

WEST VIRGINIA DEPARTMENT OF TRANSPORTATION
DIVISION OF HIGHWAYS
CONTRACT ADMINISTRATION DIVISION

MATERIALS PROCEDURE

PROCEDURAL GUIDELINES FOR MAINTAINING CONTROL CHARTS
FOR AGGREGATE GRADATIONS

- 1.0 PURPOSE
- 1.1 To provide a standard method for developing and maintaining control charts to evaluate the grading characteristics of mineral aggregates.
- 2.0 SCOPE
- 2.1 Control charts shall be maintained where specified for sized aggregates, for bases and sub-bases, aggregates for Portland Cement and hot-mix asphalt, etc.
- 3.0 INTENT
- 3.1 It is the intent to have the procedure outlined hereinafter used in instances in which it can be reasonably and logically applied. The applicability of the procedure will normally depend on circumstances such as the number of samples, the continuity of delivery, etc. The moving average may not necessarily be continuous for the entire project. A new moving average series may be started after periods of inactivity, changes in materials or processes, change in job mix formula, resuming operations after correcting deficiencies, etc.
- 4.0 GENERAL
- 4.1 Paper Charts
- 4.1.1 Control charts should be prepared on 10 x 10 cross section paper approximately 25 inches wide. A chart length of approximately 30 inches should be displayed at all times. When standard cross section sheets are used, the most recent sheet must be displayed and all the previous sheets placed chronologically in a holder.

- 4.1.2 The item number and/or description of the material should be noted on the top of the chart and visible at all times.
- 4.1.3 Control charts will be maintained at the project office or at the testing site where applicable.
- 4.1.4 Scale - The control chart should have a vertical scale of one division equal to one percentage point (or one inch equal to 10 percent), except in the following cases: (a) a vertical scale of two divisions equal to one percentage point (or one inch equals five percent) should be used for any sieve which has a specification tolerance range less than ten percent, and (b) in the case of coarse aggregates used in Portland Cement concrete, a vertical scale of one division equal to 0.1 percentage point (or one inch equal to one percent) should be used for the #200 sieve.
- 4.1.5 On the horizontal scale the test values will be plotted on the heavy, vertical lines (one inch apart), progressing from the left to the right.
- 4.1.6 General Arrangement - Control charts are to be arranged on the cross section paper in the manner described below; an example of the arrangement is shown on Attachment I. [Note on the attachment the 10 X 10 squares are "stretched" vertically to allow the graph to fit the 8 1/2 by 11 paper]
- 4.1.7 The largest sieve size will be located toward the top of the chart and the smallest sieve size toward the bottom of the chart. The spacing between the lower limit of one sieve and the upper limit of the adjacent sieve should be a minimum of one inch.
- 4.1.8 The vertical scale for each sieve will be arranged so that the heavy lines will have a value of zero or a value which is a multiple of five. For instance, zero, five, ten, fifteen, etc.
- 4.1.9 Lines corresponding to the upper and lower limits of the specification will be drawn in red (pen or pencil) across the graph. At the beginning and end of each sheet (or length of the displayed portion) a vertical red line will be drawn between the specification limits of each sieve, an arrow will be placed at the end of each vertical line. The specification limits will be indicated above and below the arrows, and the sieve size and scale will be indicated between the limits on the outside of the displayed portion of the chart.

- 4.1.10 Inside the solid red lines, that define the specification limits, two green dashed lines will be drawn. (Note exception in Section 4.1.11). These lines will be located parallel to the specification lines and at a distance from each specification line equal to approximately twenty (20) percent of the specification range. The band (area) between the green dashed lines and the specification line will be known as the caution band. This band may be shaded a light yellow or amber to symbolize the caution which the contractor should exercise to prevent the quality of his/her work from going outside the specification limits.
- 4.1.11 For screens specifying only 100 percent passing, plotting of caution band is not applicable. Also when the lower specification limit is zero, plotting of the lower caution band is not necessary.
- 4.1.12 Plotting of Test Data - Individual test values will be plotted with a blue color pen, or pencil, using the symbol 0. [For paper charts the circle should be approximately 1/10 (0.1) inch in diameter]
- 4.1.13 Averages of consecutive test values will be plotted with a red color pen, or pencil, using the symbol . [For paper charts the square should be approximately 1/10 (0.1) inch on either side]
- 4.2 Computer Generated Charts
- 4.2.1 Computer generated charts using any standard variable control charting program may be used that allow hand plotting or computer plotting of the individual data and in a sequence that displays the applicable sieve sizes vertically from largest sieve size at the top of the display to smallest sieve size toward the bottom of the display in the least number of pages as practical when printed. The screen display should show horizontally on any given sieve at least eight potential data areas.
- 4.2.2 The item number and/or description of the material should be noted on the top of the chart and visible at all times.
- 4.2.3 Control charts will be maintained at the project office or at the testing site where applicable. These charts must be kept current, printed daily when applicable, and prominently displayed vertically in the specified sieve sequence (from largest sieve to smallest sieve). When printed, the most recent sheet(s) should be displayed and the previous sheets shall be placed chronologically in a holder.

- 4.2.4 Scale - To the extent possible, the control chart should have a vertical scale which visualizes the differences in tolerances limits between the specified sieves.
- 4.2.5 On the horizontal scale the test values should be plotted on heavy, vertical lines, progressing from the left to the right.
- 4.2.6 General Arrangement - Control charts are to be arranged on the computer screen (and when printed and displayed) in the manner described hereinafter.
- 4.2.7 The largest sieve size will be located toward the top of the chart and the smallest sieve size toward the bottom of the chart. The spacing between the lower limit of one sieve and the upper limit of the bordering sieve should be such that a clear demarcation between sieves is provided.
- 4.2.8 The vertical scale for each sieve will be arranged so that the heavy lines will have a value of zero or a value which is a multiple of five. For instance zero, five, ten, fifteen, etc.
- 4.2.9 General construction of the control chart should be the same as described in Sections 4.1.9 through 4.1.13 as applicable.
- 5.0 PLOTTING TEST DATA
- 5.1 Symbols and Color Code
 - 5.1.1 Individual test values will be plotted in a blue color using the symbol described in Section 4.1.12.
 - 5.1.2 Averages of consecutive test values will be plotted with a red color using the symbol described in Section 4.1.13.
- 5.2 Individual Test Values and Moving Average
 - 5.2.1 Test values will be rounded to the nearest whole percentage point and plotted, except the No. 200 sieve will be rounded to the nearest one tenth (0.1) percentage point then plotted.
 - 5.2.2 The average at the start of the job begins with the second sample result. This average will be plotted on the appropriate line on the control chart. Likewise the average is continued for the third through fourth result, averaging all previous results and plotting each of these averages on the appropriate line on the control chart. The moving average will be considered to be the average of five

consecutive test values and is determined by starting with the fifth test value and averaging it with the four preceding test values. Thereafter only the last consecutive five sample result will be averaged, i.e., second test value through sixth test value, third test value through seventh test value, and so forth. All averages will be plotted on the control chart in the manner described in Section 4.1.13 and rounded in the manner described in Section 5.2.1.

- 5.2.3 As successive symbols are plotted across the control chart, from left to right, the blue symbol  (individual value) will be connected with a dashed blue line as depicted in Attachment 1, and the red symbols  will be connected with a solid red line as depicted in Attachment 1.
- 5.2.4 All additional samples, if taken, will be plotted on successive heavy vertical lines and treated in the same manner as above.
- 5.2.5 At the bottom of the cross section paper, or below the last (smallest) represented sieve size printed from the computer, and immediately left of the vertical line on which test data is plotted, the following information will be written:
- 1) The laboratory number assigned to the test.
 - 2) The initials of the person plotting the test data.
 - 2) The date the sample was taken.
- 6.0 INDIVIDUAL OR MOVING AVERAGE TEST VALUES OUTSIDE THE SPECIFICATIONS
- 6.1 Individual Test Values
- 6.1.1 When the individual test value on a sieve is outside the specification limits, or differs markedly from those preceding it, the Project Engineer/Supervisor and the contractor will be promptly advised. The contractor will immediately take any steps that may be necessary to bring the production under control.
- 6.2 Moving Average
- 6.2.1 When an average value of consecutive tests falls in the caution zone the contractor will be advised that the material is, or is becoming, borderline, and the following notation will be made in the plant or project diary:

"Contractor advised that _____ material is borderline". (Write item number for base course or aggregate size and item number for other material in the blank space).

6.3 Material Outside Specification Limits

- 6.3.1 When three consecutive individual test values are outside the specification limits or when an average of consecutive tests falls outside the specification limits the contractor will be promptly advised that the material is non-conforming, and the contractor will immediately take any necessary steps to correct the deficiencies. When an average falls outside of the specification limits and the two immediately following individual test values are also outside the specification limits, operations will be discontinued until the contractor gives reasonable assurance that the deficiency has been corrected. After the contractor has taken significant steps to correct the deficiency the next individual sample that meets the specifications after production is resumed will be used to start a new average.



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Attachment

