



SECTION 502

PORTLAND CEMENT CONCRETE BASE AND PAVEMENT

502.1 Description. This work shall consist of constructing a Portland cement concrete base or pavement, with or without reinforcement as specified, shown on the plans or directed by the engineer.

502.2 Material. All material, proportioning, air-entrainment, mixing, slump and transporting for Portland cement concrete shall be in accordance with [Sec 501](#). All material shall be in accordance with Division 1000, Material Details, and specifically as follows:

Item	Section
Emulsified Asphalt (SS-1, SS-1H, CSS-1 or CSS-1H)	1015
Steel Welded Wire Reinforcement for Concrete	1036
Concrete Curing Material	1055
Material for Joints	1057

502.3 Equipment. Equipment and tools necessary for handling material and performing all parts of the work shall be satisfactory to the engineer as to design, capacity and mechanical condition. The equipment shall be at the job site sufficiently ahead of the start of construction operations to be examined thoroughly by the engineer and shall be in accordance with the following:

502.3.1 Batching Plant, Mixer and Hauling Equipment. The batching plant, mixer, water measuring equipment, weighing and hauling equipment shall be in accordance with [Sec 501](#).

502.3.2 Slip-Form Construction. Concrete base or pavement may be constructed by the use of sliding form methods. Slip-form construction shall be in accordance with these specifications.

502.3.2.1 Consolidating and Finishing Equipment. The concrete shall be consolidated and finished by a slip-form paver designed to spread, consolidate and shape the concrete in one complete pass of the machine in such a manner to provide a smooth, dense and homogeneous pavement in conformance with the plans and specifications. No apparent slumping of the concrete shall occur within 6 inches of the pavement edge. If necessary to stop the forward movement of the paver, the vibratory and tamping elements shall be stopped immediately.

502.3.3 Vibrators. Vibrators used for full width vibration of the concrete shall be of the internal type. Vibrating equipment shall be operated in accordance with the manufacturer's recommendation at a frequency to provide satisfactory results, but shall be no less than 4500 impulses per minute. Hand vibrators shall have a frequency of no less than 4500 impulses per minute. The contractor shall have a tachometer available at all times for checking the vibration frequency.

502.3.4 Concrete Saw. If sawed joints are required, equipment shall be capable of providing a groove of the specified dimensions in the concrete. Equipment shall be a wet-cut saw, referred to as a "conventional concrete saw" or a lighter weight dry-cut saw, referred to as an "early-entry concrete saw," used to establish joints sooner than the conventional saw.

502.3.5 Equipment for Sealing Joints. An approved double boiler-type heating kettle equipped with a mechanical agitator and a satisfactory temperature indicating device shall be required. The equipment shall be capable of heating the joint sealing material uniformly without damage.

502.3.6 Auxiliary Equipment. Auxiliary equipment shall be available at all times as follows:

- (a) A minimum of one footbridge designed to be readily transportable and having no contact with the concrete base or pavement.
- (b) Metal dyes with beveled face numerals 3 inches to 5 inches high and thick enough to make an indentation of 1/4 inch. A satisfactory dye shall be used for marking the location of the station number.

502.3.7 Field Laboratory. The contractor shall provide a Type 1 field laboratory in accordance with [Sec 601](#).

502.4 Construction Requirements.

502.4.1 Weather Limitations. Concrete shall not be placed upon frozen subgrade. All concrete shall be effectively protected from freezing until a minimum compressive strength of 3,500 psi has been attained. The contractor shall provide a method, meeting the approval from the engineer, of monitoring the concrete that demonstrates that the concrete has been protected from freezing. Regardless of precautions taken, the contractor shall assume all risks, and all frozen concrete shall be replaced at the contractor's expense.

502.4.2 Protection Against Rain. To protect against rain, the contractor shall have on location at all times material for the protection of the edges and surface of the unhardened concrete. The contractor shall protect the concrete from damage due to rain. Failure to properly protect unhardened concrete may constitute cause for the removal and replacement of defective concrete at the contractor's expense.

502.4.3 Setting Forms. Forms shall be sufficiently supported to avoid displacement during paving operations. Both straight and curved forms shall be supported in such position that the face of the form shall be vertical on tangents and perpendicular to the superelevated section on curves. The top of the form shall not vary more than 1/8 inch from the true grade line during placing, compacting and finishing operations. The form alignment shall not vary more than 1/4 inch from the true alignment.

502.4.4 Conditioning of Subgrade. When forms have been securely set to grade, the subgrade shall be brought to proper cross-section in accordance with [Sec 209](#). Low areas of treated bases shall be filled only with concrete integral with the pavement. No direct payment will be made for the concrete used to fill these low areas.

502.4.5 Proportioning and Mixing Concrete. Concrete shall be proportioned and mixed by truck or central mixers in accordance with [Sec 501](#). This shall consist of batching all aggregate, cement and water by means of automatic weighing or metering, with all additives dispensed automatically and interlocked with the automatic weighing or metering controls. For central mixed concrete, the mixing cycle shall be timed and interlocked with the weight batch cycle. The weight setting controls shall be equipped such that the controls may be locked when directed by the engineer. The automatic batching equipment shall be capable of conversion to manual operation if necessary. Manual operation shall not be permitted beyond 24 hours after breakdown in the automatic equipment, except by written approval of the engineer. When a project includes paving that cannot be performed in a normal sequence, the

contractor will be permitted to place a maximum of 7000 square yards using manual batching methods. For all contracts having a total of no more than 20,000 square yards of concrete base course and concrete pavement combined, manual batching methods will be permitted.

502.4.6 Placing Concrete. The concrete shall be deposited over the entire width of the subgrade in such a manner as to prevent segregation and to minimize handling. Mixers, including truck mixers and trucks used for transporting concrete, will be permitted to discharge concrete by chute or by dumping directly on the subgrade or prepared base provided the underlying material is not damaged or distorted. Honeycomb in the concrete base or pavement edge may be cause for rejection of the concrete.

502.4.7 Tie Bar Placement. Tie bars shall be supported in the proper position by chairs driven into the subgrade, or may be placed by approved mechanical methods prior to the consolidation of the concrete after the concrete has been struck off. Tie bars shall be free from dirt, oil, paint and grease. Tie bars required at longitudinal construction joints shall be positioned before concrete base or pavement consolidation.

502.4.8 Final Strike-off, Consolidation and Finishing. Machine finishing by extrusion methods or by vibrating and screeding processes shall be required for all concrete except as permitted in accordance with [Sec 502.4.8.6](#). After the final course of the concrete has been placed, the concrete shall be struck-off and thoroughly vibrated until concrete of a uniform and satisfactory density is attained. The surface of the pavement shall be of uniform texture and to the proper grade and typical section.

502.4.8.1 Consolidation. Vibrating tubes shall extend into the concrete the distance necessary to provide adequate consolidation. Vibrators shall be operated only when the machine to which the vibrators are attached is moving. Care shall be taken that the vibrator does not penetrate the subgrade or dislodge or move the joints. Vibrators shall not come in contact with the reinforcement, load transfer devices, subgrade or side forms.

502.4.8.2 Added Finishing Water. Moisture in any form shall not be applied to the surface of the concrete except for emergency conditions. When emergency conditions exist and it becomes necessary to apply additional moisture to the surface of the concrete in order to complete the final finishing operation, water may only be applied in the form of a fine pressure spray. Under such conditions, placement of additional concrete on the subgrade shall be discontinued until the emergency conditions cease.

502.4.8.3 Surface Texture. After surface irregularities have been removed, the concrete surface shall be given a uniformly roughened finish. The surface texture shall be tested in accordance with ASTM E 965, except as modified herein, to ensure the texture is adequate for desired friction characteristics. The test locations will be the same locations as identified for strength and thickness determination.

502.4.8.3.1 Sample Container. Plastic sample containers for ASTM E 965 testing shall be of a rigid material that will crack or break if the container is deformed. Damaged or deformed containers shall not be used.

502.4.8.3.2 Required Texture Depth. The results of ASTM E 965 shall show a texture depth of any subplot, as defined in [Sec 502.10.1](#), to have a minimum value of 1.00 mm. Any subplot showing a texture depth of less than 1.00 mm shall require diamond grinding of the pavement represented by this subplot to attain the necessary texture. All testing of the surface texture shall be completed no later than the day following pavement placement.

502.4.8.3.3 Minimum Diamond Grinding Length. Diamond grinding, except for bump correction, shall be across the entire width of the traveled way and shall be continuous for a minimum of 0.1 mile.

502.4.8.3.4 Wave Texture Testing. ASTM E 965 will be waived if the contractor elects to diamond grind or tine the concrete with a wire comb. The concrete may be tined either longitudinally or transversely.

502.4.8.3.4.1 Wire Comb. A wire comb shall be no less than 10 feet long with a single line of wires exposed to a length of approximately 4 inches. The wire shall be blue-tempered and polished spring steel with nominal dimensions of 0.028 inch thick and 0.100 to 0.125 inch wide. The wires shall be spaced to provide 1/2-inch clear space between wires and securely mounted in a rigid head. Except for concrete finished by hand methods, the wire comb shall be mechanically operated and capable of covering the full width of slab in a single pass, at a uniform speed and at a uniform depth. Final approval of the wire comb will be based on satisfactory performance during actual use

502.4.8.3.4.2 Texturing with Wire Comb. Successive passes of the comb shall be overlapped the minimum necessary to attain a continuously textured surface. The surface texture produced shall have an average texture depth of approximately 0.125 inch. Small or irregular areas, or areas not suitable for machine texturing when adjacent surrounding concrete is ready for texturing, may be textured with a hand operated device producing a textured surface equivalent to that required for machine combing.

502.4.8.4 Edging at Forms and Joints. After the final finish, but before the concrete initial set, the edges of the concrete along each form line, and on each side of transverse expansion joints and construction joints shall be worked with an edging tool having a radius of approximately 3/8 inch. A well-defined and continuous radius having a smooth, dense finish shall be produced. The surface of the concrete shall not be unduly disturbed by tilting of the tool during use. Tool marks on the pavement shall be eliminated by brooming or dragging the surface. In doing this, the rounding of the corner of the pavement shall not be disturbed. All concrete on top of the joint filler shall be completely removed. All joints shall be tested with a straightedge before the concrete has set, and corrections made if one side of the joint is higher than the other.

502.4.8.5 Station Numbers. The contractor shall indent station numbers into all pavement immediately following the final finishing operations and before the concrete's final set. The numbers shall be placed at alternating full stations as ascertained by measurements determined by the engineer. Equations in stationing shall also be marked in the pavement. On undivided pavement, the station numbers shall be on the left side of the pavement with respect to the ascending stationing and shall be on the pavement edge unless an integral curb is involved, in which case the numbers shall be placed on the face of the curb. On divided pavement, station numbers shall be placed on the median side of each pavement. The numbers shall be placed facing the centerline of the pavement, or the centerline of each pavement in the case of divided pavements. The numbers shall be placed on a troweled area of the finished surface. No direct payment will be made for marking station numbers.

502.4.8.6 Hand Finishing. Compacting, vibrating and finishing concrete by hand methods will be permitted:

- (a) For all curves having a form line radius of less than 200 feet or where wood forms are used.
- (b) For all irregularly shaped areas.

- (c) For pavement lanes less than 200 feet long.
- (d) For pavement lanes less than 10 feet wide.
- (e) For bridge approaches and pavement to first expansion joint.
- (f) When a breakdown of the mechanical compacting and finishing equipment occurs or in the event of some other emergency. After a breakdown, only material which has already been proportioned and which may be rendered unsatisfactory for use may be finished by hand.
- (g) For all Portland cement concrete base.

502.5 Joints. Joints shall be of the specified type and dimensions, and constructed at the locations shown on the plans or as approved by the engineer. Where joints are preformed, the form or joint shall be set and securely fastened to ensure the joint being in the required position when the concrete is finished. The final position of dowels and tie bars shall be parallel to the subgrade and perpendicular to the line of the joint. Dowel supporting assemblies shall conform to one of the types shown on the plans. The concrete shall be placed to avoid displacement or disarrangement of the joint installations.

502.5.1 Expansion Joints. Expansion joints shall extend for the full cross-section of the concrete pavement. Filler placed prior to the placement of the concrete shall be installed with a removable cap or edging bar as a guide for edging the joint and protection of the filler during the concrete's placing and finishing. Joints constructed after the placement of concrete shall be sawed full depth, and the exposed edges shall be ground to a chamfer of 3/8 inch. The filler shall rest snugly on the subgrade from form to form. The joints shall be sealed in accordance with [Sec 502.5.4](#). Upon removal of the forms, any struts or fins of concrete extending across the joint shall be removed to the full width of the joint and the full thickness of the concrete base or pavement.

502.5.2 Construction Joints. Construction joints shall be made at the close of each day's work or when the work is stopped or interrupted for more than 30 minutes. Transverse construction joint shall be located 15 feet from the last contraction joint. Construction joints shall be constructed perpendicular to the top surface and the centerline of the concrete base or pavement. Construction joints may be formed with a timber header or may be sawed full depth. The final joint shall conform to the cross-section of the pavement. Before paving operations are resumed, all surplus concrete and other refuse shall be removed from the subgrade.

502.5.3 Sawing Joints. Unless otherwise provided, all transverse contraction joints and all Type L longitudinal joints shall be sawed in a single cutting operation with all joint cuts to the dimensions shown on the plans. For intersections and irregular pavement, joints shall be sawed at locations as approved by the engineer. Sawing of the joints shall begin as soon as the concrete has hardened sufficiently to permit sawing without excessive raveling. All joints shall be established before uncontrolled shrinkage cracking takes place. The sawing of any joint shall be omitted if a crack occurs at or near the joint location prior to the time of sawing. Sawing shall be discontinued when a crack develops ahead of the saw. The engineer reserves the right to have the contractor install preformed type joints on multiple width construction when the use of sawed joints fails to prevent random cracking. Any pavement with random cracking not controlled by dowels or tie bars shall be either removed and replaced using dowels or tie bars as appropriate to the nearest controlled joint or repaired with some other method approved by the engineer at the contractor's expense.

502.5.3.1 Forming Longitudinal Joint. A joint forming device may be used to establish the longitudinal joint between the two driving lanes or between the driving lane and shoulder 6 foot wide or greater. The pavement shall have a plan thickness of 8 inches or greater.

502.5.3.1.1 Notification. The contractor shall indicate in the Quality Control Plan if the longitudinal joint forming device is going to be utilized on the project.

502.5.3.1.2 Joint Forming Device. The joint forming device shall consist of a pair of straight blades mounted under the paver. The first blade shall be placed under the front of the primary pan extending forward between the vibrators, if mechanically possible. The second blade shall be placed on the finishing pan in identical alignment to the first blade. Blade depth shall be equal to one-third of the slab thickness.

502.5.3.1.3 Depth Verification. The engineer shall have access behind the paver to randomly check joint formation by inserting a thin metal strip equal to one-third of the slab thickness into the formed joint.

502.5.3.1.4 Weak Plane Verification. The contractor shall take four 4-inch diameter cores in the longitudinal joint. Cores shall be taken and tested the following day after the first day of paving. Samples shall be taken from random locations determined by the engineer. The cores shall be centered within $\pm \frac{1}{2}$ inch around the joint forming trail. The first one-third of the slab thickness and the second one-third of the slab thickness of each core shall be sawed off from the top and tested in the vertical position for split tensile strength. The average strength ratio of the first and second cores shall be 1/3 or less.

502.5.3.1.5 Testing Frequency. For each successive day after the first day of paving, two 4-inch diameter cores shall be taken in the longitudinal joint. Samples shall be taken from random locations determined by the engineer. Cores shall be taken and tested the following day after placement. Cores shall be tested to determine the indirect tensile strength ratios. If satisfactory results are consistently achieved, the engineer may reduce the number of cores taken.

502.5.3.1.6 Joint Continuity. The contractor shall ensure longitudinal joint continuity between consecutive day's paving.

502.5.3.1.7 Unacceptable Results. If the test results or the quality of the joint forming process are not satisfactory to the engineer, the contractor shall saw the longitudinal joint for the length affected.

502.5.4 Sealing Joints. All sawed contraction joints shall be unsealed, unless otherwise specified. Sawed or formed expansion joints shall be sealed with joint sealing material before the pavement is opened to any traffic, including construction traffic. Immediately prior to sealing, the joints shall be thoroughly cleaned and dried. The sealing material shall be heated to the pouring temperature recommended by the manufacturer. Any material which has been heated above the maximum safe heating temperature will be rejected. Any excess material shall be removed from the pavement surface.

502.5.5 Joint Filler at Railroad Crossings. Bituminous filler for use between railroad crossing approach slabs and the crossing shall be an approved commercial bituminous mixture in accordance with [Sec 401](#). The mixture shall be tamped into a firm and compacted state.

502.6 Curing. Immediately after the finishing operations have been completed and as soon as marring of the concrete will not occur, the entire surface and exposed edges of the newly placed concrete shall be covered and cured in accordance with one of the following methods.

The concrete shall not be left exposed for more than 30 minutes between stages of curing or during the curing period.

502.6.1 White Pigmented Membrane. After the free water has left the pavement surface, the entire surface shall be sealed by spraying with a uniform application of white pigmented membrane curing material. The contractor shall provide satisfactory equipment to ensure uniform mixture and coverage of curing material, without loss, on the pavement at the rate of not less than one gallon for each 200 square feet. If rain falls on the newly coated pavement before the film has dried sufficiently to resist damage, or if the film is damaged in any other way, the contractor shall apply additional curing material to the affected portions. All areas cut by finishing tools subsequent to the application of the curing material shall immediately be given new applications at the rate specified above. If hairline cracking develops before the membrane can be applied, the concrete shall be initially cured with wet burlap in accordance with [Sec 502.6.2](#) before the membrane is placed. Membrane curing shall not be used on Portland cement concrete base. Emulsified asphalt may be used to cure the concrete base if the surface course is to be a bituminous type.

502.6.2 Burlap. The top surface of the concrete shall be temporarily covered with thoroughly damp burlap after the concrete has set sufficiently to prevent marring of the surface. Burlap shall be handled in such a manner that contact with earth or other deleterious substances is avoided. All burlap, except burlap previously used for curing concrete, shall be thoroughly washed. The burlap shall be kept thoroughly wet until removed for application of the final curing material. Neither the top nor the edge of the concrete shall be left unprotected for more than 30 minutes. When the burlap is removed, white pigmented membrane curing material shall be continued by one of the approved methods.

502.7 Removing Forms. Forms shall be removed carefully to avoid damage to the concrete base or pavement. Honeycombed areas not rejected shall be immediately repaired. If the forms are removed less than 72 hours after placing concrete, the sides of the concrete shall be cured by one of the methods specified above. Any trench excavated for the forms shall be entirely backfilled so water will not stand next to the concrete base or pavement.

502.8 Surface Smoothness. The pavement surface shall be thoroughly tested for smoothness by profiling or straightedging as indicated in [Sec 610](#).

502.9 Opening to Traffic. The concrete base and pavement shall not be opened for low volume, light construction traffic until the concrete has attained a minimum compressive strength of 2500 psi. The concrete base and pavement shall not be opened to all types of traffic until the concrete has attained a minimum compressive strength of 3,000 psi and all sawed joints that have opened more than ¼ inch are sealed. Compressive strength will be determined by tests conducted in accordance with MoDOT test methods. Pavement shall be cleaned prior to opening to traffic.

502.10 Material Acceptance. Acceptance will be based on the following criteria being met:

- (a) Test results indicating the concrete base or pavement meets the specification requirements
- (b) Contractor following the approved Quality Control Plan (QCP)
- (c) Favorable comparison between the contractor's quality control tests and the engineer's quality assurance tests. Favorable comparison will be obtained when the engineer's QA tests results are within two standard deviations from the mean of the QC test results for each individual lot of material. For properties not evaluated on a

lot by lot basis, favorable comparison will be obtained when both the QC and QA tests results meet the specification requirements. Compressive strength and slab thickness will be evaluated on a lot by lot basis.

502.10.1 Lot Definition. A lot shall be the surface area placed in a single day. Each lot shall be divided into no less than four or more than six sublots of equal surface area. For high daily production rates exceeding 7,500 square yards per day, the contractor may choose to divide the day's production into two equal lots consisting of no less than four or more than six sublots each. The contractor shall notify the engineer of the size of the subplot or of the decision to divide a day's production into two equal lots prior to taking any core samples. When a day's production involves less than 600 square yards, combine the following day's or days' production to reach 600 square yards and treat as a single lot, except while completing a particular mix design or project, in which case combine with the previous day's production and treat as a single lot. If a project has less than 7,500 square yards of a particular mix type, the lot will be defined as the plan quantity shown in the contract documents.

502.10.2 Sampling. One QC sample shall be taken for each subplot and a minimum of one QA sample shall be taken per lot. A sample shall be taken from the finished concrete consisting of a 4-inch diameter core for concrete bases or pavements less than 12 inches thick and a 6-inch diameter core for concrete bases or pavements 12 inches or greater. Sampling locations will be determined by the engineer using random sampling procedures in accordance with ASTM D 3665.

502.10.3 Coring. Cores shall be taken in accordance with AASHTO T 24. Cores shall not be taken until a minimum compressive strength of 3,000 psi has been attained. Cores shall be neatly cut with a core drill. The contractor shall furnish all tools, labor and material for cutting samples and filling the cored hole. The contractor shall fill the core holes with an approved non-shrink grout within one day after sampling.

502.10.3.1 Testing Cores. The core thickness shall be determined by the average caliper measurement in accordance with AASHTO T 148. After the thickness is determined, the cores shall be sawed to an L/D ratio of 2.0 and tested in accordance with AASHTO T 22. Cores shall not be taken until a minimum compressive strength of 3,000 psi has been attained. The contractor shall determine the compressive strength by approved methods. Cores shall be tested for compressive strength 28 days after placement.

502.10.3.2 Pavement Thickness after Diamond Grinding. If the contractor elects to diamond grind to improve smoothness or surface texture, in accordance with [Sec 610.5.1.3](#) and [610.5.1.4](#), then pavement thickness determination will be made after all smoothness correction has been completed. Cores shall be 4 inch in diameter. Location of coring will be determined by the engineer using random sampling procedures in accordance with ASTM D 3665.

502.10.4 Quality Level Analysis. Compressive strength and thickness shall be evaluated for acceptance on a lot-by-lot basis using a Quality Level Analysis (QLA). The QLA will consider the variability (standard deviation) of the material and the testing procedures, as well as the average (mean) value of the test results to calculate the percentage of material that is above the lower specification tolerance limit (LSL) for compressive strength and thickness.

502.10.4.1 Determine Quality Index. The Percent Within Limits (PWL) will be based on the mean, standard deviation and quality index of each lot's test results as follows:

Mean

$$\bar{x}_a = \sum \frac{x_i}{n}$$

where:

\bar{x}_a = Mean of the individual values being considered
 $\sum x_i$ = The summation of all the individual values being considered
 n = The number of individual values under consideration

Standard Deviation

$$s = \sqrt{\frac{\sum (x_i - \bar{x}_a)^2}{n - 1}}$$

Where:

s = Standard Deviation

Upper Quality Index

$$Q_U = \frac{USL - \bar{x}_a}{s}$$

Lower Quality Index

$$Q_L = \frac{\bar{x}_a - LSL}{s}$$

Where:

Q_U = Upper Quality Index
 Q_L = Lower Quality Index
USL = Pay Factor Item Upper Spec Limit
LSL = Pay Factor Item Lower Spec Limit

502.10.4.2 Determine Percent Within limits. The upper (PWL_U) and lower (PWL_L) will be determined from Table I. Total percent within limits is: $PWL_t = (PWL_U + PWL_L) - 100$. For thickness and compressive strength in this specification, PWL_U shall be 100.

502.10.4.3 Utilizing Quality Control Test Results. The engineer will make the Quality Level Analysis (QLA) within 24 hours after receipt of the contractor's test results, by determining the PWL_t for each designated pay factor item. The contractor's test results will be used when applicable to determine the PWL_t , provided the contractor's QC tests and the engineer's QA tests compare favorably, and provided the engineer's inspection and monitoring activities indicate the contractor is following the approved QC Plan.

502.10.4.4 Material Rendered Unfit. The engineer may at any time reject and require the contractor to dispose of any batch of concrete mixture which is rendered unfit for use due to contamination, segregation, improper slump or improper entrained air content. Such rejection

may be based on only visual inspection. In the event of such rejection, the contractor may take a representative sample of the rejected material in the presence of the engineer, and if demonstrated in the laboratory in the presence of the engineer that such material was erroneously rejected, payment will be made for the material at the contract unit price.

502.10.4.5 Lower Specification Limits. The lower specification limit (LSL) for compressive strength and thickness shall be:

- (a) Compressive Strength – 4,000 psi.
- (b) Thickness – Plan thickness minus 1/2 inch.

502.10.5 Outliers. Individual compressive strength tests within a lot may be checked for an outlier in accordance with the determination of statistic T in ASTM E 178, at a significance level of 5 percent. Replacement cores shall be obtained at the location designated and in the presence of the engineer. The PWL shall be determined using the replacement values.

502.11 Contractor Quality Control.

502.11.1 Quality Control Plan. Prior to approval of concrete mix designs by the engineer, the contractor shall submit a QCP to Construction and Materials. The QCP shall be approved prior to placing any concrete. The QCP shall include:

- (a) Name and contact information should be provided for the contractor's representative in charge of QC and the project level representative if different from the contractor's representative.
- (b) Identify the number of sublots each lot will utilize and describe how lots and sublots will be designated.
- (c) State the method for determining when concrete cores can be extracted.
- (d) State the method for demonstrating the concrete has been protected from freezing.
- (e) State the location where control charts will be posted, if utilized by the contractor.
- (f) For optimized concrete mix, state the target gradation and allowable gradation ranges for each fraction being used.
- (g) A proposed independent third party company name, contact person, address, and phone number for dispute resolution.

502.11.1.1 Third Party. The third party shall be independent of the contractor, MoDOT consultants, and all project subcontractors or suppliers on each specific project. All testing of material for dispute resolution shall be performed by an approved laboratory that is AASHTO Accreditation Program certified in the areas of the material being tested.

502.11.2 Quality Control Testing. The contractor shall perform all quality control tests necessary to control the production and construction processes applicable to this specification and as set forth in the QCP. Quality control testing shall be performed by technicians qualified through MoDOT's technician certification program. Testing shall include, but not necessarily be limited to, deleterious content, coarse aggregate absorption, thin or elongated pieces, entrained air content, slump, pavement thickness and compressive strength. The

contractor shall record all test results and furnish a copy to the engineer no later than the beginning of the day following the test.

502.11.2.1 Fine and Coarse Aggregate.

502.11.2.1.1 Aggregate Gradation. A sieve analysis shall be performed once a week. Testing shall be performed in accordance with AASHTO T 27 from randomly sampled material taken from the discharge gate of storage bins or from the conveyor belt. Sieve analysis shall be performed on the following sieves:

Mix Design Method	Sieves Tested
Absolute Volume	Maximum sieve size ^a
Optimized	Sieves sizes specified by the mix design

^aCoarse aggregate only

502.11.2.1.2 Deleterious Materials. Deleterious content shall be determined each day at a frequency of one test per 7500 square yards of material placed or fraction thereof. Test shall be performed in accordance with MoDOT Test Method TM 71 from randomly sampled material taken from the discharge gate of the storage bin or from the conveyor belt. Test shall be performed on coarse aggregate fractions.

502.11.2.1.3 Absorption. Samples for coarse aggregate absorption shall be taken from the discharge gate of the storage bins or from the conveyor belt at least once every 2,000 cubic yards with a minimum of once per project. Coarse aggregate absorption shall be in accordance with AASHTO T 85.

502.11.2.1.4 Thin or Elongated Pieces. Thin or elongated pieces shall be determined on samples of coarse aggregate taken from the discharge gate of the storage bins or from the conveyor belt. The aggregate particles retained on the 3/4 in. sieve shall not exceed 5 percent when tested in accordance with ASTM D 4791, based on a 5:1 ratio. Test shall be performed at least once every 10,000 cubic yards with a minimum of once per project.

502.11.2.1.5 Retained Samples. All aggregate samples taken by the contractor for determining the gradation, deleterious content, absorption, and thin or elongated pieces shall be retained for the engineer for a minimum of seven days unless otherwise instructed. The retained sample shall be the remaining half of the final reduction in sample size obtained for QC testing. These samples shall be maintained in clean covered containers, without contamination, readily accessible to the engineer. The retained sample's identification shall consist of, but is not limited to:

- (a) Time and date sampled.
- (b) Product specification number.
- (c) Type of sample, i.e. belt, bin, stockpile.
- (d) Lot and subplot designation.
- (e) Sampler/Tester.
- (f) Project Job Number.

502.11.2.2 Slump. Slump tests shall be performed on a random basis for each 500 cubic yards of material produced. The engineer will designate the random location at the

time of sampling. If a day's material production does not exceed 500 cubic yards, one slump test shall be performed. Slump tests shall be in accordance with AASHTO T 119 from randomly sampled material discharged from trucks at the paving site. Material samples shall be in accordance with AASHTO R 60.

502.11.2.3 Entrained Air Content. Tests for entrained air content shall be performed on a random basis for each 500 cubic yards of material produced. The engineer will designate the random location at the time of sampling. The minimum air content in front of the paver shall be 5.0 percent plus the air loss through the paver. The air loss through the paver is determined a minimum of once per half-day production by sampling the concrete ahead of the paver and behind the paver and subtracting the value obtained ahead of the paver from the value obtained behind the paver. The engineer shall be given notification prior to determining the air loss in order to witness the air loss determination. On the first day of paving, the target air content shall be determined immediately after placing 200 cubic yards of concrete. The entrained air content of the first 200 cubic yards of concrete placed on the first day of paving, sampled in front of the paver, shall be greater than 6.0 percent. Tests shall be in accordance with AASHTO T 152.

502.11.3 Corrective Action. As a minimum, a process shall be deemed out of control and corrective action taken if any one of the conditions below exists. In addition, each truckload of material en route prior to the process of being deemed out of control shall be tested for specification compliance.

502.11.3.1 Aggregate Gradation. When one test is outside the allowable range, immediate steps shall be taken to correct the gradation.

502.11.3.2 Deleterious Content. When one test is outside the specification limits, immediate steps shall be taken to correct the deleterious content.

502.11.3.3 Slump, Air Content, and Absorption. The contractor shall halt production and make appropriate adjustments whenever either of the following occurs:

- (a) One point falls outside the action limit line for individual measurements or range.
- (b) Two points in a row fall outside the specification limit but within the action limit line for individual measurements.

Individual Measurements	
Control Parameter	Action Limit
Slump	+1 in.
Air Content	4.5 to 5.0%
Absorption	Mix Design plus 0.3% to Mix Design plus 0.6%

502.11.4 Pavement. For pavements with a plan thickness below 8 inches, the following shall apply:

- (a) QC shall determine compressive strength at a frequency of no less than one per 7,500 square yards. Compressive strength shall be determined from at least two 6- by 12-inch cylinders or from at least three 4- by 8-inch cylinders made in accordance with AASHTO T-23 or by the Maturity Method in accordance with the contract documents. QA will determine the compressive strength at least once per

30,000 square yards. Cylinders shall be tested in accordance with AASHTO T-22. A compressive strength of 3,500 shall be attained by 28-day. Sampling location will be determined by the engineer using random sampling procedures in accordance with ASTM D 3665

(b) QC shall determine pavement thickness of the fresh concrete at a frequency of no less than one per 7,500 square yards. QA will determine the pavement thickness of the fresh concrete at least once per 30,000 square yards. Sampling locations will be determined by the engineer using random sampling procedures in accordance with ASTM D 3665

(c) QC shall determine the slump, air content, gradation, deleterious, thin and elongated and absorption in accordance with [Sec 502.11](#). QA will determine the slump, air content, gradation, deleterious, thin and elongated and absorption in accordance with [Sec 502.12](#).

502.11.5 Shoulders. Shoulders with a plan thickness 8 inches or greater shall be inspected in accordance with requirements applied to concrete placed in the travel way. Shoulders with a plan thickness below 8 inches shall be handled in accordance with [Sec 502.11.4](#).

502.11.6 Dispute Resolution. When there are significant discrepancies between the engineer's and the contractor's test results, dispute resolution procedures will be used.

502.11.6.1 Cease Work. The contractor's operations may be required to cease until the dispute is resolved, if the test results indicate the mixture is unacceptable.

502.11.6.2 Third Party Resolution. The first step in dispute resolution will be to identify differences in procedures and to correct inappropriate procedures before moving to third party resolution. If that does not resolve the dispute, either the contractor or the engineer may request the approved QCP third party involvement. The recommendations of the approved third party will be binding on both the engineer and contractor.

502.11.6.3 Third Party Payment. The contractor shall be responsible for the costs associated with third party testing and resolution if the final result indicates the engineer's test results were correct. Likewise the Commission will be responsible for the cost associated with the third party testing and resolution if the final result indicates the contractor's results were correct.

502.11.6.4 Other Adjustments. The contractor will not be entitled to any additional payment for costs incurred due to use of the dispute resolution procedures such as, but not limited to, those for delay, cessation of operations, costs to subcontractors, etc. The engineer may give consideration to adjustment of working days, if warranted.

502.11.7 Concrete Mix Design Adjustment.

502.11.7.1 Field Adjustment. When test results indicate the concrete produced does not meet the specification requirements or is not performing satisfactory, the contractor may adjust the mix design in the field as noted herein. Field adjustments may consist of changing the constituents listed on the approved mix design by no more than 5.0 percent or changing the water cement ratio by no more than 0.02 from the approved mix design. The engineer shall be notified immediately when any change is made to the mix design. Additional fractions of material or new material will not be permitted as a field adjustment. The field adjusted mix shall meet the requirements specified in [Sec 501](#).

502.11.7.2 Field Redesign. When the constituents listed on the approved mix design are adjusted by more than 5.0 percent or the water cement ratio is changed by more than 0.02, the contractor shall submit a new mix design meeting the requirements specified in [Sec 501](#). The mix design shall be submitted immediately to the District for approval. The contractor will be allowed to continue production while the mix design is reviewed.

502.12 Quality Assurance. Corrective action shall be required in accordance with [Sec 502.11.3](#) for any QA tests outside the action limit. The engineer will at a minimum, independently test at the following frequency:

Test	Frequency
Compressive Strength	1 per lot
Thickness	1 per lot
Surface Texture	1 per lot
Slump	1 per day
Entrained Air Content	1 per day
Aggregate Gradation	1 per project
Coarse Aggregate Deleterious	1 per week
Aggregate Absorption	1 per 10,000 cubic yards
Thin or Elongated Pieces	1 per project

502.12.1 Retained Samples. The QA inspector will test at least ten percent of the retained portion of the QC samples for aggregate gradation and deleterious content. The QA inspector will test at least twenty percent of the QC retained samples for absorption and thin or elongated pieces. Retained samples will be chosen at random. A comparison will be considered favorable when the QA results of a QC retained sample are within the applicable limits specified in [Sec 403.18.3](#).

502.12.2 Core Chain of Custody. QA strength and thickness cores that are not in possession of the engineer for the entire time from extraction till testing shall be sealed in tamper proof bags after extraction.

502.12.3 Quality Control Equipment. All QC mixture testing shall be performed using equipment maintained in accordance with [Sec 403.17.3](#), except as follows:

Equipment – Test Method (AASHTO)	Requirement	Interval (Month)
Sieves	Check Physical Condition	6
Mechanical Shakers - T27	Check Sieving Thoroughness	12
Ovens	Verify Temp. Settings	4
Balances	Verify	12 ^a
Air Meters - T152	Calibrate	12
Compression Testing Machine - T22	Verify Load Indications	12
Capping Material	Check Strength	3
Slump Cones - T119	Check Critical Dimensions	12

^aVerify after each move.

502.13 Unacceptable Material. Any material meeting the following criteria shall be considered unacceptable:

- (a) If any core measurement of thickness is greater than 10 percent deficient from the plan thickness.

(b) If any core measurement of compressive strength is less than 3,500 psi.

(c) All material with an entrained air content less than 4.0 percent.

502.14 Method of Measurement. Final measurement of the completed pavement will not be made except for authorized changes during construction, or where appreciable errors are found in the contract quantity. Where required, measurement of the Portland cement concrete base and pavement complete in place will be made to the nearest 1/10 square yard. The revision or correction will be computed and added to or deducted from the contract quantity.

502.15 Basis of Payment.

502.15.1 Compensation. The contract unit price for Portland cement concrete base and pavement will be considered as full compensation for all material, including reinforcement, dowels, dowel supports, tie bars and any other items entering into the construction of the traveled way pavement or Portland cement concrete shoulders, and for the cost of QC testing and smoothness testing. No additional compensation will be allowed for any excess thickness.

502.15.2 Payment. The accepted quantities of concrete base will be paid for at the contract unit price with proper allowance made for any deductions for deficiency in thickness and compressive strength. The accepted quantities of Portland cement concrete pavement will be paid for at the contract unit price with proper allowance made for any deductions for deficiency in thickness, compressive strength, smoothness or marred surface.

502.15.3 Width. When paving widths are greater than the travel lane widths, payment for profiling will apply to the traffic lane design driving width only, normally 12 feet. Random lane coring for thickness or required lane replacement will include the full paved lane width to the longitudinal joints or edge of shoulder, whichever is first.

502.15.4 Pay Factors. The total pay factor (PF_t) for each lot is equal to the weighted sum of the pay factors (PF) for each pay factor item for each lot, and is determined as follows:

$$PF_t = + (0.5) PF_T + (0.5) PF_{CS}$$

Where: PF_T = Pay Factor for Thickness

PF_{CS} = Pay Factor for Compressive Strength

The PF for each pay factor item for each lot is based on the PWL_t of each pay factor item of each lot and is determined as follows:

When PWL_t is greater than or equal to 70: PF = 0.5 PWL_t + 55

When PWL_t is less than 70: PF = 2 PWL_t - 50

502.15.5 Small Quantities. For each mix type less than 7,500 square yards, the following shall apply:

QLA and PWL will not be required.

Concrete mix shall be within the specified limits for compressive strength, pavement thickness, slump, air content, gradation, deleterious, and thin and elongated.

Payment for each mix type will be made at 100 percent of the contract unit price if compressive strength is equal to or greater than 3,500 psi and the pavement thickness is not deficient by more than 10 percent of the plan thickness.

502.15.6 Pavements. For pavements with a plan thickness below 8 inches, the following shall apply:

(a) QLA and PWL will not be required

(b) Concrete mix shall be within the specified limits for compressive strength, pavement thickness, slump, air content, gradation, deleterious, and thin and elongated.

(c) Payment will be made at 100 percent of the contract unit price if compressive strength is equal to or greater than 3500psi and pavement thickness is not deficient by more than 10 percent of the plan thickness

502.15.7 Shoulders. Shoulders with a plan thickness below 8 inches shall be handle in accordance with [Sec 502.15.6](#).

502.15.8 PWL Determination Table. Values in Table I are estimates of the PWL corresponding to specific values of the Quality Index (Q). For Q values less than zero, the table shall be subtracted from 100.

TABLE I
Variability-Unknown Procedure
Standard-Deviation Method

Quality Index (Q_U or Q_L)	PWL For Selected Sample Sizes							
	n=3	n=4	n=5	n=6	n=7	n=8	n=9	n=10
0.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00
0.01	50.28	50.33	50.36	50.37	50.37	50.38	50.38	50.38
0.02	50.55	50.67	50.71	50.74	50.75	50.76	50.76	50.77
0.03	50.83	51.00	51.07	51.10	51.12	51.13	51.15	51.15
0.04	51.10	51.34	51.42	51.47	51.50	51.51	51.53	51.54
0.05	51.38	51.67	51.78	51.84	51.87	51.89	51.91	51.92
0.06	51.66	52.00	52.14	52.21	52.24	52.27	52.29	52.30
0.07	51.93	52.33	52.49	52.57	52.62	52.65	52.67	52.69
0.08	52.21	52.67	52.85	52.94	52.99	53.02	53.06	53.07
0.09	52.48	53.00	53.20	53.30	53.37	53.40	53.44	53.46
0.10	52.76	53.33	53.56	53.67	53.74	53.78	53.82	53.84
0.11	53.04	53.66	53.91	54.04	54.11	54.16	54.20	54.22
0.12	53.32	54.00	54.27	54.40	54.48	54.54	54.58	54.60
0.13	53.59	54.33	54.62	54.77	54.86	54.91	54.95	54.99
0.14	53.87	54.67	54.98	55.13	55.23	55.29	55.33	55.37
0.15	54.15	55.00	55.33	55.50	55.60	55.67	55.71	55.75
0.16	54.43	55.33	55.68	55.86	55.97	56.04	56.09	56.13
0.17	54.71	55.67	56.04	56.23	56.34	56.42	56.47	56.51
0.18	54.98	56.00	56.39	56.59	56.72	56.79	56.84	56.89
0.19	55.26	56.34	56.75	56.96	57.09	57.17	57.22	57.27
0.20	55.54	56.67	57.10	57.32	57.46	57.54	57.60	57.65
0.21	55.82	57.00	57.45	57.68	57.83	57.91	57.98	58.03
0.22	56.10	57.33	57.81	58.05	58.20	58.29	58.35	58.40
0.23	56.39	57.67	58.16	58.41	58.56	58.66	58.73	58.78
0.24	56.67	58.00	58.52	58.78	58.93	59.04	59.10	59.15
0.25	56.95	58.33	58.87	59.14	59.30	59.41	59.48	59.53
0.26	57.23	58.66	59.22	59.50	59.67	59.78	59.85	59.90
0.27	57.52	59.00	59.57	59.86	60.03	60.15	60.22	60.28
0.28	57.80	59.33	59.93	60.22	60.40	60.51	60.60	60.65
0.29	58.09	59.67	60.28	60.58	60.76	60.88	60.97	61.03
0.30	58.37	60.00	60.63	60.94	61.13	61.25	61.34	61.40
0.31	58.66	60.33	60.98	61.30	61.49	61.62	61.71	61.77
0.32	58.94	60.67	61.33	61.66	61.85	61.98	62.08	62.14
0.33	59.23	61.00	61.68	62.01	62.22	62.35	62.44	62.51
0.34	59.51	61.34	62.03	62.37	62.58	62.71	62.81	62.88
0.35	59.80	61.67	62.38	62.73	62.94	63.08	63.18	63.25
0.36	60.09	62.00	62.73	63.09	63.30	63.44	63.54	63.61
0.37	60.38	62.33	63.08	63.44	63.66	63.80	63.91	63.98
0.38	60.68	62.67	63.42	63.80	64.02	64.17	64.27	64.34
0.39	60.97	63.00	63.77	64.15	64.38	64.53	64.64	64.71
0.40	61.26	63.33	64.12	64.51	64.74	64.89	65.00	65.07
0.41	61.56	63.66	64.46	64.86	65.09	65.25	65.36	65.43
0.42	61.85	64.00	64.81	65.21	65.45	65.60	65.72	65.79
0.43	62.15	64.33	65.15	65.57	65.80	65.96	66.07	66.15
0.44	62.44	64.67	65.50	65.92	66.16	66.31	66.43	66.51
0.45	62.74	65.00	65.84	66.27	66.51	66.67	66.79	66.87

TABLE I
Variability-Unknown Procedure
Standard-Deviation Method

Quality Index (Q_U or Q_L)	PWL For Selected Sample Sizes							
	n=3	n=4	n=5	n=6	n=7	n=8	n=9	n=10
0.46	63.04	65.33	66.18	66.62	66.86	67.02	67.14	67.22
0.47	63.34	65.67	66.53	66.96	67.21	67.37	67.49	67.57
0.48	63.65	66.00	66.87	67.31	67.56	67.73	67.85	67.93
0.49	63.95	66.34	67.22	67.65	67.91	68.08	68.20	68.28
0.50	64.25	66.67	67.56	68.00	68.26	68.43	68.55	68.63
0.51	64.56	67.00	67.90	68.34	68.61	68.78	68.90	68.98
0.52	64.87	67.33	68.24	68.69	68.95	69.12	69.24	69.32
0.53	65.18	67.67	68.58	69.03	69.30	69.47	69.59	69.67
0.54	65.49	68.00	68.92	69.38	69.64	69.81	69.93	70.01
0.55	65.80	68.33	69.26	69.72	69.99	70.16	70.28	70.36
0.56	66.12	68.66	69.60	70.06	70.33	70.50	70.62	70.70
0.57	66.44	69.00	69.94	70.40	70.67	70.84	70.96	71.04
0.58	66.75	69.33	70.27	70.73	71.00	71.17	71.29	71.38
0.59	67.07	69.67	70.61	71.07	71.34	71.51	71.63	71.72
0.60	67.39	70.00	70.95	71.41	71.68	71.85	71.97	72.06
0.61	67.72	70.33	71.28	71.74	72.01	72.11	72.30	72.39
0.62	68.05	70.67	71.61	72.08	72.34	72.37	72.63	72.72
0.63	68.37	71.00	71.95	72.41	72.68	72.63	72.97	73.06
0.64	68.70	71.34	72.28	72.75	73.01	72.89	73.30	73.39
0.65	69.03	71.67	72.61	73.08	73.34	73.15	73.63	73.72
0.66	69.37	72.00	72.94	73.41	73.67	73.55	73.95	74.04
0.67	69.71	72.33	73.27	73.73	73.99	73.95	74.28	74.36
0.68	70.05	72.67	73.60	74.06	74.32	74.35	74.60	74.69
0.69	70.39	73.00	73.93	74.38	74.64	74.75	74.93	75.01
0.70	70.73	73.33	74.26	74.71	74.97	75.15	75.25	75.33
0.71	71.08	73.66	74.59	75.03	75.29	75.46	75.57	75.64
0.72	71.44	74.00	74.91	75.35	75.61	75.78	75.88	75.96
0.73	71.79	74.33	75.24	75.68	75.92	76.09	76.20	76.27
0.74	72.15	74.67	75.56	76.00	76.24	76.41	76.51	76.59
0.75	72.50	75.00	75.89	76.32	76.56	76.72	76.83	76.90
0.76	72.87	75.33	76.21	76.63	76.87	77.03	77.14	77.21
0.77	73.24	75.67	76.53	76.95	77.18	77.34	77.44	77.51
0.78	73.62	76.00	76.85	77.26	77.50	77.64	77.75	77.82
0.79	73.99	76.34	77.17	77.58	77.81	77.95	78.05	78.12
0.80	74.36	76.67	77.49	77.89	78.12	78.26	78.36	78.43
0.81	74.75	77.00	77.81	78.20	78.42	78.56	78.66	78.72
0.82	75.15	77.33	78.12	78.51	78.72	78.86	78.95	79.02
0.83	75.54	77.67	78.44	78.81	79.03	79.16	79.25	79.31
0.84	75.94	78.00	78.75	79.12	79.33	79.46	79.54	79.61
0.85	76.33	78.33	79.07	79.43	79.63	79.76	79.84	79.90
0.86	76.75	78.66	79.38	79.73	79.92	80.05	80.13	80.19
0.87	77.18	79.00	79.69	80.03	80.22	80.34	80.42	80.47
0.88	77.60	79.33	80.00	80.33	80.51	80.63	80.70	80.76
0.89	78.03	79.67	80.31	80.63	80.81	80.92	80.99	81.04
0.90	78.45	80.00	80.62	80.93	81.10	81.21	81.28	81.33
0.91	78.91	80.33	80.92	81.22	81.38	81.49	81.56	81.61

TABLE I
Variability-Unknown Procedure
Standard-Deviation Method

Quality Index (Q_U or Q_L)	PWL For Selected Sample Sizes							
	n=3	n=4	n=5	n=6	n=7	n=8	n=9	n=10
0.92	79.37	80.67	81.23	81.51	81.67	81.77	81.84	81.88
0.93	79.83	81.00	81.53	81.81	81.95	82.05	82.11	82.16
0.94	80.29	81.34	81.84	82.10	82.24	82.33	82.39	82.43
0.95	80.75	81.67	82.14	82.39	82.52	82.61	82.67	82.71
0.96	81.27	82.00	82.44	82.67	82.80	82.88	82.94	82.97
0.97	81.78	82.33	82.74	82.95	83.07	83.15	83.20	83.24
0.98	82.30	82.67	83.04	83.24	83.35	83.42	83.47	83.50
0.99	82.81	83.00	83.34	83.52	83.62	83.69	83.73	83.77
1.00	83.33	83.33	83.64	83.80	83.90	83.96	84.00	84.03
1.01	83.93	83.66	83.93	84.08	84.17	84.22	84.26	84.28
1.02	84.53	84.00	84.22	84.35	84.43	84.48	84.51	84.53
1.03	85.14	84.33	84.51	84.63	84.70	84.74	84.77	84.79
1.04	85.74	84.67	84.80	84.90	84.96	85.00	85.02	85.04
1.05	86.34	85.00	85.09	85.18	85.23	85.26	85.28	85.29
1.06	87.10	85.33	85.38	85.44	85.49	85.51	85.53	85.53
1.07	87.87	85.67	85.66	85.71	85.74	85.76	85.77	85.77
1.08	88.63	86.00	85.95	85.97	86.00	86.01	86.02	86.02
1.09	89.40	86.34	86.23	86.24	86.25	86.26	86.26	86.26
1.10	90.16	86.67	86.52	86.50	86.51	86.51	86.51	86.50
1.11	91.55	87.00	86.80	86.76	86.75	86.75	86.74	86.73
1.12	92.95	87.33	87.07	87.01	87.00	86.99	86.98	86.96
1.13	94.34	87.67	87.35	87.27	87.24	87.22	87.21	87.20
1.14	95.74	88.00	87.62	87.52	87.49	87.46	87.45	87.43
1.15	97.13	88.33	87.90	87.78	87.73	87.70	87.68	87.66
1.16	100.00	88.66	88.17	88.03	87.96	87.93	87.90	87.88
1.17	100.00	89.00	88.44	88.27	88.20	88.15	88.12	88.10
1.18	100.00	89.33	88.70	88.52	88.43	88.38	88.35	88.32
1.19	100.00	89.67	88.97	88.76	88.67	88.60	88.57	88.54
1.20	100.00	90.00	89.24	89.01	88.90	88.83	88.79	88.76
1.21	100.00	90.33	89.50	89.25	89.12	89.05	89.00	88.97
1.22	100.00	90.67	89.76	89.48	89.35	89.26	89.21	89.17
1.23	100.00	91.00	90.02	89.72	89.57	89.48	89.43	89.38
1.24	100.00	91.34	90.28	89.95	89.80	89.69	89.64	89.58
1.25	100.00	91.67	90.54	90.19	90.02	89.91	89.85	89.79
1.26	100.00	92.00	90.79	90.41	90.23	90.12	90.05	89.99
1.27	100.00	92.33	91.04	90.64	90.44	90.32	90.25	90.19
1.28	100.00	92.67	91.29	90.86	90.65	90.53	90.44	90.38
1.29	100.00	93.00	91.54	91.09	90.86	90.73	90.64	90.58
1.30	100.00	93.33	91.79	91.31	91.07	90.94	90.84	90.78
1.31	100.00	93.66	92.03	91.52	91.27	91.13	91.03	90.96
1.32	100.00	94.00	92.27	91.73	91.47	91.32	91.22	91.15
1.33	100.00	94.33	92.50	91.95	91.68	91.52	91.40	91.33
1.34	100.00	94.67	92.74	92.16	91.88	91.71	91.59	91.52
1.35	100.00	95.00	92.98	92.37	92.08	91.90	91.78	91.70
1.36	100.00	95.33	93.21	92.57	92.27	92.08	91.96	91.87
1.37	100.00	95.67	93.44	92.77	92.46	92.26	92.14	92.04

TABLE I
Variability-Unknown Procedure
Standard-Deviation Method

Quality Index (Q_U or Q_L)	PWL For Selected Sample Sizes							
	n=3	n=4	n=5	n=6	n=7	n=8	n=9	n=10
1.38	100.00	96.00	93.66	92.97	92.64	92.45	92.31	92.22
1.39	100.00	96.34	93.89	93.17	92.83	92.63	92.49	92.39
1.40	100.00	96.67	94.12	93.37	93.02	92.81	92.67	92.56
1.41	100.00	97.00	94.33	93.56	93.20	92.98	92.83	92.72
1.42	100.00	97.33	94.55	93.75	93.37	93.15	93.00	92.88
1.43	100.00	97.67	94.76	93.94	93.55	93.31	93.16	93.05
1.44	100.00	98.00	94.98	94.13	93.72	93.48	93.33	93.21
1.45	100.00	98.33	95.19	94.32	93.90	93.65	93.49	93.37
1.46	100.00	98.66	95.39	94.49	94.06	93.81	93.64	93.52
1.47	100.00	99.00	95.59	94.67	94.23	93.97	93.80	93.67
1.48	100.00	99.33	95.80	94.84	94.39	94.12	93.95	93.83
1.49	100.00	99.67	96.00	95.02	94.56	94.28	94.11	93.98
1.50	100.00	100.00	96.20	95.19	94.72	94.44	94.26	94.13
1.51	100.00	100.00	96.39	95.35	94.87	94.59	94.40	94.27
1.52	100.00	100.00	96.57	95.51	95.02	94.73	94.54	94.41
1.53	100.00	100.00	96.76	95.68	95.18	94.88	94.69	94.54
1.54	100.00	100.00	96.94	95.84	95.33	95.02	94.83	94.68
1.55	100.00	100.00	97.13	96.00	95.48	95.17	94.97	94.82
1.56	100.00	100.00	97.30	96.15	95.62	95.30	95.10	94.95
1.57	100.00	100.00	97.47	96.30	95.76	95.44	95.23	95.08
1.58	100.00	100.00	97.63	96.45	95.89	95.57	95.36	95.20
1.59	100.00	100.00	97.80	96.60	96.03	95.71	95.49	95.33
1.60	100.00	100.00	97.97	96.75	96.17	95.84	95.62	95.46
1.61	100.00	100.00	98.12	96.88	96.30	95.96	95.74	95.58
1.62	100.00	100.00	98.27	97.02	96.43	96.08	95.86	95.70
1.63	100.00	100.00	98.42	97.15	96.55	96.21	95.98	95.81
1.64	100.00	100.00	98.57	97.29	96.68	96.33	96.10	95.93
1.65	100.00	100.00	98.72	97.42	96.81	96.45	96.22	96.05
1.66	100.00	100.00	98.84	97.54	96.92	96.56	96.33	96.16
1.67	100.00	100.00	98.97	97.66	97.04	96.67	96.44	96.27
1.68	100.00	100.00	99.09	97.78	97.15	96.79	96.54	96.37
1.69	100.00	100.00	99.22	97.90	97.27	96.90	96.65	96.48
1.70	100.00	100.00	99.34	98.02	97.38	97.01	96.76	96.59
1.71	100.00	100.00	99.43	98.13	97.48	97.11	96.86	96.69
1.72	100.00	100.00	99.53	98.23	97.58	97.21	96.96	96.78
1.73	100.00	100.00	99.62	98.34	97.69	97.31	97.05	96.88
1.74	100.00	100.00	99.72	98.44	97.79	97.41	97.15	96.97
1.75	100.00	100.00	99.81	98.55	97.89	97.51	97.25	97.07
1.76	100.00	100.00	99.86	98.64	97.98	97.60	97.34	97.16
1.77	100.00	100.00	99.91	98.73	98.07	97.69	97.43	97.25
1.78	100.00	100.00	99.95	98.81	98.17	97.78	97.52	97.33
1.79	100.00	100.00	100.00	98.90	98.26	97.87	97.61	97.42
1.80	100.00	100.00	100.00	98.99	98.35	97.96	97.70	97.51
1.81	100.00	100.00	100.00	99.06	98.43	98.04	97.78	97.59
1.82	100.00	100.00	100.00	99.14	98.51	98.12	97.86	97.67
1.83	100.00	100.00	100.00	99.21	98.58	98.19	97.93	97.75

TABLE I
Variability-Unknown Procedure
Standard-Deviation Method

Quality Index (Q_U or Q_L)	PWL For Selected Sample Sizes							
	n=3	n=4	n=5	n=6	n=7	n=8	n=9	n=10
1.84	100.00	100.00	100.00	99.29	98.66	98.27	98.01	97.83
1.85	100.00	100.00	100.00	99.36	98.74	98.35	98.09	97.91
1.86	100.00	100.00	100.00	99.42	98.81	98.42	98.16	97.98
1.87	100.00	100.00	100.00	99.48	98.87	98.49	98.23	98.05
1.88	100.00	100.00	100.00	99.53	98.94	98.55	98.30	98.11
1.89	100.00	100.00	100.00	99.59	99.00	98.62	98.37	98.18
1.90	100.00	100.00	100.00	99.65	99.07	98.69	98.44	98.25
1.91	100.00	100.00	100.00	99.69	99.13	98.75	98.50	98.31
1.92	100.00	100.00	100.00	99.73	99.18	98.81	98.56	98.37
1.93	100.00	100.00	100.00	99.77	99.24	98.87	98.62	98.44
1.94	100.00	100.00	100.00	99.81	99.29	98.93	98.68	98.50
1.95	100.00	100.00	100.00	99.85	99.35	98.99	98.74	98.56
1.96	100.00	100.00	100.00	99.87	99.39	99.04	98.79	98.61
1.97	100.00	100.00	100.00	99.90	99.44	99.09	98.84	98.67
1.98	100.00	100.00	100.00	99.92	99.48	99.14	98.90	98.72
1.99	100.00	100.00	100.00	99.95	99.53	99.19	98.95	98.78
2.00	100.00	100.00	100.00	99.97	99.57	99.24	99.00	98.83
2.01	100.00	100.00	100.00	99.98	99.60	99.28	99.05	98.88
2.02	100.00	100.00	100.00	99.98	99.64	99.32	99.09	98.92
2.03	100.00	100.00	100.00	99.99	99.67	99.37	99.14	98.97
2.04	100.00	100.00	100.00	99.99	99.71	99.41	99.18	99.01
2.05	100.00	100.00	100.00	100.00	99.74	99.45	99.23	99.06
2.06	100.00	100.00	100.00	100.00	99.76	99.48	99.27	99.10
2.07	100.00	100.00	100.00	100.00	99.79	99.51	99.30	99.14
2.08	100.00	100.00	100.00	100.00	99.81	99.55	99.34	99.18
2.09	100.00	100.00	100.00	100.00	99.84	99.58	99.37	99.22
2.10	100.00	100.00	100.00	100.00	99.86	99.61	99.41	99.26
2.11	100.00	100.00	100.00	100.00	99.88	99.64	99.44	99.29
2.12	100.00	100.00	100.00	100.00	99.89	99.66	99.47	99.32
2.13	100.00	100.00	100.00	100.00	99.91	99.69	99.51	99.36
2.14	100.00	100.00	100.00	100.00	99.92	99.71	99.54	99.39
2.15	100.00	100.00	100.00	100.00	99.94	99.74	99.57	99.42
2.16	100.00	100.00	100.00	100.00	99.95	99.76	99.59	99.45
2.17	100.00	100.00	100.00	100.00	99.96	99.78	99.62	99.48
2.18	100.00	100.00	100.00	100.00	99.97	99.80	99.64	99.50
2.19	100.00	100.00	100.00	100.00	99.98	99.82	99.67	99.53
2.20	100.00	100.00	100.00	100.00	99.99	99.84	99.69	99.56
2.21	100.00	100.00	100.00	100.00	99.99	99.85	99.71	99.58
2.22	100.00	100.00	100.00	100.00	99.99	99.87	99.73	99.61
2.23	100.00	100.00	100.00	100.00	100.00	99.88	99.75	99.63
2.24	100.00	100.00	100.00	100.00	100.00	99.90	99.77	99.66
2.25	100.00	100.00	100.00	100.00	100.00	99.91	99.79	99.68
2.26	100.00	100.00	100.00	100.00	100.00	99.92	99.80	99.70
2.27	100.00	100.00	100.00	100.00	100.00	99.93	99.82	99.72
2.28	100.00	100.00	100.00	100.00	100.00	99.94	99.83	99.73
2.29	100.00	100.00	100.00	100.00	100.00	99.95	99.85	99.75

