Standard Practice for Quality Management of Mechanical Coal Sampling Systems[1]

This standard is issued under the fixed designation D 4702; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This practice is applicable to cross-belt, falling stream, and auger sampling systems.

1.2 Spacing of increments pertains to the kind of interval between increments. Intervals can be defined in quantitative terms, such as units of time or mass, or in terms of position over the lot.

1.2.1 *Spacing of Increments for Cross-Belt and Falling Stream Samplers*—Cross-belt and falling stream type mechanical sampling systems take increments based on time, either at fixed time intervals or at random times during a fixed time strata. Some falling stream samplers can take increments based on equal mass of coal sampled as determined by scales. The sections of this practice that pertain to cross-belt and falling stream samplers describe procedures for only time-based sampling systems. This time-based inspection guideline will satisfy most criteria for mass-based or combination mass-based and time-based sampling systems. If there are items that are not covered, the inspector should refer to the manufacturer's literature.

1.2.2 *Spacing of Increments for Auger Sampling*—The spacing of increments collected by auger sampling systems is defined in terms of position over the lot.

1.3 It is essential that the inspector have the documentation listed in Section 2 of this practice when conducting an inspection.

1.4 The values stated in SI units are to be regarded as the standard. The values given in parentheses are for information only.

1.5 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* For a specific hazard statement, see Section 5.

2. Referenced Documents

2.1 *ASTM Standards:* [2]

D 121 Terminology of Coal and Coke

D 2013 Practice for Preparing Coal Samples for Analysis

D 2234/D 2234M Practice for Collection of a Gross Sample of Coal

D 4749 Test Method for Performing the Sieve Analysis of Coal and Designating Coal Size

D 4916 Practice for Mechanical Auger Sampling

3. Terminology

3.1 *Definitions*—Definitions applicable to this practice are listed in Terminology D 121 and Practices D 2013, D 2234/D 2234M and D 4916.

4. Significance and Use

4.1 This practice addresses quality assurance criteria for operation of a mechanical coal-sampling system in accordance with Practice D 2234/D 2234M, Practice D 2013, and Practice D 4916. It provides recommendations for performance monitoring, inspection, and maintenance, which are necessary in maintaining a sampling system's capability to consistently obtain a representative sample.

5. Hazards

5.1 *Precautions*—In addition to other precautions, personnel visiting facilities for observation of mechanical sampling system performance should immediately upon arrival report to the facility management to inform them of their presence and the purpose of their visit. The inspector should ask for

[1] This practice is under the jurisdiction of ASTM Committee D05 on Coal and Coke and is the direct responsibility of Subcommittee D05.23 on Sampling.

Current edition approved April 1, 2006. Published May 2006. Originally approved in 1987. Last previous edition approved in 2004 as D 4702 – 04.

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

drawings, specifications, and instructions on the applicable safety practices and regulations to be followed on the site.

6. Assessing the Organization and Planning of Sampling Operations

6.1 It is recommended that inspection personnel meet with the appropriate personnel responsible for the mechanical sampling system, on all visits, to discuss the organization and planning of sampling operations. ASTM standards provide for the use of various options. Examples and references are given in 6.1.1 and 6.1.2 as follows:

6.1.1 *Cross-Belt and Falling Stream Samplers*—The number of primary increments for the gross sample collected by cross-belt and falling stream systems can be determined from sections 8.1.1.4 and 8.1.1.5 of Practice D 2234/D 2234M.

6.1.2 *Auger Sampling*—Considerations for the number of auger increments per lot and per vehicle are discussed in the Consideration for Number of Auger Increments section (6.3) of Practice D 4916.

6.2 Inspection personnel should refer to the sections of Practice D 2234/D 2234M and Practice D 4916 referenced in 6.2.1 and 6.2.2 of this practice when assessing the conformance of the organization and planning of cross-belt, falling stream, and auger sampling operations as follows:

6.2.1 *Planning of Cross-Belt or Falling Stream Sampling Operations*—When assessing the conformance of the organization and planning of sampling operations for a specific cross-belt or falling stream mechanical sampling system, the inspector should use Section 7, Organization and Planning of Sampling Operations, of Practice D 2234/D 2234M which covers the items that would be used in evaluating the sampling plan. Items covered are: Precautions, Selection of Appropriate Sampling Procedure, Number and Weight of Increments, Increment Collection Method to be Used, Distribution of Increments, Dimensions of Sampling Device, Movement of Sampling Device, Preservation of Moisture, Contamination, Mechanical System Features, Personnel, Criteria of Satisfactory Performance, and Relative Location of Sampling and Weighing.

6.2.2 *Planning of Auger Sampling Operations*—When assessing the conformance of the organization and planning of sampling operations for a specific auger sampling system, the inspector should use Section 6, Organization and Planning of Sampling Operations, of Practice D 4916, which covers the following items: Precautions, Consideration of Top Size, Consideration for Number of Auger Increments, Considerations for Auger Placement Patterns and Increment Collections, Preservation of Moisture, Contamination, Mechanical System Features, Personnel, Relative Location of Sampling and Weighing, and Reduction and Mechanical Division of the Auger Increments.

7. General Observations of Coal Stream Variability as Related to Primary Increment Collection by Falling Stream and Cross-Belt Samplers

7.1 The entire coal-handling system up to the cross-belt or falling stream mechanical sampler should be examined to determine if any unloading, storage, or reclaiming procedures produce a cyclical pattern which could cause the increment collection to get *in phase* with the sequence of coal variability. Variations in the physical characteristics, such as particle-size distribution, surface moisture, extraneous matter, and oversized material, can become cyclical and even could be in phase with the time-based increment collection. When such cyclical variations occur in the coal stream, the source of the variations should be investigated to determine the practicability of eliminating the variations. If there is no practical way to eliminate the variations, then either the number of primary increments or the primary cutter velocity or both shall be varied.

NOTE 1—The number of primary increments should be varied by adjusting the time interval between primary cuts so that the period of cyclic variation is not evenly divisible by the number of primary cuts per period or by using a method of random collection of primary increments.

8. General Observations of Auger Placement

8.1 At a minimum, the inspector should examine the following two aspects of the placement of the auger over the surface of the coal being sampled: (*1*) human discretion in placement of the auger over the surface of the coal in the vehicle(s) and (*2*) the pattern of auger placement from vehicle to vehicle for lots comprised of more than one vehicle load of coal.

8.1.1 *Human Discretion*—To the extent possible, human discretion should be minimized with respect to auger placement over the surface of the coal in the vehicle(s). The inspector should examine the placement of the auger over the surface of the coal in at least one vehicle to determine that human discretion is minimized in positioning the auger.

8.1.2 *Auger Placement Patterns*—The inspector should refer to the Considerations for Auger Placement Patterns and Increment Collections section (6.4) of Practice D 4916 in regard to considerations for auger placement patterns and increment collections.

9. Inspection of the Primary Sampler in Time-Based Cross-Belt or Falling Stream Sampling Systems

9.1 It is suggested that the inspector start at the primary cross-belt or falling stream sampler and follow through the system to the final *online* sample collection point. The inspection should be made with and without coal running through the system.

9.2 The following items should be checked for the primary sampler:

9.2.1 Check the cross-belt or falling stream cutter opening to determine that it complies with the Dimensions of Sampling Device section (7.4) of Practice D 2234/D 2234M.

9.2.2 Sufficient inspection doors shall be available to observe that the primary cross-belt or falling stream cutter cuts the full stream of coal.

9.2.3 Observe, or if necessary, measure, the movement of the primary cross-belt or falling stream cutter to verify uniform speed while in the coal stream.

9.2.4 Determine the velocity of the cross-belt or falling stream cutter by dividing the distance the cutter travels while in the coal stream by the time required for traveling that distance. Make the velocity check for both directions if applicable. See the Characteristics and Movement of Sampling Device section (7.5) of Practice D 2234/D 2234M for recommendations.

9.2.5 For cross-belt or falling stream systems, it should be determined that the proper number of primary increments are taken to satisfy the requirements of the Sampling of Coals Based on Size and Condition of Preparation or the Sampling of Coals Based on Known Sampling Characteristics of Practice D 2234/D 2234M. It should be determined that the time interval between primary cuts is correct to assure that the minimum number of increments are collected for the lot of coal being sampled during the inspection based on maximum attainable feed rates.

9.2.6 The inspector shall determine that the falling stream sample cutter is parked out of the stream of coal in the *at rest* position and that no coal is entering the cutter opening. There shall be no holes in the baffle plate, dust doors, or seals that may cause leaking of the sample into the primary sample hopper.

9.2.7 For cross-belt and falling stream systems, the minimum weight of the primary sample increment shall be as specified in Table 2 of Practice D 2234/D 2234M.

10. Inspection of Augers

10.1 The following items should be checked for the auger:

10.1.1 Check the auger assembly to determine that it complies with the Consideration of Top Size section (6.2) of Practice D 4916.

10.1.2 Check the auger to determine that it extracts a vertical increment of coal extending from the surface to as close as practicable to the bottom of the transport vehicle.

10.1.3 For auger sampling systems, it should be determined that the proper number of primary (auger) increments are taken to satisfy the requirements of the Consideration for the Number of Auger Increments section (6.3) of Practice D 4916.

11. Criteria for Secondary Sampler Operation

11.1 The items discussed in 11.2-11.6 of this practice apply regardless of whether the primary increments are collected by cross-belt, falling stream, or auger sampling devices. References are provided to applicable sections of Practice D 2234/D 2234M and Practice D 4916.

11.2 The following items should be checked for the primary sample hopper:

11.2.1 The primary sample hopper shall be enclosed to minimize moisture change and shall be of adequate size to hold the amount of primary increments collected.

11.3 The feeder from the primary sample hopper to a secondary sampler or to a sample crusher should distribute the coal flow over a long enough time interval so the required number of secondary increments are collected or to minimize pluggage of the sample crusher.

11.3.1 The feeder shall be enclosed to minimize moisture change and designed to prevent spillage.

11.3.2 A primary belt feeder or conveyor or both shall be provided with an effective wiper designed to discharge the wipings into the next unit of the mechanical sampling system, thus avoiding loss of sample.

11.4 If the primary feeder discharges the primary increment directly into a secondary sampler without intermediate crushing, the inspector should check the following items:

11.4.1 A minimum of six secondary increments shall be collected from each uncrushed primary increment as specified in section 8.2.1.2 of Practice D 2234/D 2234M and section 6.10.1.1 of Practice D 4916. The six or more secondary increments should be equally spaced throughout the entire flow of the primary increment.

11.4.2 Each secondary increment must conform to the minimum increment weight specified in Table 2 of Practice D 2234/D 2234M for nominal top size.

11.4.3 Secondary cutter velocity must be uniform across the entire coal stream and conform to the recommendations of the Increment Collection Method to be Used and the Characteristics and Movement of Sampling Device sections (7.2.2 and 7.5) of Practice D 2234/D 2234M, and the Speed of Sampling Device section (6.10.1.3) of Practice D 4916.

NOTE 2—The use of a stopwatch may not provide sufficient accuracy for short travel.

11.4.4 Cutter opening shall conform to the recommendations of the Dimensions of Sampling Device section (7.4) of Practice D 2234/D 2234M, and the Opening of Sampling Device section (6.10.1.2) of Practice D 4916.

11.4.5 The secondary cutter is out of the coal stream when in the *at rest* position. See 9.2.6 of this practice for precautions against leakage.

11.5 The sample crusher is fed from either the primary or secondary sampler by a feeder. The requirements and criteria for the secondary feeder are the same as for the primary feeder as described in 11.3 of this practice.

11.6 The sampling system can be designed to crush to an intermediate coal size, which in turn would be resampled before it would be fed to a secondary sampler crusher or, as is done in many sampling systems, to crush to the final sample size.

11.6.1 The sample crusher shall produce a product as required by design and shall be ample in size so as to be essentially free of plugging.

11.6.2 Performance of the sample crusher in achieving the designed particle-size distribution can be determined from the procedures and equipment prescribed in Test Method D 4749.

11.6.3 As specified in the Preservation of Moisture section of Practice D 2234/D 2234M, the flow of air through the sampling system shall be minimized. (Also see the Preservation of Moisture section (6.5) of Practice D 4916.) There are numerous devices for minimizing air windage in a sampling system, such as a pressure equalizing pipe connecting inlet to outlet of the crusher, air curtains, or baffles, and so forth.

12. Criteria for Tertiary or Final Sampler Operation

12.1 The criteria for tertiary or final sampler operation discussed in Section 11 of this practice apply regardless of whether the primary increments are collected by cross-belt, falling stream, or auger sampling devices. References are provided to applicable sections of Practice D 2234/D 2234M and Practice D 4916.

12.2 The operation of the tertiary sampler cutter should be observed to determine that the cutter cuts the full coal stream and that it does so in the manner described in the Characteristics and Movement of Sampling Device section (7.5) of Practice D 2234/D 2234M.

12.3 Tertiary cutter velocity must be uniform across the entire coal stream and conform to the recommendations of the Increment Collection Method to be Used and Characteristics and Movement of Sampling Device sections (7.2.2 and 7.5) of Practice D 2234/D 2234M, and the Speed of Sampling Device and Speed of Sampling Device (After Crushing) sections (6.10.1.3 or 6.10.2.3) of Practice D 4916.

12.4 The cutter opening shall conform to the Dimensions of Sampling Device section (7.4) of Practice D 2234/D 2234M, and 6.10.1.2 or 6.10.2.2 of Practice D 4916, which include the recommendation that the opening shall not be less than 30.0 mm (1¼ in.).

12.5 Minimum increment weight before sample crushing shall conform to Table 2 of Practice D 2234/D 2234M. At present, there are no minimum increment weights after crushing given in Practice D 2013.

12.6 The tertiary or final cutter will be out of the coal stream in the *at rest* position.

12.7 The sampler shall be enclosed to minimize moisture change as specified in the Preservation of Moisture section of Practice D 2234/D 2234M. (Also see the Preservation of Moisture section (6.5) of Practice D 4916.)

12.8 When there is a crushing stage, the paragraph on the number of increments under Procedure B of Practice D 2013 specifies for mechanical division of the sample that at least 60 increments be taken at each stage of division. Therefore, this criteria can be used for determining the minimum number of increments to be collected by the tertiary or final sampler. Although not required by the standard, it is good practice to have at least one increment at every stage of reduction for every primary increment.

13. Cautions for Collecting Final Sample

13.1 The cautions for collecting the final sample discussed in Section 12 of this practice apply regardless of whether the primary increments are collected by cross-belt, falling stream, or auger sampling devices. References are provided to applicable sections of Practice D 2234/D 2234M and Practice D 4916.

13.2 The container receiving the final sample increments shall be enclosed to minimize moisture change, as specified in the Preservation of Moisture section (7.7) of Practice D 2234/D 2234M. (Also see the Preservation of Moisture section (6.5) of Practice D 4916.)

13.3 The transfer pipe or chute from the final sampler to the final sample container should be as short as possible. There is a potential for significant moisture change if the relatively small amount of final sample falls through a long transfer pipe or chute.

14. General Considerations to be Observed by the Inspector

14.1 ASTM standards allow for flexibility in designing mechanical systems so that at any point in the division and reduction of the primary sample, such reduction and division can be done *online* in the mechanical sampling system or *offline* by a number of options and equipment specified in Practice D 2013. Practice D 2013 also specifies in Table 1 the minimum sample weight for four top sizes.

14.2 The conveyor belts shall be started and run for a period of time before the coal to be sampled is placed on the belt so that foreign substances (including water) are purged.

14.3 The mechanical sampling system should be started at some time in advance of the start of conveying coal. Where hydraulic drives are used, sufficient time should be allowed for the hydraulic oil and the associated system to reach temperature equilibrium. After reaching temperature equilibrium, cutter velocities should not change during sampling.

14.4 It is recommended that the inspector review any records or logs maintained by the operator. These records or logs may include such things as amounts of coal handled, amounts of coal sampled, and notations as to system malfunctions, stoppages, pluggages, or other deficiencies. The inspector may also wish to use a checklist, such as the example in Appendix X1, when actually conducting an inspection. It is recommended that the inspector complete all items on the checklist pertinent to the inspection. Such a checklist is also recommended for inclusion in the operator's records.

15. Keywords

15.1 coal sampling; inspection; mechanical sampling; sampling systems

ANNEX

(Mandatory Information)

A1. TEST METHOD FOR ESTIMATING THE OVERALL VARIANCE FOR INCREMENTS

A1.1 Scope

A1.1.1 This test method describes the procedure for estimating the overall variance for increments of one fixed weight of a given coal. It is applicable to mechanical sampling when there is no need to explore system and random variance components, but there is a need for obtaining the overall variance for increments (the size of increments is dictated by the sampling equipment).

A1.2 Procedure

A1.2.1 The following procedure should be used to determine the overall variance of increments:

A1.2.2 Collect two series of individual increments at widely spaced intervals, for example, a series of ten increments, two each day for five days, followed by a second series of ten collected in similar fashion. Both series must be from the same coal.

A1.2.3 Collect each increment by using as much of the equipment and procedure used in routine sampling operations as possible. Remove the individual increment from the sampling system without mixing with or contaminating by any other increment. Where possible, allow it to pass through any mechanical crusher or subsampler, or both, which is located in the system before the point of blending with other increments.

A1.2.4 Then weigh the individual increment (if desired for record purposes) and reduce to a laboratory sample by procedures identical as possible to those used in the routine preparation and reduction of gross samples.

A1.2.5 Analyze the sample for the constituents for which the variance calculations are to be made. Usually sampling specifications are based on dry ash, but where total moisture or as-received Btu is of particular concern, the analyses should be made for these.

TABLE A1.1 Variance Ratio Limit Values

1	2	3
Increment per Set	Variance Ratio Limit	"*C*" Factor
10	3.18	1.92
20	2.17	1.53
30	1.86	1.40
40	1.70	1.33
50	1.61	1.29

A1.3 Calculation

A1.3.1 For each series, compute a variance value from the analyses of the ten increments as follows:

$$s^2 = (\Sigma x^2 - (\Sigma x)^2/n)/(n - 1) \quad \text{(A1.1)}$$

where:

s^2 = variance value for series,
Σx^2 = sum of squares of ash results,
$(\Sigma x)^2$ = square of the sum of ash results, and
n = number of individual ash results in the series.

A1.3.2 For the two series, the ratio of the larger variance to the smaller should not exceed the value given in Table A1.1, Column 2. If they differ by less than this amount, the variances are combined to give the estimated overall increment variance for the coal as follows:

$$s_o^2 = C[(s_1^2 + s_2^2)/2] \quad \text{(A1.2)}$$

where:
s_o^2 = probable maximum value of the overall variance for increments,
C = factor from Table A1.1, Column 3, corresponding to the number of increments per set,
s_1^2 = s^2 from first series, and
s_2^2 = s^2 from second series.

A1.3.3 If the ratio of the larger variance to the smaller does give a greater value than the Table A1.1, Column 2 value, the two series are to be considered in a single set of increments, and another set equal to this enlarged set is to be taken. For example, if originally 2 sets of 10 increments were taken, these would be combined to give a set of 20. Then an additional set of 20 increments would be collected, giving 2 sets of 20 increments each. Variance values are computed for the two new series and the test is repeated using the appropriate factors given in Table A1.2. If these results have a ratio which is less than the appropriate value in Column 2 of Table A1.2, they are combined by using Eq A1.2 and used as the new variance for increments.

A1.3.4 *Example*—The example given in Table A1.2 illustrates the computation of the overall variance for increments, s_o^2. Two series of ten increments each are used.

TABLE A1.2 Determination of the Overall Variance for Increments[A]

Series 1			Series 2		
Increment Number, n	Dry Ash[B] (x)	(Dry Ash)[2B] $(x)^2$	Increment Number, n	Dry Ash[B] (x)	(Dry Ash)[2B] $(x)^2$
1	4.17	17.3889	11	3.07	9.4249
2	3.62	13.1044	12	4.88	23.8144
3	1.79	3.2041	13	5.14	26.4196
4	4.37	19.0969	14	3.63	13.1769
5	4.64	21.5296	15	3.17	10.0489
6	7.03	49.4209	16	7.20	51.8400
7	6.27	39.3129	17	3.52	12.3904
8	3.91	15.2881	18	0.87	0.7569
9	6.04	36.4816	19	0.72	0.5184
10	4.18	17.4724	20	4.78	22.8484
Sum	46.02	232.2998	Sum	36.98	171.2388

[A] This example involves increment weights in the approximate range from 45 to 90 kg (100 to 200 lbs).
[B] 10 % ash was subtracted from each of the ash results to simplify the calculations.

$$s^2 = (\Sigma(x)^2 - (\Sigma x)^2/n)/(n - 1)$$

Series 1:

$$s_1^2 = (232.2998 - (46.02)^2/10)/9 = 2.2795$$

Series 2:

$$s_2^2 = (171.2388 - (36.98)^2/10)/9 = 3.8319$$

Variance ratio limit from Table A1.1 = 3.18.
Variance ratio for two test series:

$$s_2^2/s_1^2 = 3.8319/2.2795 = 1.68 < 3.18$$

Since the computed value for the ratio is less than 3.18, variances are combined to give an estimate of the overall variance for increments, s_o^2:

$$s_o^2 = [1.92(2.2795 + 3.8319)]/2 = 5.867$$

APPENDIXES

(Nonmandatory Information)

X1. TYPICAL MECHANICAL COAL SAMPLER CHECKLIST

Company: ______________________________ Date: ______________________________
Sampler Location and Identification: ______________________________ Inspector: ______________________________

			Operators	Recommended Inspection Frequency
I.	General Information			
	(a) Weather conditions ______________________________			
	(b) Coal type (raw, clean, appearance, etc.) ______________________________			
	(c) Coal top size ______________________________			
	(d) Lot size ______________________________			
	(e) Feed rate (maximum and normal) ______________________________			
	(f) Purpose of sample ______________________________			
	(g) Source of coal (rail car, barge, truck, stockpile) ______________________________			
II.	Type of Sampling System	Falling Stream	______________	A Daily
		Cross-Belt	______________	B Monthly
		Auger	______________	C Each system operation
III.	Number of Stages		______________	
IV.	Start-up of Falling Stream and Cross-Belt Systems			
	(a) System Checked, started prior to sampling		______________	C
	(b) Fluid level		______________	C
	(c) Oil temperature equilibrium		______________	C
V.	General Observations of Augers			
	(a) Human discretion in auger placement		______________	C
	b) Auger placement patterns		______________	C
VI.	Primary Falling Stream and Cross-Belt Cutters			
	(a) Size opening		______________	B
	(b) Cutting full stream		______________	C
	(c) Uniform speed		______________	B
	(d) Velocity		______________	B
	(e) Interval between cuts		______________	B
	(f) Contamination or loss of sample by leakage		______________	B
	(g) Parked out of coal stream		______________	B
	(h) Sample hopper enclosed		______________	B
	(i) Number of cuts per lot		______________	
VII.	Augers			
	(a) Consideration of top size		______________	C
	(b) Depth of extraction		______________	C
	(c) Number of increments		______________	A
VIII.	Primary Sample Feeder			
	(a) Type		______________	
	(b) Enclosed		Yes ______ No ______	B
	(c) Feedrate		______________	B
	(d) Belt wiper		Yes ______ No ______	B
IX.	Secondary Cutter			
	(a) Size opening		______________	B
	(b) Cutting full stream		______________	C
	(c) Uniform speed		______________	B
	(d) Velocity		______________	B
	(e) Interval between cuts		______________	B
	(f) Contamination or loss of sample by leakage		______________	B
	(g) Parked out of coal stream		______________	A
	(h) Sample hopper enclosed		______________	B
	(i) Number of cuts		______________	B
X.	Secondary Sample Feeder			
	(a) Type		______________	
	(b) Enclosed		Yes ______ No ______	B
	(c) Feedrate		______________	C
	(d) Belt wiper		Yes ______ No ______	A
XI.	Sample Crusher			
	(a) Coal product top size		______________	B
	(b) Equalizing pipe		Yes ______ No ______	B
XII.	Tertiary Cutter			
	(a) Size opening		______________	B
	(b) Cutting full stream		______________	C
	(c) Uniform speed		______________	B
	(d) Velocity		______________	B
	(e) Interval between cuts		______________	B
	(f) Contamination or loss of sample by leakage		______________	B
	(g) Parked out of coal stream		______________	A
	(h) Sample hopper enclosed		______________	A
	(i) Number of cuts		______________	B
XIII.	Final Sample			
	(a) Enclosed container		Yes ______ No ______	C
	(b) Length and size used for sample chute		______________	B
	(c) Calculated weight of final sample from mechanical sampling system		______________	B
	(d) Actual weight of sample		______________	B
	(e) Ratio of actual sample weight (line XIII (d)) to lot size (line I (d))		______________	B

X2. MONITORING COAL SAMPLING RATIOS USING CONTROL CHARTS

X2.1 Scope

X2.1.1 This procedure may be used to monitor the consistency of coal sampling ratios obtained with common mechanical sampling system control settings of cutter operating intervals, cutter openings, cutter speeds (for falling-stream samplers), and belt speeds (for cross-belt samplers). Out-of-control conditions (see Section X2.4) or excessive variation (see Section X2.5) will serve to alert the operator to potential problems that need to be investigated.

X2.2 Rationale (Commentary)

X2.2.1 Practice D 2234/D 2234M suggests that sampling systems should be given a rough performance check as a matter of routine by comparing the weight or volume of the collected sample with that of the total flow of coal to ensure a constant sampling ratio (see Practice D 2234/D 2234M, 7.11). The procedure offered in this Appendix is one means of continual monitoring of the consistency of the sampling ratio using methodology following the general principles of the *ASTM Manual on Presentation of Data and Control Chart Analysis*. An explanation of the value and use of control charts is given in *Out of the Crisis*.[3]

X2.3 Data Collection and Charting Procedure

X2.3.1 For each lot sampled using a common sampling scheme, obtain and record the net weight of the sample collected at the final stage of mechanical sampling before any off-line sample preparation. Weights should be accurate to within 0.5 % of the weight recorded.

X2.3.2 Obtain and record the lot size (in Mg or tons) using belt scales or other similarly accurate device normally used for determining the lot size.

X2.3.3 Divide the sample weight by the lot size and express the result in pounds per 1000 kilograms or tons per 1000 metric tons.

[3] Deming, W.E., *Out of the Crisis*, MIT Center for Advanced Engineering Studies, 1986, pp. 309–370.

X2.3.4 Calculate the average sampling ratio $\bar{r}$ using Eq X2.1, where n is the number of sampling ratios in the chart and r_j is the ith sampling ratio in the series of ratios numbered 1 to n. The central line on the chart (CL) is equal to the average, $\bar{r}$.

$$\bar{r} = \frac{1}{n}\sum_{i=1}^{n} r_i \quad \text{(X2.1)}$$

X2.3.5 Calculate the average moving range $\bar{R}$ using Eq X2.2, where Abs denotes the absolute value.

$$\bar{R} = \frac{1}{n-1}\sum_{i=2}^{n} \text{Abs}\,(r_i - r_{i-1}) \quad \text{(X2.2)}$$

X2.3.6 Calculate the lower control limit line (LCL) and upper control limit line (UCL) as,

$$\text{LCL} = \bar{r} - 2.66\bar{R} \quad \text{(X2.3)}$$

$$\text{UCL} = \bar{r} + 2.66\bar{R}$$

NOTE X2.1—The values of these limits are such that if there is a common system of chance causes of variation (no special cause is present) there is only about 1 chance in 100 that a sampling ratio value will be either below the value LCL or above the value UCL.

NOTE X2.2—The constant 2.66 is not a function of the number of n of sampling ratios being charted.

X2.3.7 Plot the sampling ratios on a line chart, with the vertical axis denoting sampling ratio values the horizontal axis denoting dates (and times, if appropriate). Sampling ratios values should always be plotted in chronological order. Add the central line (CL), the lower control limit line (LCL), and the upper control limit line (UCL) to the chart. See Fig. X2.1.

X2.4 Detection of Special Causes (Out-of-Control Conditions)

X2.4.1 A special cause of variation is indicated if one or more values are either above the upper control line or below the lower control line.

X2.4.2 A special cause of variation is indicated when there is a run defined by one of the following:

(1) At least seven consecutive values are on one side of the central line.

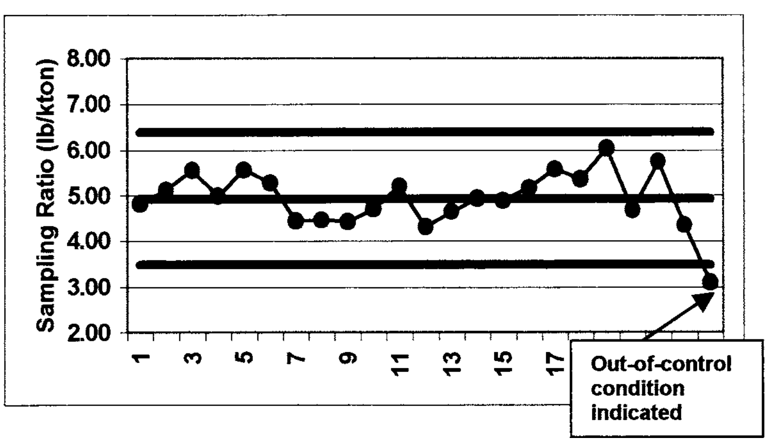

FIG. X2.1 Sampling Ratio Values

(2) At least ten out of eleven consecutive values are on one side of the central line.

(3) At least twelve out of fourteen consecutive points on one side of the central line.

X2.4.3 A special cause of variation is indicated if there is a trend indicated by at least seven consecutive points increasing continually or at least seven consecutive points decreasing continually.

X2.4.4 If no out-of-control conditions are indicated, the sampling system is considered to be stable and in-control.

X2.5 Monitoring the Coefficient of Variation

X2.5.1 When there are 20 or more sampling ratios charted ($n \geq 20$) and the system is stable, calculate the percent coefficient of variation (*%cv*) using,

$$\%cv = \frac{s_r(100)}{\bar{r}} \quad \text{(X2.4)}$$

where s_r is the sample standard deviation of the sampling ratios obtained from

$$s_r = \left[\frac{1}{n-1}\sum_{i=1}^{n}(r_i - \bar{r})^2\right]^{1/2} \quad \text{(X2.5)}$$

X2.5.2 A value for the *%cv* greater than 15 may indicate a need for system improvement. Among the items to be checked include the consistency of velocity of sampling system cutters; the cleanliness of oil and filters; hydraulic oil temperature variations; proper operation of all valves, cylinders, and pumps; the consistency of operation of timers; and the accuracy of the sample weights and lot sizes used in the calculations.

X2.6 Monitoring the Average Observed Sampling Ratio

X2.6.1 The division ratio d of either a falling stream or a cross-belt sampler is calculated from the following equation:

$$d = \frac{w}{tv} \quad \text{(X2.6)}$$

where:

w = the tip-to-tip cutter aperture width, in mm [in.],
t = the activation interval, in seconds, and
v = the velocity of the cutter (for falling stream samplers) or velocity of the conveyor belt (for cross-belt samplers) in mm/s [in./s].

X2.6.2 The division ratio d_{sys} for a sampling system consisting of *N* sampling stages is calculated from the following equation:

$$d_{sys} = d_1 d_2 ... d_N \quad \text{(X2.7)}$$

where:

d_1 = the division ratio for the primary stage
d_2 = the division ratio for the secondary stage, and
d_N = the division ratio for the Nth stage

X2.6.3 The expected value of the observed sampling ratio is the design sampling ratio (alternatively known as the theoretical sampling ratio). The value r_D, in kg per thousand Mg [pounds per thousand tons] is calculated from the following equation:

$$r_D = d_{sys} K \quad \text{(X2.8)}$$

where:

K = 1,000,000 [2,000,000]

NOTE X2.3—The term design sampling ratio means the sampling ratio expected (by design), given the specific set of operating parameters (w, t, v) for each sampling stage. If one or more of these operating parameters is changed at any stage of sampling, the design sampling ratio changes.

NOTE X2.4—The constant value K in Equation X1.8 converts the division ratio from a fraction to units of kg/1000 Mg [lb/1000 ton].

Table X2.1 illustrates an example of such calculations.

X2.6.4 When there are twenty or more observed sampling ratios charted with no out-of-control condition indicated and the %cv calculated using Eq. X1.4 is less than fifteen percent, compare the average observed ratio to the calculated design ratio. If the difference between the design ratio and the average observed ratio is greater than ten percent of the design ratio, an investigation of the cause is needed. One of the following may have occurred: *(1)* There is a significant error in one of the measured parameters w, t, or v for one or more stages of sampling. *(2)* There is a mechanical problem with the sampling system.

TABLE X2.1 Calculations of Systems Design Sampling Ratio

	w	t	v	d	r_D
Primary stage	6 in.	190 s	100 in./s	0.0003158	
Secondary stage	2 in.	21 s	14 in./s	0.0068027	
System				2.148E-06	4.30 kton/lb.