VIRGINIA'S EXPERIENCE WITH A QUALITY ASSURANCE AND ACCEPTANCE SPECIFICATION FOR ASPHALTIC CONCRETE

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The Virginia Department of Highways has used a statistical quality assurance and acceptance specification for asphaltic concrete production since 1968. During this period, nearly 3 million tons of plant mix have been bought under this specification. The major benefits derived from use of the specification include a clear-cut understanding between the producer and the state as to control and acceptance responsibilities. Also, a large decrease in acceptance testing with no change in quality has occurred. Some aspects of the specification, however, could be improved by slight modifications.

•THE Virginia Department of Highways has had a quality assurance and acceptance specification for the control of the density of asphaltic concrete in effect since 1965 (1). This specification is now employed in the construction of most flexible pavements on the primary and Interstate systems. Encouraged by the success of this specification, the Department instituted in 1968 an acceptance specification for asphaltic concrete production (the Appendix contains the latest revision). During 1968, this specification was used on 3 construction projects and 1 maintenance schedule. The following year, 5 construction projects and 2 maintenance schedules were let to contract under the specification. In 1970, practically all of the asphaltic concrete used in construction and maintenance, more than 1.2 million tons, was bought under this acceptance specification. In 1971, the total exceeded 1.4 million tons. The specification is used on both state and federally financed projects; the Federal Highway Administration approves the latter on a project-by-project basis. It is used on all projects having more than 4,000 tons of one mix type. The reason for this practice is primarily administrative because the state's personnel force is small at asphalt plants producing very limited quantities.

SPECIFICATION

In a specification for the acceptance of asphaltic concrete, many items must be included to ensure a quality material; and many additional items must be included to ensure a clear understanding of the respective responsibilities of the consumer and the producer. It is imperative that the producer realize that his responsibility lies in supplying a product that will meet specifications and that the consumer realize that he has the responsibility of testing the product for acceptance.

The 5 elements discussed below are necessary in any thorough acceptance specification. Virginia's method of handling these elements is indicated in the discussion. (Elements 1 through 4 are based primarily on technical and administrative considerations and not statistical ones.)

1. The specification must identify the place of testing. The asphalt plant is designated because sampling and testing can be done quicker and more conveniently there than elsewhere. (Before this specification was written, the point of testing was not stated. Sometimes the asphaltic concrete was tested at the plant, sometimes at the district lab, and sometimes at both places. The establishment of a single place for acceptance testing is important.)

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2. The method of test must be prescribed and must not be changed. The reflux extractor is designated. (Although this method is not so rapid as the centrifuge, it is more accurate. It is important to state the method of test because the tolerances are based on it. If the test method is changed, new acceptance limits must be established.)

3. A definite lot size must be stated. Originally, the lot size was 2,000 tons, which was thought to be generally compatible with previous testing rates. This was subsequently modified as will be discussed later. (A great deal of discussion accompanied the decision to use a lot size of tons rather than one based on a time period, such as a day's production. In the end, the decision was based on administrative considerations, the primary one being the number of personnel normally assigned to a plant.)

4. The specification must state the number of tests to be obtained per lot. Four tests per lot are used to judge acceptance because this number is generally compatible with the lot size determined by previous testing rates.

5. Naturally, the elements to be tested for acceptance and the tolerances to be applied must be stated. In the Virginia specification, acceptance is determined by the application of a tolerance to the average of 4 samples for the process average of each lot. The allowable variability is based on the overall standard deviation of a particular mix for the entire project.

Ideally, the contractor should run his own control tests and not rely on the state for guidance. This suggestion is not at present very realistic because many contractors are not familiar with control testing. Therefore, strictly to aid the contractor, the state's inspection personnel plot the acceptance data in the form of a control chart for the contractor's use if he so desires.

In any acceptance specification, provision must be made for handling material that does not meet the established tolerances. If the state is not going to control the product and thus infringe on the contractor's prerogative, there is a need to apply an adjustment factor to that material not meeting the tolerances. The adjustment procedure is spelled out so that the contractor at any time knows what, if any, adjustment will be made.

BENEFITS

A natural question is, Why are quality assurance and acceptance specifications desirable? Under the specification at hand, 2 advantages are evident thus far.

First, the specification required detailed decisions concerning what the state really wanted in the way of asphaltic concrete and how this material could be specified. The discussions leading to these decisions were very enlightening technologically and administratively. Some of the facets that had to be considered were (a) changes in the tolerances to make them compatible with normal production; (b) complete confidence in the plant inspection personnel, who after all actually become purchasing agents of the material; and (c) clear realization that plant control is the contractor's responsibility.

Second, the amount of acceptance testing has been greatly reduced. As a typical example, a project completed in 1970 required 37,267 tons of asphaltic concrete. The old specification under which this project was let to contract required 121 control tests and 114 acceptance tests for a total of 235 tests. Under the present acceptance specification, 75 tests would have been required—a reduction of 38 percent in acceptance tests and 68 percent in total tests.

One might also ask whether the quality of the product is sacrificed in the acceptance procedure that requires fewer tests. It will be shown later that the material being produced under the present specification is essentially the same as that produced in the past under a combination acceptance and control procedure.

REVISIONS OR MODIFICATIONS

A new specification generally must be revised or modified as a result of the experience gained in applying it on a daily basis. For this specification, a cooperative study (2) was established with the Federal Highway Administration to analyze the data collected in 1970.

Even before the cooperative study, a need for modification was realized on large projects for which asphalt plants were producing 4,000 tons or more per day. Under the original specification this amount of material would have necessitated 8 or more tests per day, which was impossible under the manpower and equipment constraints found at the plants. To alleviate this problem, the specification was modified to increase the lot size to 4,000 tons on contracts calling for more than 50,000 tons.

Several of the conclusions from the cooperative study are discussed below.

Comparison of Asphalt Production

One of the first conclusions from the study of the 1970 data was that the asphalt produced was amazingly similar to that produced in 1967, from which the tolerances for the acceptance specification were derived. Some explanation is necessary for the data given in Tables 1 and 2, which show the closeness of the test results for the material produced in these 2 years. It should be noted that the acceptance specification was not introduced to upgrade the quality of the asphaltic mixes.

The ability of a plant to remain within the process tolerances for each sieve and the asphalt content is based on 2 production characteristics:

1. An ability to "hit" the job mix, which is determined by taking the difference between the job mix and the production average, and
2. The production variability, which is simply the production standard deviation and is numerically equivalent to 2 standard errors because the sample size per lot is 4.

When these 2 characteristics are combined, the "total" value is best described by data shown in Figure 1 for the 1970 I-2 mix, No. 4 sieve. The tolerance for this sieve is 4.5 percent measured from the job mix. The data analyzed for 39 projects indicated that the production average missed the job mix by 1.50 percent, and the measured standard deviation (or 2 standard errors) equaled 2.68 percent, for a total value of 4.18 percent.

As long as the sum of the combined values for a majority of the projects is close to the tolerance, the tolerance can be considered satisfactory; however, when the combined value consistently exceeds the tolerance, then the tolerance should be increased. Conversely, if the total variability does not consistently approach the tolerance, then the tolerance should be decreased.

Admittedly, this concept is somewhat foreign to the usual statistical approach of control limits. However, because the job mix is consistently different from the production average, as data given in Table 1 demonstrate, this approach appears rational.

Data given in Table 1 indicate that the acceptance system induced no changes in the overall asphaltic concrete production.

Method of Variability Acceptance

One of the few complaints from contractors related to the method of variability acceptance. One of the greatest concerns is that the test results be immediately available so that the contractor can know whether he should institute plant changes in order to avoid price adjustments. The lot size used in the present specification provides the needed information for the process average very well. However, the variability acceptance is not determined until the entire project is finished. Although the contractors could have determined their own variability at any time, this point was somewhat disconcerting to them.

To develop an alternative to the present variability procedure, if one were needed, we analyzed the 1970 data by determining the range on each lot as an estimate of the standard deviation because of the simplicity of this determination and because it is the commonly accepted statistical method of determining the variability in production processes.

In this analysis, the first question that had to be answered was how well the range predicted the standard deviation. The statistical formula for predicting the standard deviation, s, from the range, R, for sample groups of 4 is

$$s_r = R \times 0.5$$

Figure 1. Concept of "total" value.

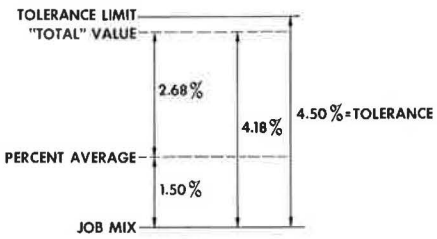


Table 1. Process tolerances.

Item	JM-$\bar{X}$	S	Total
Sieve			
3/4 in.	2.0	3.5	5.5
1/2 in.	2.0	3.5	5.5
3/8 in.	2.0	3.5	5.5
No. 4	1.5	3.0	4.5
No. 8	1.5	3.0	4.5
No. 30	1.5	3.0	4.5
No. 50	1.0	2.0	3.0
No. 200	0.5	1.0	1.5
Asphalt content	0.25	0.25	0.5

Note: JM-$\bar{X}$ = job mix less production average; S = production standard deviation; and total = sum of the 2 values.

Table 2. Summary of average standard deviations and differences between job mix and production average.

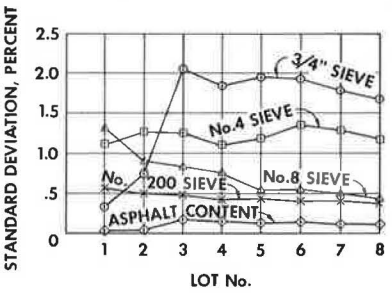
	1967*						1970								
	Mix I-2			Mix S-5			Mix B-3			Mix I-2			Mix S-5		
Item	JM-$\bar{X}$	S	Total	JM-$\bar{X}$	S	Total	JM-$\bar{X}$	S	Total	JM-$\bar{X}$	S	Total	JM-$\bar{X}$	S	Total
Sieve															
3/4 in.	2.63	0.79	3.42				1.39	2.75	4.14						
3/8 in.	1.09	3.10	4.19	2.95	1.54	4.49				1.82	3.30	5.12	1.57	1.37	2.94
No. 4	2.49	3.09	5.58	2.35	2.90	5.25	1.85	2.91	4.76	1.50	2.68	4.18	2.02	2.90	4.92
No. 8	1.67	2.68	4.35	1.49	2.89	4.38	1.26	2.53	3.79	1.94	2.20	4.14	1.29	2.79	4.08
No. 30				1.18	1.74	2.92							1.37	1.87	3.24
No. 50	0.75	1.29	2.04	1.60	1.39	2.99				1.10	1.15	2.25	0.82	1.31	2.13
No. 100	0.97	1.14	2.11	1.02	1.41	2.43									
No. 200				0.55	1.17	1.72	0.52	0.61	1.13	0.60	0.64	1.24	0.59	0.76	1.35
Asphalt content	0.08	0.22	0.30	0.09	0.24	0.33	0.10	0.22	0.32	0.15	0.24	0.39	0.12	0.22	0.34

Note: JM-$\bar{X}$ = job mix less production average; S = production standard deviation; and total = sum of the 2 values.
*No mix B-3 was tested during 1967.

Table 3. Standard deviation versus range estimate.

	Base		Intermediate		Surface	
Item	s	s_r	s	s_r	s	s_r
Sieve						
3/4 in.	2.75	2.73	—	—	—	—
3/8 in.	—	—	3.07	3.43	1.37	1.44
No. 4	2.91	2.79	2.67	2.79	2.90	3.03
No. 8	2.53	2.45	2.42	2.66	2.79	2.93
No. 30	—	—	—	—	1.63	1.93
No. 50	—	—	1.15	1.17	1.30	1.87
No. 200	0.61	0.57	0.62	0.64	0.76	0.84
Asphalt content	0.22	0.22	0.24	0.24	0.21	0.23

Figure 2. Typical association between plant variability and time.



where s_r is the standard deviation estimated from the range.

Table 3 gives the average calculated standard deviation and the average standard deviations estimated for the range for each mix type. These values were also determined on a project-by-project basis, and the F-ratio was determined from the 2 variances. The F-values were checked for significance at the 95 percent confidence level, and a significant difference was found in only 10 out of 637 cases. The absence of significant differences and the closeness of the average results are certainly evidence that the range method can accurately and consistently predict the standard deviations and that there is no statistical reason for not using the range method as a variability acceptance procedure.

Variability Versus Length of Operation

During the development of the acceptance specification, there was some contention that for the first day or two of plant operation the variability is much higher than it is after the process has been running for a while. Contractors thought that because this argument might be valid the test results for the first 1,000 or so tons should not be used in the variability criterion. In order to verify or refute this contention we made an analysis of accumulated standard deviations plotted against the number of lots tested. This analysis resulted in a graph for each mix and project as shown in Figure 2. The graphs were examined visually, and the variability of each sieve was judged to be either stable, increasing, or decreasing.

The first observations were that about 50 percent of the project variabilities tended to remain stable, and slightly more increased than decreased. It also appeared that the variabilities of the No. 200 sieve and the asphalt content tended to remain more stable than did those for the other sieves. These observations tend to refute the contention that the variability decreases over time of operation.

OBSERVATIONS

Administrators of the Virginia Department of Highways appear to be very satisfied with the operation of the specification. It is obvious that the product being purchased has not diminished in quality, and yet inspection costs have decreased appreciably. Contractors took a wait-and-see attitude on the new specification and, naturally, felt some trepidation. However, after 2 years, by and large they feel that it is successful and that they are getting acceptance and yet are allowed to control their processes as they wish. The acceptance specification is viewed as a progressive step and has led to the use of similar specifications in other areas.

ACKNOWLEDGMENT

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REFERENCES

1. Hughes, C. S. Methods of Compaction Control. AAPT Proc., Vol. 36, 1967.
2. Runkle, S. N., and Hughes, C. S. Review of a Bituminous Concrete Statistical Specification. Virginia Highway Research Council, May 1971.

APPENDIX

SPECIAL PROVISIONS FOR SECTION 212, BITUMINOUS CONCRETE (STATISTICAL QUALITY CONTROL SPECIFICATION, revised 4-1-71)

Section 212.03 of the 1970 specifications is completely replaced by the following:

Section 212.03: Job-Mix Formula—The contractor shall submit, for the Engineer's approval, a job-mix formula for each mixture to be supplied for the project prior to starting work. The job-mix formula shall be within the design range specified in Table A-I, Bituminous Concrete Mixtures, for the particular type of bituminous concrete specified. The job-mix formula shall establish a single percentage of aggregate passing each required sieve size, a single percentage of bituminous material to be added to the aggregate and a single temperature at which the mixture is to be produced. The job-mix formula for each mixture shall be in effect until modified in writing by the Engineer.

Materials from more than one source shall not be used alternately nor mixed when used in surface courses without the written consent of the Engineer. Where additional sources of materials are approved, a job-mix formula shall be established and approved before the new material is used. When unsatisfactory results or other conditions make it necessary, the Contractor shall prepare and submit a new job-mix formula for approval. Approximately one week may be required for the evaluation of a new job-mix formula.

The Marshall design density of a mixture shall not exceed 98.0 percent of the theoretical maximum density. In the event Marshall densities begin to exceed 98 percent of theoretical maximum density during construction the Contractor shall alter the grading of the aggregate or otherwise shall obtain his aggregate from a different source.

Section 212.06 is completely replaced by the following:

Section 212.06: Plant Inspection—The preparation of all bituminous mixtures shall be subject to inspection at the plant. For this purpose the Contractor shall provide a suitable building to be used as a field laboratory in accordance with requirements of Supplemental Specifications for Section 517. The Contractor shall

Table A-I. Bituminous concrete mixtures (design range).

Type	Percentage by Weight Passing Square Mesh Sieves *											Percent Bitumen	Mix Temperature (At Plant)
	2	1 - 1/2	1	3/4	1/2	3/8	No. 4	No. 8	No. 30	No. 50	No. 200		
S-1							100	94 - 100	69 - 77	38 - 49	2 - 6	8.5 - 10.5	245 - 280°F
S-2						100	91 - 100	69 - 77	26 - 34	16 - 24	4 - 8	9.5 - 12.0	245 - 280°F
S-3						100	88 - 100	79 - 87	36 - 44	21 - 29	5 - 9	6.5 - 10.5	210 - 220°F
S-4					100	88 - 100	76 - 90	66 - 74	31 - 39	16 - 24	4 - 8	5.5 - 9.5	245 - 280°F
S-5					100	83 - 97	53 - 67	41 - 49	19 - 27	11 - 19	4 - 8	5.0 - 8.5	245 - 280°F
I - 1			100	88 - 100		86 - 100	81 - 95	74 - 82	39 - 47	20 - 28	4 - 8	5.0 - 7.5	245 - 280°F
I - 2			100	95 - 100		63 - 77	43 - 57	31 - 39		6 - 14	2 - 6	4.5 - 8.0	245 - 280°F
B-1			100	88 - 100			78 - 92	71 - 79	41 - 49	22 - 30	2 - 6	3.0 - 6.5	245 - 280°F
B-2		100		56 - 70			21 - 35	16 - 24			1 - 5	4.0 - 6.0	210 - 220°F
B-3		100		73 - 85			38 - 48	28 - 35			2 - 6	4.0 - 7.0	245 - 280°F
B-4	100	88 - 100		78 - 92			51 - 65	44 - 52	26 - 34		5 - 13	2.5 - 4.0	245 - 280°F
P-1						100	86 - 100	76 - 84	36 - 44	21 - 29	5 - 7	6.5 - 9.5	145 - 155°F
P-2					100	83 - 97	53 - 67	41 - 49	19 - 27	9 - 17	4 - 8	6.5 - 8.5	145 - 155°F
P-3				100		63 - 77	38 - 52	24 - 32			1 - 5	5.5 - 7.5	145 - 155°F

* In inches, except where otherwise indicated. Numbered sieves are those of the U. S. Standard Sieve Series.

furnish, maintain and replace as condition necessitates, the following testing equipment:

2 reflux extractors (2,000 gram capacity)
2 electric hot plates (thermostatically controlled) suitable for use with the above reflux extractors
(One additional reflux extractor and one additional electric hot plate shall be furnished for each 1,000 tons of material produced per day in excess of 2,000 tons except when a lot size of 4,000 tons is used.)
1 beam-type balance meeting the following minimum requirements:
(a) Capacity—Not less than 2,000 grams
(b) Dial—"Over" and "under" with center mark
(c) Beam—12 inch minimum length, 100 gram capacity, notched in increments of 1 gram, with hanging and self-locking poise counterweight
1 set of graduated gram weights
1 electric hot plate or oven for drying sample (temperature range to at least 300° F)
1 mechanical sieve shaker
1 set of sieves (2" through #200 mesh)
1 separator for separating the plus and minus ¾ inch material for bituminous concrete base courses (Minimum dimensions of ¾ inch sieve shall be 12 inches by 12 inches.)
1 set of milk scales
miscellaneous supplies—pans, brushes, scoops or large spoons, several 1,000 ml. graduated beakers and an adequate supply of running water, which is not to exceed 80° F in temperature, shall be provided.

The above mentioned equipment shall be installed ready for operation in a field laboratory meeting the requirements of Supplemental Specifications for Section 517. Additionally, the building shall be adequately ventilated by exhaust fan.

The requirements stated hereinabove shall not be construed as a nullification of the requirements of Sections 106.05 and 200.01.

The Department's representative shall have ready access to all parts of the plant for checking the accuracy of the equipment in use, inspecting the condition and operation of the plant and for any purpose in connection with the materials and their processing.

Section 212.29 is added as follows:

Section 212.29: Acceptance—Sampling for determination of gradation and asphalt content will be performed at the plant, and no further sampling will be performed for these properties. However, should visual examination reveal that the material in any batch or load is obviously contaminated, deficient in asphalt content or not thoroughly mixed, that batch or load will be rejected without additional sampling or testing of the lot. In the event it is necessary to determine, quantitatively, the quality of the material in an individual batch or load, one sample (taken from the batch or load) will be tested and the results compared to the "process tolerance for one test" as described hereinbelow. The results obtained in the testing of a specific individual batch or load will apply only to the batch or load in question. Gradation and asphalt content determinations will be performed in the plant laboratory furnished by the Contractor; however, the Department reserves the right to discontinue the use of the plant laboratory for acceptance testing in the event of mechanical malfunctions in the laboratory equipment and in cases of emergency involving plant inspection personnel. In the event of such malfunctions or emergencies, acceptance testing will be performed at the District or Central Office laboratory until the malfunction or emergency has been satisfactorily corrected or resolved.

Acceptance for gradation and asphalt content will be based upon a mean of the results of four tests performed on samples taken in a stratified random manner from each 2,000 ton lot (4,000 ton lot when the contract item is in excess of 50,000 tons).

A lot will be considered to be acceptable for gradation and asphalt content if the mean of the results obtained from the four tests fall within the following process tolerances allowed for deviation from the job-mix formula:

Sieve	Process Tolerance (percent passing)
Top size	±0.0
1½"	5.5
¾"	5.5
½"	5.5
⅜"	5.5
#4	4.5
#8	4.5
#30	4.5
#50	3.0
#200	1.5
Asphalt content*	0.5

*Asphalt content will be measured as extractable asphalt.

In the event asphalt input is monitored by automated recordation, the above process tolerance for asphalt will not apply. Variability control for asphalt content will be evaluated based upon extractable asphalt. At any time the asphalt content, as evidenced by automated recordation, deviates more than ±0.2 percent from that shown in the job-mix formula, the production shall be halted and corrective action taken to bring the asphalt content to within this tolerance.

The temperature of the mixture at the plant shall not vary more than ±20° F from the approved job-mix temperature. The temperature of the mixture at the time of placement in the road shall not be more than 30° F below the approved job-mix temperature. Loads which do not conform to these temperature tolerances will be rejected.

In the event that the job requires less than 2,000 tons of material; or that the amount of material necessary to complete the job is less than 2,000 tons (4,000 tons for contract items in excess of 50,000 tons); or that the job-mix formula is modified within a lot, the mean results of samples taken will be compared to a new process tolerance, computed as follows:

Process tolerance for one test = process tolerance for mean of four tests/0.5
Process tolerance for mean of two tests = process tolerance for mean of four tests/0.7
Process tolerance for mean of three tests = process tolerance for mean of four tests/0.9

Individual test results and lot averages obtained from acceptance testing will be plotted on control charts as the information is obtained. Standard deviations, when computed, will be made available to the Contractor. However, the Inspector will in no way attempt to interpret test results, lot averages or standard deviations for the Contractor in terms of needful plant or process adjustments.

Section 212.30 is added as follows:

Section 212.30: Adjustment System–An adjustment of the unit bid price will not be made for the value of one test result or the mean value of two or three test results, unless circumstances as stated in Section 212.29 require that the lot size be less than 2,000 tons (4,000 tons for contract items in excess to 50,000 tons). Should the value of one test result or the mean value of two or more test results, as required by Section 212.29 fall outside the allowable process tolerance, an adjustment will be applied to the unit bid price as follows:

Sieve	Adjustment Points for Each 1 Percent That the Gradation Is Out of Process Tolerance
2"	1
1½"	1
1"	1
¾"	1
½"	1
⅜"	1
#4	1
#8	1
#30	2
#50	2
#200	3

A one point adjustment will be applied for each 0.1 percent that the material is out of the process tolerance for asphalt content.

In the event the total adjustment for a lot is greater than 25 points, the failing material shall be removed from the road. In the event the total adjustment is 25 points or less and the Contractor does not elect to remove and replace the material, the unit price paid for the material will be reduced 1 percent of the unit price bid for each adjustment point. The adjustment will be applied to the tonnage represented by the sample or samples.

The Contractor shall control the variability of his product in order to furnish the project with a uniform mix. When the contract item is greater than 4,000 tons and an adjustment is necessary as indicated in the following table, it shall be for the entire quantity of that type material on the project based upon its variability as measured by the standard deviation.

Sieve Size and Asphalt Content	Standard Deviation		
	1 Adjustment Point	2 Adjustment Points	3 Adjustment Points
1½"	4.6-5.5	5.6-6.5	6.6-7.5
¾"	4.6-5.5	5.6-6.5	6.6-7.5
½"	4.6-5.5	5.6-6.5	6.6-7.5
⅜"	4.6-5.5	5.6-6.5	6.6-7.5
#4	4.6-5.5	5.6-6.5	6.6-7.5
#8	4.1-5.0	5.1-6.0	6.1-7.0
#30	4.1-5.0	5.1-6.0	6.1-7.0
#50	3.1-4.0	4.1-5.0	5.1-6.0
#200	2.1-3.0	3.1-4.0	4.1-5.0
Asphalt content	0.33-0.42	0.43-0.52	0.53-0.62

The unit bid price shall be reduced by 0.5 percent for each adjustment point applied.

The disposition of material having standard deviations larger than those shown in the table, shall be determined by the Engineer.

Section 212.31 is added as follows:

Section 212.31: Referee System—(a) In the event the test results obtained from one of the four samples taken to evaluate a particular lot do not appear to be representative, the Contractor or the Engineer may request that the results of the questionable sample be disregarded; whereupon, tests will be performed on five additional samples taken from randomly selected locations in the roadway where the lot was placed. The test results of the three original (unquestioned) samples

will be averaged with the test results of the five road samples and the mean of the test values obtained for the eight samples will be compared to the following process tolerance:

Process tolerance for mean of eight tests = process tolerance for mean of four tests/1.4

(b) In the event the Contractor elects to question the mean of the four original test results obtained for a particular lot, he may request additional testing of that lot. Upon receipt of written request for additional testing, the Department will test four samples taken from randomly selected locations in the roadway where the lot was placed. The test results of the original four samples will be averaged with the test results of the four additional road samples and the mean of the test values obtained for the eight samples will be compared to the "process tolerance for mean of eight tests" as described hereinabove.

In the event the mean of the test values obtained for the eight samples is within the process tolerance for the mean of the results of eight tests, the material will be considered acceptable. In the event the mean of the test values obtained for the eight samples is outside of the process tolerance for the mean of the results of eight tests, the lot will be adjusted in accordance with the adjustment rate specified hereinabove.

Additional tests, requested by the Contractor under the provisions of Section 212.31 (a) and (b), will be paid for by the Contractor in the event the mean of the test values obtained for the eight samples falls outside of the process tolerances. Such additional tests shall be paid for at a rate of five times the bid price per ton of material per sample.