Bias Test of the Clean Coal Sampling System at Crossville Coal, Inc.

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1.0 Introduction

This report gives the results of a test for bias in the Crossville Coal clean coal sample system. A total of 17 sets of samples were collected from November 15, 2005 through February 1, 2006. Collection of stopped-belt reference samples and mechanical system save samples was performed by Rick Schubert, Quality Control Manager of Crossville Coal and Stephen Smith of Coalsmith Consultants.

This is a test of a sample system on the clean coal belt from a wash plant. Coal is mined using continuous miners in the Sewanee Seam. Raw coal goes through a rotary breaker with 4 inch openings. Coal is screened at 2 inch, and +2 inch is crushed and recycled to the screen. Two inch by 16 mesh coal is washed in a heavy medium cyclone circuit, with spirals for 16 mesh x 100 mesh. The 100 mesh x 0 coal is rejected and filtered in a belt press. The sampler tested is on the 36 inch wide, horizontal, clean coal belt.

Coal samples were dried, prepared, and analyzed at Standard Laboratories in Jacksboro, TN using ASTM methods of preparation and analysis. Procedures for the bias test conformed to the standard bias test procedure in ASTM D6518. Calculation of results of the test were performed using Datawolff Bias Test spreadsheet add-in script provided by Wolffware, Ltd. Test logs, coal analysis, calculations, and photographs of the system tested are attached.

2.0 Description of Sampling System

Manufacturer……Ramsey Engineering
Year installed……1997
No. of sampling stages……..2
Primary Sampling Stage
- Type……Sweep arm cutter
- Drive……Electric
- Cutter opening……12 inches
- Operating interval……....120 seconds

Primary Feeder
- Type……Chute

Crusher
- Manufacturer……Ramsey
- Type……Minimill

Secondary Sampling Stage
- Drive System……Electric
- Type……..Sweep arm cutter
- Cutter opening ……2 inches
- Operating interval……13 seconds

3.0 Options Selected in Test Design

The bias testing procedure offers options to the user. The following options were selected:

a) Coal Characteristics for the test were moisture, ar ash, ar sulfur, and ar Btu.
b) An 80-minute test batch interval was chosen. This provided a target system save sample weighing 1000 grams at 8 mesh.
c) A total of 30 test pairs were planned for and 17 pairs were collected.
d) Two stopped-belt reference increments were collected and combined from each test batch of coal. Pre-selected random sample collection times (for each test batch) were followed during

the test. These reference samples were crushed to 8-mesh, riffled, and analyzed concurrently with the system save samples.

4.0 Results of the Test for Independent Differences

Individual differences between laboratory analyses of reference and laboratory analysis of system samples were examined to see if there was evidence that revealed they may not be independent. Should the assumption of independence not be true, conclusions drawn from the test using all sets of data to determine confidence intervals might be suspect.

The number of differences above (+) and below (-) the median difference, the low (l) and upper (u) table values, and the number of runs (r) found for each coal characteristic, are given below.

	n_1, n_2	l, u	runs
Moisture	8,8	5,13	7
Dry Ash	8,8	5,13	6
Dry Sulfur	4,8	3,i	6
AR Btu	8,8	5,13	7

The number of runs for all characteristics falls within the closed interval (l,u) for p = 4. Thus, there is insufficient evidence to reject the assumption of independence of the individual bias test differences. Due to the precision of analysis of sulfur, being limited to two significant digits, resulted in an indeterminate upper limit for independence. Since 5 of the 17 sets showed a zero difference in sulfur, this reduced the number of runs (differences of zero are ignored in counting runs.). Therefore the significance of the independence of data is adequate, and this result was disregarded. We may proceed to calculate confidence intervals for bias.

5.0 Conclusions Regarding Bias

Walsh averages of the differences were calculated and confidence limits determined. Concluding statements are as follows:

If a chance error, which prior to the test had a maximum probability of occurring equal to no more than about 1 in 20, did not occur, biases of mechanically collected samples against stopped-belt reference samples lie within the closed intervals given below.

Moisture	$-1.485 \leq b(m) \leq 0.215$
Dry Ash	$-0.970 \leq b(arash) \leq 0.265$
Dry Sulfur	$-0.015 \leq b(arsulfur) \leq 0.015$
AR Btu	$-171.5 \leq b(arhv) \leq 369.5$

B(m), b(arash), b(arsulfur), and b(arhv) represent moisture, ar ash, ar sulfur, and ar heating value biases, respectively.

The confidence interval for the four coal characteristics tested includes the value zero. Thus, this test offers insufficient evidence to reject a hypothesis of no bias of system samples against stopped-belt reference samples. Therefore the hypothesis of no bias in these parameters is accepted.

The point estimates of biases for the four parameters studied (the median value of Walsh averages) are as follows:

Moisture =	-0.64
Ar Ash =	-0.265
Ar Sulfur =	-0.005
Ar HV =	+138

Respectfully submitted,

Stephen R. Smith

Table 1. Log of test conditions, stop belt times, weights of samples and clean tons per batch

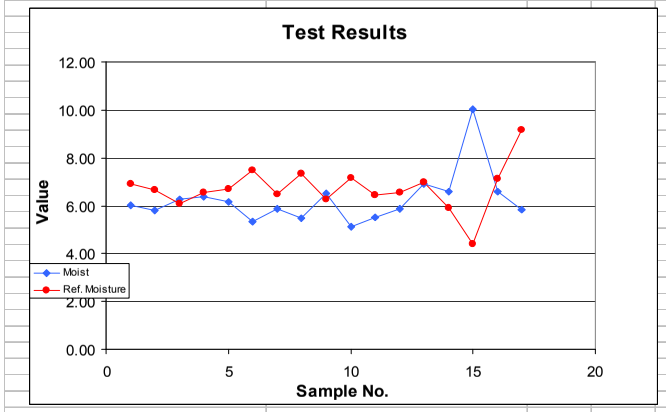
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Date of test	11/15/2006	11/15/2006	11/15/2006	11/15/2006	11/17/2006	11/17/2006	11/17/2006	12/20/2005	12/20/2005	12/20/2005	1/20/2005	1/20/2005	1/20/2005	1/20/2005	2/1/2006	2/1/2006	2/1/2006
Start time	8:13	9:40	11:04	12:32	9:44	11:20	12:50	9:30	10:45	12:15	9:04	10:36	12:05	1:20	8:48	10:20	11:50
End time	9:40	11:04	12:32	2:10	11:20	12:50	2:15	10:45	12:15	1:50	10:35	12:05	1:20	2:48	10:20	11:50	1:20
Temperature	60	60	60	60	31	31	31	32	32	32	46	46	46	46	45	45	45
Precipitation	dry	dry	dry	dry	light	light	light	dry	dr	dr	clear, windy	clear, windy	clear, windy	clear, windy	r, light wind	r, light wind	r, light wind
First Stop Belt Time (min.)	21	13	8	8	6	1	11	27	30	18	2	27	7	14	25	10	4
Second Stop Belt Time (min.)	61	53	48	48	46	41	51	67	70	58	42	67	47	54	65	50	44
Weight of reference (stopped belt) sample	19.6	23.2	25.2	29.0	20.4	21.6	25.8	19.4	19.0	18.1	21.8	23.6	15.4	19.4	21.6	20.6	21.0
Weight of system save sample	1.4	2.2	2.6	2.6	3.0	1.6	2.6	1.6	2.0	1.0	0.6	1.2	1.6	1.8	2.6	1.6	1.6
Total Clean Tons	139	134	141	146	140	141	158	89	89	92	103	104	98	113	111	108	119
Description of failures in sampling or coal handling equipment				iron in centrifuge			ran out of coal at 70 min						trash on screen				
Duration of downtime				:20			:10						:02				

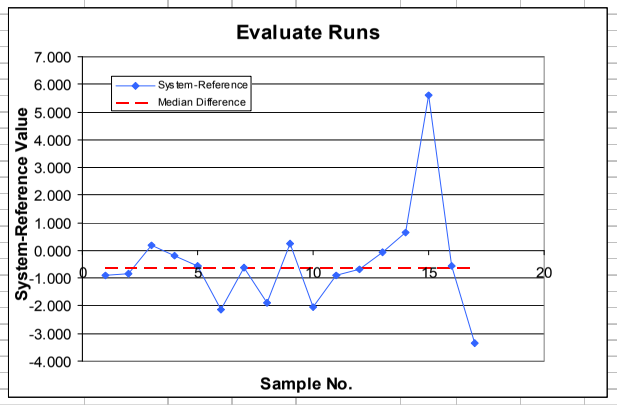
Table 2. Results of calulations using Wilcoxon non-parametric method in ASTM D6518

Title	**Values**			**Characteristic**	**Appears Independent**	**Bias not Detected**	**Lower Bias Limit**	**Bias Estimate**	**Upper Bias Limit**
Data Check Passed	TRUE			Moist	TRUE	TRUE	-1.485	-0.640	0.215
Number of Samples	17			Ash	TRUE	TRUE	-0.970	-0.265	0.400
Number of Characteristics	4			Sulfur	TRUE	TRUE	-0.015	-0.005	0.015
Test Results Appear to be Independent	**TRUE**			BTU	TRUE	TRUE	-171.5	138	369.5

Table 3. Bias test results for Moisture

Title	Values	Ref. Sample No.	Ref. Moisture	Sys. Sample No.	Moist	System-Reference	Sample No.	Difference-Median	Plus (=1) or Minus(= -1)	Number of Runs	Median Difference
		basis	ar	basis	ar						
Parameter	Moist	SB1	6.91	SYS1	6.01	-0.900	SYS1	-0.290	-1	1	-0.610
Average Difference	-0.47	SB2	6.65	SYS2	5.82	-0.830	SYS2	-0.220	-1	1	-0.610
Median of Difference	-0.61	SB3	6.09	SYS3	6.28	0.190	SYS3	0.800	1	2	-0.610
Number of Plusses	8	SB4	6.55	SYS4	6.37	-0.180	SYS4	0.430	1	2	-0.610
Number of Minuses	8	SB5	6.71	SYS5	6.15	-0.560	SYS5	0.050	1	2	-0.610
Number of Runs	7	SB6	7.47	SYS6	5.33	-2.140	SYS6	-1.530	-1	3	-0.610
Lower Independence Limit	5	SB7	6.49	SYS7	5.88	-0.610	SYS7	0.000	0	3	-0.610
Upper Independence Limit	13	SB8	7.36	SYS8	5.47	-1.890	SYS8	-1.280	-1	3	-0.610
Is Independent (True if OK, False if not independent)	TRUE	SB9	6.28	SYS9	6.52	0.240	SYS9	0.850	1	4	-0.610
Text Result	The number of runs falls between the upper and lower bias limits. The observations within each series appear to be independent.	SB10	7.18	SYS10	5.14	-2.040	SYS10	-1.430	-1	5	-0.610
Point Estimate of Bias	-0.640	SB11	6.43	SYS11	5.52	-0.910	SYS11	-0.300	-1	5	-0.610
Lower Bias Limit	-1.485	SB12	6.56	SYS12	5.89	-0.670	SYS12	-0.060	-1	5	-0.610
Upper Bias Limit	0.215	SB13	6.99	SYS13	6.91	-0.080	SYS13	0.530	1	6	-0.610
Not Biased	**TRUE**	SB14	5.92	SYS14	6.58	0.660	SYS14	1.270	1	6	-0.610
Bias Test Result	**The confidence interval for this coal characteristic includes 0; thus, the statistical analysis for this characteristic indicates the system is unbiased.**	SB15	4.4	SYS15	10.02	5.620	SYS15	6.230	1	6	-0.610
		SB16	7.13	SYS16	6.58	-0.550	SYS16	0.060	1	6	-0.610
		SB17	9.17	SYS17	5.83	-3.34	SYS17	-2.73	-1	7	-0.61





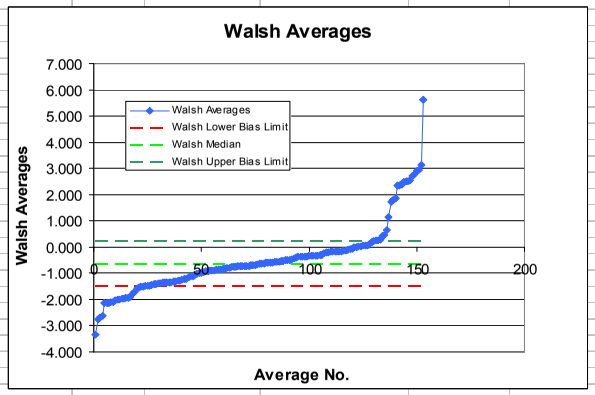
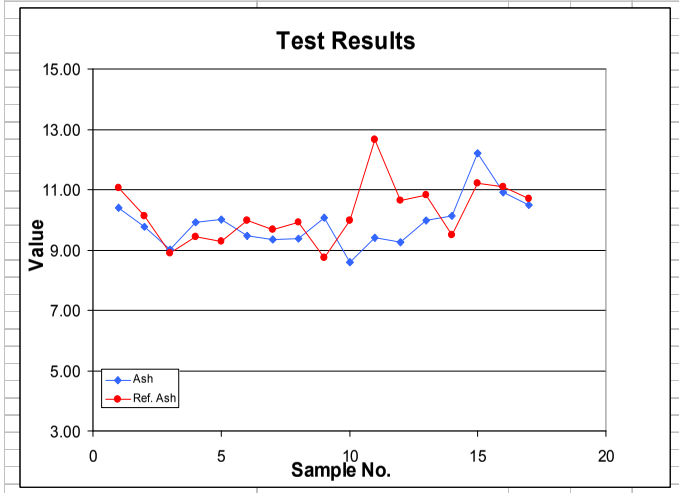
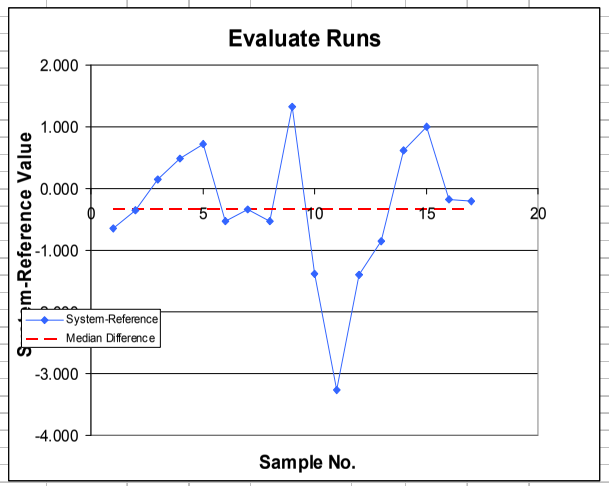


Table 4. Results for As-Received Ash

Title	Values	Ref. Sample No.	Ref. Ash	Sys. Sample No.	Ash	System-Reference	Sample No.	Difference-Median	Plus (=1) or Minus(= -1)	Number of Runs	Median Difference
		basis	ar	basis	ar						
Parameter	Ash	SB1	11.05	SYS1	10.41	-0.640	SYS1	-0.300	-1	1	-0.340
Average Difference	-0.32	SB2	10.12	SYS2	9.76	-0.360	SYS2	-0.020	-1	1	-0.340
Median of Difference	-0.34	SB3	8.88	SYS3	9.02	0.140	SYS3	0.480	1	2	-0.340
Number of Plusses	8	SB4	9.43	SYS4	9.91	0.480	SYS4	0.820	1	2	-0.340
Number of Minuses	8	SB5	9.28	SYS5	10	0.720	SYS5	1.060	1	2	-0.340
Number of Runs	6	SB6	9.99	SYS6	9.46	-0.530	SYS6	-0.190	-1	3	-0.340
Lower Independence Limit	5	SB7	9.68	SYS7	9.34	-0.340	SYS7	0.000	0	3	-0.340
Upper Independence Limit	13	SB8	9.92	SYS8	9.39	-0.530	SYS8	-0.190	-1	3	-0.340
Is Independent (True if OK, False if not independent)	TRUE	SB9	8.74	SYS9	10.06	1.320	SYS9	1.660	1	4	-0.340
Text Result	The number of runs falls between the upper and lower bias limits. The observations within each series appear to be independent.	SB10	9.97	SYS10	8.59	-1.380	SYS10	-1.040	-1	5	-0.340
Point Estimate of Bias	-0.265	SB11	12.66	SYS11	9.4	-3.260	SYS11	-2.920	-1	5	-0.340
Lower Bias Limit	-0.970	SB12	10.64	SYS12	9.25	-1.390	SYS12	-1.050	-1	5	-0.340
Upper Bias Limit	0.400	SB13	10.82	SYS13	9.97	-0.850	SYS13	-0.510	-1	5	-0.340
Not Biased	**TRUE**	SB14	9.51	SYS14	10.13	0.620	SYS14	0.960	1	6	-0.340
Bias Test Result	**The confidence interval for this coal characteristic includes 0; thus, the statistical analysis for this characteristic indicates the system is unbiased.**	SB15	11.21	SYS15	12.21	1.000	SYS15	1.340	1	6	-0.340
		SB16	11.09	SYS16	10.92	-0.170	SYS16	0.170	1	6	-0.340
		SB17	10.7	SYS17	10.5	-0.2	SYS17	0.14	1	6	-0.34





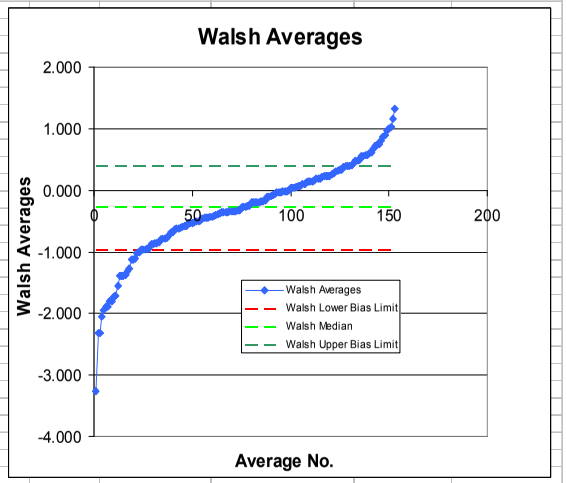
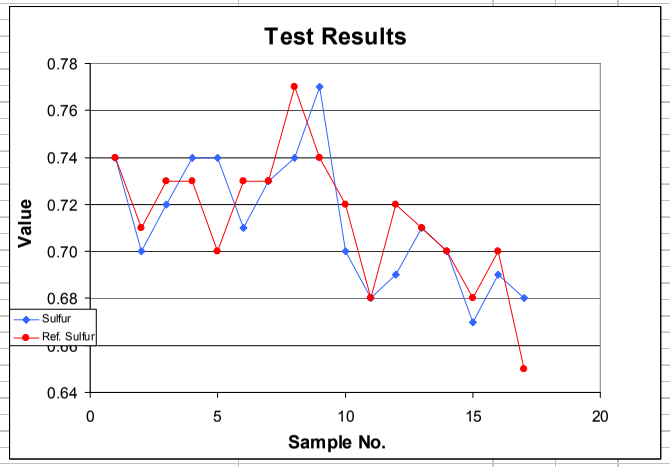
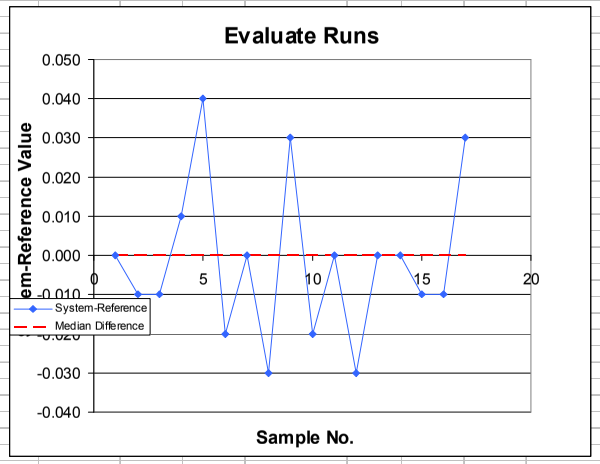


Table 5. Results for As-Received Sulfur

Title	Values	Ref. Sample No.	Ref. Sulfur	Sys. Sample No.	Sulfur	System-Reference	Sample No.	Difference-Median	Plus (=1) or Minus(= -1)	Number of Runs	Median Difference
		basis	ar	basis	ar						
Parameter	Sulfur	SB1	0.74	SYS1	0.74	0.000	SYS1	0.000	0	0	0.000
Average Difference	0.00	SB2	0.71	SYS2	0.7	-0.010	SYS2	-0.010	-1	1	0.000
Median of Difference	0.00	SB3	0.73	SYS3	0.72	-0.010	SYS3	-0.010	-1	1	0.000
Number of Plusses	4	SB4	0.73	SYS4	0.74	0.010	SYS4	0.010	1	2	0.000
Number of Minuses	8	SB5	0.7	SYS5	0.74	0.040	SYS5	0.040	1	2	0.000
Number of Runs	6	SB6	0.73	SYS6	0.71	-0.020	SYS6	-0.020	-1	3	0.000
Lower Independence Limit	3	SB7	0.73	SYS7	0.73	0.000	SYS7	0.000	0	3	0.000
Upper Independence Limit	Indeterminate	SB8	0.77	SYS8	0.74	-0.030	SYS8	-0.030	-1	3	0.000
Is Independent (True if OK, False if not independent)	TRUE	SB9	0.74	SYS9	0.77	0.030	SYS9	0.030	1	4	0.000
Text Result	The number of runs falls between the upper and lower bias limits. The observations within each series appear to be independent.	SB10	0.72	SYS10	0.7	-0.020	SYS10	-0.020	-1	5	0.000
Point Estimate of Bias	-0.005	SB11	0.68	SYS11	0.68	0.000	SYS11	0.000	0	5	0.000
Lower Bias Limit	-0.015	SB12	0.72	SYS12	0.69	-0.030	SYS12	-0.030	-1	5	0.000
Upper Bias Limit	0.015	SB13	0.71	SYS13	0.71	0.000	SYS13	0.000	0	5	0.000
Not Biased	**TRUE**	SB14	0.7	SYS14	0.7	0.000	SYS14	0.000	0	5	0.000
Bias Test Result	**The confidence interval for this coal characteristic includes 0; thus, the statistical analysis for this characteristic indicates the system is unbiased.**	SB15	0.68	SYS15	0.67	-0.010	SYS15	-0.010	-1	5	0.000
		SB16	0.7	SYS16	0.69	-0.010	SYS16	-0.010	-1	5	0.000
		SB17	0.65	SYS17	0.68	0.03	SYS17	0.03	1	6	0





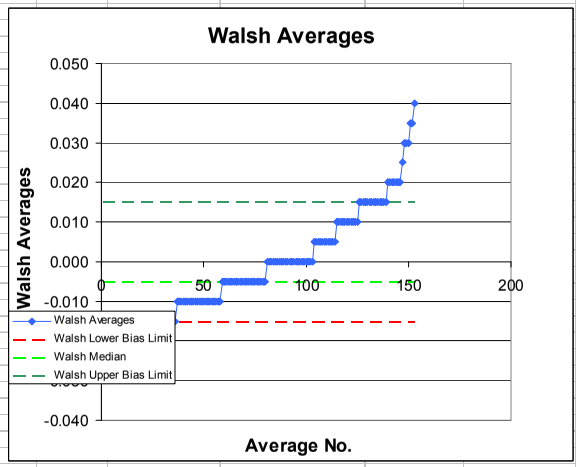
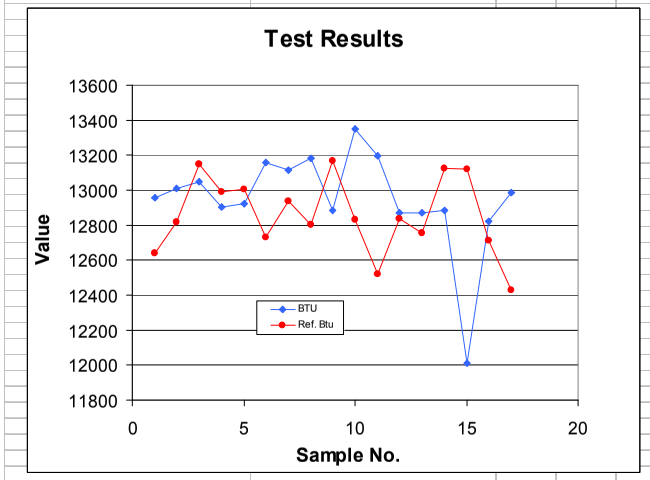
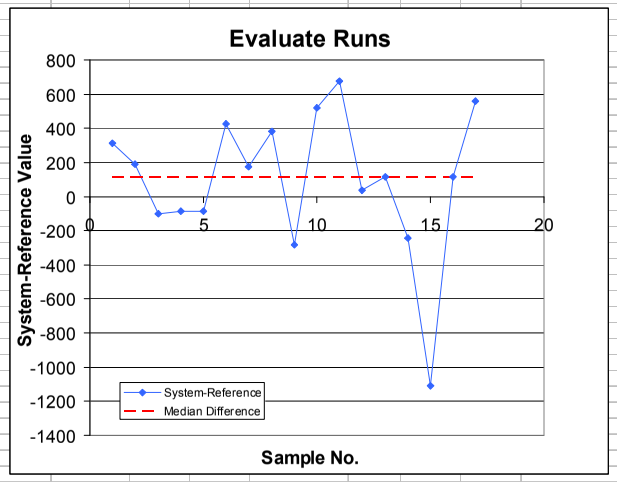


Table 6. Results for As-Received BTU

Title	Values	Ref. Sample No.	Ref. Btu	Sys. Sample No.	BTU	System-Reference	Sample No.	Difference-Median	Plus (=1) or Minus(= -1)	Number of Runs	Median Difference
		basis	ar	basis	ar						
Parameter	BTU	SB1	12640	SYS1	12955	315	SYS1	198	1	1	117
Average Difference	93.88	SB2	12819	SYS2	13009	190	SYS2	73	1	1	117
Median of Difference	117.00	SB3	13148	SYS3	13048	-100	SYS3	-217	-1	2	117
Number of Plusses	8	SB4	12991	SYS4	12906	-85	SYS4	-202	-1	2	117
Number of Minuses	8	SB5	13007	SYS5	12923	-84	SYS5	-201	-1	2	117
Number of Runs	7	SB6	12733	SYS6	13157	424	SYS6	307	1	3	117
Lower Independence Limit	5	SB7	12938	SYS7	13113	175	SYS7	58	1	3	117
Upper Independence Limit	13	SB8	12804	SYS8	13184	380	SYS8	263	1	3	117
Is Independent (True if OK, False if not independent)	TRUE	SB9	13169	SYS9	12884	-285	SYS9	-402	-1	4	117
Text Result	The number of runs falls between the upper and lower bias limits. The observations within each series appear to be independent.	SB10	12831	SYS10	13350	519	SYS10	402	1	5	117
Point Estimate of Bias	138.000	SB11	12521	SYS11	13196	675	SYS11	558	1	5	117
Lower Bias Limit	-171.500	SB12	12835	SYS12	12872	37	SYS12	-80	-1	6	117
Upper Bias Limit	369.500	SB13	12755	SYS13	12872	117	SYS13	0	0	6	117
Not Biased	**TRUE**	SB14	13127	SYS14	12884	-243	SYS14	-360	-1	6	117
Bias Test Result	**The confidence interval for this coal characteristic includes 0; thus, the statistical analysis for this characteristic indicates the system is unbiased.**	SB15	13121	SYS15	12009	-1112	SYS15	-1229	-1	6	117
		SB16	12710	SYS16	12824	114	SYS16	-3	-1	6	117
		SB17	12429	SYS17	12988	559	SYS17	442	1	7	117





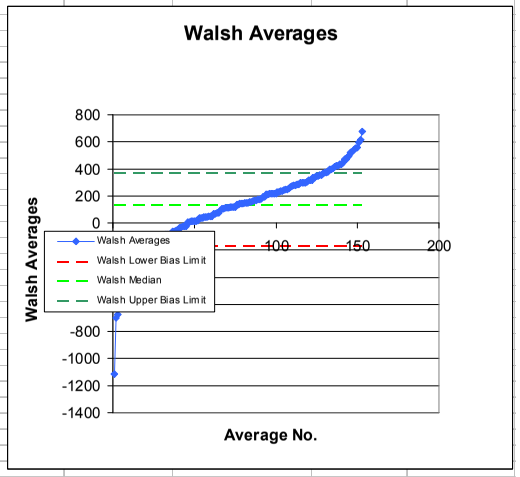


Figure 1. Photograph of the Clean Coal Sampling System at Crossville Coal Inc

Figure 2. Photograph of the stopped belt sample collection site and cutter

Figure 3. Photograph of system save and stopped belt samples