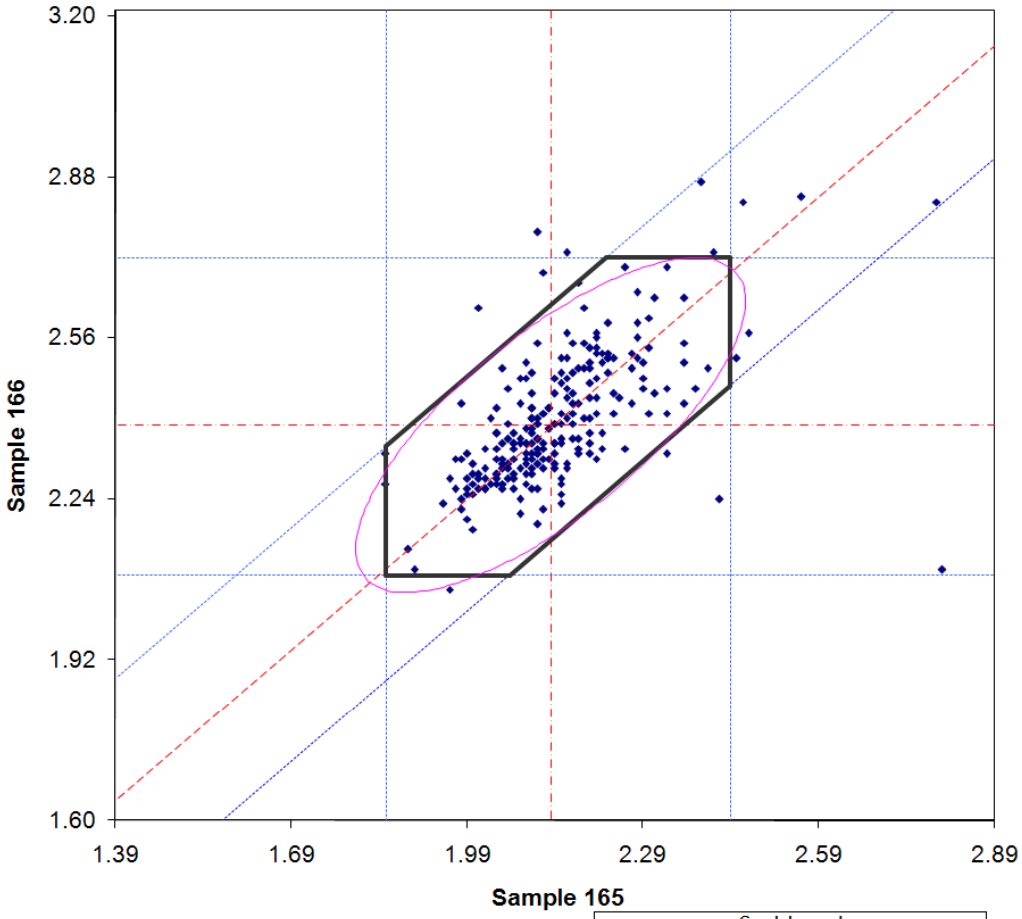
Reproducability (Sample 164)		
1s	d2s	CV%
0.06	0.16	5.29

Graph and Analysis Results for AASHTO T 105

Chemical Analysis of Hydraulic Cement

CCRL Samples 165 and 166

Test Property: Loss on Ignition (%), Type I / II Cement w/ Limestone



Graph Legend
Lines With Small Dash Marks - Sample Outlier Boundaries
Lines With Alternating Dash Marks - Sample Medians
Line With Large Dash Marks - Center Diagonal
Black Hexagon - Data Within is Used for Analysis
Ellipse - 2 Std Dev for Within and Between Lab Variation

Source of Data: AASHTO Materials Reference Laboratory Proficiency Sample Program
CCRL Samples 165 and 166
Final Report Issued Oct 2006

Participation:

242	Total Laboratories
8	Laboratories Determined to be Invalid
14	Laboratories Determined to be Outliers
220	Total Laboratorires Included in Analysis

Average Results	
Sample 165 Average	Sample 166 Average
2.13	2.39

Repeatability			
1s	d2s	CV% (165)	CV% (166)
0.06	0.16	2.6	2.4

Reproducability (Sample 165)		
1s	d2s	CV%
0.10	0.27	4.5

Reproducability (Sample 166)		
1s	d2s	CV%
0.11	0.31	4.6

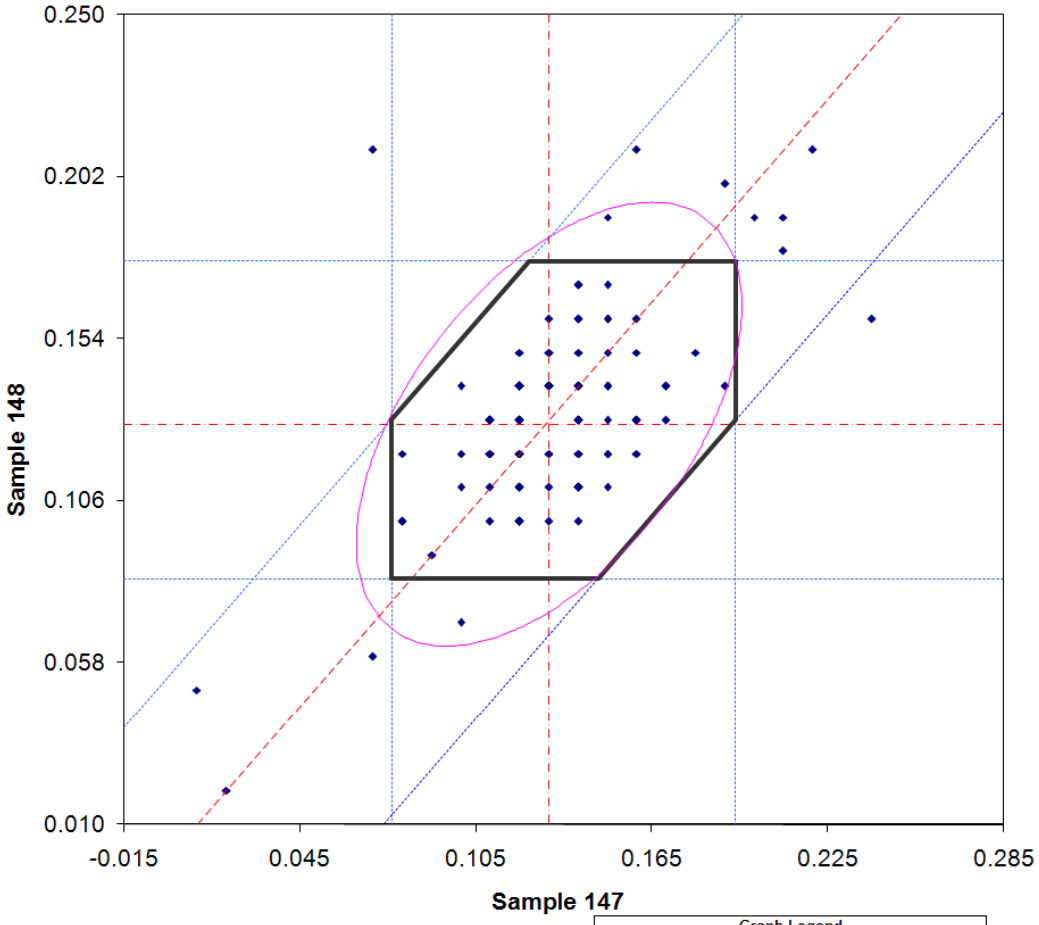
APPENDIX H: SODIUM OXIDE (NA_2O)

Graph and Analysis Results for AASHTO T 105

Chemical Analysis of Hydraulic Cement

CCRL Samples 147 and 148

Test Property: Sodium Oxide (Na2O) %, Type I / II Cement



Graph Legend
Lines With Small Dash Marks - Sample Outlier Boundaries
Lines With Alternating Dash Marks - Sample Medians
Line With Large Dash Marks - Center Diagonal
Black Hexagon - Data Within is Used for Analysis
Ellipse - 2 Std Dev for Within and Between Lab Variation

Source of Data: AASHTO Materials Reference Laboratory Proficiency Sample Program
CCRL Samples 147 and 148
Final Report Issued March 2003

Participation:

135	Total Laboratories
6	Laboratories Determined to be Invalid
9	Laboratories Determined to be Outliers
120	Total Laboratorires Included in Analysis

Average Results	
Sample 147 Average	Sample 148 Average
0.130	0.129

Repeatability			
1s	d2s	CV% (147)	CV% (148)
0.015	0.042	11.5	11.6

Reproducability (Sample 147)		
1s	d2s	CV%
0.020	0.058	15.7

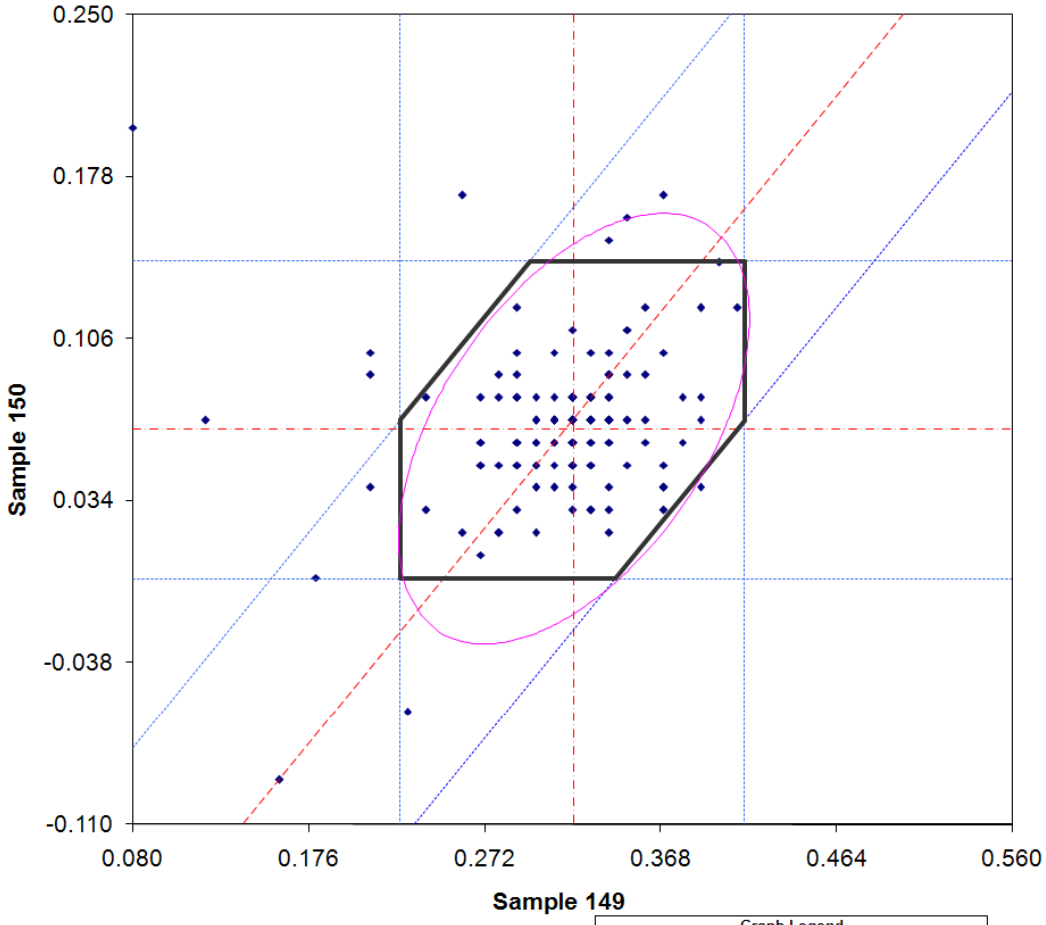
Reproducability (Sample 148)		
1s	d2s	CV%
0.018	0.050	13.8

Graph and Analysis Results for AASHTO T 105

Chemical Analysis of Hydraulic Cement

CCRL Samples 149 and 150

Test Property: Sodium Oxide (Na2O) %, Type I Cement



Graph Legend
Lines With Small Dash Marks - Sample Outlier Boundaries
Lines With Alternating Dash Marks - Sample Medians
Line With Large Dash Marks - Center Diagonal
Black Hexagon - Data Within is Used for Analysis
Ellipse - 2 Std Dev for Within and Between Lab Variation

Source of Data: AASHTO Materials Reference Laboratory Proficiency Sample Program
CCRL Samples 149 and 150
Final Report Issued Sept. 2003

Participation:

149	Total Laboratories
8	Laboratories Determined to be Invalid
9	Laboratories Determined to be Outliers
132	Total Laboratorires Included in Analysis

Average Results	
Sample 149 Average	Sample 150 Average
0.321	0.066

Repeatability			
1s	d2s	CV% (149)	CV% (150)
0.022	0.063	6.9	33.7

Reproducability (Sample 149)		
1s	d2s	CV%
0.031	0.089	9.8

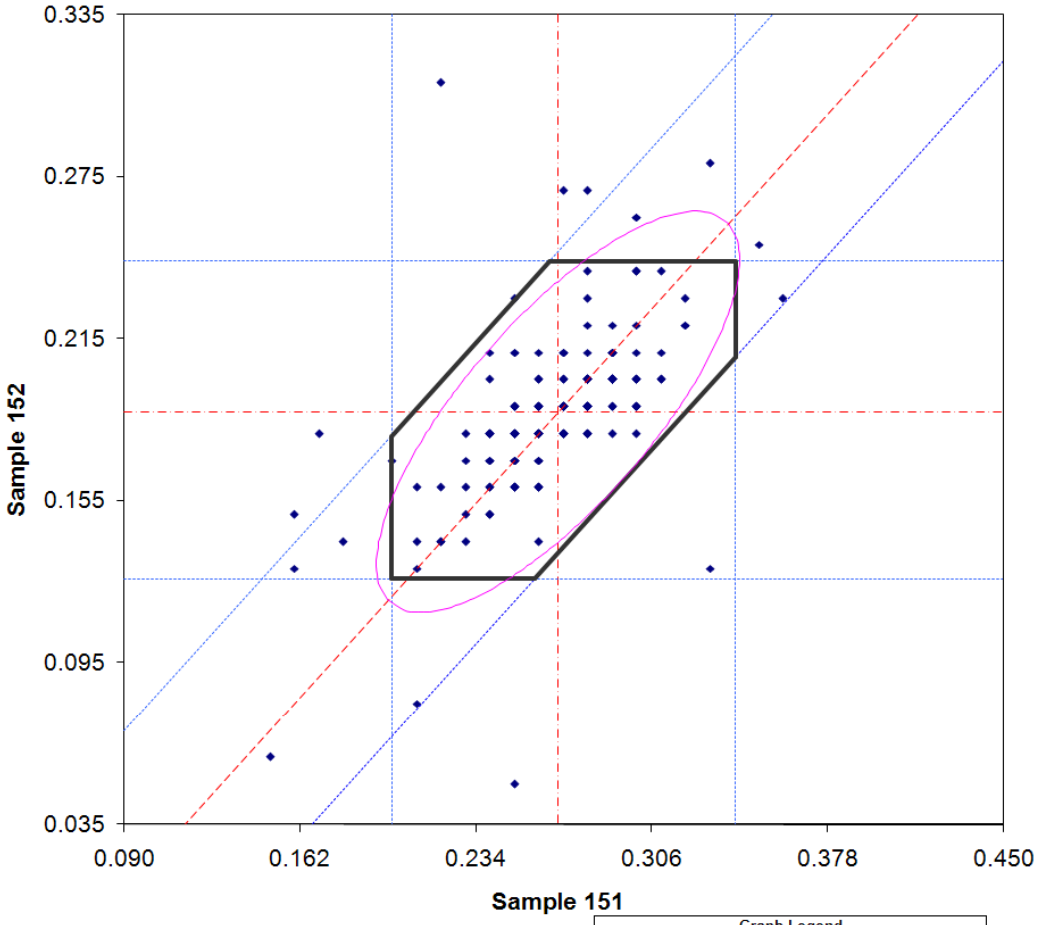
Reproducability (Sample 150)		
1s	d2s	CV%
0.024	0.067	35.6

Graph and Analysis Results for AASHTO T 105

Chemical Analysis of Hydraulic Cement

CCRL Samples 151 and 152

Test Property: Sodium Oxide (Na2O) %, Type I Cement



Graph Legend
Lines With Small Dash Marks - Sample Outlier Boundaries
Lines With Alternating Dash Marks - Sample Medians
Line With Large Dash Marks - Center Diagonal
Black Hexagon - Data Within is Used for Analysis
Ellipse - 2 Std Dev for Within and Between Lab Variation

Source of Data: AASHTO Materials Reference Laboratory Proficiency Sample Program
CCRL Samples 151 and 152
Final Report Issued April 2004

Participation:

165	Total Laboratories
10	Laboratories Determined to be Invalid
14	Laboratories Determined to be Outliers
141	Total Laboratorires Included in Analysis

Average Results	
Sample 151 Average	Sample 152 Average
0.268	0.188

Repeatability			
1s	d2s	CV% (151)	CV% (152)
0.012	0.034	4.5	6.5

Reproducability (Sample 151)		
1s	d2s	CV%
0.025	0.070	9.2

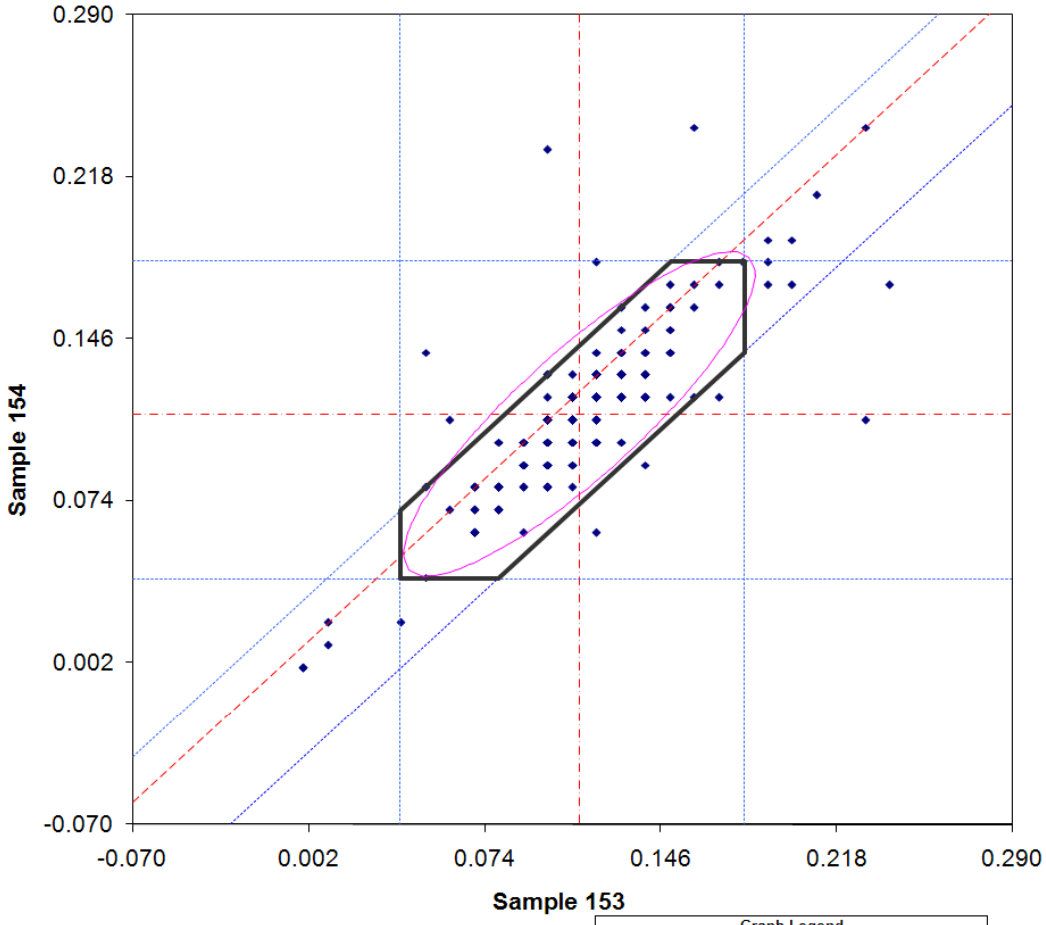
Reproducability (Sample 152)		
1s	d2s	CV%
0.022	0.061	11.5

Graph and Analysis Results for AASHTO T 105

Chemical Analysis of Hydraulic Cement

CCRL Samples 153 and 154

Test Property: Sodium Oxide (Na2O) %, Type I / II Cement



Graph Legend
Lines With Small Dash Marks - Sample Outlier Boundaries
Lines With Alternating Dash Marks - Sample Medians
Line With Large Dash Marks - Center Diagonal
Black Hexagon - Data Within is Used for Analysis
Ellipse - 2 Std Dev for Within and Between Lab Variation

Source of Data: AASHTO Materials Reference Laboratory Proficiency Sample Program
CCRL Samples 153 and 154
Final Report Issued Oct. 2004

Participation:

218	Total Laboratories
11	Laboratories Determined to be Invalid
16	Laboratories Determined to be Outliers
191	Total Laboratorires Included in Analysis

Average Results	
Sample 153 Average	Sample 154 Average
0.113	0.113

Repeatability			
1s	d2s	CV% (153)	CV% (154)
0.009	0.025	7.8	7.8

Reproducability (Sample 153)		
1s	d2s	CV%
0.022	0.063	19.8

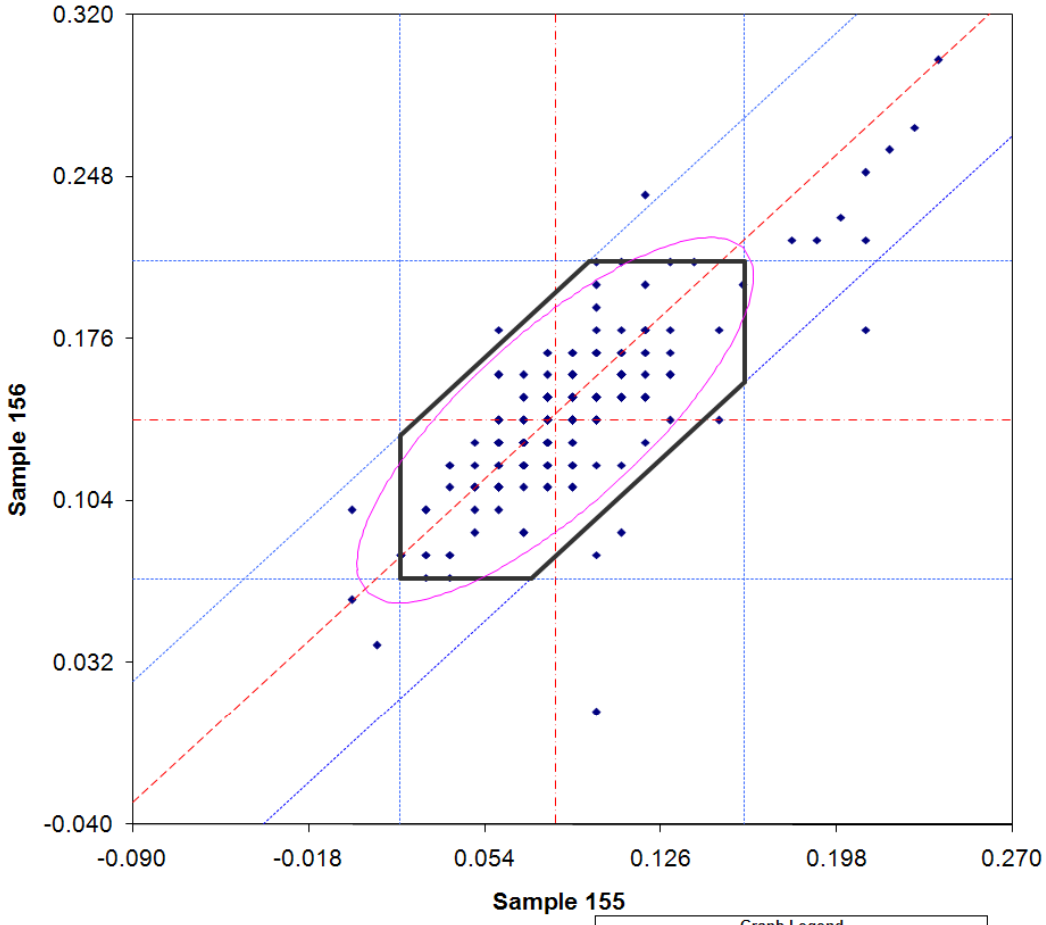
Reproducability (Sample 154)		
1s	d2s	CV%
0.024	0.068	21.3

Graph and Analysis Results for AASHTO T 105

Chemical Analysis of Hydraulic Cement

CCRL Samples 155 and 156

Test Property: Sodium Oxide (Na2O) %, Type I Cement



Graph Legend
Lines With Small Dash Marks - Sample Outlier Boundaries
Lines With Alternating Dash Marks - Sample Medians
Line With Large Dash Marks - Center Diagonal
Black Hexagon - Data Within is Used for Analysis
Ellipse - 2 Std Dev for Within and Between Lab Variation

Source of Data: AASHTO Materials Reference Laboratory Proficiency Sample Program
CCRL Samples 155 and 156
Final Report Issued April 2005

Participation:

225	Total Laboratories
11	Laboratories Determined to be Invalid
14	Laboratories Determined to be Outliers
200	Total Laboratorires Included in Analysis

Average Results	
Sample 155 Average	Sample 156 Average
0.083	0.140

Repeatability			
1s	d2s	CV% (155)	CV% (156)
0.012	0.035	15.0	8.9

Reproducability (Sample 155)		
1s	d2s	CV%
0.025	0.070	29.7

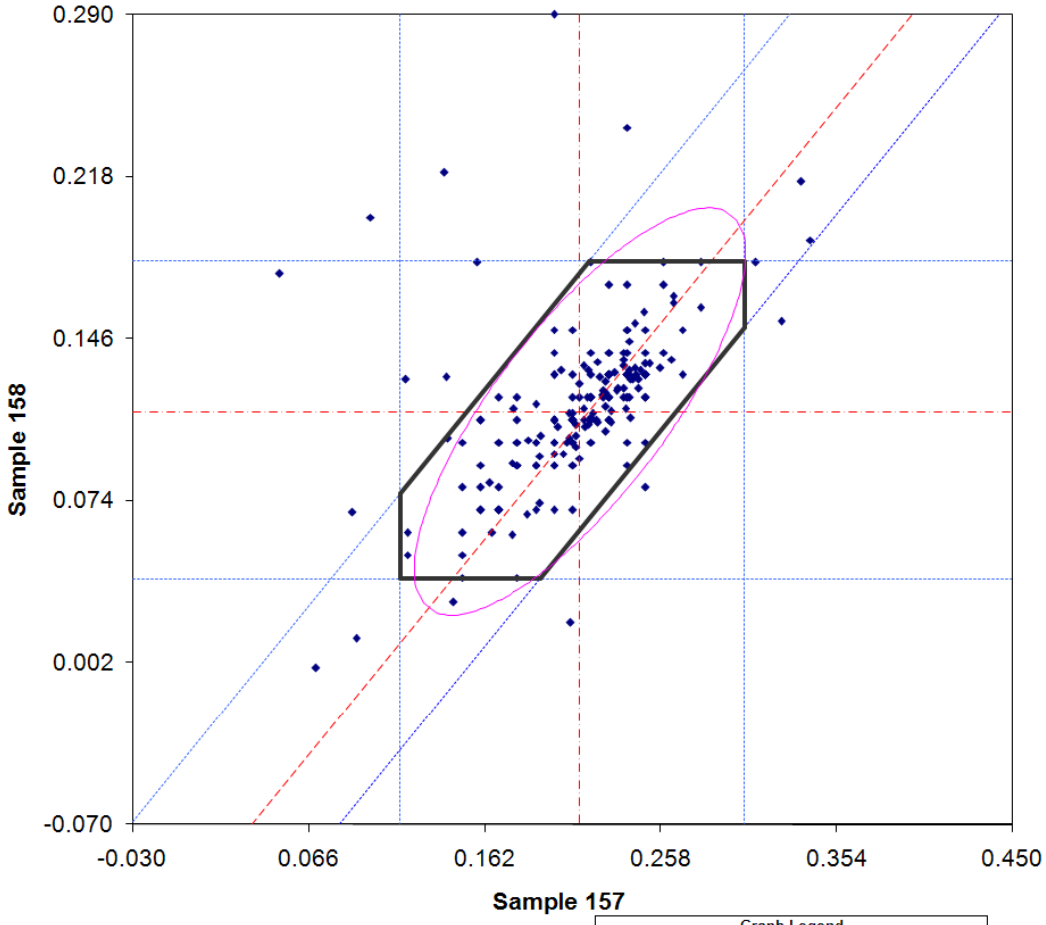
Reproducability (Sample 156)		
1s	d2s	CV%
0.026	0.075	18.9

Graph and Analysis Results for AASHTO T 105

Chemical Analysis of Hydraulic Cement

CCRL Samples 157 and 158

Test Property: Sodium Oxide (Na2O) %, Type V Cement w/ Limestone



Graph Legend
Lines With Small Dash Marks - Sample Outlier Boundaries
Lines With Alternating Dash Marks - Sample Medians
Line With Large Dash Marks - Center Diagonal
Black Hexagon - Data Within is Used for Analysis
Ellipse - 2 Std Dev for Within and Between Lab Variation

Source of Data: AASHTO Materials Reference Laboratory Proficiency Sample Program
CCRL Samples 157 and 158
Final Report Issued Oct. 2005

Participation:

217	Total Laboratories
10	Laboratories Determined to be Invalid
12	Laboratories Determined to be Outliers
195	Total Laboratorires Included in Analysis

Average Results	
Sample 157 Average	Sample 158 Average
0.214	0.114

Repeatability			
1s	d2s	CV% (157)	CV% (158)
0.014	0.040	6.6	12.5

Reproducability (Sample 157)		
1s	d2s	CV%
0.031	0.087	14.3

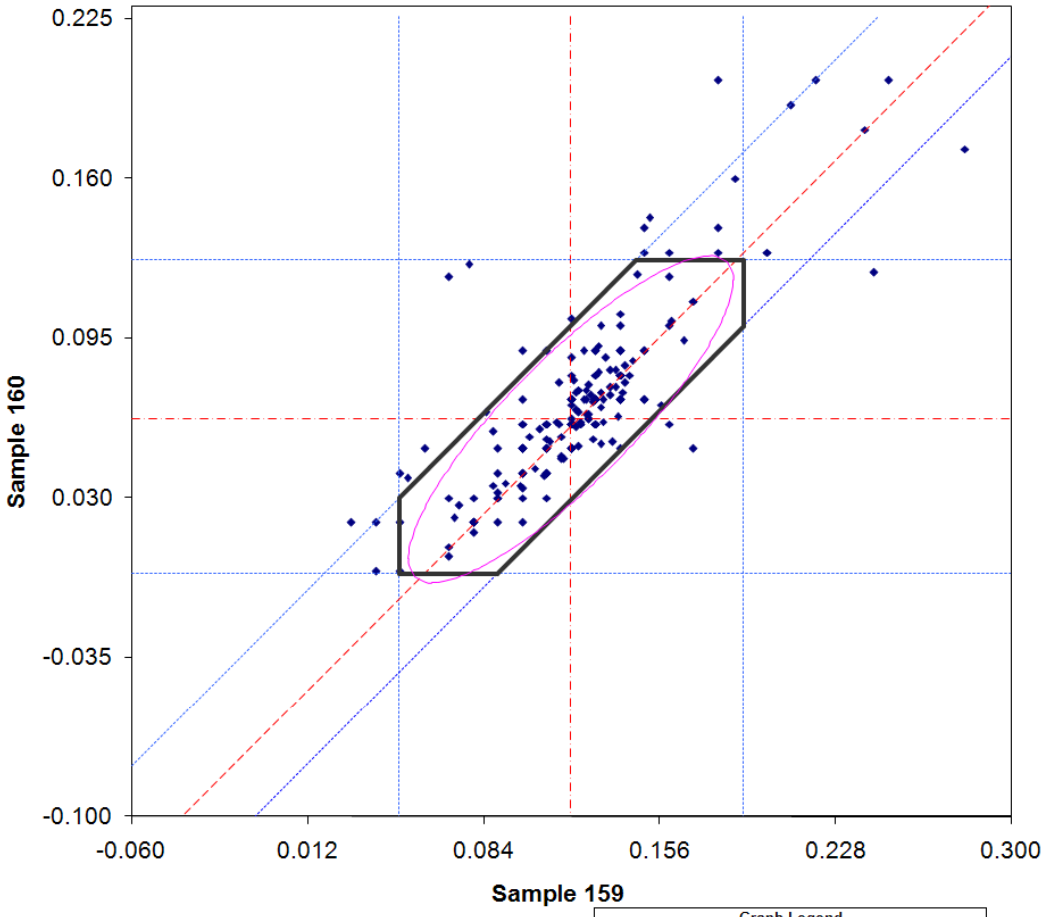
Reproducability (Sample 158)		
1s	d2s	CV%
0.026	0.073	22.8

Graph and Analysis Results for AASHTO T 105

Chemical Analysis of Hydraulic Cement

CCRL Samples 159 and 160

Test Property: Sodium Oxide (Na2O) %, Type I Cement w/ Limestone



Graph Legend
Lines With Small Dash Marks - Sample Outlier Boundaries
Lines With Alternating Dash Marks - Sample Medians
Line With Large Dash Marks - Center Diagonal
Black Hexagon - Data Within is Used for Analysis
Ellipse - 2 Std Dev for Within and Between Lab Variation

Source of Data: AASHTO Materials Reference Laboratory Proficiency Sample Program
CCRL Samples 159 and 160
Final Report Issued April 2006

Participation:

219	Total Laboratories
11	Laboratories Determined to be Invalid
24	Laboratories Determined to be Outliers
184	Total Laboratorires Included in Analysis

Average Results	
Sample 159 Average	Sample 160 Average
0.120	0.062

Repeatability			
1s	d2s	CV% (159)	CV% (160)
0.008	0.024	7.0	13.6

Reproducability (Sample 159)		
1s	d2s	CV%
0.021	0.060	17.8

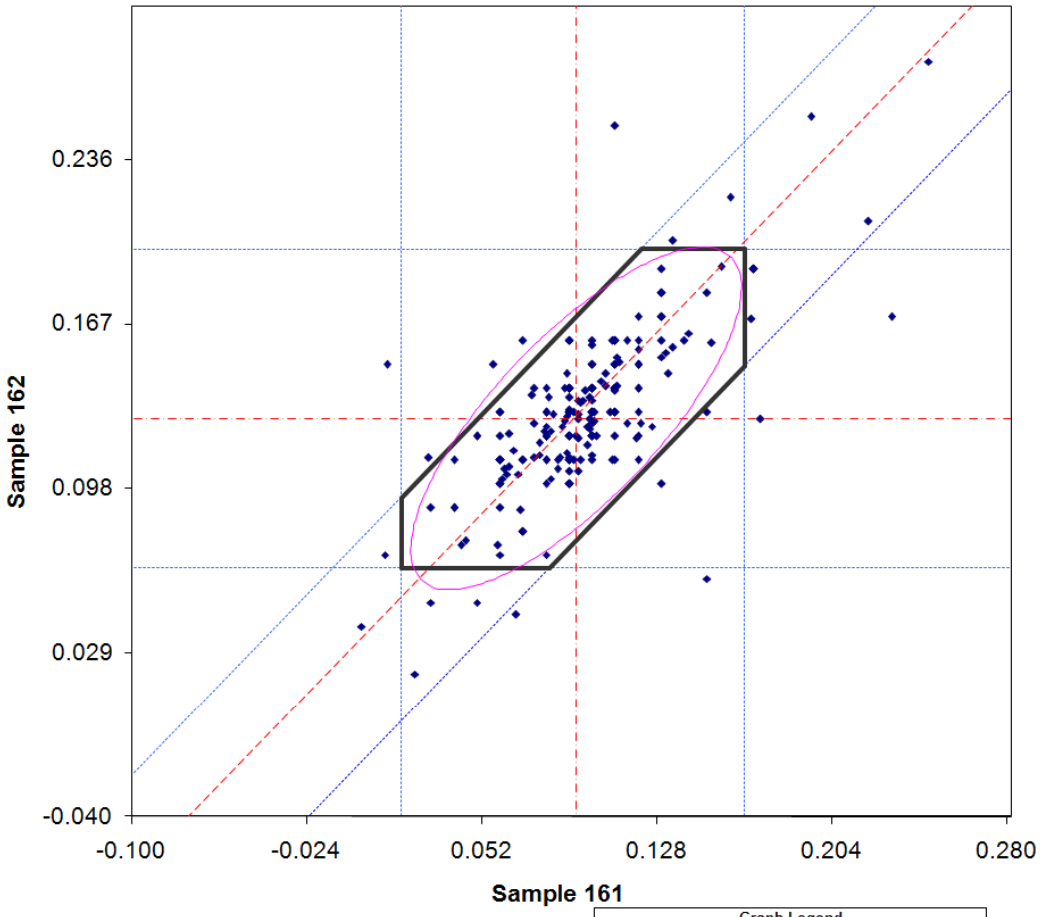
Reproducability (Sample 160)		
1s	d2s	CV%
0.021	0.061	34.6

Graph and Analysis Results for AASHTO T 105

Chemical Analysis of Hydraulic Cement

CCRL Samples 161 and 162

Test Property: Sodium Oxide (Na2O) %, Type I Cement w/ Limestone



Graph Legend
Lines With Small Dash Marks - Sample Outlier Boundaries
Lines With Alternating Dash Marks - Sample Medians
Line With Large Dash Marks - Center Diagonal
Black Hexagon - Data Within is Used for Analysis
Ellipse - 2 Std Dev for Within and Between Lab Variation

Source of Data: AASHTO Materials Reference Laboratory Proficiency Sample Program
CCRL Samples 161 and 162
Final Report Issued Oct. 2006

Participation:

222	Total Laboratories
9	Laboratories Determined to be Invalid
20	Laboratories Determined to be Outliers
193	Total Laboratorires Included in Analysis

Average Results	
Sample 161 Average	Sample 162 Average
0.093	0.127

Repeatability			
1s	d2s	CV% (161)	CV% (162)
0.012	0.033	12.4	9.1

Reproducability (Sample 161)		
1s	d2s	CV%
0.023	0.064	24.4

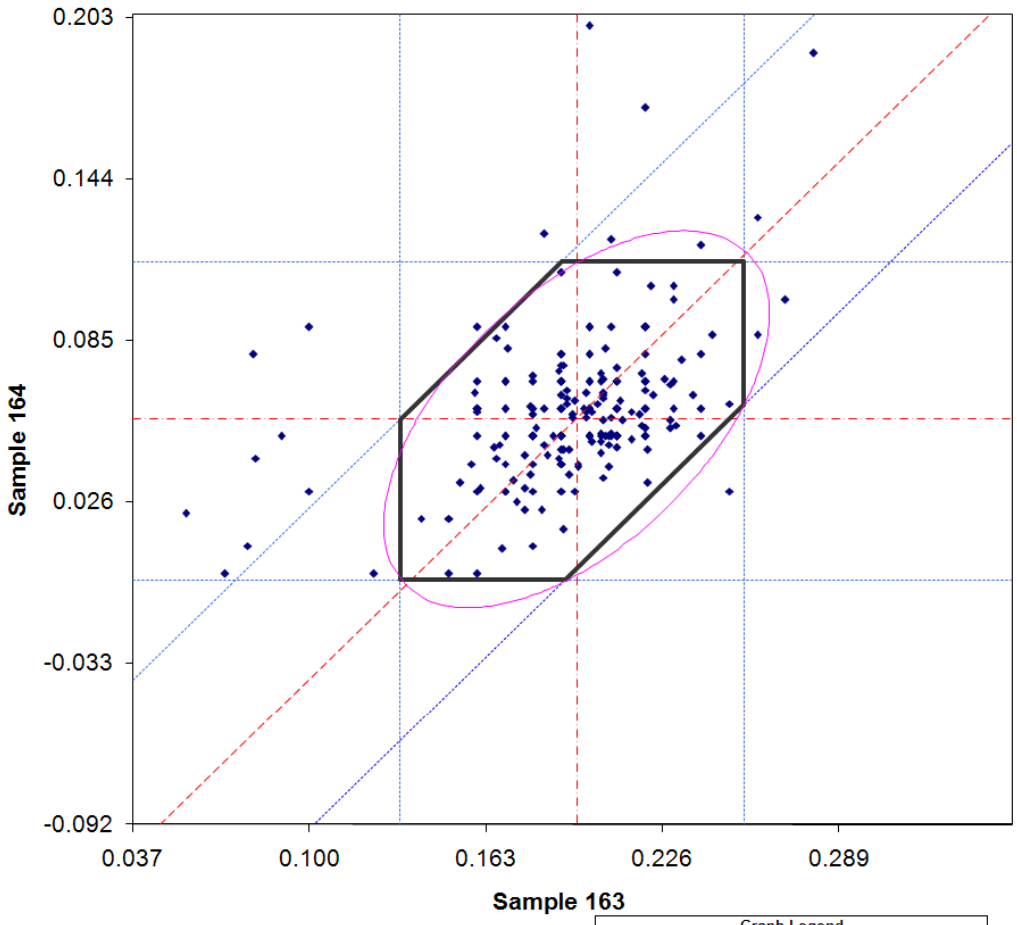
Reproducability (Sample 162)		
1s	d2s	CV%
0.022	0.063	17.5

Graph and Analysis Results for AASHTO T 105

Chemical Analysis of Hydraulic Cement

CCRL Samples 163 and 164

Test Property: Sodium Oxide (Na2O) %, Type I / II Cement



Graph Legend
Lines With Small Dash Marks - Sample Outlier Boundaries
Lines With Alternating Dash Marks - Sample Medians
Line With Large Dash Marks - Center Diagonal
Black Hexagon - Data Within is Used for Analysis
Ellipse - 2 Std Dev for Within and Between Lab Variation

Source of Data: AASHTO Materials Reference Laboratory Proficiency Sample Program
CCRL Samples 163 and 164
Final Report Issued April 2007

Participation:

224	Total Laboratories
9	Laboratories Determined to be Invalid
16	Laboratories Determined to be Outliers
199	Total Laboratorires Included in Analysis

Average Results	
Sample 163 Average	Sample 164 Average
0.196	0.056

Repeatability			
1s	d2s	CV% (163)	CV% (164)
0.015	0.043	7.8	27.0

Reproducability (Sample 163)		
1s	d2s	CV%
0.021	0.060	10.9

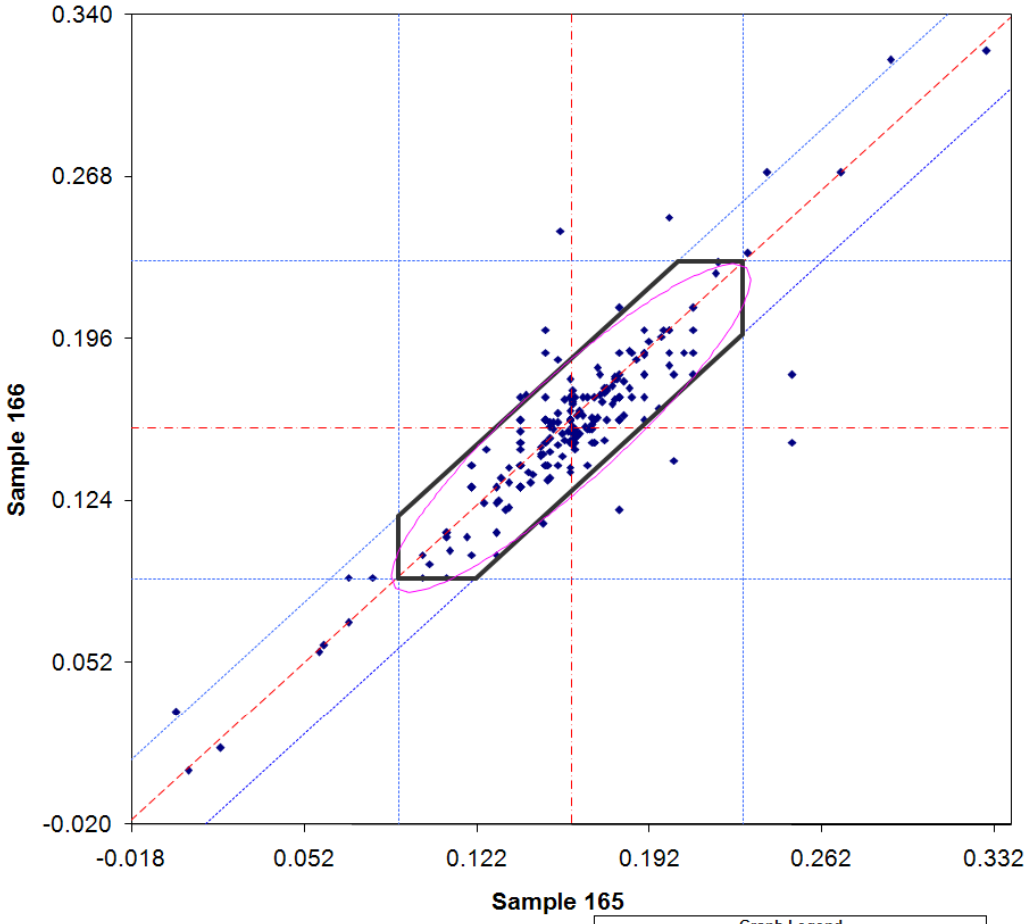
Reproducability (Sample 164)		
1s	d2s	CV%
0.019	0.055	34.2

Graph and Analysis Results for AASHTO T 105

Chemical Analysis of Hydraulic Cement

CCRL Samples 165 and 166

Test Property: Sodium Oxide (Na2O) %, Type I / II Cement w/ Limestone



Graph Legend
Lines With Small Dash Marks - Sample Outlier Boundaries
Lines With Alternating Dash Marks - Sample Medians
Line With Large Dash Marks - Center Diagonal
Black Hexagon - Data Within is Used for Analysis
Ellipse - 2 Std Dev for Within and Between Lab Variation

Source of Data: AASHTO Materials Reference Laboratory Proficiency Sample Program
CCRL Samples 165 and 166
Final Report Issued Sept. 2007

Participation:

231	Total Laboratories
10	Laboratories Determined to be Invalid
16	Laboratories Determined to be Outliers
205	Total Laboratorires Included in Analysis

Average Results	
Sample 165 Average	Sample 166 Average
0.160	0.156

Repeatability			
1s	d2s	CV% (165)	CV% (166)
0.007	0.021	4.6	4.7

Reproducability (Sample 165)		
1s	d2s	CV%
0.023	0.066	14.6

Reproducability (Sample 166)		
1s	d2s	CV%
0.024	0.068	15.4

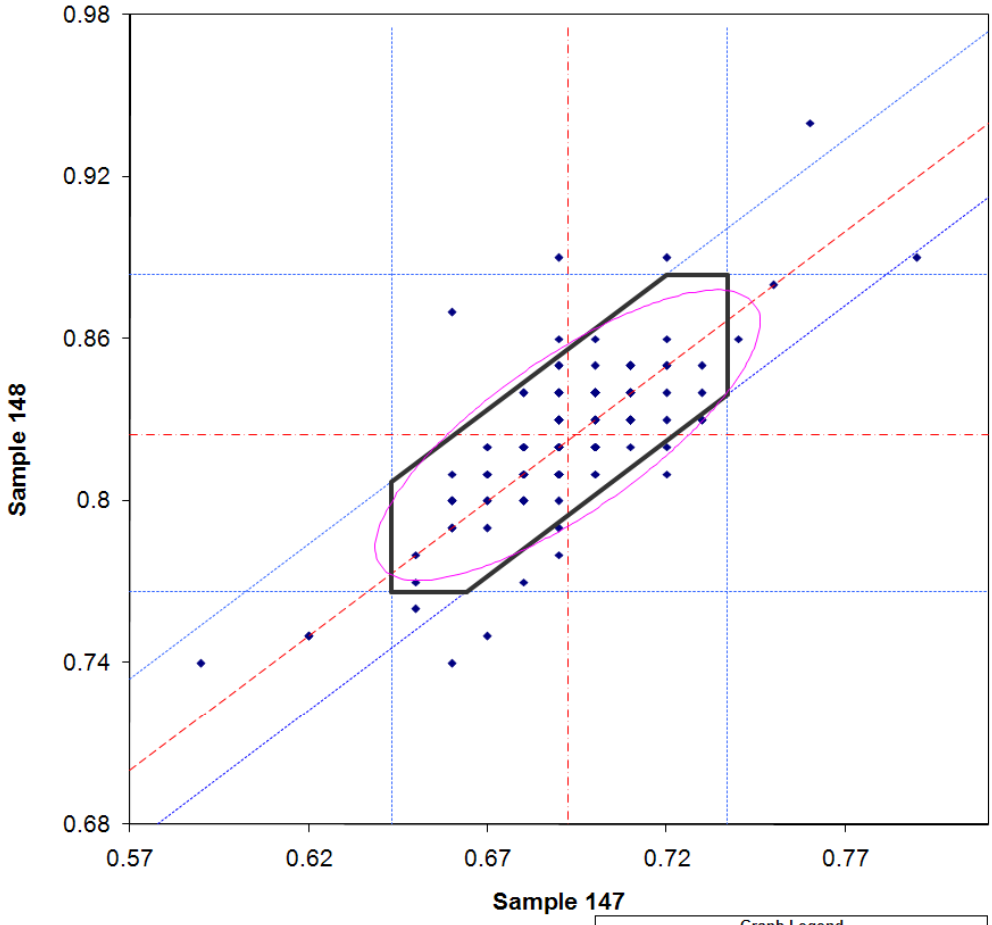
APPENDIX I: POTASSIUM OXIDE (K_2O)

Graph and Analysis Results for AASHTO T 105

Chemical Analysis of Hydraulic Cement

CCRL Samples 147 and 148

Test Property: % Potassium Oxide (K2O), Type I / II Cement



Graph Legend
Lines With Small Dash Marks - Sample Outlier Boundaries
Lines With Alternating Dash Marks - Sample Medians
Line With Large Dash Marks - Center Diagonal
Black Hexagon - Data Within is Used for Analysis
Ellipse - 2 Std Dev for Within and Between Lab Variation

Source of Data: AASHTO Materials Reference Laboratory Proficiency Sample Program
CCRL Samples 147 and 148
Final Report Issued March 2003

Participation:

138	Total Laboratories
6	Laboratories Determined to be Invalid
18	Laboratories Determined to be Outliers
114	Total Laboratorires Included in Analysis

Average Results	
Sample 147 Average	Sample 148 Average
0.69	0.82

Repeatability			
1s	d2s	CV% (147)	CV% (148)
0.01	0.02	1.22	1.02

Reproducability (Sample 147)		
1s	d2s	CV%
0.02	0.05	2.36

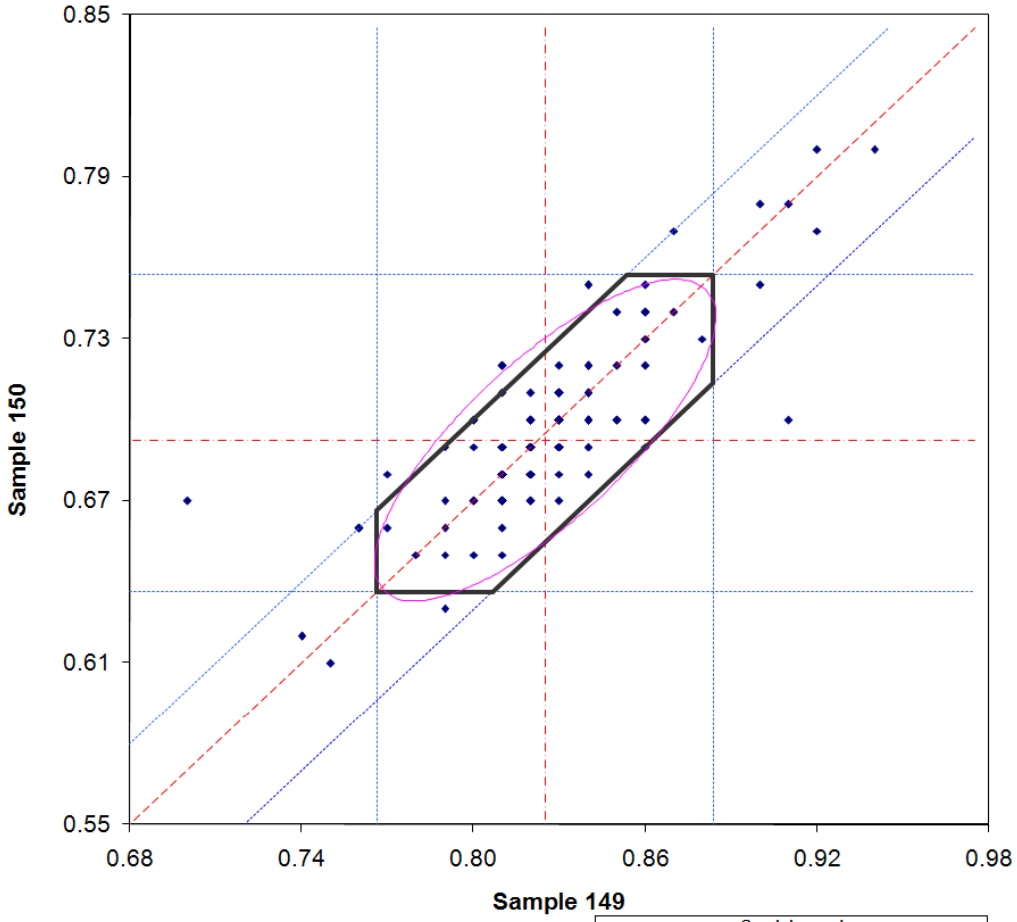
Reproducability (Sample 148)		
1s	d2s	CV%
0.02	0.05	2.12

Graph and Analysis Results for AASHTO T 105

Chemical Analysis of Hydraulic Cement

CCRL Samples 149 and 150

Test Property: % Potassium Oxide (K2O), Type I Cement



Graph Legend
Lines With Small Dash Marks - Sample Outlier Boundaries
Lines With Alternating Dash Marks - Sample Medians
Line With Large Dash Marks - Center Diagonal
Black Hexagon - Data Within is Used for Analysis
Ellipse - 2 Std Dev for Within and Between Lab Variation

Source of Data: AASHTO Materials Reference Laboratory Proficiency Sample Program
CCRL Samples 149 and 150
Final Report Issued Sept. 2003

Participation:

154	Total Laboratories
9	Laboratories Determined to be Invalid
17	Laboratories Determined to be Outliers
128	Total Laboratorires Included in Analysis

Average Results	
Sample 149 Average	Sample 150 Average
0.83	0.69

Repeatability			
1s	d2s	CV% (149)	CV% (150)
0.01	0.03	1.15	1.37

Reproducability (Sample 149)		
1s	d2s	CV%
0.02	0.05	2.25

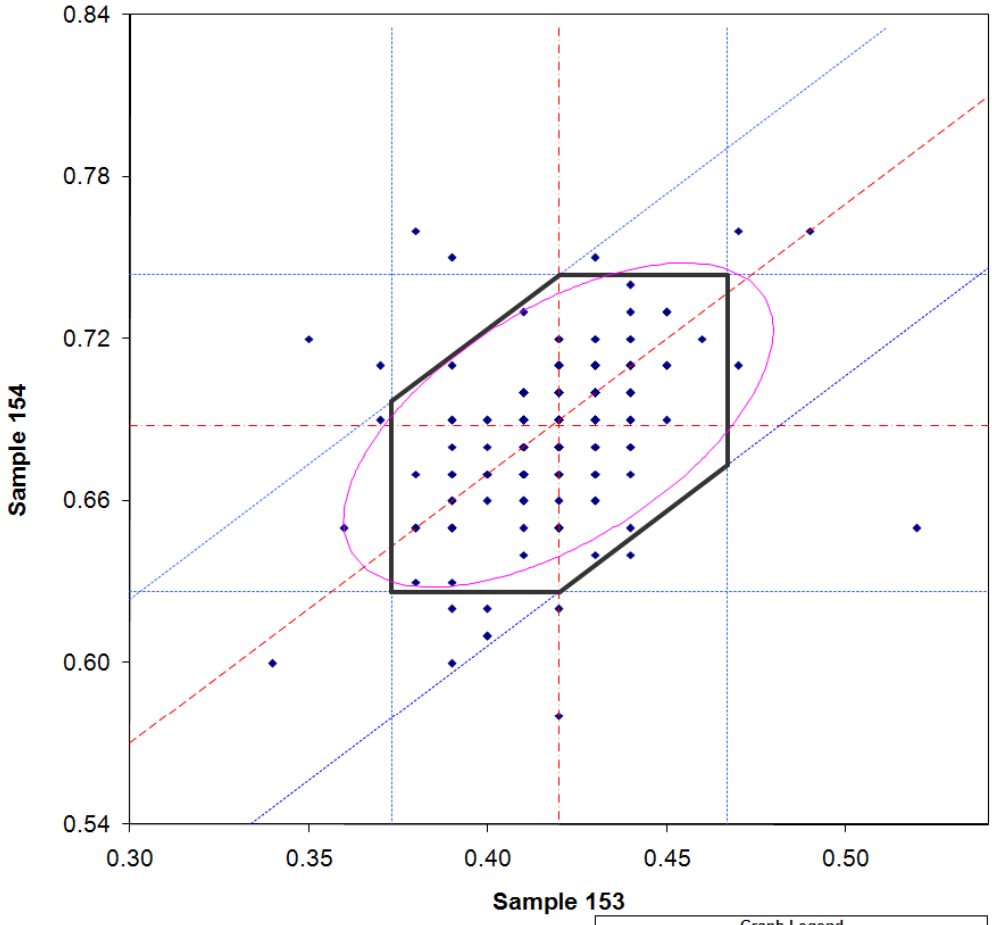
Reproducability (Sample 150)		
1s	d2s	CV%
0.02	0.05	2.72

Graph and Analysis Results for AASHTO T 105

Chemical Analysis of Hydraulic Cement

CCRL Samples 153 and 154

Test Property: % Potassium Oxide (K2O), Type I / II Cement



Graph Legend
Lines With Small Dash Marks - Sample Outlier Boundaries
Lines With Alternating Dash Marks - Sample Medians
Line With Large Dash Marks - Center Diagonal
Black Hexagon - Data Within is Used for Analysis
Ellipse - 2 Std Dev for Within and Between Lab Variation

Source of Data: AASHTO Materials Reference Laboratory Proficiency Sample Program
CCRL Samples 153 and 154
Final Report Issued Oct. 2004

Participation:

220	Total Laboratories
9	Laboratories Determined to be Invalid
16	Laboratories Determined to be Outliers
195	Total Laboratorires Included in Analysis

Average Results	
Sample 153 Average	Sample 154 Average
0.42	0.69

Repeatability			
1s	d2s	CV% (153)	CV% (154)
0.01	0.04	3.07	1.87

Reproducability (Sample 153)		
1s	d2s	CV%
0.01	0.04	3.49

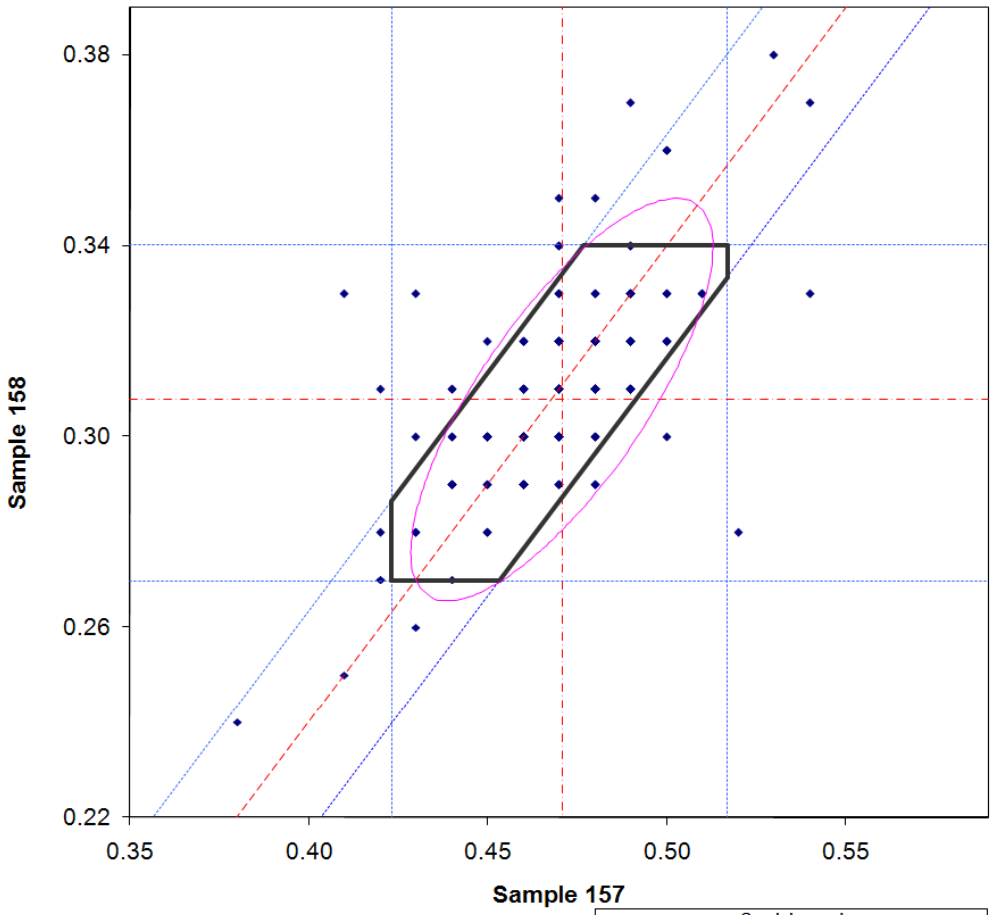
Reproducability (Sample 154)		
1s	d2s	CV%
0.02	0.06	2.98

Graph and Analysis Results for AASHTO T 105

Chemical Analysis of Hydraulic Cement

CCRL Samples 157 and 158

% Potassium Oxide (K2O), Type V w/ Limestone (157) & Type I / II w/ Limestone (158)



Graph Legend
Lines With Small Dash Marks - Sample Outlier Boundaries
Lines With Alternating Dash Marks - Sample Medians
Line With Large Dash Marks - Center Diagonal
Black Hexagon - Data Within is Used for Analysis
Ellipse - 2 Std Dev for Within and Between Lab Variation

Source of Data: AASHTO Materials Reference Laboratory Proficiency Sample Program
CCRL Samples 157 and 158
Final Report Issued Oct. 2005

Participation:

222	Total Laboratories
12	Laboratories Determined to be Invalid
24	Laboratories Determined to be Outliers
186	Total Laboratorires Included in Analysis

Average Results	
Sample 157 Average	Sample 158 Average
0.47	0.31

Repeatability			
1s	d2s	CV% (157)	CV% (158)
0.01	0.02	1.46	2.24

Reproducability (Sample 157)		
1s	d2s	CV%
0.01	0.04	2.99

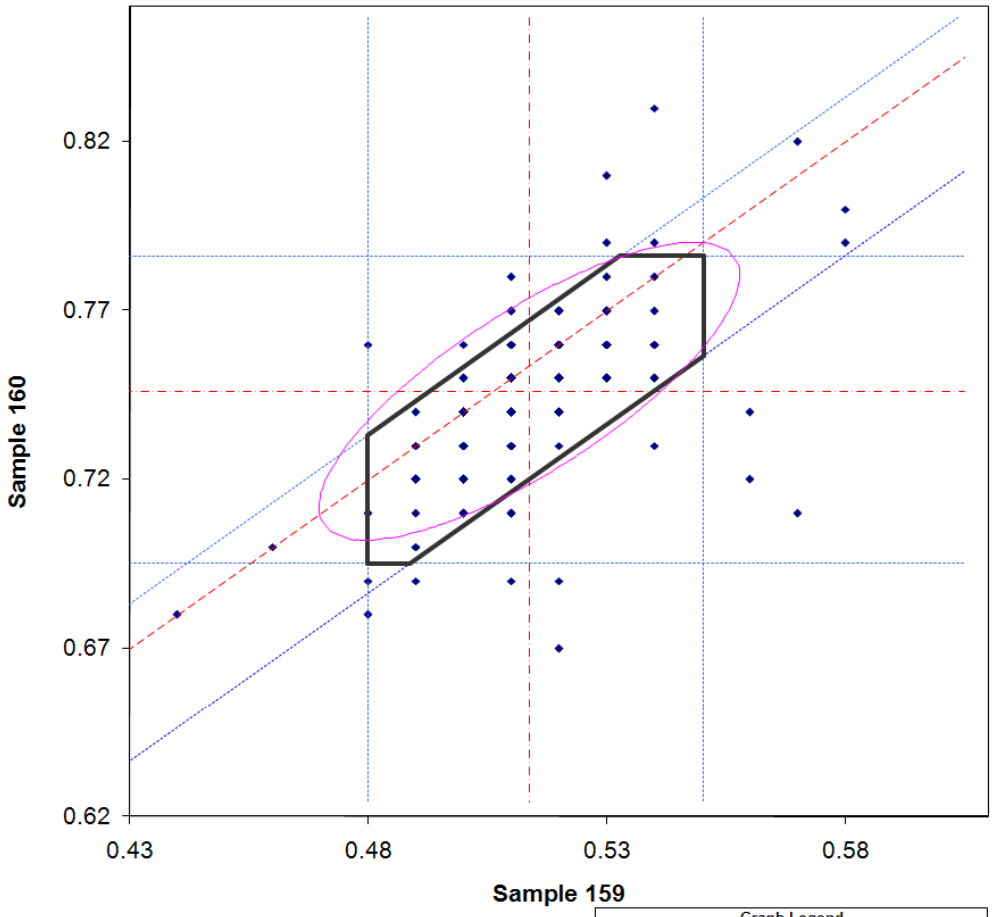
Reproducability (Sample 158)		
1s	d2s	CV%
0.01	0.03	4.00

Graph and Analysis Results for AASHTO T 105

Chemical Analysis of Hydraulic Cement

CCRL Samples 159 and 160

% Potassium Oxide (K2O), Type I w/ Limestone (159) & Type I / II w/ Limestone (160)



Graph Legend
Lines With Small Dash Marks - Sample Outlier Boundaries
Lines With Alternating Dash Marks - Sample Medians
Line With Large Dash Marks - Center Diagonal
Black Hexagon - Data Within is Used for Analysis
Ellipse - 2 Std Dev for Within and Between Lab Variation

Source of Data: AASHTO Materials Reference Laboratory Proficiency Sample Program
CCRL Samples 159 and 160
Final Report Issued April 2006

Participation:

224	Total Laboratories
22	Laboratories Determined to be Invalid
14	Laboratories Determined to be Outliers
188	Total Laboratorires Included in Analysis

Average Results	
Sample 159 Average	Sample 160 Average
0.51	0.75

Repeatability			
1s	d2s	CV% (159)	CV% (160)
0.01	0.02	1.34	0.92

Reproducability (Sample 159)		
1s	d2s	CV%
0.01	0.04	2.41

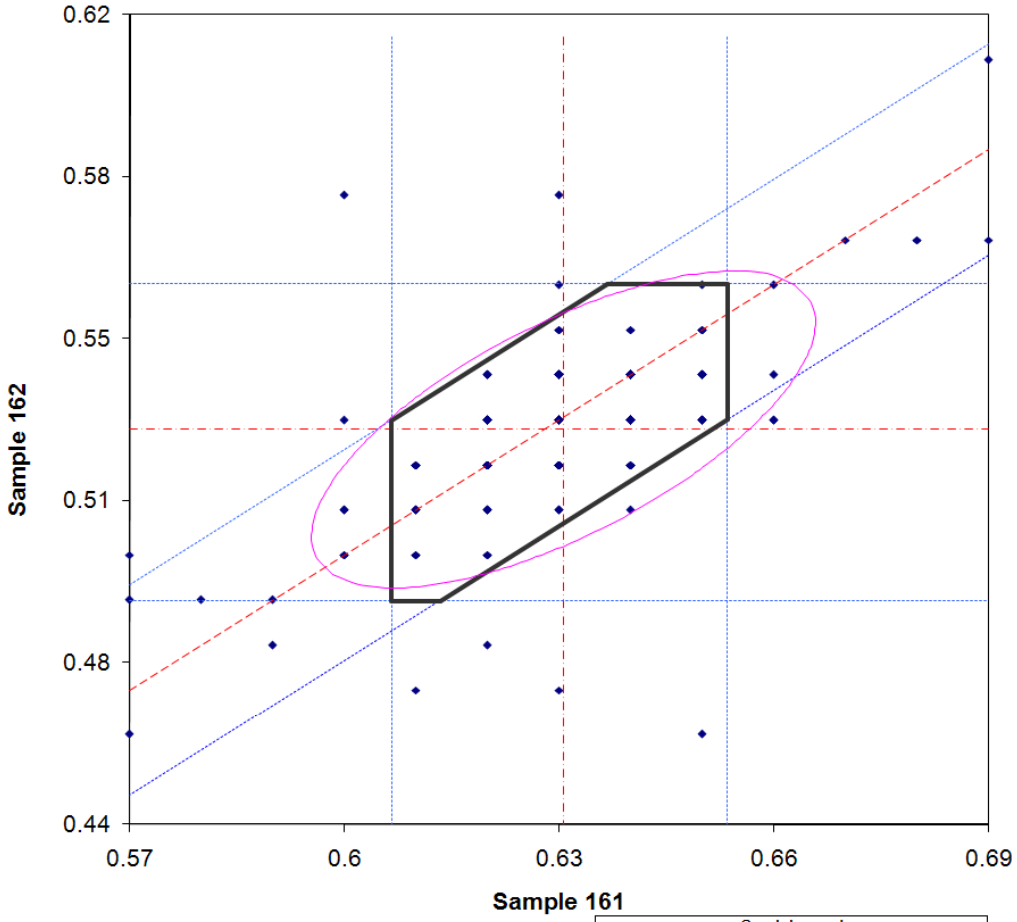
Reproducability (Sample 160)		
1s	d2s	CV%
0.02	0.04	2.04

Graph and Analysis Results for AASHTO T 105

Chemical Analysis of Hydraulic Cement

CCRL Samples 161 and 162

% Potassium Oxide (K2O), Type I Cement (161) & Type I Cement w/ Limestone (162)



Graph Legend
Lines With Small Dash Marks - Sample Outlier Boundaries
Lines With Alternating Dash Marks - Sample Medians
Line With Large Dash Marks - Center Diagonal
Black Hexagon - Data Within is Used for Analysis
Ellipse - 2 Std Dev for Within and Between Lab Variation

Source of Data: AASHTO Materials Reference Laboratory Proficiency Sample Program
CCRL Samples 161 and 162
Final Report Issued Oct. 2006

Participation:

228	Total Laboratories
24	Laboratories Determined to be Invalid
24	Laboratories Determined to be Outliers
180	Total Laboratorires Included in Analysis

Average Results	
Sample 161 Average	Sample 162 Average
0.63	0.53

Repeatability			
1s	d2s	CV% (161)	CV% (162)
0.007	0.019	1.06	1.26

Reproducability (Sample 161)		
1s	d2s	CV%
0.011	0.030	1.67

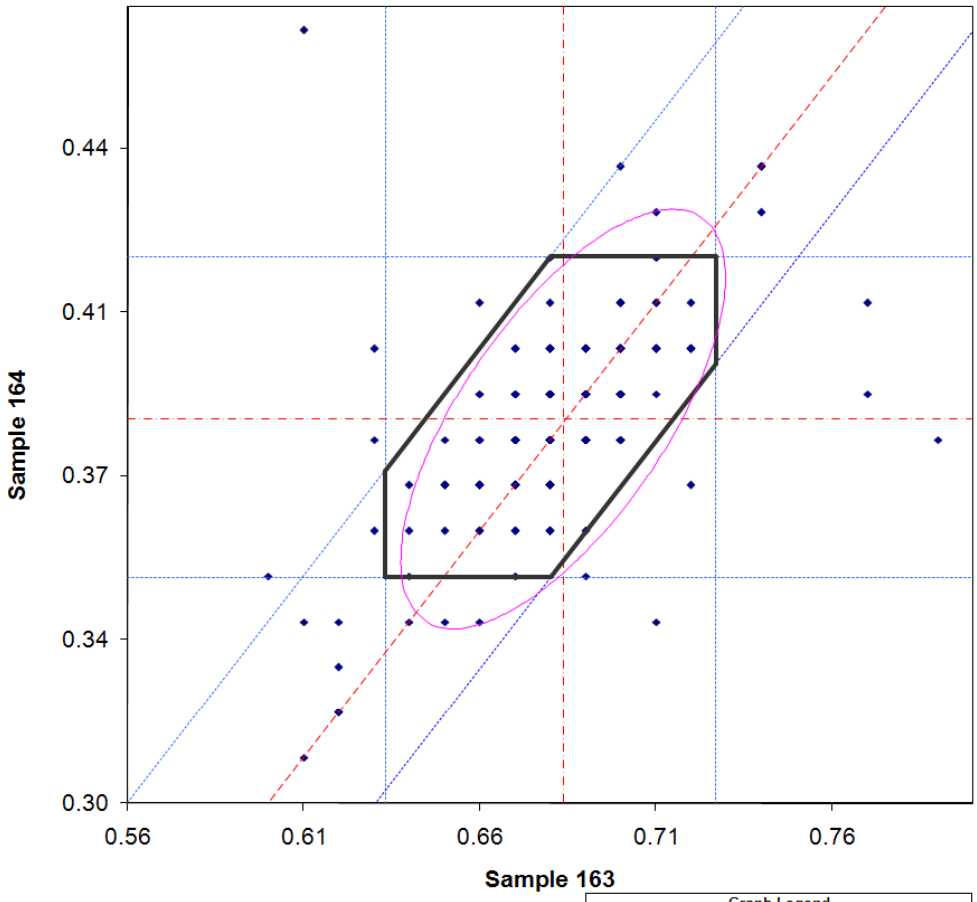
Reproducability (Sample 162)		
1s	d2s	CV%
0.011	0.031	2.08

Graph and Analysis Results for AASHTO T 105

Chemical Analysis of Hydraulic Cement

CCRL Samples 163 and 164

% Potassium Oxide (K2O), Type I / II Cement



Graph Legend
Lines With Small Dash Marks - Sample Outlier Boundaries
Lines With Alternating Dash Marks - Sample Medians
Line With Large Dash Marks - Center Diagonal
Black Hexagon - Data Within is Used for Analysis
Ellipse - 2 Std Dev for Within and Between Lab Variation

Source of Data: AASHTO Materials Reference Laboratory Proficiency Sample Program
CCRL Samples 163 and 164
Final Report Issued April 2007

Participation:

229	Total Laboratories
14	Laboratories Determined to be Invalid
20	Laboratories Determined to be Outliers
195	Total Laboratorires Included in Analysis

Average Results	
Sample 163 Average	Sample 164 Average
0.68	0.38

Repeatability			
1s	d2s	CV% (163)	CV% (164)
0.009	0.025	1.27	2.26

Reproducability (Sample 163)		
1s	d2s	CV%
0.015	0.043	2.23

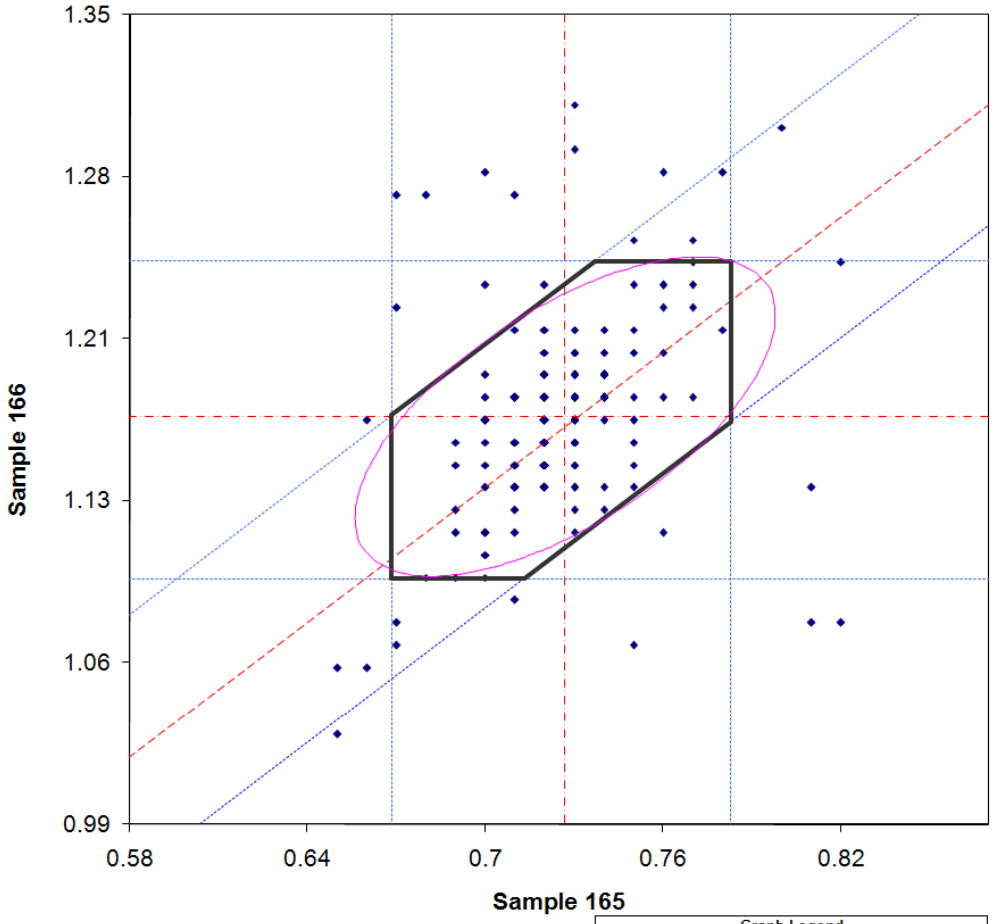
Reproducability (Sample 164)		
1s	d2s	CV%
0.013	0.036	3.33

Graph and Analysis Results for AASHTO T 105

Chemical Analysis of Hydraulic Cement

CCRL Samples 165 and 166

% Potassium Oxide (K2O), Type I / II Cement w/ Limestone



Graph Legend
Lines With Small Dash Marks - Sample Outlier Boundaries
Lines With Alternating Dash Marks - Sample Medians
Line With Large Dash Marks - Center Diagonal
Black Hexagon - Data Within is Used for Analysis
Ellipse - 2 Std Dev for Within and Between Lab Variation

Source of Data: AASHTO Materials Reference Laboratory Proficiency Sample Program
CCRL Samples 165 and 166
Final Report Issued September 2007

Participation:

234	Total Laboratories
16	Laboratories Determined to be Invalid
21	Laboratories Determined to be Outliers
197	Total Laboratorires Included in Analysis

Average Results	
Sample 165 Average	Sample 166 Average
0.73	1.17

Repeatability			
1s	d2s	CV% (165)	CV% (166)
0.014	0.040	2.0	1.2

Reproducability (Sample 165)		
1s	d2s	CV%
0.017	0.047	2.3

Reproducability (Sample 166)		
1s	d2s	CV%
0.025	0.071	2.1

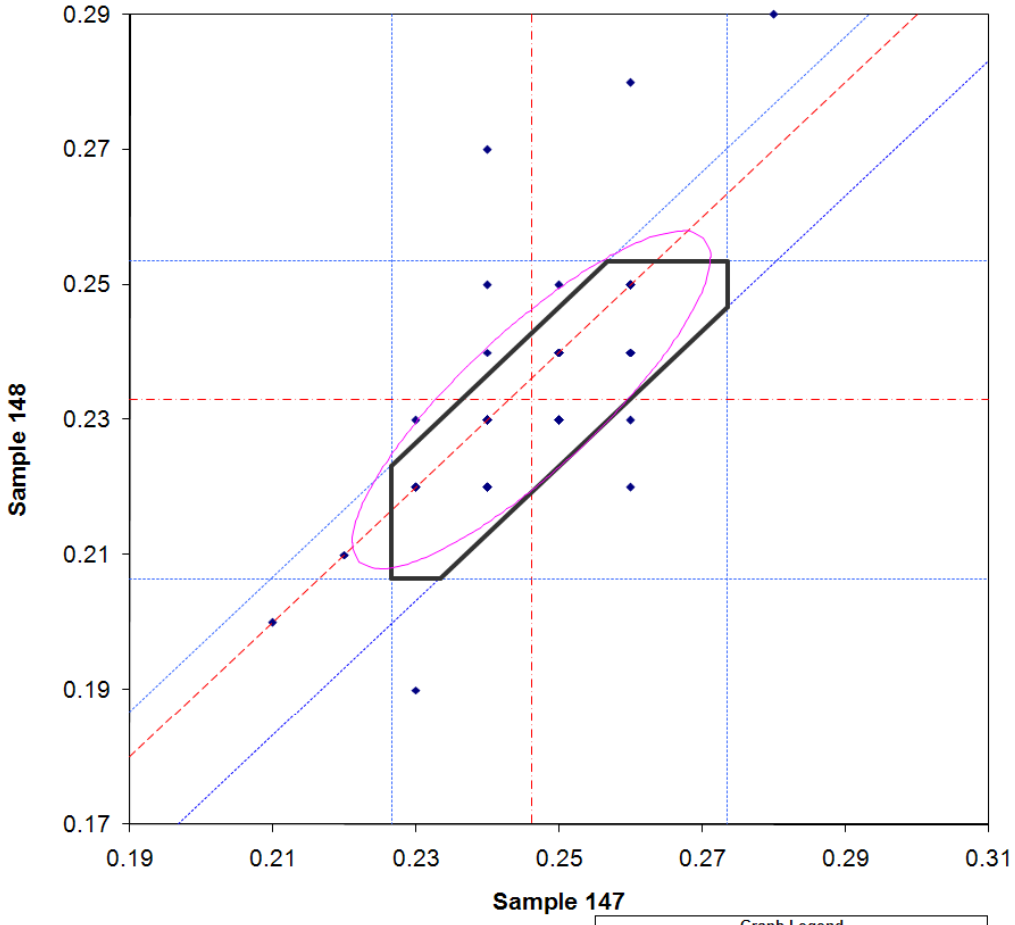
APPENDIX J: TITANIUM DIOXIDE (TiO_2)

Graph and Analysis Results for AASHTO T 105

Chemical Analysis of Hydraulic Cement

CCRL Samples 147 and 148

Test Property: % Titanium Dioxide (TiO2), Type I / II Cement



Graph Legend
Lines With Small Dash Marks - Sample Outlier Boundaries
Lines With Alternating Dash Marks - Sample Medians
Line With Large Dash Marks - Center Diagonal
Black Hexagon - Data Within is Used for Analysis
Ellipse - 2 Std Dev for Within and Between Lab Variation

Source of Data: AASHTO Materials Reference Laboratory Proficiency Sample Program
CCRL Samples 147 and 148
Final Report Issued March 2003

Participation:

88	Total Laboratories
10	Laboratories Determined to be Invalid
7	Laboratories Determined to be Outliers
71	Total Laboratorires Included in Analysis

Average Results	
Sample 147 Average	Sample 148 Average
0.246	0.233

Repeatability			
1s	d2s	CV% (147)	CV% (148)
0.003	0.009	1.34	1.41

Reproducability (Sample 147)		
1s	d2s	CV%
0.008	0.023	3.33

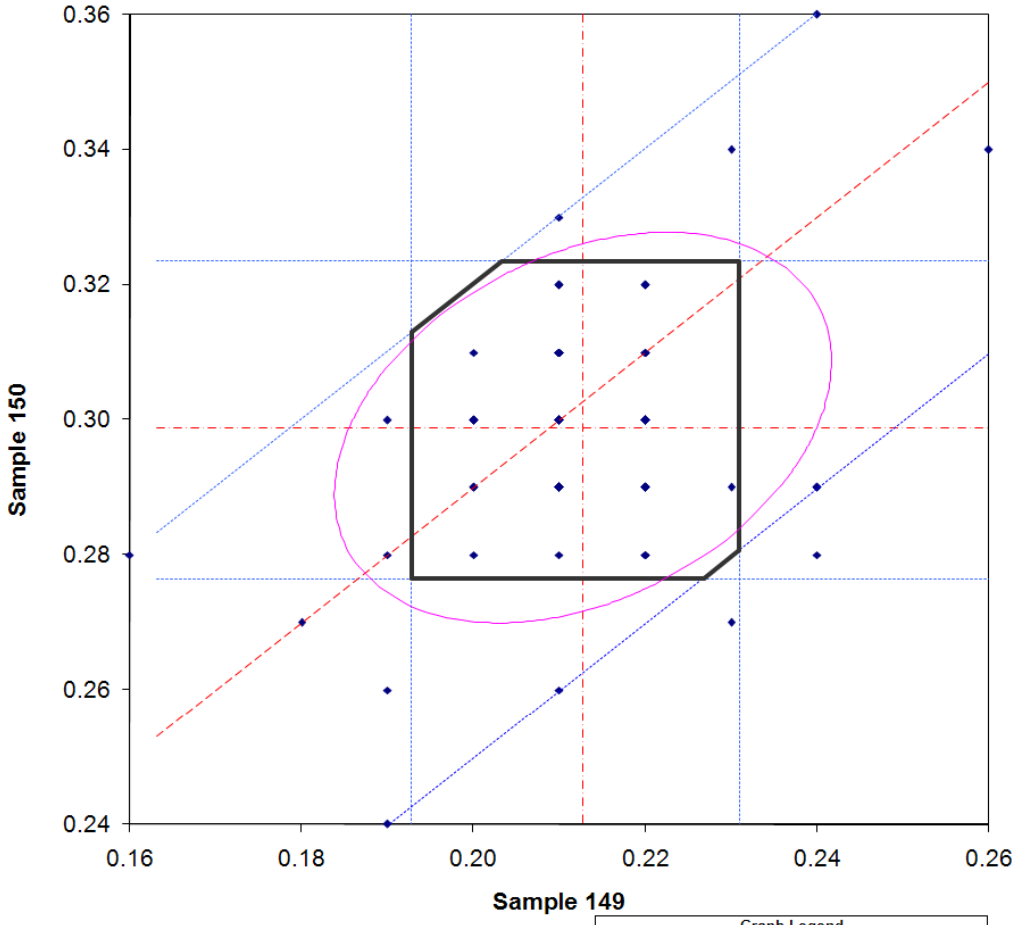
Reproducability (Sample 148)		
1s	d2s	CV%
0.008	0.022	3.36

Graph and Analysis Results for AASHTO T 105

Chemical Analysis of Hydraulic Cement

CCRL Samples 149 and 150

Test Property: Titanium Dioxide (TiO2) %, Type I Cement



Graph Legend
Lines With Small Dash Marks - Sample Outlier Boundaries
Lines With Alternating Dash Marks - Sample Medians
Line With Large Dash Marks - Center Diagonal
Black Hexagon - Data Within is Used for Analysis
Ellipse - 2 Std Dev for Within and Between Lab Variation

Source of Data: AASHTO Materials Reference Laboratory Proficiency Sample Program
CCRL Samples 149 and 150
Final Report Issued Sept. 2003

Participation:

108	Total Laboratories
8	Laboratories Determined to be Invalid
12	Laboratories Determined to be Outliers
88	Total Laboratorires Included in Analysis

Average Results	
Sample 149 Average	Sample 150 Average
0.213	0.299

Repeatability			
1s	d2s	CV% (149)	CV% (150)
0.008	0.022	3.68	2.62

Reproducability (Sample 149)		
1s	d2s	CV%
0.006	0.018	3.00

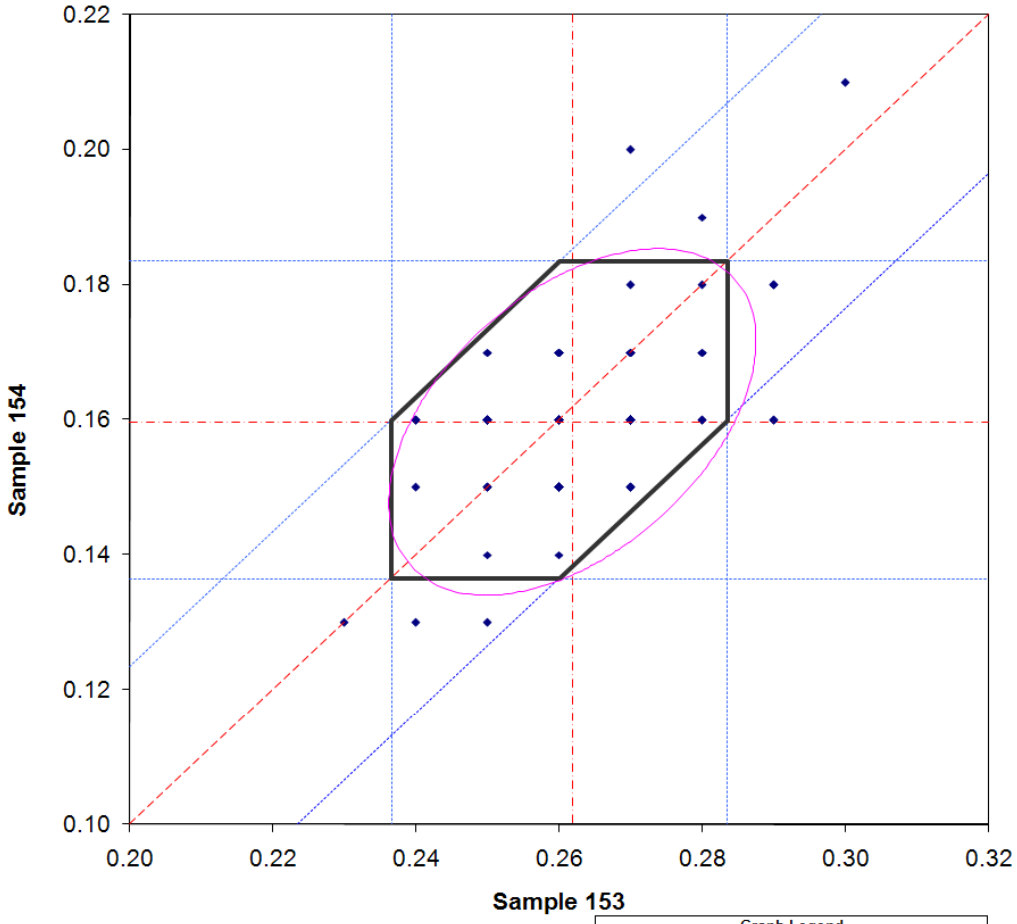
Reproducability (Sample 150)		
1s	d2s	CV%
0.009	0.026	3.06

Graph and Analysis Results for AASHTO T 105

Chemical Analysis of Hydraulic Cement

CCRL Samples 153 and 154

Test Property: % Titanium Dioxide (TiO2), Type I / II Cement



Graph Legend
Lines With Small Dash Marks - Sample Outlier Boundaries
Lines With Alternating Dash Marks - Sample Medians
Line With Large Dash Marks - Center Diagonal
Black Hexagon - Data Within is Used for Analysis
Ellipse - 2 Std Dev for Within and Between Lab Variation

Source of Data: AASHTO Materials Reference Laboratory Proficiency Sample Program
CCRL Samples 153 and 154
Final Report Issued Oct. 2004

Participation:

158	Total Laboratories
10	Laboratories Determined to be Invalid
9	Laboratories Determined to be Outliers
139	Total Laboratorires Included in Analysis

Average Results	
Sample 153 Average	Sample 154 Average
0.26	0.16

Repeatability			
1s	d2s	CV% (153)	CV% (154)
0.006	0.018	2.38	3.90

Reproducability (Sample 153)		
1s	d2s	CV%
0.008	0.023	3.09

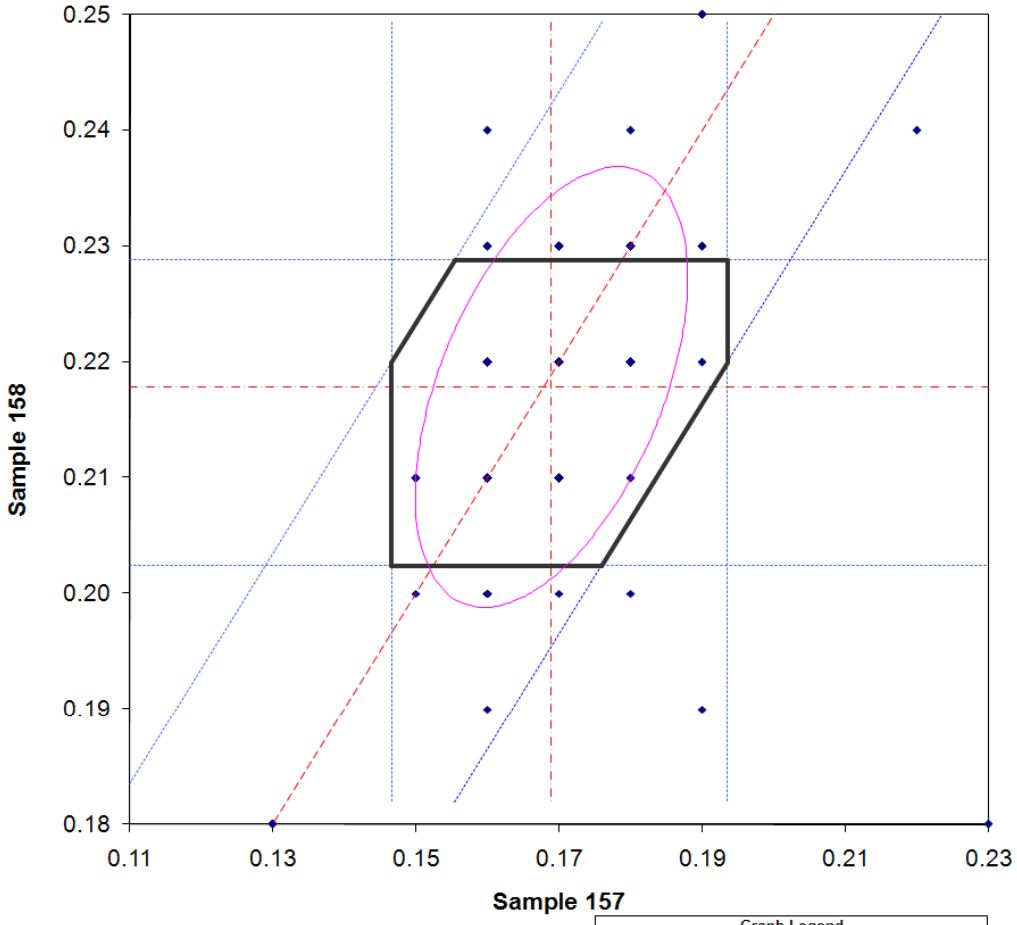
Reproducability (Sample 154)		
1s	d2s	CV%
0.006	0.018	4.06

Graph and Analysis Results for AASHTO T 105

Chemical Analysis of Hydraulic Cement

CCRL Samples 157 and 158

% Titanium Dioxide (TiO2), Type V w/ Limestone (157) & Type I / II w/ Limestone (158)



Graph Legend
Lines With Small Dash Marks - Sample Outlier Boundaries
Lines With Alternating Dash Marks - Sample Medians
Line With Large Dash Marks - Center Diagonal
Black Hexagon - Data Within is Used for Analysis
Ellipse - 2 Std Dev for Within and Between Lab Variation

Source of Data: AASHTO Materials Reference Laboratory Proficiency Sample Program
CCRL Samples 157 and 158
Final Report Issued Oct. 2005

Participation:

164	Total Laboratories
20	Laboratories Determined to be Invalid
28	Laboratories Determined to be Outliers
116	Total Laboratorires Included in Analysis

Average Results	
Sample 157 Average	Sample 158 Average
0.17	0.22

Repeatability			
1s	d2s	CV% (157)	CV% (158)
0.005	0.013	2.67	2.07

Reproducability (Sample 157)		
1s	d2s	CV%
0.007	0.019	3.89

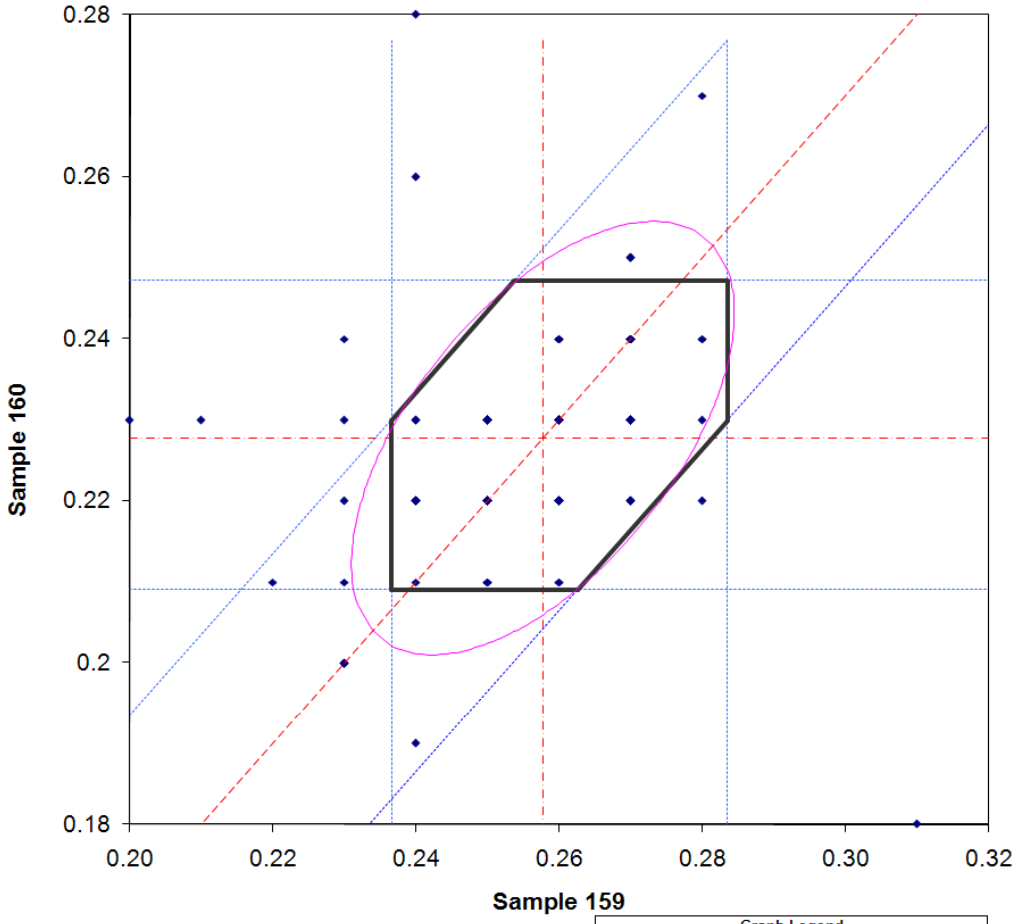
Reproducability (Sample 158)		
1s	d2s	CV%
0.004	0.012	1.90

Graph and Analysis Results for AASHTO T 105

Chemical Analysis of Hydraulic Cement

CCRL Samples 159 and 160

% Titanium Dioxide (TiO2), Type I Cement w/ Limestone & Type I / II w/ Limestone



Graph Legend
Lines With Small Dash Marks - Sample Outlier Boundaries
Lines With Alternating Dash Marks - Sample Medians
Line With Large Dash Marks - Center Diagonal
Black Hexagon - Data Within is Used for Analysis
Ellipse - 2 Std Dev for Within and Between Lab Variation

Source of Data: AASHTO Materials Reference Laboratory Proficiency Sample Program
CCRL Samples 159 and 160
Final Report Issued April 2006

Participation:

173	Total Laboratories
17	Laboratories Determined to be Invalid
13	Laboratories Determined to be Outliers
143	Total Laboratorires Included in Analysis

Average Results	
Sample 159 Average	Sample 160 Average
0.26	0.23

Repeatability			
1s	d2s	CV% (159)	CV% (160)
0.006	0.016	2.24	2.54

Reproducability (Sample 159)		
1s	d2s	CV%
0.009	0.025	3.41

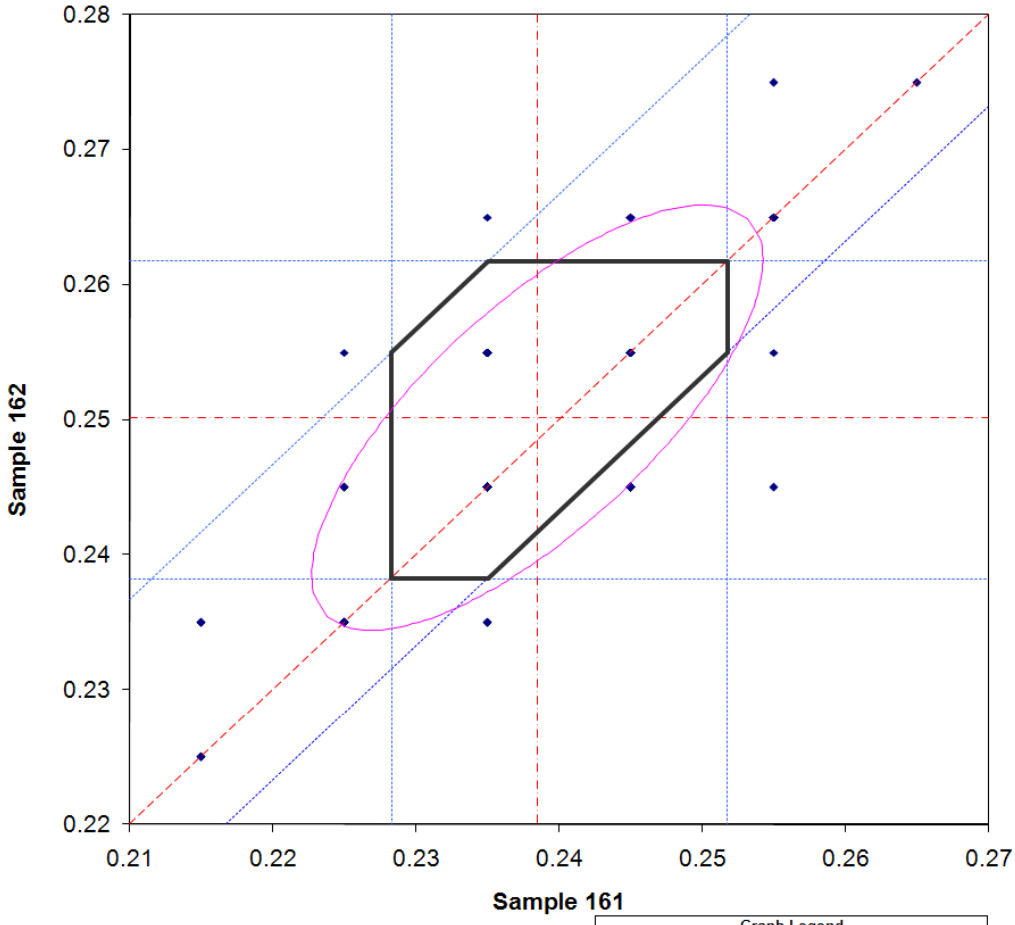
Reproducability (Sample 160)		
1s	d2s	CV%
0.007	0.020	3.06

Graph and Analysis Results for AASHTO T 105

Chemical Analysis of Hydraulic Cement

CCRL Samples 161 and 162

Test Property: % Titanium Dioxide (TiO2), Type I Cement (161) & Type I w/ Limestone (162)



Graph Legend
Lines With Small Dash Marks - Sample Outlier Boundaries
Lines With Alternating Dash Marks - Sample Medians
Line With Large Dash Marks - Center Diagonal
Black Hexagon - Data Within is Used for Analysis
Ellipse - 2 Std Dev for Within and Between Lab Variation

Source of Data: AASHTO Materials Reference Laboratory Proficiency Sample Program
CCRL Samples 161 and 162
Final Report Issued Oct 2006

Participation:

175	Total Laboratories
12	Laboratories Determined to be Invalid
47	Laboratories Determined to be Outliers
116	Total Laboratorires Included in Analysis

Average Results	
Sample 161 Average	Sample 162 Average
0.23	0.25

Repeatability			
1s	d2s	CV% (161)	CV% (162)
0.003	0.008	1.15	1.09

Reproducability (Sample 161)		
1s	d2s	CV%
0.005	0.014	2.04

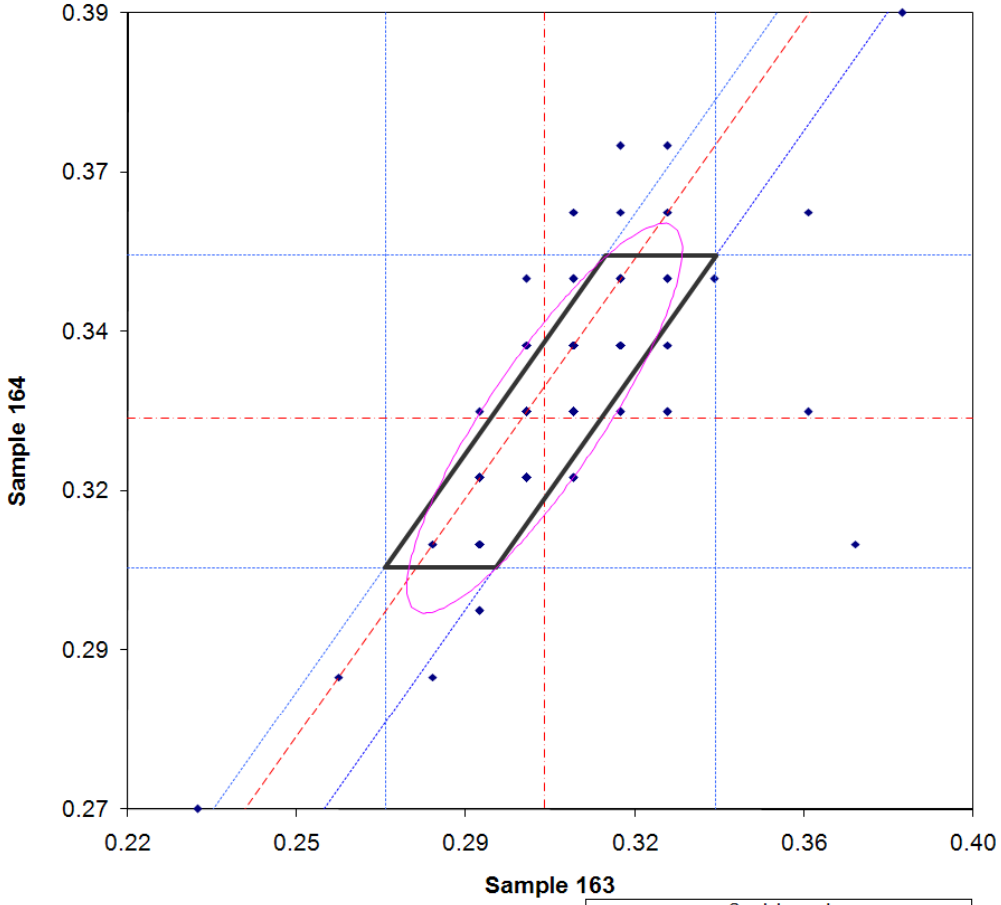
Reproducability (Sample 162)		
1s	d2s	CV%
0.005	0.014	2.05

Graph and Analysis Results for AASHTO T 105

Chemical Analysis of Hydraulic Cement

CCRL Samples 163 and 164

Test Property: % Titanium Dioxide (TiO2), Type I / II Cement



Graph Legend
Lines With Small Dash Marks - Sample Outlier Boundaries
Lines With Alternating Dash Marks - Sample Medians
Line With Large Dash Marks - Center Diagonal
Black Hexagon - Data Within is Used for Analysis
Ellipse - 2 Std Dev for Within and Between Lab Variation

Source of Data: AASHTO Materials Reference Laboratory Proficiency Sample Program
CCRL Samples 163 and 164
Final Report Issued April 2007

Participation:

167	Total Laboratories
16	Laboratories Determined to be Invalid
25	Laboratories Determined to be Outliers
126	Total Laboratorires Included in Analysis

Average Results	
Sample 163 Average	Sample 164 Average
0.30	0.33

Repeatability			
1s	d2s	CV% (163)	CV% (164)
0.004	0.010	1.17	1.08

Reproducability (Sample 163)		
1s	d2s	CV%
0.009	0.026	3.08

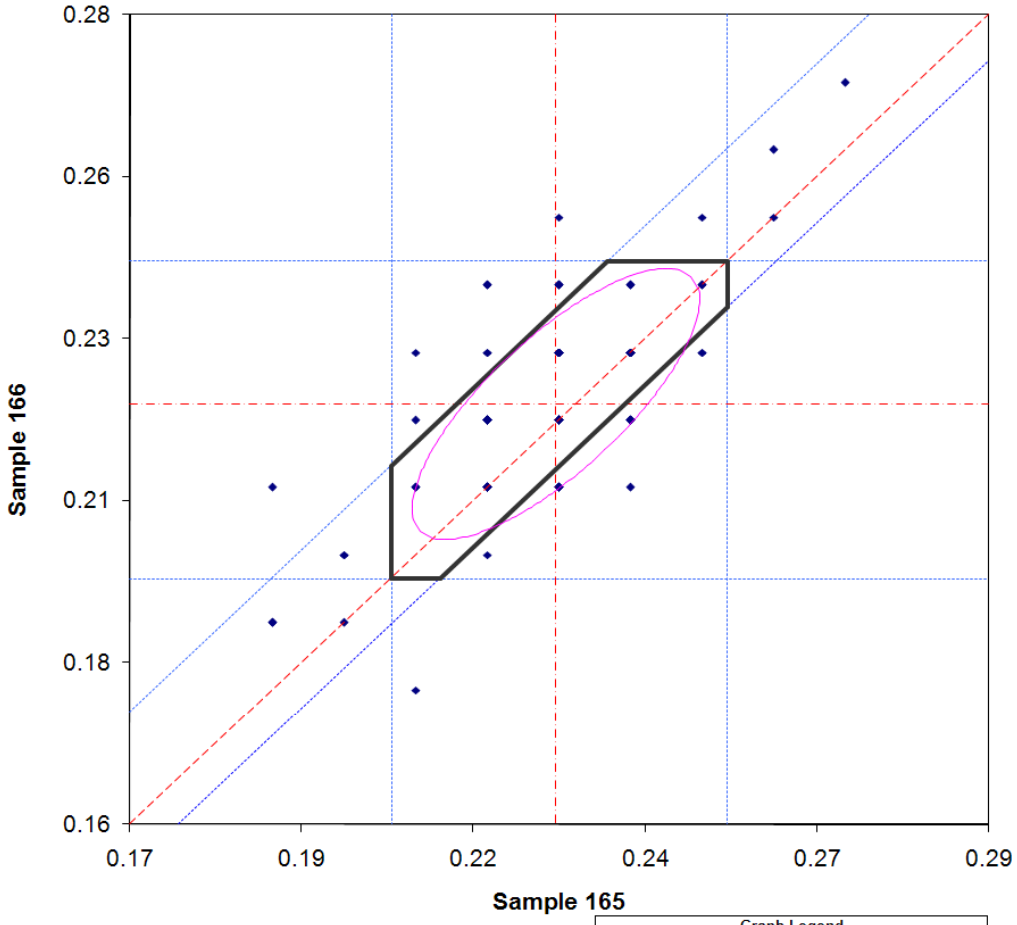
Reproducability (Sample 164)		
1s	d2s	CV%
0.010	0.027	2.90

Graph and Analysis Results for AASHTO T 105

Chemical Analysis of Hydraulic Cement

CCRL Samples 165 and 166

Test Property: % Titanium Dioxide (TiO2), Type I / II Cement w/ Limestone



Graph Legend
Lines With Small Dash Marks - Sample Outlier Boundaries
Lines With Alternating Dash Marks - Sample Medians
Line With Large Dash Marks - Center Diagonal
Black Hexagon - Data Within is Used for Analysis
Ellipse - 2 Std Dev for Within and Between Lab Variation

Source of Data: AASHTO Materials Reference Laboratory Proficiency Sample Program
CCRL Samples 165 and 166
Final Report Issued September 2007

Participation:

182	Total Laboratories
11	Laboratories Determined to be Invalid
28	Laboratories Determined to be Outliers
143	Total Laboratorires Included in Analysis

Average Results	
Sample 165 Average	Sample 166 Average
0.23	0.22

Repeatability			
1s	d2s	CV% (165)	CV% (166)
0.003	0.009	1.4	1.4

Reproducability (Sample 165)		
1s	d2s	CV%
0.006	0.018	2.7

Reproducability (Sample 166)		
1s	d2s	CV%
0.006	0.018	2.9

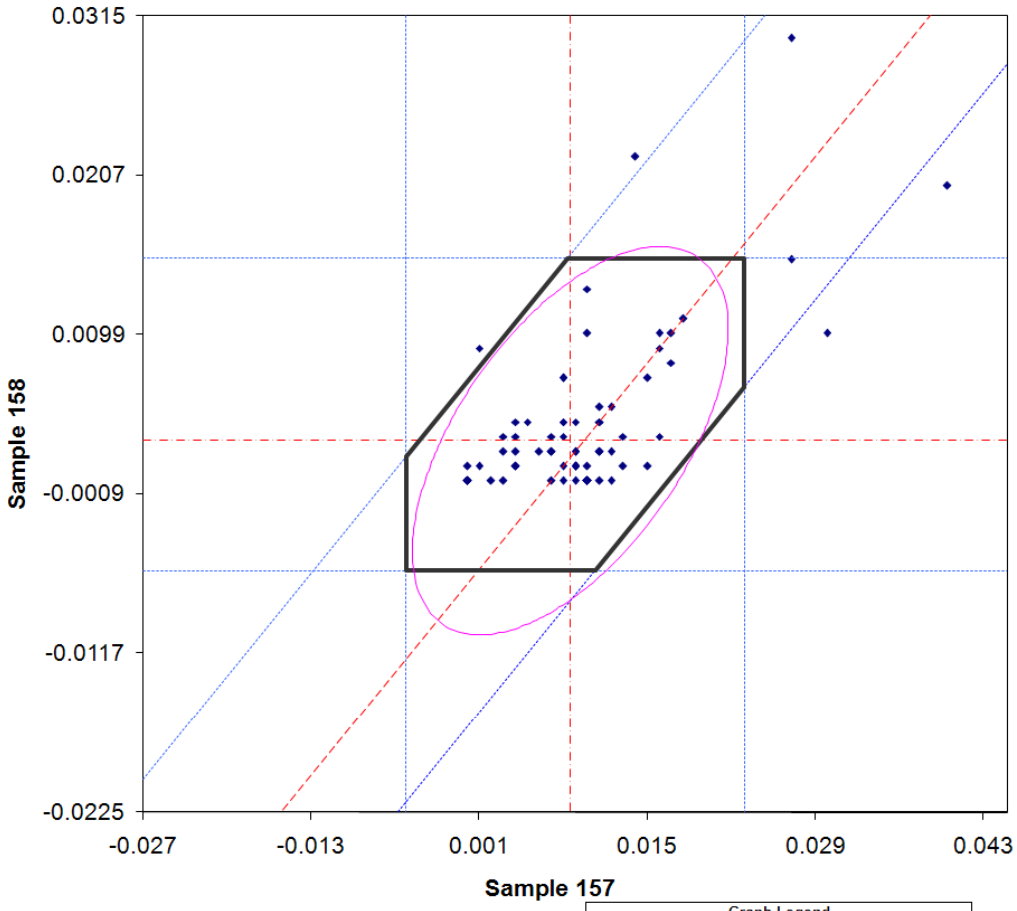
APPENDIX K: CHLORIDE (CL)

Graph and Analysis Results for AASHTO T 105

Chemical Analysis of Hydraulic Cement

CCRL Samples 157 and 158

Test Property: Chloride (Cl) %, Type V Cement w/ Limestone



Graph Legend
Lines With Small Dash Marks - Sample Outlier Boundaries
Lines With Alternating Dash Marks - Sample Medians
Line With Large Dash Marks - Center Diagonal
Black Hexagon - Data Within is Used for Analysis
Ellipse - 2 Std Dev for Within and Between Lab Variation

Source of Data: AASHTO Materials Reference Laboratory Proficiency Sample Program
CCRL Samples 157 and 158
Final Report Issued Oct. 2005

Participation:

76	Total Laboratories
6	Laboratories Determined to be Invalid
4	Laboratories Determined to be Outliers
66	Total Laboratorires Included in Analysis

Average Results	
Sample 157 Average	Sample 158 Average
0.009	0.003

Repeatability			
1s	d2s	CV% (157)	CV% (158)
0.0029	0.0081	33.4	105.2

Reproducability (Sample 157)		
1s	d2s	CV%
0.0045	0.0127	52.3

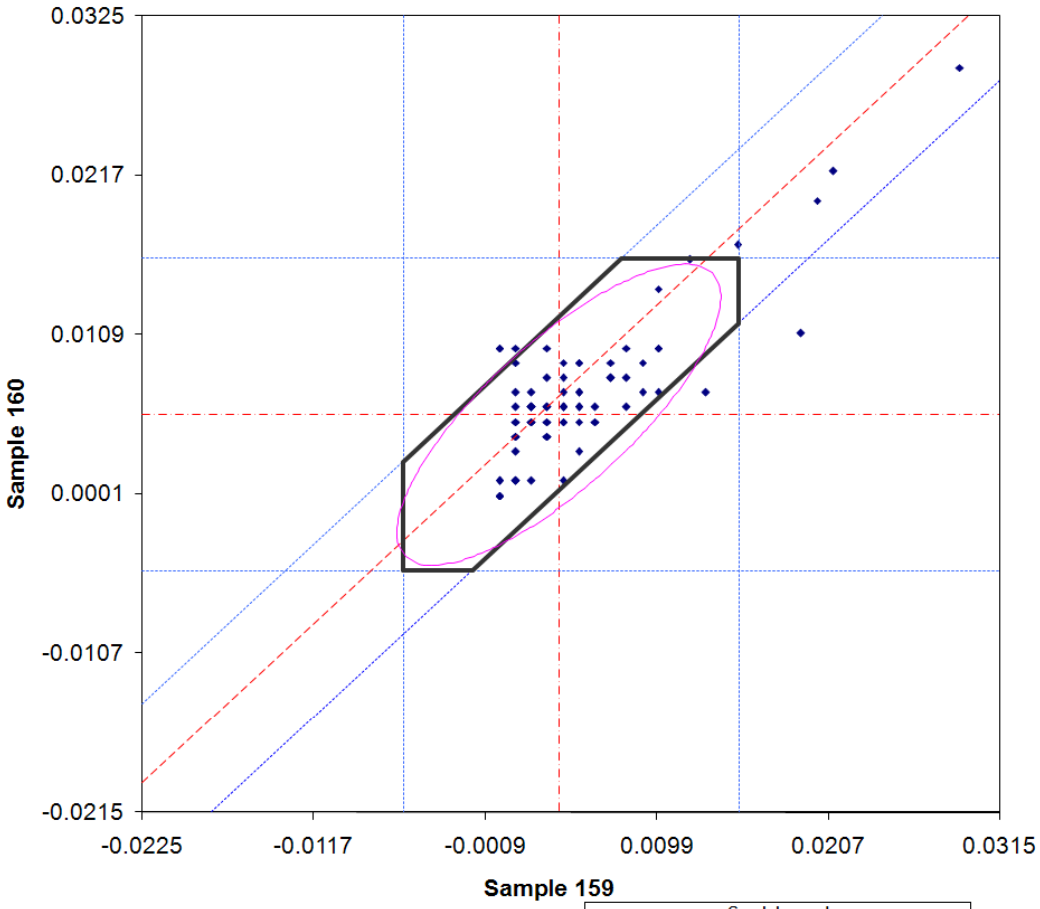
Reproducability (Sample 158)		
1s	d2s	CV%
0.0032	0.0090	116.8

Graph and Analysis Results for AASHTO T 105

Chemical Analysis of Hydraulic Cement

CCRL Samples 159 and 160

Test Property: Chloride (Cl) %, Type I Cement w/ Limestone



Graph Legend
Lines With Small Dash Marks - Sample Outlier Boundaries
Lines With Alternating Dash Marks - Sample Medians
Line With Large Dash Marks - Center Diagonal
Black Hexagon - Data Within is Used for Analysis
Ellipse - 2 Std Dev for Within and Between Lab Variation

Source of Data: AASHTO Materials Reference Laboratory Proficiency Sample Program
CCRL Samples 159 and 160
Final Report Issued April 2006

Participation:

87	Total Laboratories
2	Laboratories Determined to be Invalid
9	Laboratories Determined to be Outliers
76	Total Laboratorires Included in Analysis

Average Results	
Sample 159 Average	Sample 160 Average
0.004	0.005

Repeatability			
1s	d2s	CV% (159)	CV% (160)
0.0016	0.0045	42.3	28.8

Reproducability (Sample 159)		
1s	d2s	CV%
0.0031	0.0087	82.0

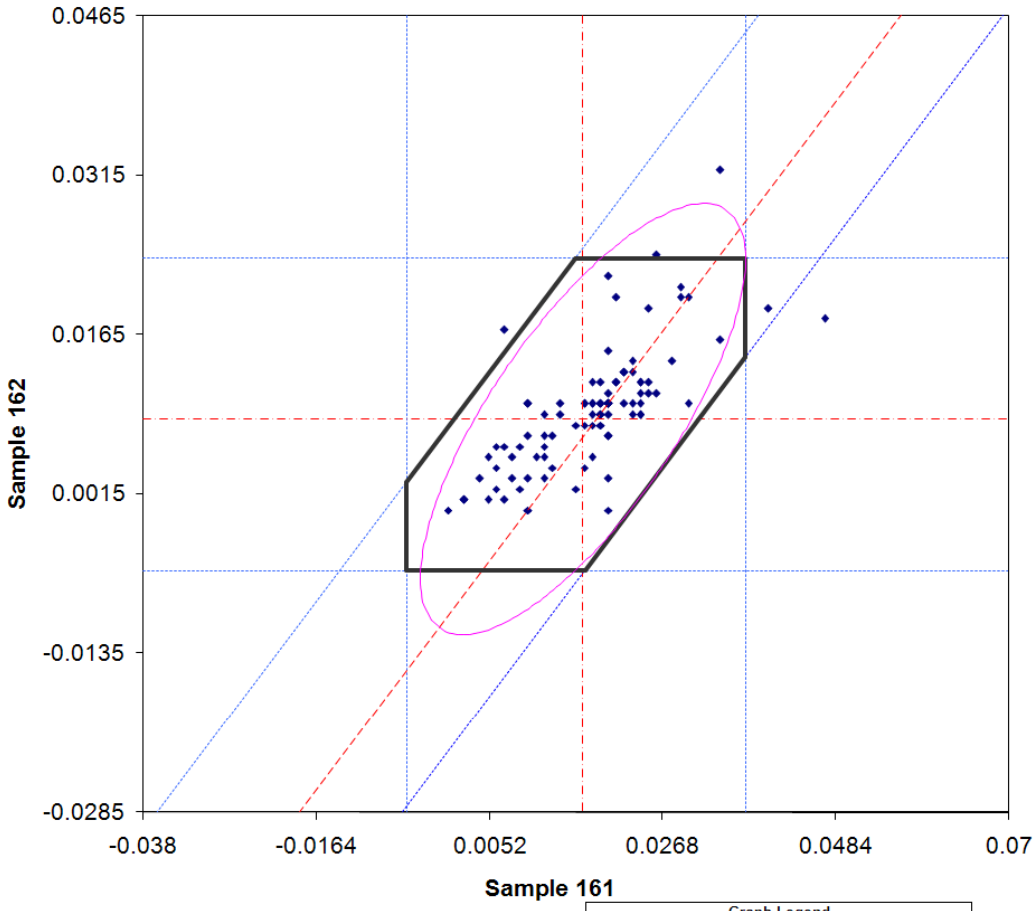
Reproducability (Sample 160)		
1s	d2s	CV%
0.0034	0.0095	61.1

Graph and Analysis Results for AASHTO T 105

Chemical Analysis of Hydraulic Cement

CCRL Samples 161 and 162

Test Property: Chloride (Cl) %, Type I Cement



Graph Legend
Lines With Small Dash Marks - Sample Outlier Boundaries
Lines With Alternating Dash Marks - Sample Medians
Line With Large Dash Marks - Center Diagonal
Black Hexagon - Data Within is Used for Analysis
Ellipse - 2 Std Dev for Within and Between Lab Variation

Source of Data: AASHTO Materials Reference Laboratory Proficiency Sample Program
CCRL Samples 161 and 162
Final Report Issued October 2006

Participation:

100	Total Laboratories
5	Laboratories Determined to be Invalid
5	Laboratories Determined to be Outliers
90	Total Laboratorires Included in Analysis

Average Results	
Sample 161 Average	Sample 162 Average
0.017	0.009

Repeatability			
1s	d2s	CV% (161)	CV% (162)
0.0034	0.0097	20.3	39.9

Reproducability (Sample 161)		
1s	d2s	CV%
0.0074	0.0209	43.9

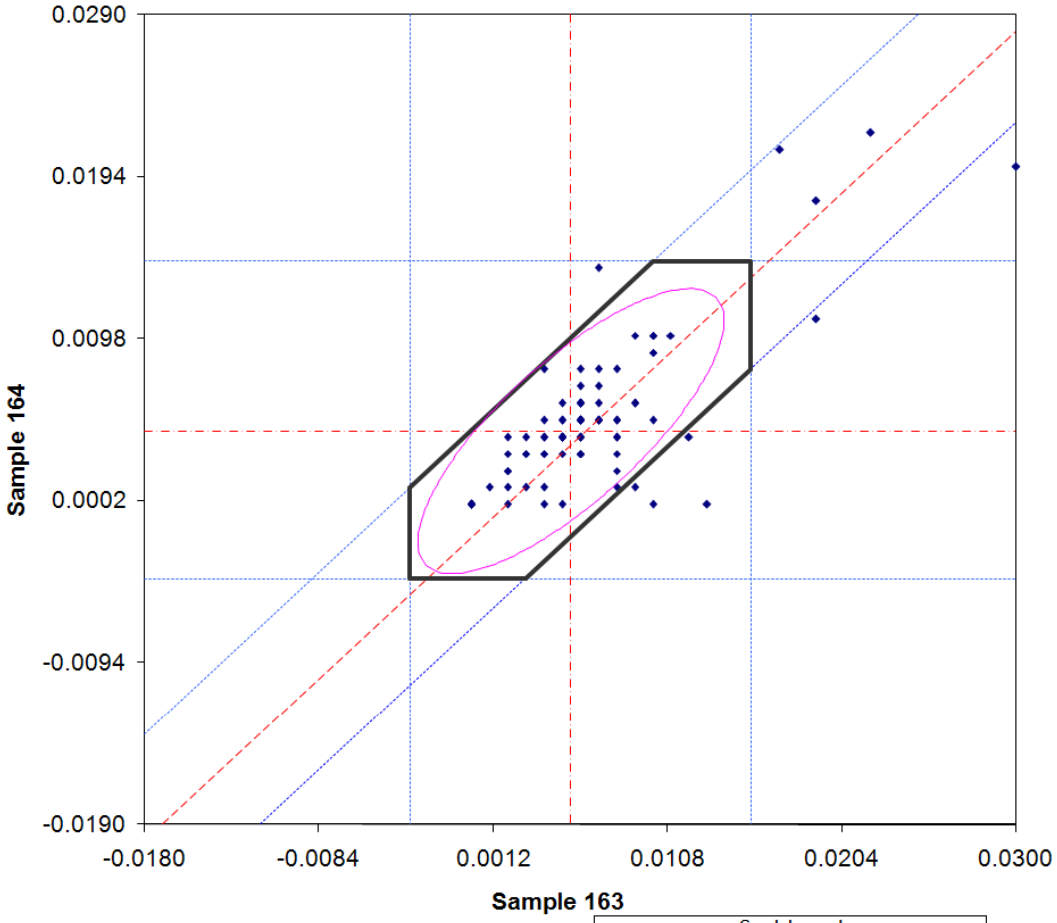
Reproducability (Sample 162)		
1s	d2s	CV%
0.0050	0.0142	58.7

Graph and Analysis Results for AASHTO T 105

Chemical Analysis of Hydraulic Cement

CCRL Samples 163 and 164

Test Property: Chloride (Cl) %, Type I / II Cement



Graph Legend
Lines With Small Dash Marks - Sample Outlier Boundaries
Lines With Alternating Dash Marks - Sample Medians
Line With Large Dash Marks - Center Diagonal
Black Hexagon - Data Within is Used for Analysis
Ellipse - 2 Std Dev for Within and Between Lab Variation

Source of Data: AASHTO Materials Reference Laboratory Proficiency Sample Program
CCRL Samples 163 and 164
Final Report Issued April 2007

Participation:

95	Total Laboratories
6	Laboratories Determined to be Invalid
9	Laboratories Determined to be Outliers
80	Total Laboratorires Included in Analysis

Average Results	
Sample 163 Average	Sample 164 Average
0.005	0.004

Repeatability			
1s	d2s	CV% (163)	CV% (164)
0.0013	0.0038	24.2	30.6

Reproducability (Sample 163)		
1s	d2s	CV%
0.0027	0.0075	48.5

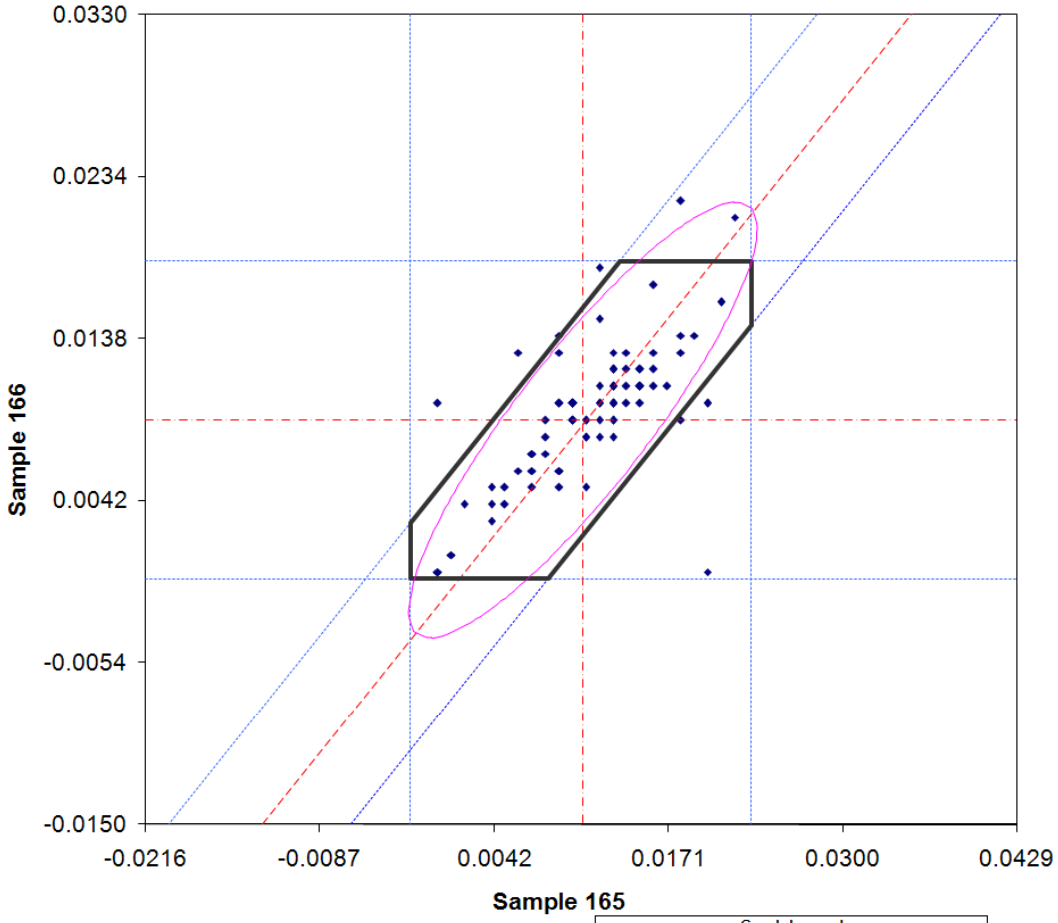
Reproducability (Sample 164)		
1s	d2s	CV%
0.0026	0.0075	60.9

Graph and Analysis Results for AASHTO T 105

Chemical Analysis of Hydraulic Cement

CCRL Samples 165 and 166

Test Property: Chloride (Cl) %, Type I / II Cement w/ Limestone



Graph Legend
Lines With Small Dash Marks - Sample Outlier Boundaries
Lines With Alternating Dash Marks - Sample Medians
Line With Large Dash Marks - Center Diagonal
Black Hexagon - Data Within is Used for Analysis
Ellipse - 2 Std Dev for Within and Between Lab Variation

Source of Data: AASHTO Materials Reference Laboratory Proficiency Sample Program
CCRL Samples 165 and 166
Final Report Issued Sept. 2007

Participation:

94	Total Laboratories
3	Laboratories Determined to be Invalid
9	Laboratories Determined to be Outliers
82	Total Laboratorires Included in Analysis

Average Results	
Sample 165 Average	Sample 166 Average
0.011	0.009

Repeatability			
1s	d2s	CV% (165)	CV% (166)
0.0015	0.0042	13.8	16.5

Reproducability (Sample 165)		
1s	d2s	CV%
0.0046	0.0131	42.9

Reproducability (Sample 166)		
1s	d2s	CV%
0.0037	0.0103	40.6

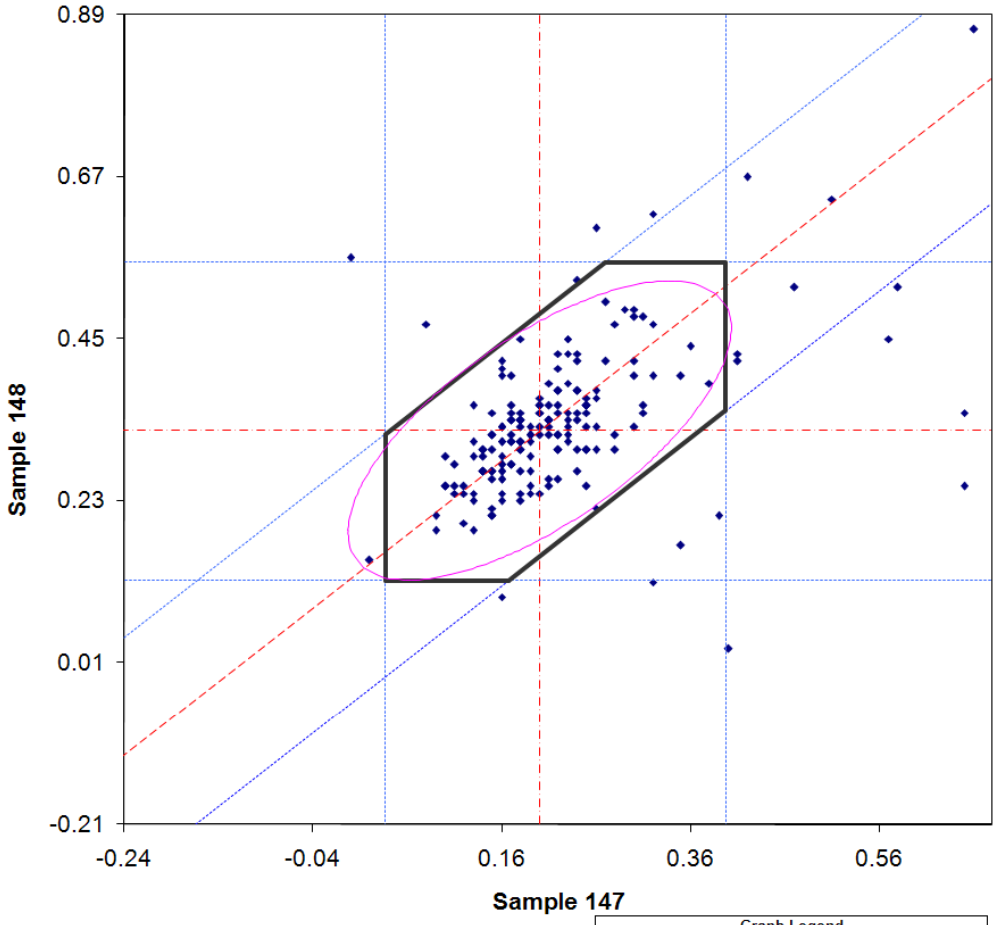
APPENDIX L: INSOLUABLE RESIDUE

Graph and Analysis Results for AASHTO T 105

Chemical Analysis of Hydraulic Cement

CCRL Samples 147 and 148

Test Property: Insoluable Residue (%), Type I / II Cement



Graph Legend
Lines With Small Dash Marks - Sample Outlier Boundaries
Lines With Alternating Dash Marks - Sample Medians
Line With Large Dash Marks - Center Diagonal
Black Hexagon - Data Within is Used for Analysis
Ellipse - 2 Std Dev for Within and Between Lab Variation

Source of Data: AASHTO Materials Reference Laboratory Proficiency Sample Program
CCRL Samples 147 and 148
Final Report Issued March 2003

Participation:

183	Total Laboratories
9	Laboratories Determined to be Invalid
14	Laboratories Determined to be Outliers
160	Total Laboratorires Included in Analysis

Average Results	
Sample 147 Average	Sample 148 Average
0.20	0.33

Repeatability			
1s	d2s	CV% (147)	CV% (148)
0.04	0.11	19.05	11.71

Reproducability (Sample 147)		
1s	d2s	CV%
0.06	0.16	28.43

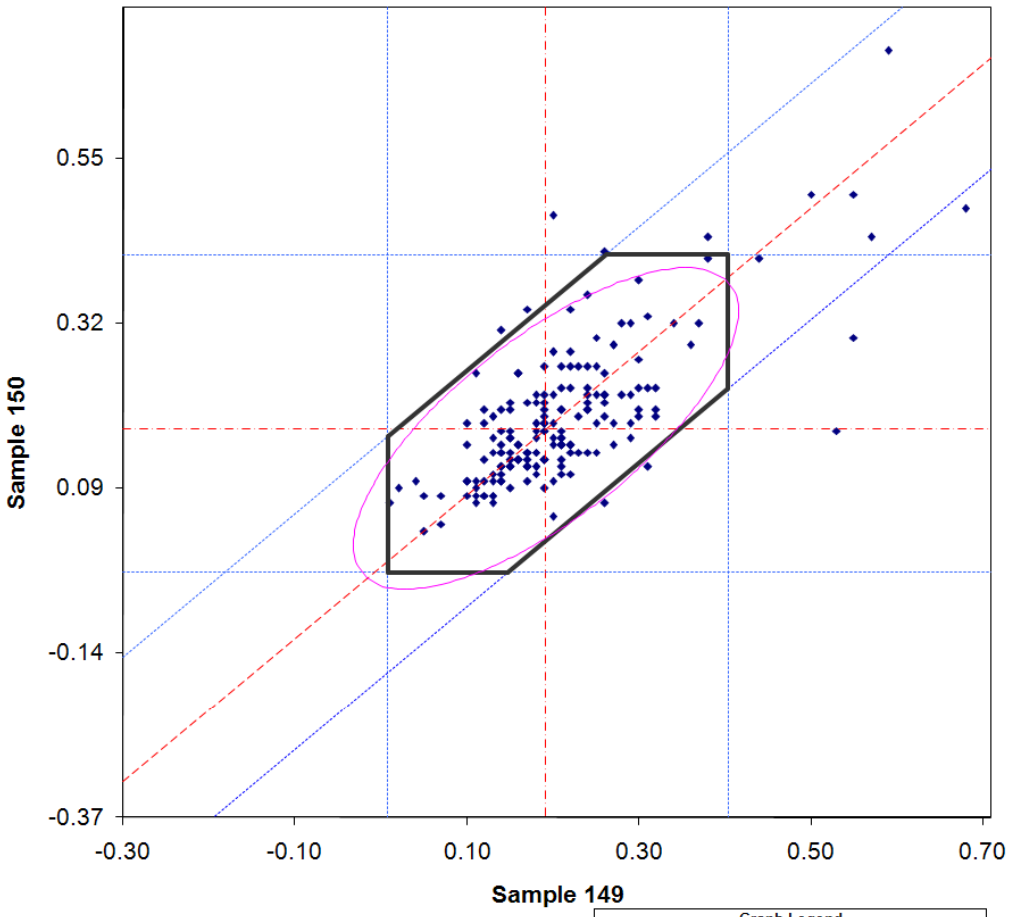
Reproducability (Sample 148)		
1s	d2s	CV%
0.07	0.19	20.52

Graph and Analysis Results for AASHTO T 105

Chemical Analysis of Hydraulic Cement

CCRL Samples 149 and 150

Test Property: Insoluable Residue (%), Type I Cement



Graph Legend
Lines With Small Dash Marks - Sample Outlier Boundaries
Lines With Alternating Dash Marks - Sample Medians
Line With Large Dash Marks - Center Diagonal
Black Hexagon - Data Within is Used for Analysis
Ellipse - 2 Std Dev for Within and Between Lab Variation

Source of Data: AASHTO Materials Reference Laboratory Proficiency Sample Program
CCRL Samples 149 and 150
Final Report Issued Sept. 2003

Participation:

183	Total Laboratories
5	Laboratories Determined to be Invalid
12	Laboratories Determined to be Outliers
166	Total Laboratorires Included in Analysis

Average Results	
Sample 149 Average	Sample 150 Average
0.19	0.17

Repeatability			
1s	d2s	CV% (149)	CV% (150)
0.04	0.11	20.27	22.37

Reproducability (Sample 149)		
1s	d2s	CV%
0.07	0.19	35.51

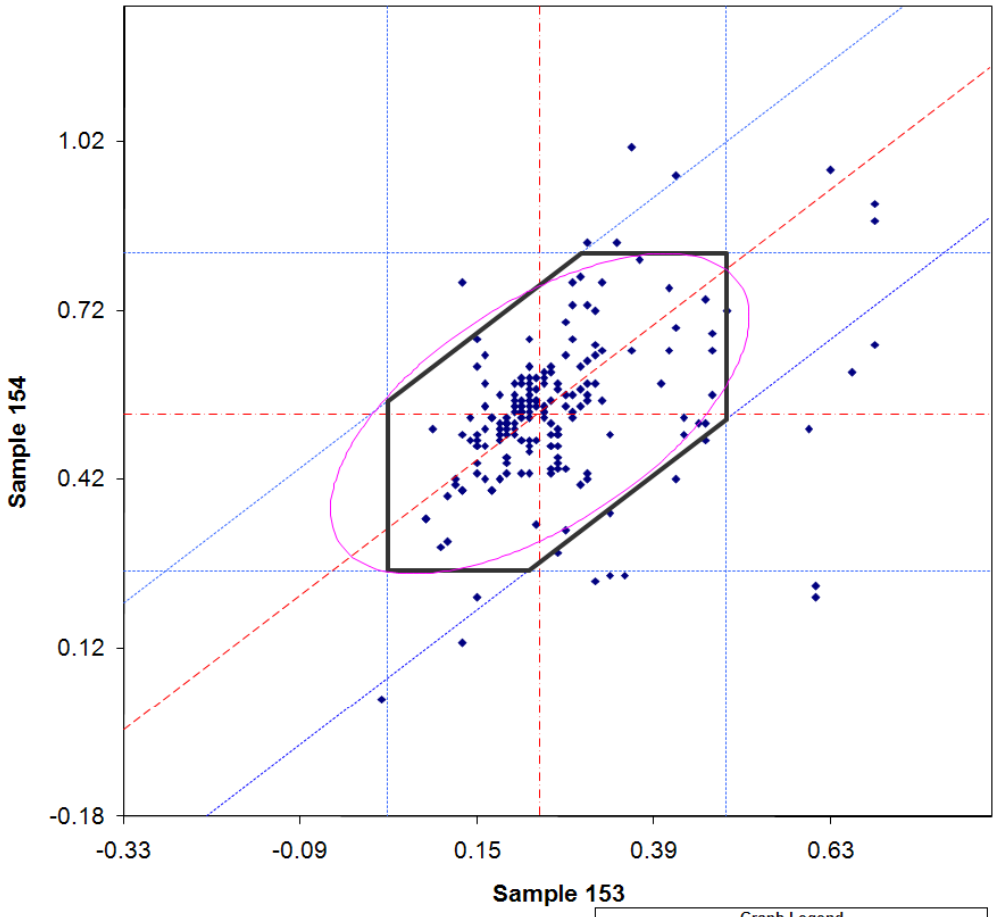
Reproducability (Sample 150)		
1s	d2s	CV%
0.07	0.20	40.86

Graph and Analysis Results for AASHTO T 105

Chemical Analysis of Hydraulic Cement

CCRL Samples 153 and 154

Test Property: Insoluable Residue (%), Type I / II Cement



Graph Legend
Lines With Small Dash Marks - Sample Outlier Boundaries
Lines With Alternating Dash Marks - Sample Medians
Line With Large Dash Marks - Center Diagonal
Black Hexagon - Data Within is Used for Analysis
Ellipse - 2 Std Dev for Within and Between Lab Variation

Source of Data: AASHTO Materials Reference Laboratory Proficiency Sample Program
CCRL Samples 153 and 154
Final Report Issued Oct. 2004

Participation:

202	Total Laboratories
6	Laboratories Determined to be Invalid
21	Laboratories Determined to be Outliers
175	Total Laboratorires Included in Analysis

Average Results	
Sample 153 Average	Sample 154 Average
0.23	0.54

Repeatability			
1s	d2s	CV% (153)	CV% (154)
0.06	0.17	25.44	11.12

Reproducability (Sample 153)		
1s	d2s	CV%
0.08	0.22	33.28

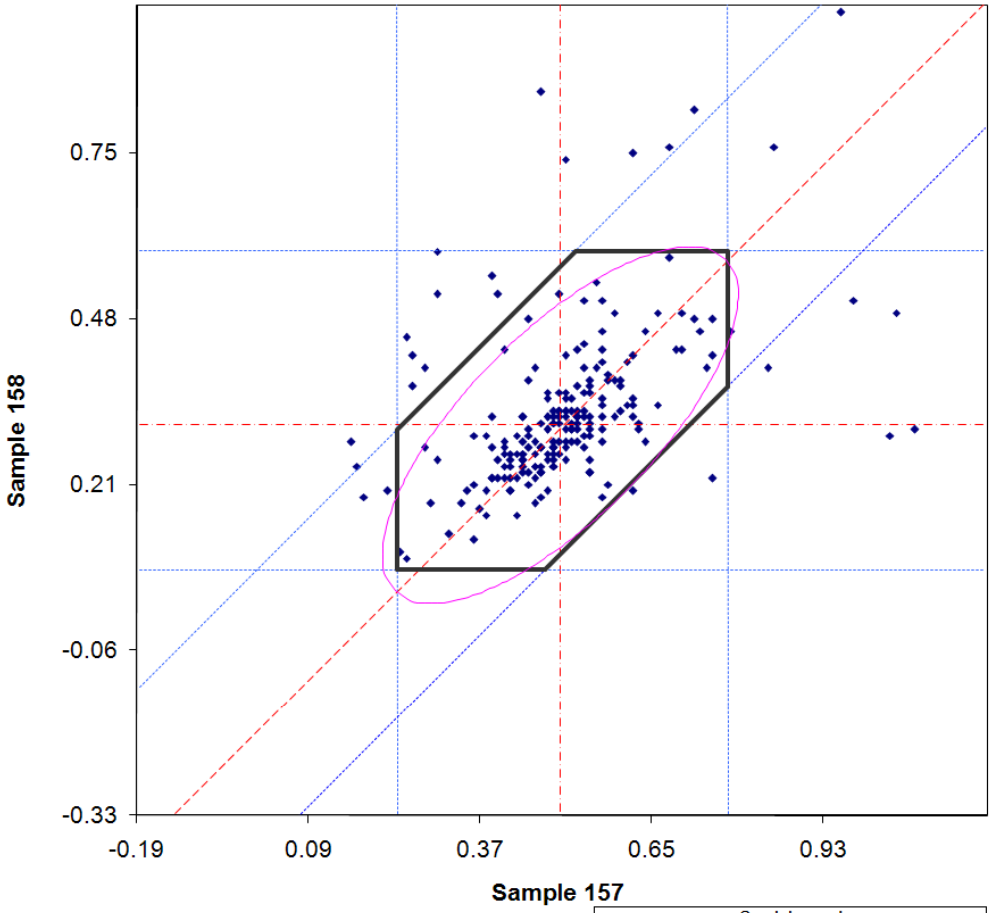
Reproducability (Sample 154)		
1s	d2s	CV%
0.09	0.26	16.98

Graph and Analysis Results for AASHTO T 105

Chemical Analysis of Hydraulic Cement

CCRL Samples 157 and 158

Insoluable Residue (%), Type V Cement w/ Limestone (157) & Type I / II w/ Limestone (158)



Graph Legend
Lines With Small Dash Marks - Sample Outlier Boundaries
Lines With Alternating Dash Marks - Sample Medians
Line With Large Dash Marks - Center Diagonal
Black Hexagon - Data Within is Used for Analysis
Ellipse - 2 Std Dev for Within and Between Lab Variation

Source of Data: AASHTO Materials Reference Laboratory Proficiency Sample Program
CCRL Samples 157 and 158
Final Report Issued Oct. 2005

Participation:

208	Total Laboratories
8	Laboratories Determined to be Invalid
21	Laboratories Determined to be Outliers
179	Total Laboratorires Included in Analysis

Average Results	
Sample 157 Average	Sample 158 Average
0.50	0.31

Repeatability			
1s	d2s	CV% (157)	CV% (158)
0.05	0.14	10.0	16.4

Reproducability (Sample 157)		
1s	d2s	CV%
0.09	0.26	18.5

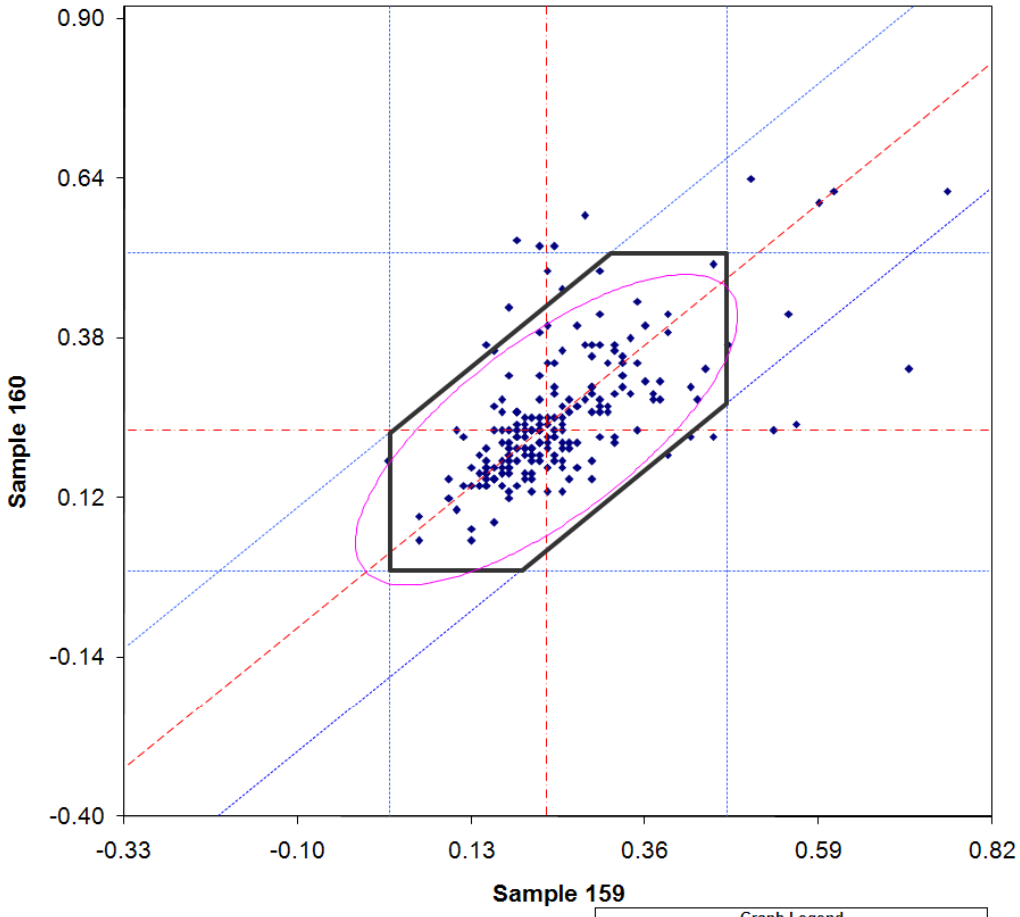
Reproducability (Sample 158)		
1s	d2s	CV%
0.09	0.25	28.5

Graph and Analysis Results for AASHTO T 105

Chemical Analysis of Hydraulic Cement

CCRL Samples 159 and 160

Insoluable Residue (%), Type I Cement w/ Limestone (159) & Type I / II w/ Limestone (160)



Graph Legend
Lines With Small Dash Marks - Sample Outlier Boundaries
Lines With Alternating Dash Marks - Sample Medians
Line With Large Dash Marks - Center Diagonal
Black Hexagon - Data Within is Used for Analysis
Ellipse - 2 Std Dev for Within and Between Lab Variation

Source of Data: AASHTO Materials Reference Laboratory Proficiency Sample Program
CCRL Samples 159 and 160
Final Report Issued April 2006

Participation:

212	Total Laboratories
4	Laboratories Determined to be Invalid
19	Laboratories Determined to be Outliers
189	Total Laboratorires Included in Analysis

Average Results	
Sample 159 Average	Sample 160 Average
0.23	0.23

Repeatability			
1s	d2s	CV% (159)	CV% (160)
0.04	0.12	19.02	18.9

Reproducability (Sample 159)		
1s	d2s	CV%
0.07	0.21	32.5

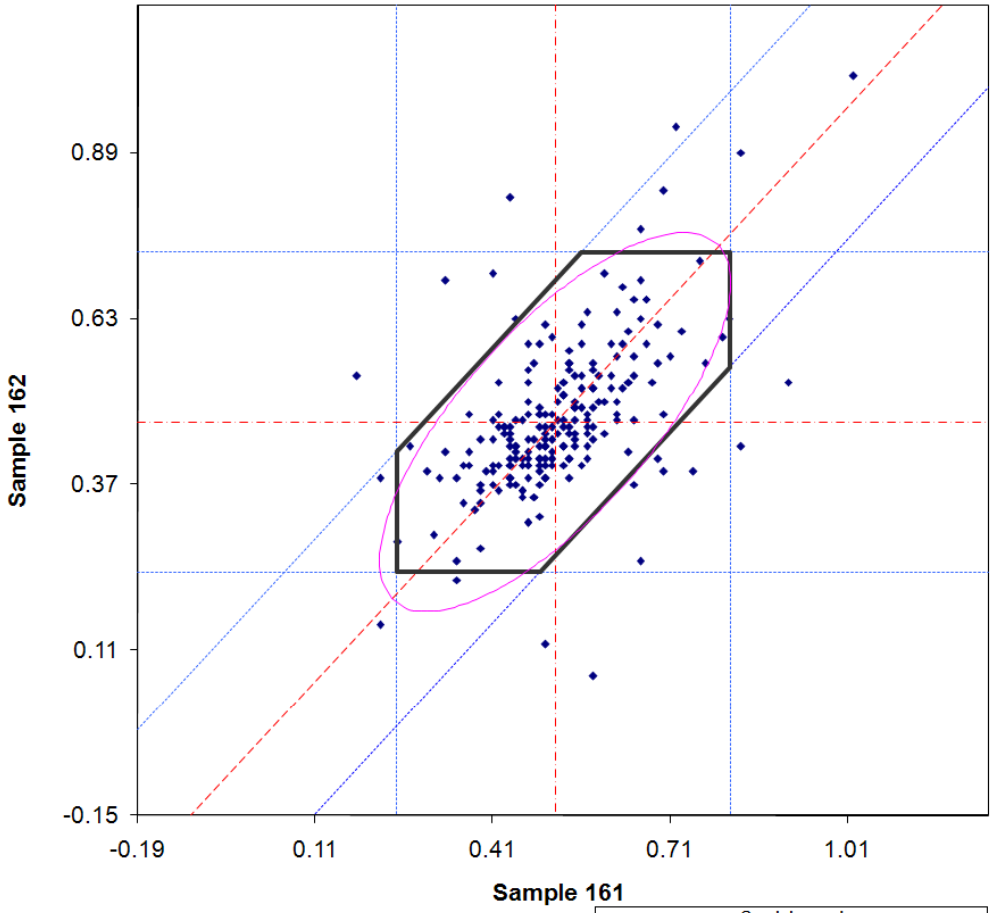
Reproducability (Sample 160)		
1s	d2s	CV%
0.08	0.23	35.7

Graph and Analysis Results for AASHTO T 105

Chemical Analysis of Hydraulic Cement

CCRL Samples 161 and 162

Insoluable Residue (%), Type I Cement (161) & Type I Cement w/ Limestone (162)



Graph Legend
Lines With Small Dash Marks - Sample Outlier Boundaries
Lines With Alternating Dash Marks - Sample Medians
Line With Large Dash Marks - Center Diagonal
Black Hexagon - Data Within is Used for Analysis
Ellipse - 2 Std Dev for Within and Between Lab Variation

Source of Data: AASHTO Materials Reference Laboratory Proficiency Sample Program
CCRL Samples 161 and 162
Final Report Issued Oct 2006

Participation:

220	Total Laboratories
6	Laboratories Determined to be Invalid
17	Laboratories Determined to be Outliers
197	Total Laboratorires Included in Analysis

Average Results	
Sample 161 Average	Sample 162 Average
0.52	0.47

Repeatability			
1s	d2s	CV% (161)	CV% (162)
0.05	0.14	9.86	10.88

Reproducability (Sample 161)		
1s	d2s	CV%
0.10	0.27	18.67

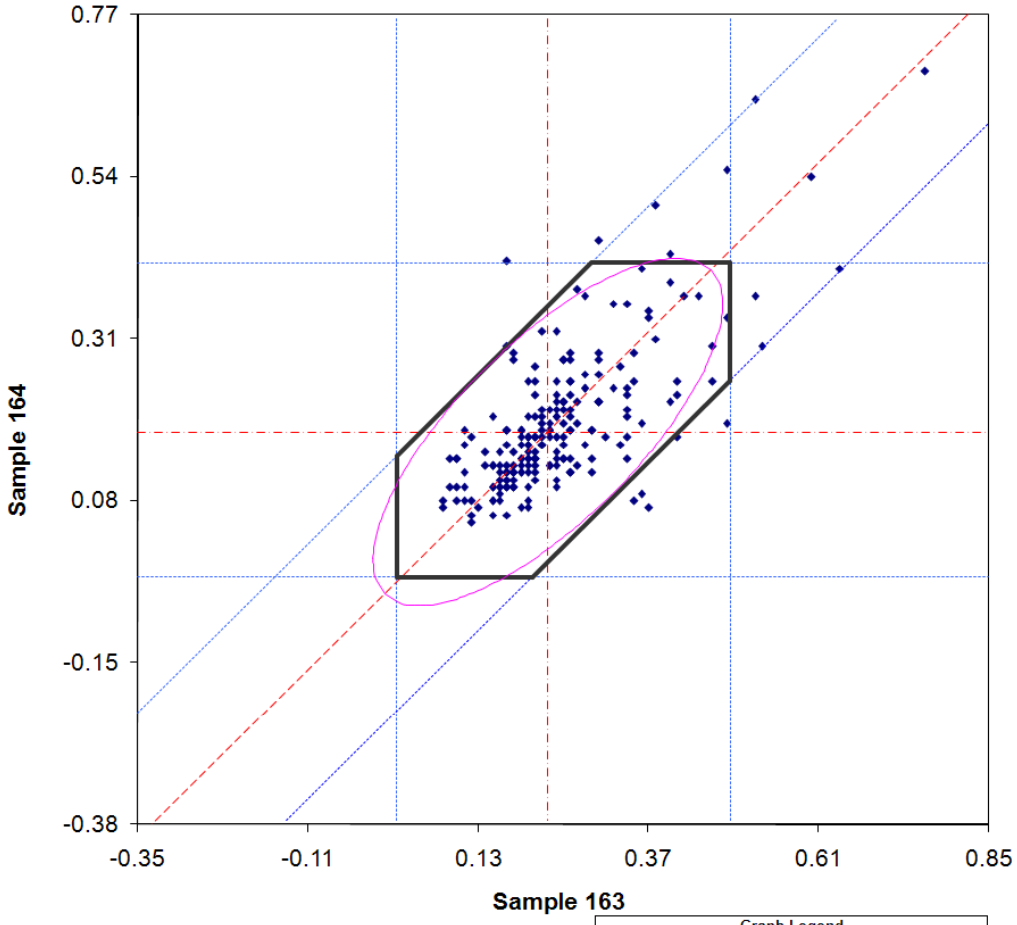
Reproducability (Sample 162)		
1s	d2s	CV%
0.09	0.25	18.81

Graph and Analysis Results for AASHTO T 105

Chemical Analysis of Hydraulic Cement

CCRL Samples 163 and 164

Insoluable Residue (%), Type I / II Cement



Graph Legend
Lines With Small Dash Marks - Sample Outlier Boundaries
Lines With Alternating Dash Marks - Sample Medians
Line With Large Dash Marks - Center Diagonal
Black Hexagon - Data Within is Used for Analysis
Ellipse - 2 Std Dev for Within and Between Lab Variation

Source of Data: AASHTO Materials Reference Laboratory Proficiency Sample Program
CCRL Samples 163 and 164
Final Report Issued April 2007

Participation:

221	Total Laboratories
8	Laboratories Determined to be Invalid
15	Laboratories Determined to be Outliers
198	Total Laboratorires Included in Analysis

Average Results	
Sample 163 Average	Sample 164 Average
0.23	0.18

Repeatability			
1s	d2s	CV% (163)	CV% (164)
0.04	0.12	18.44	23.64

Reproducability (Sample 163)		
1s	d2s	CV%
0.08	0.22	34.25

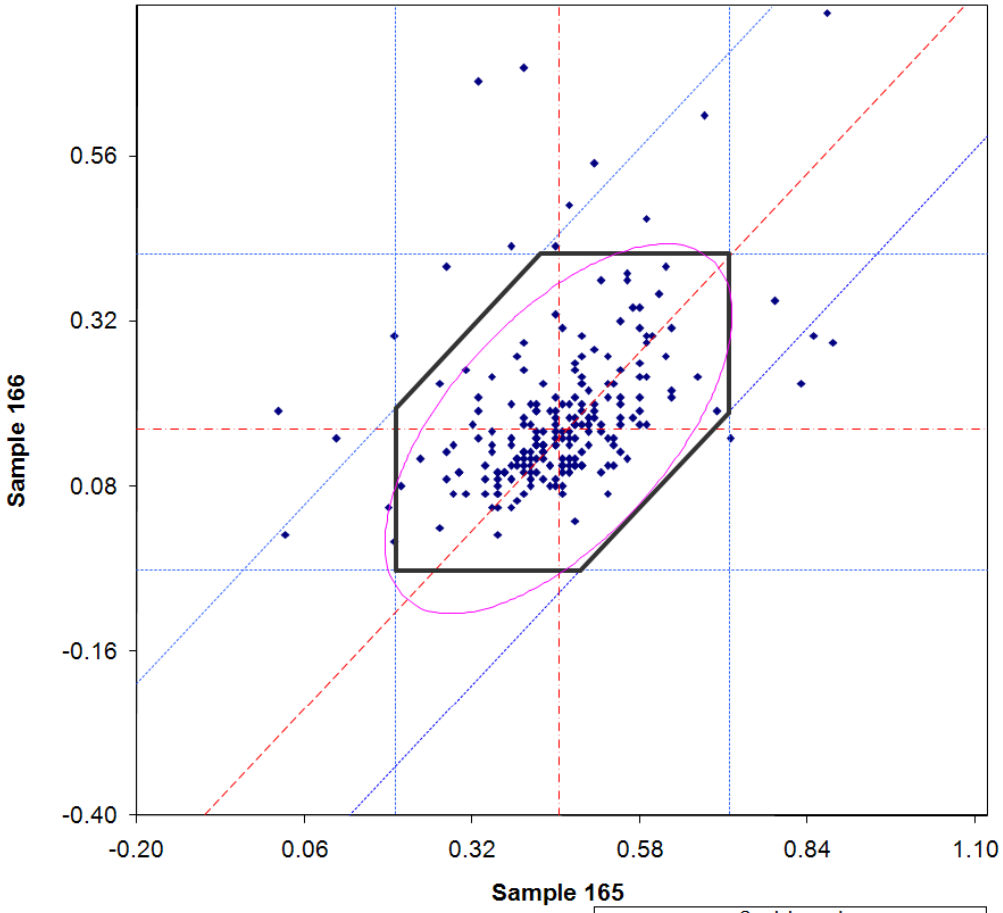
Reproducability (Sample 164)		
1s	d2s	CV%
0.08	0.21	42.22

Graph and Analysis Results for AASHTO T 105

Chemical Analysis of Hydraulic Cement

CCRL Samples 165 and 166

Insoluable Residue (%), Type I / II Cement w/ Limestone



Graph Legend
Lines With Small Dash Marks - Sample Outlier Boundaries
Lines With Alternating Dash Marks - Sample Medians
Line With Large Dash Marks - Center Diagonal
Black Hexagon - Data Within is Used for Analysis
Ellipse - 2 Std Dev for Within and Between Lab Variation

Source of Data: AASHTO Materials Reference Laboratory Proficiency Sample Program
CCRL Samples 165 and 166
Final Report Issued September 2007

Participation:

228	Total Laboratories
8	Laboratories Determined to be Invalid
18	Laboratories Determined to be Outliers
202	Total Laboratorires Included in Analysis

Average Results	
Sample 165 Average	Sample 166 Average
0.45	0.16

Repeatability			
1s	d2s	CV% (165)	CV% (166)
0.06	0.16	12.19	33.75

Reproducability (Sample 165)		
1s	d2s	CV%
0.09	0.24	19.00

Reproducability (Sample 166)		
1s	d2s	CV%
0.07	0.21	45.62

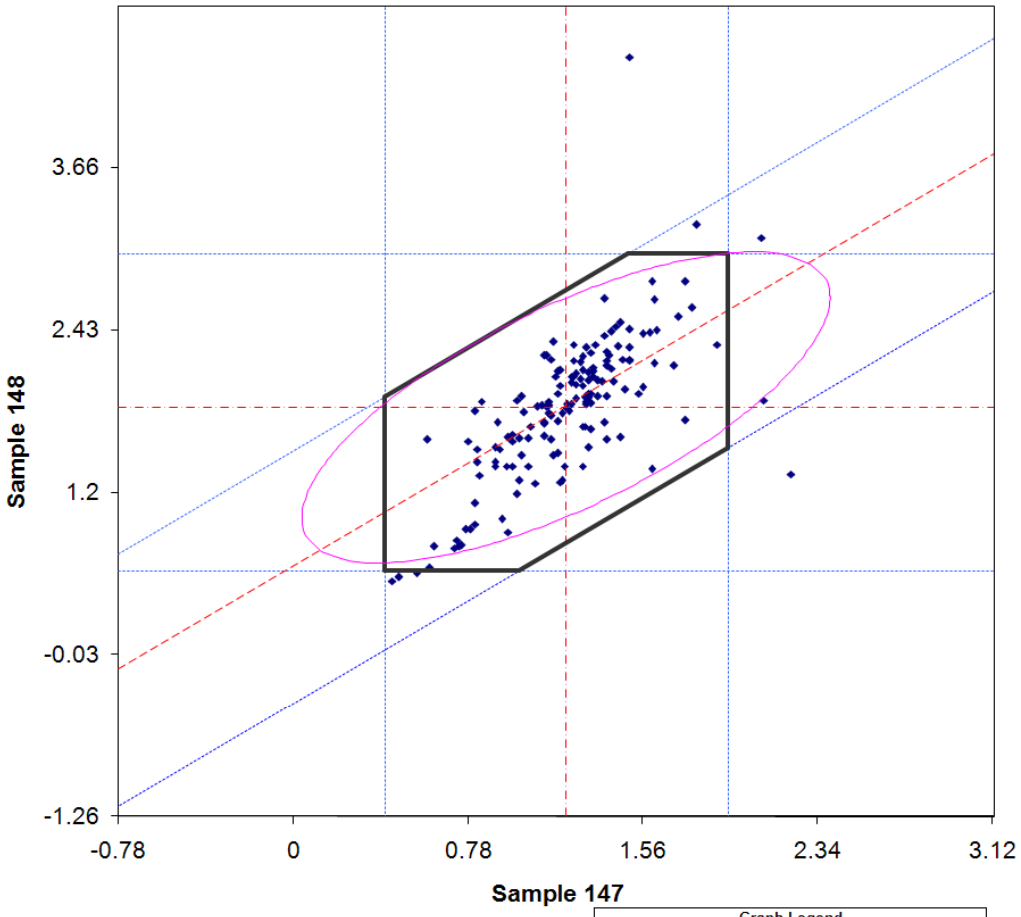
APPENDIX M: FREE CALCIUM OXIDE (CX)

Graph and Analysis Results for AASHTO T 105

Chemical Analysis of Hydraulic Cement

CCRL Samples 147 and 148

Test Property: % Free Calcium Oxide (Free CaO), Type I / II Cement



Graph Legend
Lines With Small Dash Marks - Sample Outlier Boundaries
Lines With Alternating Dash Marks - Sample Medians
Line With Large Dash Marks - Center Diagonal
Black Hexagon - Data Within is Used for Analysis
Ellipse - 2 Std Dev for Within and Between Lab Variation

Source of Data: AASHTO Materials Reference Laboratory Proficiency Sample Program
CCRL Samples 147 and 148
Final Report Issued March 2003

Participation:

155	Total Laboratories
1	Laboratories Determined to be Invalid
7	Laboratories Determined to be Outliers
147	Total Laboratorires Included in Analysis

Average Results	
Sample 147 Average	Sample 148 Average
1.22	1.84

Repeatability			
1s	d2s	CV% (147)	CV% (148)
0.21	0.60	17.41	11.48

Reproducability (Sample 147)		
1s	d2s	CV%
0.26	0.73	21.15

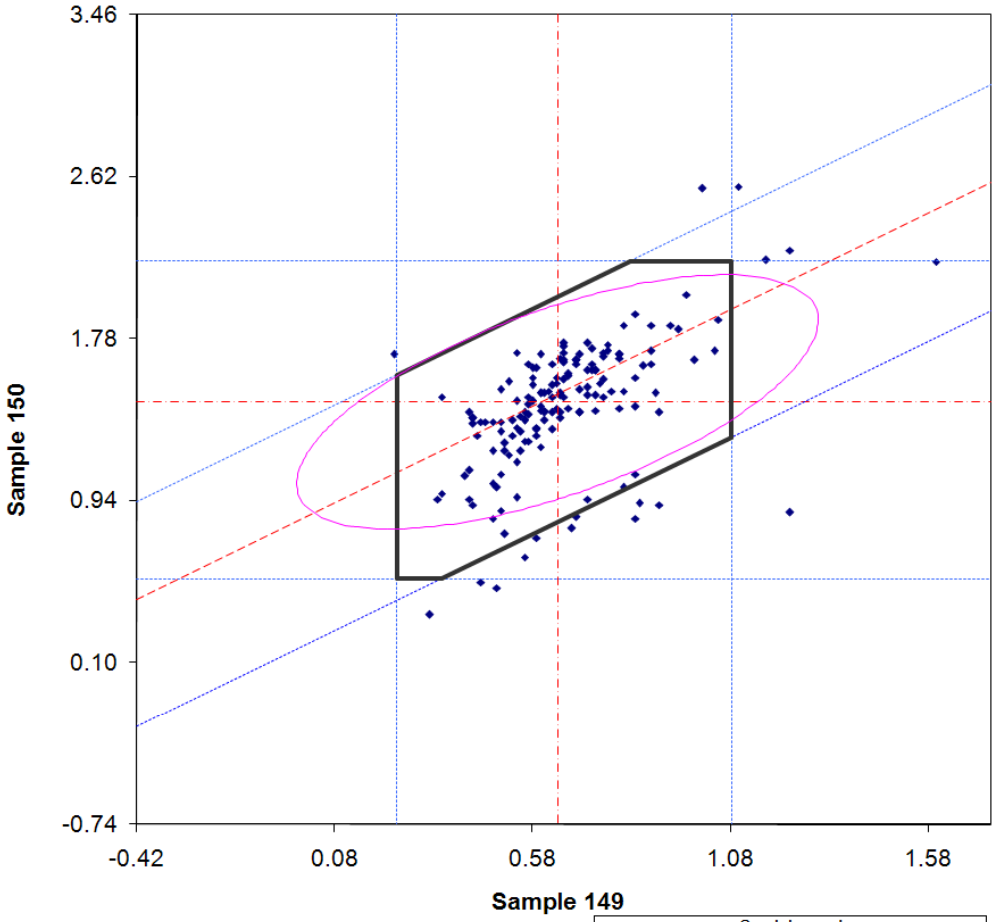
Reproducability (Sample 148)		
1s	d2s	CV%
0.44	1.26	24.10

Graph and Analysis Results for AASHTO T 105

Chemical Analysis of Hydraulic Cement

CCRL Samples 149 and 150

Test Property: % Free Calcium Oxide (Free CaO), Type I Cement



Graph Legend
Lines With Small Dash Marks - Sample Outlier Boundaries
Lines With Alternating Dash Marks - Sample Medians
Line With Large Dash Marks - Center Diagonal
Black Hexagon - Data Within is Used for Analysis
Ellipse - 2 Std Dev for Within and Between Lab Variation

Source of Data: AASHTO Materials Reference Laboratory Proficiency Sample Program
CCRL Samples 149 and 150
Final Report Issued Sept. 2003

Participation:

159	Total Laboratories
4	Laboratories Determined to be Invalid
15	Laboratories Determined to be Outliers
140	Total Laboratorires Included in Analysis

Average Results	
Sample 149 Average	Sample 150 Average
0.64	1.45

Repeatability			
1s	d2s	CV% (149)	CV% (150)
0.13	0.37	20.42	9.03

Reproducability (Sample 149)		
1s	d2s	CV%
0.14	0.41	22.54

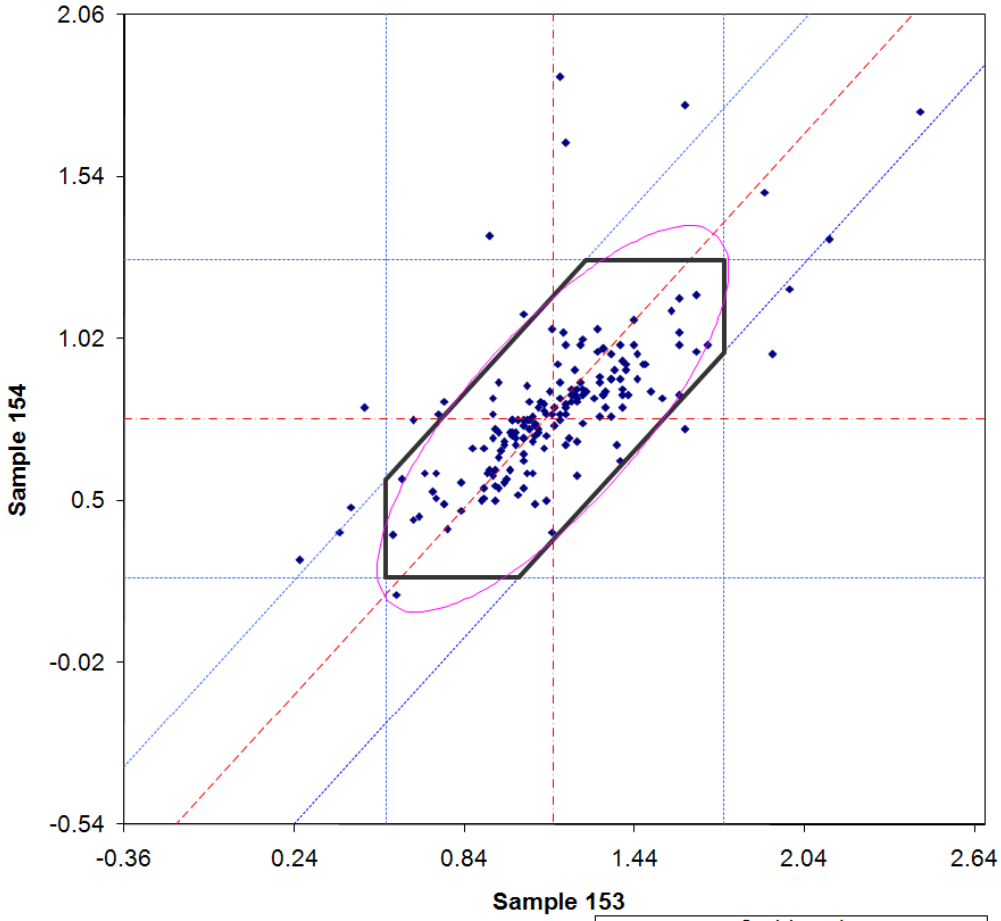
Reproducability (Sample 150)		
1s	d2s	CV%
0.24	0.68	16.61

Graph and Analysis Results for AASHTO T 105

Chemical Analysis of Hydraulic Cement

CCRL Samples 153 and 154

Test Property: % Free Calcium Oxide (Free CaO), Type I / II Cement



Graph Legend
Lines With Small Dash Marks - Sample Outlier Boundaries
Lines With Alternating Dash Marks - Sample Medians
Line With Large Dash Marks - Center Diagonal
Black Hexagon - Data Within is Used for Analysis
Ellipse - 2 Std Dev for Within and Between Lab Variation

Source of Data: AASHTO Materials Reference Laboratory Proficiency Sample Program
CCRL Samples 153 and 154
Final Report Issued Oct. 2004

Participation:

179	Total Laboratories
5	Laboratories Determined to be Invalid
14	Laboratories Determined to be Outliers
160	Total Laboratorires Included in Analysis

Average Results	
Sample 153 Average	Sample 154 Average
1.15	0.76

Repeatability			
1s	d2s	CV% (153)	CV% (154)
0.10	0.28	8.44	12.75

Reproducability (Sample 153)		
1s	d2s	CV%
0.22	0.63	19.21

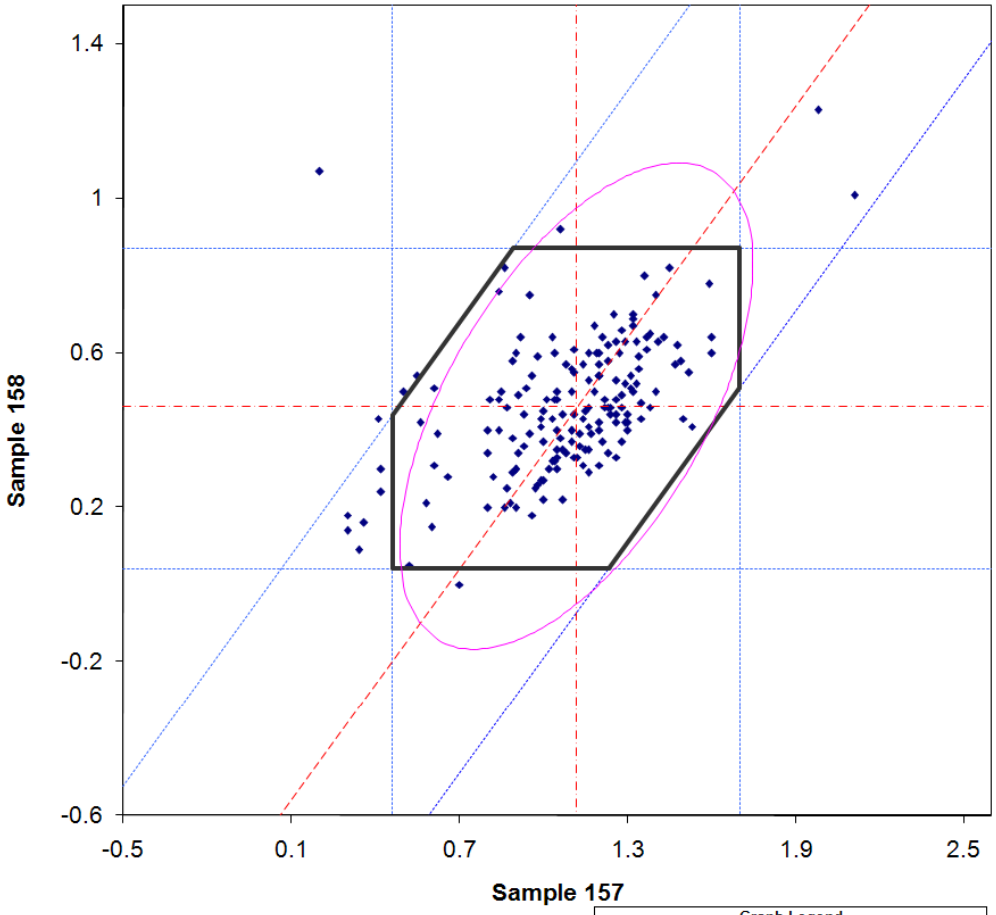
Reproducability (Sample 154)		
1s	d2s	CV%
0.16	0.46	21.47

Graph and Analysis Results for AASHTO T 105

Chemical Analysis of Hydraulic Cement

CCRL Samples 157 and 158

% Free Calcium Oxide (Free CaO), Type V w/ limestone (157) & Type I / II w/ limestone (158)



Graph Legend
Lines With Small Dash Marks - Sample Outlier Boundaries
Lines With Alternating Dash Marks - Sample Medians
Line With Large Dash Marks - Center Diagonal
Black Hexagon - Data Within is Used for Analysis
Ellipse - 2 Std Dev for Within and Between Lab Variation

Source of Data: AASHTO Materials Reference Laboratory Proficiency Sample Program
CCRL Samples 157 and 158
Final Report Issued Oct. 2005

Participation:

177	Total Laboratories
3	Laboratories Determined to be Invalid
12	Laboratories Determined to be Outliers
162	Total Laboratorires Included in Analysis

Average Results	
Sample 157 Average	Sample 158 Average
1.12	0.46

Repeatability			
1s	d2s	CV% (157)	CV% (158)
0.14	0.39	12.18	29.42

Reproducability (Sample 157)		
1s	d2s	CV%
0.22	0.62	19.66

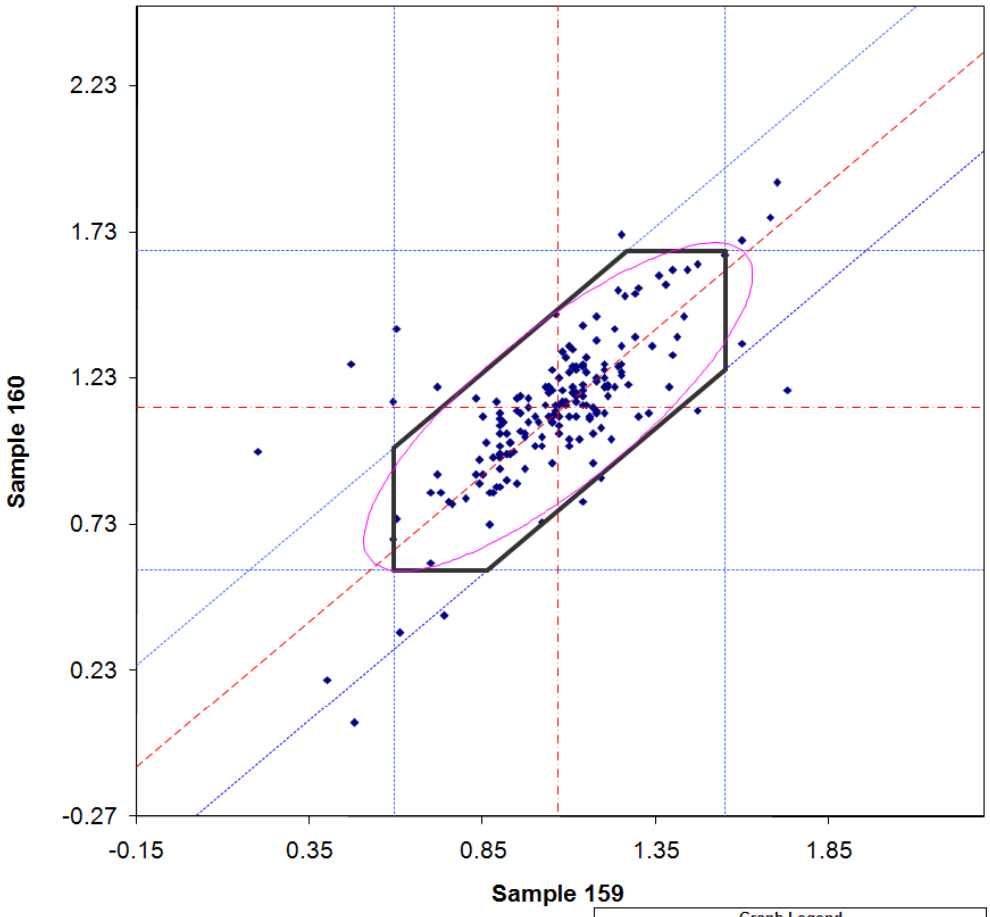
Reproducability (Sample 158)		
1s	d2s	CV%
0.15	0.41	31.69

Graph and Analysis Results for AASHTO T 105

Chemical Analysis of Hydraulic Cement

CCRL Samples 159 and 160

% Free Calcium Oxide (Free CaO), Type I w/ limestone (159) & Type I / II w/ limestone (160)



Graph Legend
Lines With Small Dash Marks - Sample Outlier Boundaries
Lines With Alternating Dash Marks - Sample Medians
Line With Large Dash Marks - Center Diagonal
Black Hexagon - Data Within is Used for Analysis
Ellipse - 2 Std Dev for Within and Between Lab Variation

Source of Data: AASHTO Materials Reference Laboratory Proficiency Sample Program
CCRL Samples 159 and 160
Final Report Issued April 2006

Participation:

182	Total Laboratories
7	Laboratories Determined to be Invalid
16	Laboratories Determined to be Outliers
159	Total Laboratorires Included in Analysis

Average Results	
Sample 159 Average	Sample 160 Average
1.07	1.13

Repeatability			
1s	d2s	CV% (159)	CV% (160)
0.08	0.23	7.64	7.21

Reproducability (Sample 159)		
1s	d2s	CV%
0.17	0.47	15.65

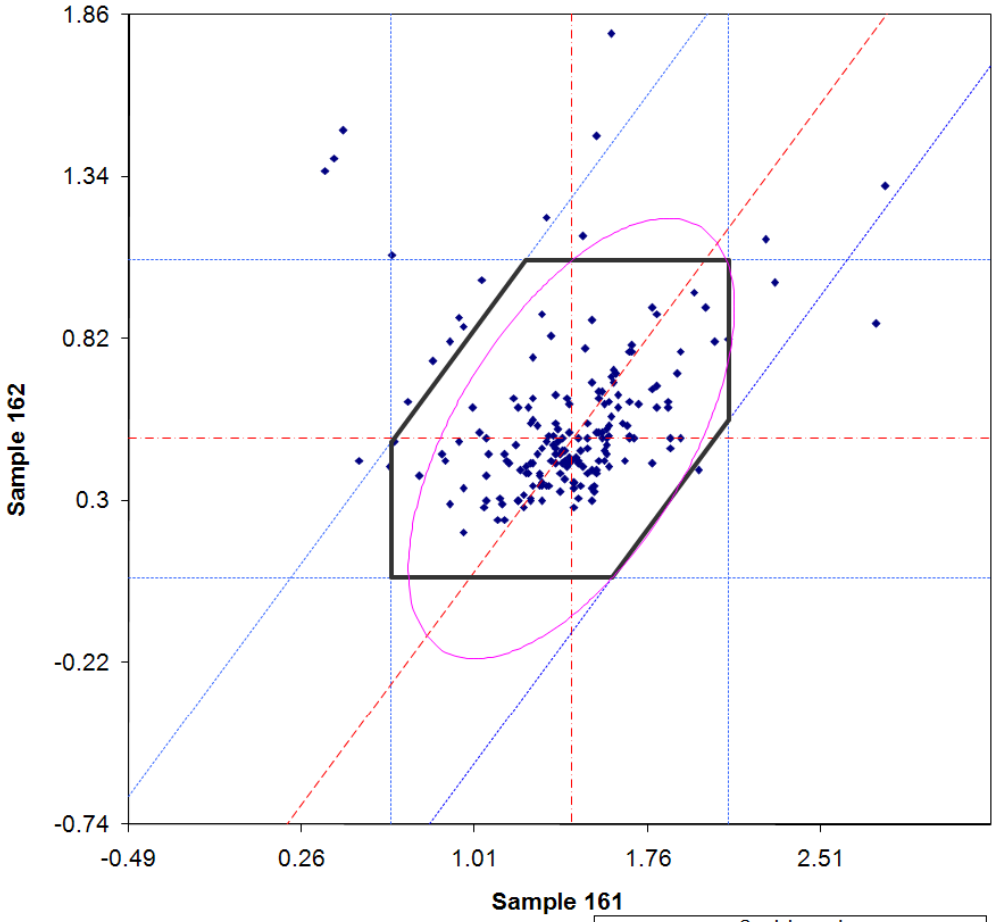
Reproducability (Sample 160)		
1s	d2s	CV%
0.19	0.53	16.66

Graph and Analysis Results for AASHTO T 105

Chemical Analysis of Hydraulic Cement

CCRL Samples 161 and 162

% Free Calcium Oxide (CaO), Type I Cement (161) & Type I w/ limestone (162)



Graph Legend
Lines With Small Dash Marks - Sample Outlier Boundaries
Lines With Alternating Dash Marks - Sample Medians
Line With Large Dash Marks - Center Diagonal
Black Hexagon - Data Within is Used for Analysis
Ellipse - 2 Std Dev for Within and Between Lab Variation

Source of Data: AASHTO Materials Reference Laboratory Proficiency Sample Program
CCRL Samples 161 and 162
Final Report Issued Oct 2006

Participation:

188	Total Laboratories
6	Laboratories Determined to be Invalid
15	Laboratories Determined to be Outliers
167	Total Laboratorires Included in Analysis

Average Results	
Sample 161 Average	Sample 162 Average
1.43	0.50

Repeatability			
1s	d2s	CV% (161)	CV% (162)
0.15	0.43	10.54	30.09

Reproducability (Sample 161)		
1s	d2s	CV%
0.25	0.71	17.68

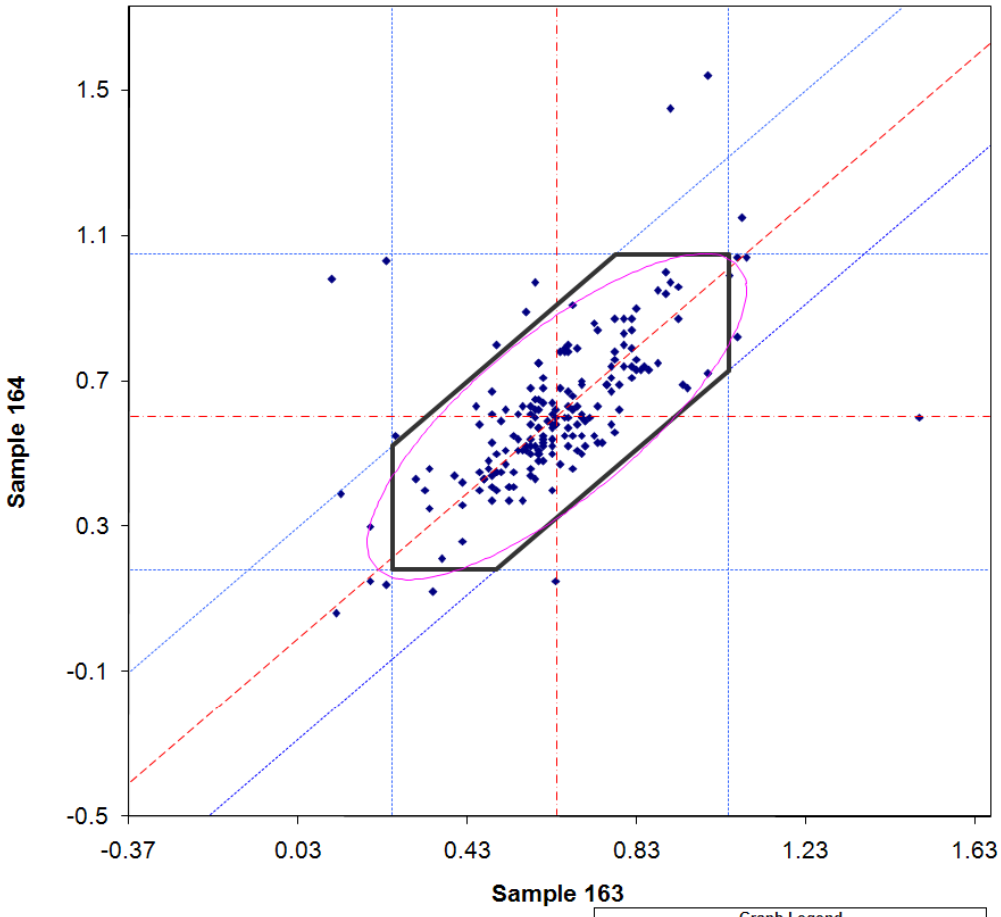
Reproducability (Sample 162)		
1s	d2s	CV%
0.16	0.44	31.38

Graph and Analysis Results for AASHTO T 105

Chemical Analysis of Hydraulic Cement

CCRL Samples 163 and 164

% Free Calcium Oxide (CaO), Type I / II Cement



Graph Legend
Lines With Small Dash Marks - Sample Outlier Boundaries
Lines With Alternating Dash Marks - Sample Medians
Line With Large Dash Marks - Center Diagonal
Black Hexagon - Data Within is Used for Analysis
Ellipse - 2 Std Dev for Within and Between Lab Variation

Source of Data: AASHTO Materials Reference Laboratory Proficiency Sample Program
CCRL Samples 163 and 164
Final Report Issued April 2007

Participation:

192	Total Laboratories
6	Laboratories Determined to be Invalid
16	Laboratories Determined to be Outliers
170	Total Laboratorires Included in Analysis

Average Results	
Sample 163 Average	Sample 164 Average
0.64	0.60

Repeatability			
1s	d2s	CV% (163)	CV% (164)
0.07	0.20	10.89	11.62

Reproducability (Sample 163)		
1s	d2s	CV%
0.13	0.38	20.90

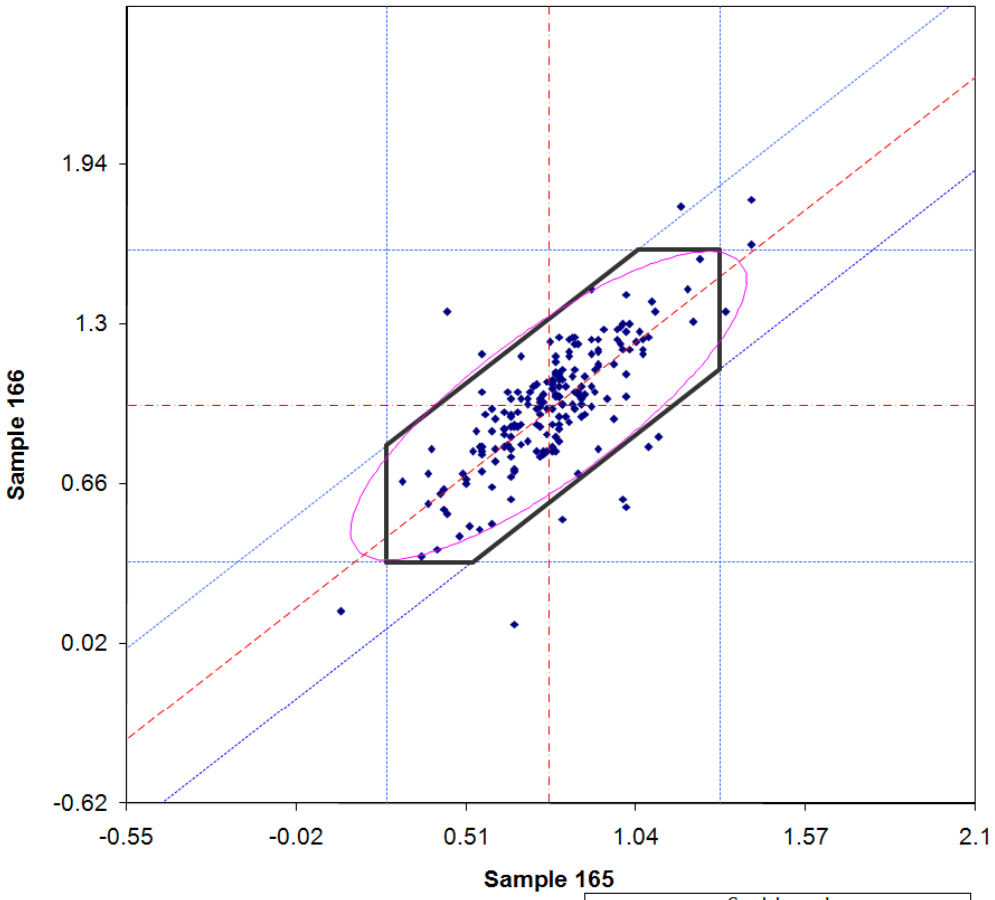
Reproducability (Sample 164)		
1s	d2s	CV%
0.15	0.42	24.50

Graph and Analysis Results for AASHTO T 105

Chemical Analysis of Hydraulic Cement

CCRL Samples 165 and 166

% Free Calcium Oxide (CaO), Type I / II Cement w/ limestone



Graph Legend
Lines With Small Dash Marks - Sample Outlier Boundaries
Lines With Alternating Dash Marks - Sample Medians
Line With Large Dash Marks - Center Diagonal
Black Hexagon - Data Within is Used for Analysis
Ellipse - 2 Std Dev for Within and Between Lab Variation

Source of Data: AASHTO Materials Reference Laboratory Proficiency Sample Program
CCRL Samples 165 and 166
Final Report Issued Sept. 2007

Participation:

193	Total Laboratories
2	Laboratories Determined to be Invalid
11	Laboratories Determined to be Outliers
180	Total Laboratorires Included in Analysis

Average Results	
Sample 165 Average	Sample 166 Average
0.77	0.97

Repeatability			
1s	d2s	CV% (165)	CV% (166)
0.09	0.25	11.5	9.1

Reproducability (Sample 165)		
1s	d2s	CV%
0.17	0.49	22.7

Reproducability (Sample 166)		
1s	d2s	CV%
0.22	0.61	22.2

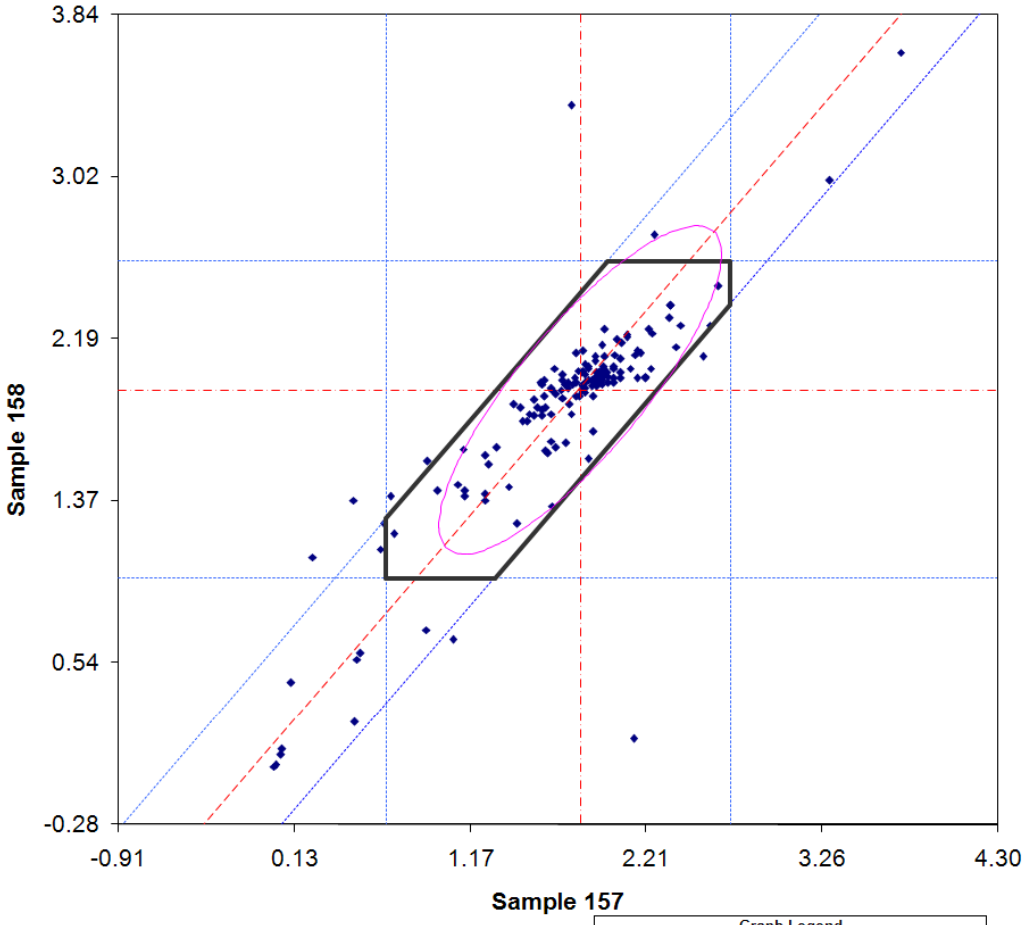
APPENDIX N: CARBON DIOXIDE (CO_2)

Graph and Analysis Results for AASHTO T 105

Chemical Analysis of Hydraulic Cement

CCRL Samples 157 and 158

Test Property: Carbon Dioxide (CO2) %, Type V Cement w/ Limestone



Graph Legend
Lines With Small Dash Marks - Sample Outlier Boundaries
Lines With Alternating Dash Marks - Sample Medians
Line With Large Dash Marks - Center Diagonal
Black Hexagon - Data Within is Used for Analysis
Ellipse - 2 Std Dev for Within and Between Lab Variation

Source of Data: AASHTO Materials Reference Laboratory Proficiency Sample Program
CCRL Samples 157 and 158
Final Report Issued Oct. 2005

Participation:

158	Total Laboratories
7	Laboratories Determined to be Invalid
15	Laboratories Determined to be Outliers
136	Total Laboratorires Included in Analysis

Average Results	
Sample 157 Average	Sample 158 Average
1.82	1.93

Repeatability			
1s	d2s	CV% (157)	CV% (158)
0.12	0.33	6.3	6.0

Reproducability (Sample 157)		
1s	d2s	CV%
0.30	0.86	16.7

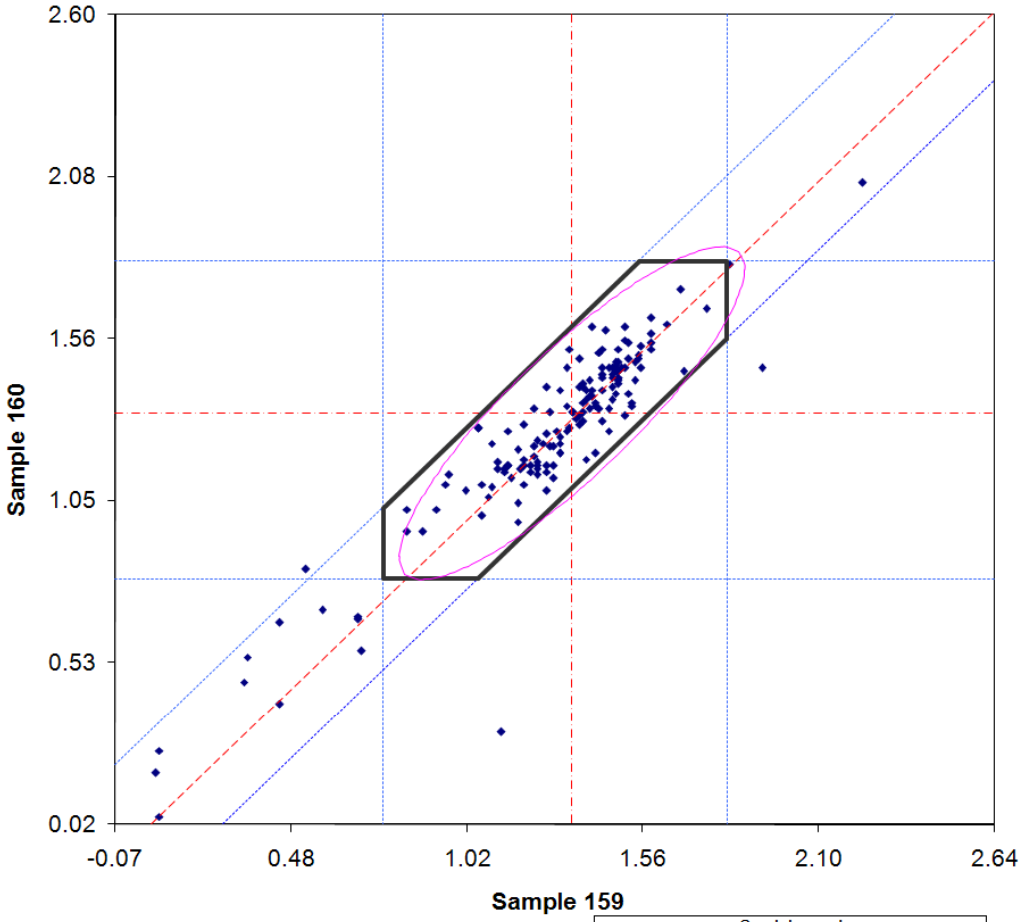
Reproducability (Sample 158)		
1s	d2s	CV%
0.22	0.63	11.6

Graph and Analysis Results for AASHTO T 105

Chemical Analysis of Hydraulic Cement

CCRL Samples 159 and 160

Test Property: Carbon Dioxide (CO2) %, Type I Cement w/ Limestone



Graph Legend
Lines With Small Dash Marks - Sample Outlier Boundaries
Lines With Alternating Dash Marks - Sample Medians
Line With Large Dash Marks - Center Diagonal
Black Hexagon - Data Within is Used for Analysis
Ellipse - 2 Std Dev for Within and Between Lab Variation

Source of Data: AASHTO Materials Reference Laboratory Proficiency Sample Program
CCRL Samples 159 and 160
Final Report Issued April 2006

Participation:

161	Total Laboratories
8	Laboratories Determined to be Invalid
12	Laboratories Determined to be Outliers
141	Total Laboratorires Included in Analysis

Average Results	
Sample 159 Average	Sample 160 Average
1.34	1.33

Repeatability			
1s	d2s	CV% (159)	CV% (160)
0.06	0.18	4.8	4.8

Reproducability (Sample 159)		
1s	d2s	CV%
0.17	0.49	13.1

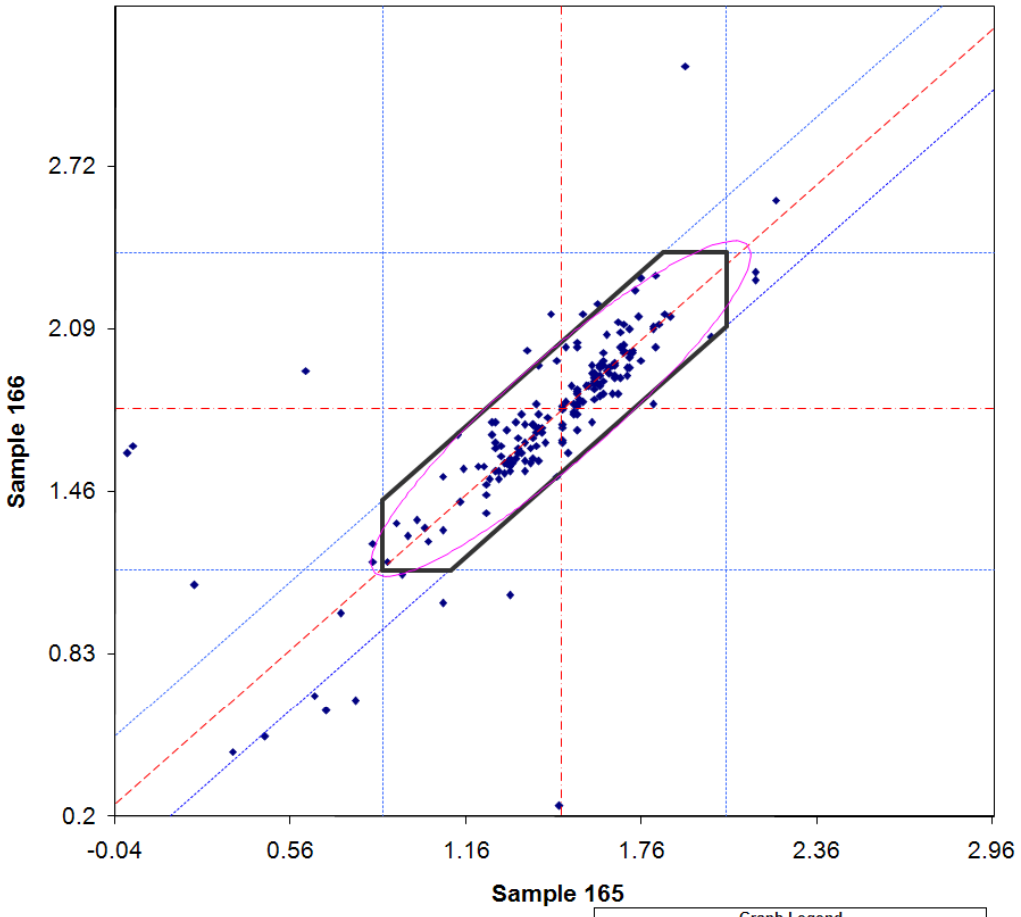
Reproducability (Sample 160)		
1s	d2s	CV%
0.17	0.47	12.5

Graph and Analysis Results for AASHTO T 105

Chemical Analysis of Hydraulic Cement

CCRL Samples 165 and 166

Test Property: Carbon Dioxide (CO2) %, Type I / II Cement w/ Limestone



Graph Legend
Lines With Small Dash Marks - Sample Outlier Boundaries
Lines With Alternating Dash Marks - Sample Medians
Line With Large Dash Marks - Center Diagonal
Black Hexagon - Data Within is Used for Analysis
Ellipse - 2 Std Dev for Within and Between Lab Variation

Source of Data: AASHTO Materials Reference Laboratory Proficiency Sample Program
CCRL Samples 165 and 166
Final Report Issued Sept. 2007

Participation:

185	Total Laboratories
11	Laboratories Determined to be Invalid
19	Laboratories Determined to be Outliers
155	Total Laboratorires Included in Analysis

Average Results	
Sample 165 Average	Sample 166 Average
1.48	1.78

Repeatability			
1s	d2s	CV% (165)	CV% (166)
0.06	0.17	4.2	3.5

Reproducability (Sample 165)		
1s	d2s	CV%
0.21	0.59	14.1

Reproducability (Sample 166)		
1s	d2s	CV%
0.22	0.61	12.1