



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 Wire Fabric 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 (mass determination) 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 (150 mm) of the pavement edge. If necessary to stop the forward movement of the paver, the vibratory and tamping elements shall be stopped immediately.

502.3.2.2 Forms and Keyways. Forms shall be used where necessary to produce a concrete base or pavement of plan section and the forms shall incorporate a keyway where required. Longitudinal tongue and groove joints of the specified type and size shall be constructed at locations shown on the plans or approved by the engineer. The groove side of the joint shall be slip-formed or formed with approved metal forms that will produce a keyway in accordance to plan location and dimensions. The form shall remain in place for sufficient time to prevent slump. Metal forms may be left in place if approved by the engineer. The tongue side of the joint may be constructed without forms provided the plan section of the concrete and joint is maintained.

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 (75 mm) to 5 inches (125 mm) high and thick enough to make an indentation of 1/4 inch (6 mm). 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 3500 psi (24 MPa) 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 (3 mm) from the true grade line during placing, compacting and finishing operations. The form alignment shall not vary more than 1/4 inch (6 mm) 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 (mass determination) or metering, with all additives dispensed automatically and interlocked with the automatic weighing (mass determination) or metering controls. For central mixed concrete, the mixing cycle shall be timed and interlocked with the weight (mass) batch cycle. The weight (mass determination) 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 (5800 m²) using manual batching methods. For all contracts having a total of no more than 20,000 square yards (16,700 m²) 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. Where tie bars are required at longitudinal construction joints, a tongue and groove type joint shall be constructed, and the tie bars shall be installed in the groove side of the joint. The bars 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 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 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 0.70 mm. Any subplot showing a texture depth of less than 0.70 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 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 (0.2 km).

502.4.8.3.4 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 A wire comb shall be no less than 10 feet (3 m) long with a single line of wires exposed to a length of approximately 4 inches (100 mm). The wire shall be blue-tempered and polished spring steel with nominal dimensions of 0.028 inch (0.71 mm) thick and 0.100 to 0.125 inch (2.54 to 3.175 mm) wide. The wires shall be spaced to provide 1/2-inch (13 mm) 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 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 (3 mm). 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 (10 mm). 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 (60 m) or where wood forms are used.

(b) For all irregularly shaped areas.

(c) For pavement lanes less than 200 feet (60 m) long.

(d) For pavement lanes less than 10 feet (3 m) 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 (10 mm). 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. No transverse construction joint shall be constructed within 10 feet (3 m) of an expansion or contraction joint. For transverse contraction joint spacing of 20 feet (6 m) or less, the transverse construction joint shall be located within the normal sequence of contraction joint spacing as shown on the plans. 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 the joint groove cut to the dimensions shown on the plans except as herein specified. Joints in Portland cement concrete base shall have a minimum width of 1/8 inch (3 mm). If an early-entry concrete saw is used, the dimensions of the transverse contraction joint groove shall be a minimum of 3/8 inch (10 mm) wide and a depth equal to one-eighth of the slab thickness. The dimensions of the longitudinal joint groove to be sawed with an early-entry saw shall be a minimum of 1/8 inch (3 mm) wide and a depth equal to one-eighth of the slab thickness. If the groove for poured type transverse joints is cut prior to removal of the forms, the groove shall be cut as close as is practical to the concrete base or pavement edge, and the resulting crescent shaped plug in the groove, immediately adjacent to the form, will be acceptable. 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. If an early-entry concrete saw is used, all joint grooves shall be established within 12 hours of finishing. All joints shall be sawed 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 non-reinforced concrete base or pavement with random cracking not controlled by dowels or tie bars shall be removed and replaced using dowels or tie bars as appropriate to the nearest controlled joint at the contractor's expense.

502.5.4 Sealing Joints. All sawed contraction joints and 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. The sealing material shall be installed in such a way as to fill the joint opening uniformly from the bottom to 1/2 inch (13 mm) from the top. Any excess material shall be removed from the pavement surface. Sawed joints in Portland cement concrete base shall not be sealed with joint sealing material.

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 coverage of curing material, without loss, on the pavement at the rate of one gallon for each 150 square feet (0.27 L/m²). 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 Test. The concrete base or pavement surface shall be thoroughly tested for smoothness by profilographing or straightedging as indicated.

502.8.1 Straightedging. As soon as practical, the engineer will straightedge all segments of the paved surface not profilographed, including shoulders. Any variations exceeding 1/8 inch in 10 feet (3 mm in 3 m) will be marked. Areas more than 1/8 inch (3 mm) high shall be removed in accordance with [Sec 502.8.6.2](#). For areas more than 1/8 inch (3 mm) low, appropriate correction will be required for suitable smoothness. The straightedge path for shoulders will be located near the shoulder's centerline. Shoulders that are paved integrally with an adjacent driving lane will not require straightedging. Correction areas on shoulders will not be considered a marred surface. Concrete base shall be finished so that the surface will not vary more than 1/4 inch (6 mm) from a 10-foot (3 m) straightedge.

502.8.2 Profilographing. Profilographing will be applicable to the surface of all mainline paving, auxiliary lanes, turning lanes and ramps for projects or combination of projects, consisting of more than 0.5 mile (1 km) of total profilographable pavement. Profilographing may be waived by the engineer if staging of the overall project, such as multiple entrance lane gaps, lane staging, etc., affects the normal paving operation, or if multiple profilograph exceptions continuously exist eliminating smoothness requirements on a large portion of the same roadway. Upon waiver, all smoothness requirements shall be in accordance with [Sec 502.8.1](#).

502.8.2.1 Starting Point. All wheels of the profilograph shall be placed on the new pavement, with stationing based on the center wheel.

502.8.2.2 Exceptions. Profilographing will not be required for the following:

- (a) Bridge decks, bridge approach slabs and concrete approach pavements.
- (b) Pavement on horizontal curves with centerline radius of curve less than 1000 feet (300 m) and pavement within the superelevation transition of such curves.
- (c) Pavement on vertical curves having a "K" value less than 90 and a length less than 500 feet (150 m).
- (d) Pavement wide transitions.

(e) Fifty feet (15 m) in direction of travel on each side of utility appurtenances such as manholes and valve boxes.

(f) Fifty feet (15 m) in direction of travel on each side of intersecting routes with special grade transition.

(g) Shoulder areas.

(h) Any lane which abuts an existing lane not constructed under the same contract.

(i) Interruptions designated by the engineer which provide independently placed sections shorter than 50 feet (15 m). Interruptions designated by the contractor's operations shall be in accordance with [Sec 502.8.5.12](#).

(j) The last 15 feet (5 m) of any section where the prime contractor is not responsible for the adjoining surface.

(k) The first or last 12.5 feet (4 m) of a pavement section adjoining any above exception area.

502.8.3 Equipment. The profilograph shall be a California-type as approved by the engineer. The equipment furnished shall be in accordance with MoDOT Test Method TM 59. The profilogram line drawn by the profilograph will be referred to as the profile trace in these specifications.

502.8.4 Calibration. All profilographs used shall be calibrated at least annually on a test section directed by MoDOT. The contractor's calibration profile index shall not vary more than 2.0 inches per mile (30 mm/km) from a standard profile index produced by a MoDOT profilograph.

502.8.4.1 Longitudinal. Longitudinal calibration shall consist of pushing the profilograph over a pre-measured test distance and determining the scale factor by dividing the premeasured test distance by the length of the paper in inches (mm). This factor shall be 25 (300), one inch equals 25 feet (25 mm equals 7.622 m). If not, the machine shall be adjusted until the scale factor is 25 (300) plus or minus 0.2 percent.

502.8.4.2 Vertical. Vertical calibration shall consist of sliding a pre-measured calibration block, measured to the nearest 0.01 inch (0.25 mm), under the sensing wheel while the profilograph is stationary. The measurement of the vertical trace line from the base line to the peak and return shall be the same as the calibration block. The trace line shall return to the base line. No tolerance will be allowed.

502.8.4.3 Comparison. A profilograph equipped with automatic profile trace reduction capabilities shall be checked by comparing the machine's results with the results obtained by the engineer. This shall be done for the profile trace obtained on MoDOT's test section. The results including all reduction settings and the profilogram shall be submitted to the engineer. The results of the comparison may not differ by more than 2.0 inches per mile (30 mm/km).

502.8.4.4 Certification. The contractor shall furnish certification that the 25-foot (7.622 m) profilograph test and evaluation was conducted by an operator trained in the use of profilograph equipment and with sufficient experience to demonstrate the operator's competence.

502.8.4.5 Settings. Reduction settings used during the annual calibration shall be used during production without exception. Changes to the reduction settings void the calibration.

502.8.5 Test Procedures and Reporting.

502.8.5.1 Section Definition. A profilogram shall be made for each continuous pavement section of 50 feet (15 m) or greater completed during each day's placement. A section will be defined where paving begins and terminates at a day's work joint. Interruptions designated by the engineer which cause placement to cease and begin at a new location will be considered as a separate section for that day's operation if the separate section is greater than 250 feet (75 m).

502.8.5.2 Profilograph Reporting. The contractor shall furnish the profilogram and the profilogram evaluation to the engineer. The testing shall be done by a certified operator in the presence of the engineer. The testing procedure and the evaluation of the profilogram shall be done in accordance with this specification and MoDOT Test Method TM 59. The profilogram and evaluation shall be furnished to the engineer no later than the end of the next working day following placement of the pavement. If corrective grinding is required, another profilogram and evaluation shall be furnished to the engineer no later than two days after completing corrective grinding. The evaluation shall be reported on an approved form for each day's placement. Separate sections in a day's placement shall be appropriately identified on the day's report for MoDOT use. Standard forms for reporting results may be obtained from MoDOT.

502.8.5.3 Profilogram Quality Acceptance. The engineer may test the surface or re-evaluate the profilogram for comparison and quality assurance purposes. If these tests or re-evaluations indicate the contractor-furnished profilograms are not accurate within 3.0 inches per mile (45 mm/km), the engineer may test the entire project length. If the entire project length is tested, the contractor will be charged for this work at the rate of \$500.00 per lane mile (\$310.00 per lane kilometer). Furnishing inaccurate test results may result in decertification of the operator.

502.8.5.4 Objects on Pavements. All objects and foreign material on the pavement surface, including protective covers, if used, shall be removed by the contractor prior to testing and, if appropriate, protective covers shall be properly replaced by the contractor after testing.

502.8.5.5 Wheel Initialization. The sensing wheel shall be lifted, rotated to take slack out of the linkage, and lowered to the pavement surface at the starting point prior to testing.

502.8.5.6 Speed. The profilograph shall be propelled at walking speed in the paths in accordance with [Sec 502.8.5.10](#) for each section of pavement. Propulsion may be provided by manually pushing or by another suitable propulsion unit. Speed of the profilograph shall be decreased if excessive spikes are encountered on the trace.

502.8.5.7 Location Indicator. A location indicator for lateral placement shall be used. The back end of the profilograph shall be kept in the required path on horizontal curves except where profilographing is not required in accordance with [Sec 502.8.2.2 \(b\)](#).

502.8.5.8 Stationing. The actual stations shall be shown on the profilogram at least every 200 feet (50 m) for necessary bump referencing. The stations may be marked on the trace by manual placement of a vertical mark when the sensing wheel reaches the station. The corresponding station shall be written at the mark. This vertical mark shall reference the upward direction of the trace.

502.8.5.9 Required Information. Both ends of the profilogram shall be labeled with the stationing, lane designation, position or track on the pavement, the direction the pavement was placed and the date placed.

502.8.5.10 Profilograph Path. Pavement profiles shall be taken near the center of each traffic lane and parallel to the edge of pavement as directed by the engineer. Each profile line will be incorporated into the section report as separate tracks.

502.8.5.11 Segment Definition. Sections shall be divided into segments of 0.1 mile (0.2 km) with the exception of the last segment. If the last segment is greater than 250 feet (75 m) and less than 0.1 mile (0.2 km), then the segment shall be considered as a 0.1 mile (0.2 km) segment. If the last segment is 250 feet (75 m) or less long, the profilogram for that segment shall be included in the evaluation for the adjacent segment in that section.

502.8.5.12 Short Sections. If an independently placed section required by the plans or the engineer is between 50 feet and 250 feet (15 m and 75 m), or an independently placed section caused by the contractor's operation is less than 50 feet (15 m), a profilogram shall be made for that section and included in the evaluation of the most recently placed adjoining segment of another day's placement.

502.8.5.13 End of Section. The last 12.5 feet (4 m) of a pavement section and the construction header shall be included in the profilogram of the next day's placement.

502.8.5.14 Profile Index. A profile index shall be calculated from the profilogram for each segment of all profile trace lines and for the overall section. A report for each day's placement shall be completed. A day's report may consist of more than one section index if a bridge or a designated interruption is encountered in a day's placement. The profile index shall be calculated by summing the vertical deviations of the profile trace above or below the reference line. The units of this measure shall be inches per mile (mm/km).

502.8.6 Surface Corrections. Bump correction or smoothness correction or both may be required after the initial smoothness report is performed to produce a final report. If the initial report has no corrections in accordance with [Secs 502.8.6.3](#) and [502.8.6.5](#), the initial report will serve as the final report.

502.8.6.1 Acceptable Index. If an average profile index of 45.0 inches per mile (711 mm/km) for pavements having a final posted speed greater than 45 mph (70 km/h), or 65.0 inches per mile (1026 mm/km) for pavements having a final posted speed of 45 mph (70 km/h) or less, is exceeded in any daily paving operation, the paving operation will be suspended and will not be permitted to resume until corrective action approved by the engineer is taken by the contractor.

502.8.6.2 Correction. Corrective action to improve the average profile index shall be accomplished by diamond grinding or by use of an approved device designed for that purpose. The use of a bush hammer or other impact device will not be permitted. The final surface texture of corrected concrete pavement shall be comparable to adjacent sections that do not require correcting. Satisfactory longitudinal grinding is acceptable as the final surface of the corrected pavements. All corrective work shall be completed prior to determination of pavement thickness.

502.8.6.3 Bumps. High points on the profile trace which correspond to high points or bumps on the pavement surface shall be separately identified. All bumps greater than 0.40 inch (10 mm) high over a 25-foot (7.622 m) span, as indicated on the profile trace, shall be corrected. The corrected bumps will be considered satisfactory when measurements by the profilograph show that the bumps are 0.40 inch (10 mm) or less high over a 25-foot (7.622 m) span. Station referencing or additional profiles may be used to accurately locate deviations greater than 0.40 inch (10 mm).

502.8.6.4 Intermediate Report. After removing all individual deviations greater than 0.40 inch (10 mm) high, an intermediate profilogram report for the appropriate section shall be provided. The report shall provide segment indexes for the entire day's section after initial bump correction. The intermediate report will serve as the final report if all average profile segment indexes are below the limits in accordance with [Sec 502.8.6.5](#).

502.8.6.5 Required Correction. After removing individual deviations of 0.40 inch (10 mm), additional correction may be necessary to reduce any average profile segment index to 25.0 inches (395 mm) or less per mile (km) for pavements having a final posted speed greater than 45 mph (70 km/h), or 45.0 inches (711 mm) or less per mile (km) for pavements having a final posted speed of 45 mph (70 km/h) or less. On pavement segments where corrections are necessary, additional profiles shall be made to verify corrections have produced an average profile segment index within the limits noted above. Upon correction, a final report will be performed.

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 3000 psi (21 MPa). The concrete base and pavement shall not be opened to all types of traffic until the concrete has attained a minimum compressive strength of 3500 psi (24 MPa) and all sawed joints 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.

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 7500 square yards (6275 m²) 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 (500 m²), combine the following day's or days' production to reach 600 square yards (500 m²) 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 or mix design has less than 600 square yards (500 m²), a lot may be smaller than 600 square yards (500 m²).

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 (100 mm) diameter core for concrete bases or pavements less than 12 inches (300 mm) thick and a 6-inch (150 mm) diameter core for concrete bases or

pavements 12 inches (300 mm) 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 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 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 3000 psi (21 MPa) 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 If the contractor elects to diamond grind to improve smoothness or surface texture, in accordance with [Sec 502.4.8.3](#), re-coring of the concrete for thickness acceptance will be required for all lots that were previously determined to be at plan thickness or less. The engineer may require re-coring, regardless of the initial slab thickness, if two or more diamond grinding passes are conducted within a given lot. Cores shall be 4 inch (100 mm) in diameter. Location of coring will be determined by the engineer using random sampling procedures in accordance with ASTM D 3665.

502.10.4 Acceptance. 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 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

$$x_a = \sum \frac{x_i}{n}$$

where:

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

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

Where:

s = Standard Deviation

Upper Quality Index

$$Q_U = \frac{USL - x_a}{s}$$

Lower Quality Index

$$Q_L = \frac{x_a - LSL}{s}$$

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 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 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 , 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 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 The lower specification limit (LSL) for compressive strength and thickness shall be:

- (a) Compressive Strength – 4000 psi (28 MPa).
- (b) Thickness – Plan thickness minus 1/2 inch (13 mm).

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. The contractor shall develop a QCP that addresses all elements affecting the quality of the concrete base or pavement including, but not limited to mix design, aggregate gradation, quality of material, stockpile management, proportioning,

mixing and transportation, placing and consolidation, joints, dowel placement and alignment, compressive strength, thickness, entrained air content, finishing and curing, and surface smoothness. The QCP shall include an independent third party name, contact, address, and phone number for dispute resolution. The QCP shall be approved by Construction and Materials prior to placing any concrete.

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, aggregate gradation and deleterious material, aggregate moisture content, entrained air content and slump.

502.11.2.1 Fine and Coarse Aggregate.

502.11.2.1.1 Gradation and Deleterious Material. A sieve analysis shall be made at least twice daily in accordance with AASHTO T 27 from randomly sampled material taken from the discharge gate of storage bins or from the conveyor belt. If less than 600 square yards (500 m²) of concrete are placed during a day's production a minimum of one sieve analysis shall be made. Deleterious substance shall be determined from these random samples in accordance with MoDOT Test Method TM 71.

502.11.2.1.2 Moisture Content. If an electric moisture meter is used, at least two direct measurements of moisture content shall be made per week to check the calibration. If direct measurements are made for fine or coarse aggregate in lieu of using an electric meter, two tests shall be made per day in accordance with AASHTO T 255.

502.11.2.2 Slump. Slump tests shall be performed on a random basis for each 500 cubic yards (375 m³) 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 (375 m³), 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 T 141.

502.11.2.3 Entrained Air Content. Tests for entrained air content shall be performed on a random basis for each 500 cubic yards (375 m³) 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 (150 m³) of concrete. The entrained air content of the first 200 cubic yards (150 m³) 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 Control Charts. The contractor shall maintain linear control charts for fine and coarse aggregate gradation, slump, entrained air content, time taken and loss through the paver, compressive strength, either by cylinders or maturity, and slab thickness. Control charts shall be posted in a location satisfactory to the engineer and shall be kept up to date at

all times. As a minimum, the control charts shall identify the project number, the contract item number, the test number, each test parameter, the action and suspension limits, or specification limits, applicable to each test parameter, and the contractor's test results. The contractor shall use the control charts as part of a process control system for identifying potential problems and assignable causes before they occur. If the contractor's projected data during production indicates a potential problem and the contractor is not taking satisfactory corrective action, the engineer may halt production or acceptance of the material.

502.11.3.1 Fine and Coarse Aggregate Gradation. The contractor shall record the gradation tests for each control sieve on linear control charts. Specification limits from [Sec 1005](#), or the limits established in the QC plan for optimized mixtures, shall be superimposed on the control chart for job control.

502.11.3.2 Slump and Air Content. The contractor shall maintain linear control charts for both individual measurements of slump and air content in accordance with the following action limits. The individual measurement control charts shall use the mix design target values as indicators of central tendency.

Individual Measurements	
Control Parameter	Action Limit
Slump	+1 in. (25 mm)
Air Content	4.5 to 5.0%
Gradation	
Aggregate	+/- 2%
-200	+0.5%

502.11.4 Corrective Action. The QCP shall indicate that appropriate action shall be taken when a process is believed to be out of control. The QCP shall detail what action shall be taken to bring a process into control and shall contain sets of rules to determine when a process is out of control. 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 halting production shall be tested for specification compliance.

502.11.4.1 Fine and Coarse Aggregate Gradation. When two consecutive tests are outside the specification limits but within the action limits or one test is outside the action limits, immediate steps, including a halt to production, shall be taken to correct the gradation.

502.11.4.2 Fine and Coarse Aggregate Moisture Content. Whenever the moisture content of the fine or coarse aggregate changes by more than 0.5 percent, the scale settings for the aggregate batcher(s) and water batcher shall be adjusted.

502.11.4.3 Slump and Air Content. 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.

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

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

502.11.5.2 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.

502.11.5.3 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.

502.11.5.4 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.

502.12 Quality Assurance. Corrective action shall be required in accordance with [Sec 502.11.4](#) 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 2 days
Aggregate Moisture	1 per 2 days

502.12.1 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 Removal of Material. Any material meeting the following criteria shall be removed and replaced at the contractor's expense:

- (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 3500 psi (24Mpa)

(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 (0.1 m²). The revision or correction will be computed and added to or deducted from the contract quantity.

502.15 Basis of Payment.

502.15.1 Thickness. Portland cement concrete base and pavement thickness determination will be made after all smoothness correction has been completed.

502.15.2 Marred Surface. For marred surface areas or slightly damaged concrete that remains in the completed pavement, a minimum deduction of 20 percent of the contract unit price will be made for the areas affected. The deduction will be applied to a section of pavement extending from edge of the pavement to a longitudinal joint or between longitudinal joints in that section of pavement affected. If the length of the section affected is less than 10 feet (3 m), the deduction will be computed for 10 feet (3 m).

502.15.3 Smoothness Adjustment. Payment for smoothness shall be based on either Table I or Table II. Table I shall be used for pavements having a final posted speed greater than 45 mph (70 km/h). Table II shall be used for pavements having a final posted speed of 45 mph (70 km/h) or less and for pavements with no posted speed limits. Constant-width acceleration and deceleration lanes shall be considered as mainline pavements.

502.15.3.1 Incentives. Smoothness incentive will be paid per section based on the profile index before any corrections. If diamond grinding is the final texture of the pavement surface, smoothness incentive will be paid per section based on the profile index after diamond grinding. Within a section qualifying for incentive pay, any segment having a profile index requiring correction will not be included in incentive payment for that section.

502.15.3.2 Deductions. Corrected areas will be considered marred surfaces. A deduction of 20 percent of the contract price will be made for the affected area. Continuous corrective action performed on the entire pavement width for a length of 0.1 mile (0.2 km) or more will not be considered a marred surface. Constant-width acceleration and deceleration lanes shall be considered as mainline pavements.

Table I	
Profile Index, Inches Per Mile (mm/km)	Percent of Contract Price
10.0 (158) or less	105
10.1 - 15.0 (159 - 237)	103
15.1 - 25.0 (238 - 395)	100
25.1 (396) or greater	100 ^a

Table II	
Profile Index, Inches Per Mile (mm/km)	Percent of Contract Price
20 (316) or less	103
20.1 - 45.0 (317 - 711)	100
45.1 (712) or greater	100 ^b

^aAfter correction to 25.0 inches per mile (395 mm/km) or less.

^bAfter correction to 45.0 inches per mile (711 mm/km) or less.

502.15.3.3 Segment Correction. After initial bump correction, segments with an average profile index of 25.1 (396) or greater (Table I), or 45.1 (712) or greater (Table II), shall be corrected as specified in [Sec 502.8.6](#) until the profile index is 25.0 (395) or less (Table I), or 45.0 (711) or less (Table II). At the contractor's option, these segments may be removed and replaced. The contractor will be paid the percent of contract price that corresponds to the replaced segment's profile index as specified above.

502.15.3.4 Section Correction. On sections where corrections are made, the pavement shall be tested by the contractor to verify that corrections have produced a profile index of 25.0 (395) or less (Table I), or 45.0 (711) or less (Table II).

502.15.3.5 Incentive Exception. The contractor will not be allowed to make corrective grinding to increase the percent of pay when the final profile index is 25.0 (395) or less (Table I), or 45.0 (711) or less (Table II).

502.15.4 Testing Cost. 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 smoothness testing. No additional compensation will be allowed for any excess thickness.

502.15.5 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.

502.15.6 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 (3.6 m). 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.

502.15.7 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:

$$\begin{aligned} \text{When PWL}_t \text{ is greater than or equal to 70: } PF &= 0.5 \text{ PWL}_t + 55 \\ \text{When PWL}_t \text{ is less than 70: } PF &= 2 \text{ PWL}_t - 50 \end{aligned}$$

502.15.8 PWL Determination Table. Values in Table III 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 III
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

TABLE III
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
0.45	62.74	65.00	65.84	66.27	66.51	66.67	66.79	66.87
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

TABLE III
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
0.91	78.91	80.33	80.92	81.22	81.38	81.49	81.56	81.61
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

TABLE III
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
1.37	100.00	95.67	93.44	92.77	92.46	92.26	92.14	92.04
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

TABLE III
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
1.83	100.00	100.00	100.00	99.21	98.58	98.19	97.93	97.75
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

