Division 02 – Technical Specifications

Division 02 – Technical Specifications shall be the Colorado Department of Transportation (CDOT) Standard Specifications for Road and Bridge Construction, 2011 Edition, except as modified in this document.

Division 02 – General Provisions

Division 02 – Project Special Provisions

Section 105 and 106	Conformity to the Contract of Hot Mix Asphalt (Less Than 5000 Tons With Volumetric Verification)
Section 409	Micro-Surfacing
Section 409	Slurry Seal

Division 02 – CDOT Standard Special Provisions

Section 101 and 630	Construction Zone Traffic Control
Section 105 and 106	Conformity to the Contract of Hot Mix Asphalt (Voids Acceptance)
Section 106, 627, and 713	Glass Beads for Pavement Marking
Section 202, 627, and 708	Pavement Marking Paint
Section 401	Compaction of Hot Mix Asphalt
Section 401	Compaction Pavement Test Section (CTS)
Section 401	Composition of Mixtures – Voids Acceptance
Section 401	Plant Mix Pavements
Section 401	Reclaimed Asphalt Pavement
Section 401	Temperature Segregation
Section 401	Tolerances for Hot Mix Asphalt (Voids Acceptance)
Section 401 and 412	Safety Edge
Section 614 and 713	Sign Panel Sheeting
Section 630 and 713	Retroreflective Sign Sheeting
Section 702	Bituminous Materials
Section 703	Aggregate for Hot Mix Asphalt

Division 02 – General Provisions

PART 1: General

Description

A. Work described elsewhere in the technical specifications, contract drawings or Part I of the contract documents shall be done in accordance with the Colorado Department of Transportation (CDOT) **2011 Standard Specifications for Road and Bridge Construction** (except as noted below) and the latest edition of the **Colorado Standard Plans (M&S Standards).**

B. The Colorado Department of Transportation General Provisions consisting of Section 100 through 109 of the above referenced "Standard Specifications" and are NOT applicable to this Contract and are hereby deleted, except were specifically added in, these project Special Provisions. In place of the deleted, the City and County of Denver's General Provisions, General Conditions, Special Conditions and Technical Specifications are attached to and made part of the contract.

The following sections shall apply as noted:

1. Section 101 Definitions and Terms
2. Section 105 Control of Work with the following exceptions:
    a. If there are any conflicts with City and County of Denver's General Provisions, General Conditions, Special Conditions or Technical Specifications and this section, those documents will take precedence.
    b. Any reference to incentives shall be disregarded. NO incentives will be paid on this project. References to disincentives, corrective work or removal and rejection of work and/or materials shall apply.
    c. Section 105.21 Acceptance shall not apply.
    d. Section 105.22 through 105.24 shall not apply.
3. Section 106 Control of Material
4. Section 109.01 Measurement of Quantities
5.

Part 2: References

1. All references to "CDOT or the Department" shall be changed to "City and County of Denver" unless otherwise noted.
2. All references to the CDOT Project Engineer and CDOT Regional Transportation Director shall mean DIA Project Manager and DIA Manager of Construction.
3. Any and all reference to incentives or positive pay factors within any documents pertaining to this contract shall not apply. NO incentives or increase pay factors will be paid on this project. References to disincentives, negative pay factors, corrective work or removal and rejection of work and/or materials shall apply.

Part 3: Applicable Publications

Copies of the Colorado Department of Transportation's Standard Specifications for Road and Bridge Construction, Colorado Standard Plans (M&S) Standards), and the Colorado Procedures Field Materials Manual 2012 are available for purchase at:

Colorado Department of Transportation
Bid Plans Room
4201 East Arkansas Avenue
Denver, CO 80222

End of Section

Division 02 – Project Special Provisions

Revision of Section 105 and 106
Conformity to the Contract of Hot Mix Asphalt (Less Than 5000 Tons with Volumetric Verification)

Sections 105 and 106 of the Standard Specifications are hereby revised for this project as follows:

This specification shall be used in conjunction with bid item 403-00700 Pavement Repair (Asphalt).

Any reference to joint density in section 105 and 106 conformity to the contract of hot mix asphalt (less than 5000 tons with volumetric verification), and relating specifically to item 403-00700 Pavement Repair (Asphalt), shall be taken for information only. Joint densities taken during the first day's production shall be used to measure consistency and uniformity throughout the duration of the project. Any joint densities that fall below the joint densities taken during the first day's production shall be at the DEN project manager's discretion for removal and replacement of the repair. Costs associated with removing and replacing repairs that do not meet joint densities shall be at the contractor's expense.

Delete subsection 105.05 and replace with the following:

105.05 Conformity to the Contract of Hot Mix Asphalt. Conformity to the Contract of all Hot Mix Asphalt, Item 403, except Hot Mix Asphalt (Patching) and temporary pavement will be determined by tests and evaluations of elements that include asphalt content, gradation, in-place density and joint density in accordance with the following:

All work performed and all materials furnished shall conform to the lines, grades, cross sections, dimensions, and material requirements, including tolerances, shown in the Contract.

For those items of work where working tolerances are not specified, the Contractor shall perform the work in a manner consistent with reasonable and customary manufacturing and construction practices.

When the Engineer finds the materials or work furnished, work performed, or the finished product are not in conformity with the Contract and has resulted in an inferior or unsatisfactory product, the work or material shall be removed and replaced or otherwise corrected at the expense of the Contractor.

Materials will be sampled randomly and tested by the Department in accordance with Section 106 and with the applicable procedures contained in the Department's Field Materials Manual. The approximate maximum quantity represented by each sample will be as set forth in Section 106. Additional samples may be selected and tested as set forth in Section 106 at the Engineer's discretion.

A process will consist of either a single test value or a series of test values resulting from related tests of an element of the Contractor's work and materials. An element is a material or workmanship property that can be tested and evaluated for quality level by the Department approved sampling, testing, and analytical procedures. All materials produced will be assigned to a process. A change in process is defined as a change that affects the element involved. For any element, with the exception of the process for joint density element, a process normally will include all produced materials associated with that element prior to a change in the job mix formula (Form 43). For joint density, a new process will be established for each new layer of pavement or for changes in joint construction. Density measurements taken within each compaction test section will be a separate process. The Engineer may separate a process in order to accommodate small quantities or unusual variations.

Evaluation of materials for pay factors (PF) will be done using only the Department's acceptance test results. Each process will have a PF computed in accordance with the requirements of this Section. Test results determined to have sampling or testing errors will not be used.

Except for in-place density measurements taken within a compaction test section, any test result for an element greater than the distance 2 x V (see Table 105-2) outside the tolerance limits will be designated as a separate process and the pay factor will be calculated in accordance with subsection 105.05(a). An element pay factor less than zero shall be zero. The calculated PF will be used to determine the Incentive/Disincentive Payment (I/DP) for the process.

In the case of in-place density or joint density the Contractor will be allowed to core the exact location (or immediately adjacent location for joint density) of a test result more than 2 x V outside the tolerance limit. The core must be taken and furnished to the Engineer within eight hours after notification by the Engineer of the test result. The result of this core will be used in lieu of the previous test result. Cores not taken within eight hours after notification by the Engineer will not be used in lieu of the test result. All costs associated with coring will be at the Contractor s expense.

(a) *Representing Small Quantities.* When it is necessary to represent a process by only one or two test results, PF will be the average of PFs resulting from the following:

If the test result is within the tolerance limits then PF = 1.00
If the test result is above the maximum specified limit, then

$$PF = 1.00 – [0.25(T_O - T_U)/V]$$

If the test result is below the minimum specified limit, then

$$PF = 1.00 – [0.25(T_L - T_O)/V]$$

Where:

PF	=	pay factor.
V	=	V factor from Table 105-2.
T_O	=	the individual test result.
T_U	=	upper specification limit.
T_L	=	lower specification limit.

The calculated PF will be used to determine the I/DP for the process.

(b) *Determining Quality Level.* Each process with three or more test results will be evaluated for a quality level (QL) in accordance with Colorado Procedure 71.

(c) *Gradation Element.* Each specified sieve, with the exception of 100 percent passing sieves, will be evaluated for QL separately. The lowest calculated QL for a sieve will be designated as the QL for gradation element for the process.

(d) *Joint Density Element.* Joint Density will be tested according to subsection 401.17.

(e) *Process Pay Factor.* Using the calculated QL for the process, compute PF as follows: The final number of random samples (Pn) in each process will determine the final pay factor. . As test values are accumulated for each process, Pn will change accordingly. When the process has been completed, the number of random samples it contains will determine the computation of PF, based on Table 105-3 and formula (1) below. When Pn is from 3 to 9, or greater than 200, PF will be computed using the formulas designated in Table 105-3. Where Pn is equal to or greater than 10 and less than 201, PF will be computed by formula (1):

$$(1)\ PF = \frac{(PF_1 + PF_2)}{2} + \left[\frac{(PF_2 + PF_3)}{2} - \frac{(PF_1 + PF_2)}{2}\right] \times \frac{(Pn_2 - Pn_X)}{(Pn_2 - Pn_3)}$$

Where, when referring to Table 105-3:

PF_1= PF determined at the next lowest Pn formula using process QL

PF_2= PF determined using the Pn formula shown for the process QL

PF_3= PF determined at the next highest Pn formula using process QL

Pn_2= the lowest Pn in the spread of values listed for the process Pn formula

Pn_3= the lowest Pn in the spread of values listed for the next highest Pn formula

Pn_X= the actual number of test values in the process

When evaluating the item of Furnish Hot mix asphalt, the PF for the element of In-Place Density shall be 1.0.

Regardless of QL, the maximum PF in relation to Pn is limited in accordance with Table 105-3. As test results become available, they will be used to calculate accumulated QL and PF numbers for each process. The process I/DP's will then be calculated and accumulated for each element and for the item. The test results and the accumulated calculations will be made available to the Contractor upon request.

Numbers from the calculations will be carried to significant figures and rounded according to AASHTO Standard Recommended Practice R-11, Rounding Method.

(f) *Evaluation of Work.* When the PF of a process is 0.75 or greater, the finished quantity of work represented by the process will be accepted at the appropriate pay factor. If the PF is less than 0.75, the Engineer may:

1. Require complete removal and replacement with specification material at the Contractor's expense;

   or

2. Where the finished product is found to be capable of performing the intended purpose and the value of the finished product is not affected, permit the Contractor to leave the material in place.

If the material is permitted to remain in place the PF for the process will not be greater than 0.75. When condition red, as described in Section 106, exists for any element, resolution and correction will be in accordance with Section 106. Material, which the Engineer determines is defective, may be isolated and rejected without regard to sampling sequence or location within a process.

If removal and replacement is required because the joint density PF for a process is below 0.75, the Contractor shall remove and replace the full lane width adjacent to and including at least 6 inches beyond the visible joint line for the entire length of joint representing the process. If the lane removed is adjacent to another joint, that joint shall also be removed to a point 6 inches beyond the visible joint line. When a single joint density core is more than 2V outside the tolerance limits, the removal and replacement limits shall be identified by coring the failing joint at 25 foot intervals until two successive cores are found to be 1V or less below the minimum tolerance limit. If removal and replacement is required, the Contractor shall submit documentation identifying the process to be used to correct the area in question in writing. The process will be approved by the Engineer before commencing the corrective work.

Table 105-2
"W" AND "V" FACTORS FOR VARIOUS ELEMENTS

Hot Mix Asphalt		
Element	**V Factor**	**W Factor**
2.36 mm (No. 8) mesh and larger sieves	2.80	N/A
600 µm (No. 30) mesh sieve	1.80	N/A
75 µm (No. 200) mesh sieve	0.80	N/A
Gradation	N/A	15
Asphalt Content	0.20	25
In-place Density	1.10	45
Joint Density	1.60	15

Table 105-3

FORMULAS FOR CALCULATING PF BASED ON PN

Pn	When Pn as shown at left is 3 to 9, or greater than 200, use designated formula below to calculate Pay Factor, PF = ..., when Pn is 10 to 200, use formula (1) above:	Maximum PF
3	$0.31177 + 1.57878 (QL/100) - 0.84862 (QL/100)^2$	1.025
4	$0.27890 + 1.51471 (QL/100) - 0.73553 (QL/100)^2$	1.030
5	$0.25529 + 1.48268 (QL/100) - 0.67759 (QL/100)^2$	1.030
6	$0.19468 + 1.56729 (QL/100) - 0.70239 (QL/100)^2$	1.035
7	$0.16709 + 1.58245 (QL/100) - 0.68705 (QL/100)^2$	1.035
8	$0.16394 + 1.55070 (QL/100) - 0.65270 (QL/100)^2$	1.040
9	$0.11412 + 1.63532 (QL/100) - 0.68786 (QL/100)^2$	1.040
10 to 11	$0.15344 + 1.50104 (QL/100) - 0.58896 (QL/100)^2$	1.045
12 to 14	$0.07278 + 1.64285 (QL/100) - 0.65033 (QL/100)^2$	1.045
15 to 18	$0.07826 + 1.55649 (QL/100) - 0.56616 (QL/100)^2$	1.050
19 to 25	$0.09907 + 1.43088 (QL/100) - 0.45550 (QL/100)^2$	1.050
26 to 37	$0.07373 + 1.41851 (QL/100) - 0.41777 (QL/100)^2$	1.055
38 to 69	$0.10586 + 1.26473 (QL/100) - 0.29660 (QL/100)^2$	1.055
70 to 200	$0.21611 + 0.86111 (QL/100)$	1.060
$\geq$ 201	$0.15221 + 0.92171 (QL/100)$	1.060

(g) *Process I/DP Computation.*

$$I/DP = (PF - 1)(QR)(UP)(W/100)$$

Where:
- I/DP = Incentive/Disincentive Payment
- PF = Pay Factor
- QR = Quantity in Tons of HMA Represented by the Process
- UP = Unit Bid Price of Asphalt Mix
- W = Element Factor from Table 105-2

When AC is paid for separately UP shall be:

$$UP = [(Ton_{HMA})(UP_{HMA}) + (Ton_{AC})(UP_{AC})]/Ton_{HMA}$$

Where:
- Ton_{HMA} = Tons of Asphalt Mix
- UP_{HMA} = Unit Bid Price of Asphalt Mix
- Ton_{AC} = Tons of Asphalt Cement
- UP_{AC} = Unit Bid Price of Asphalt Cement

For the joint density element:

$UP = UP_{HMA}$
Where: UP_{HMA} is as defined above.

When AC is paid for separately UP shall be:

$$UP = [(BTon_{HMA})(BUP_{HMA}) + (BTon_{AC})(BUP_{AC})]/BTon_{HMA}$$

Where: $BTon_{HMA}$ = Bid Tons of Asphalt Mix
BUP_{HMA} = Unit Bid Price of Asphalt Mix
$BTon_{AC}$ = Bid Tons of Asphalt Cement
BUP_{AC} = Unit Bid Price of Asphalt Cement

(h) *Element I/DP.* The I/DP for an element shall be computed by accumulating the process I/DP's for that element.

(i) *I/DP for a Mix Design.* The I/DP for a mix design shall be computed by accumulating the individual I/DP's for the asphalt content, in-place density, and gradation elements for that mix design. The accumulated quantities of materials for each element must be the same at the end of I/DP calculations for a mix design.

(j) *Project I/DP.* The I/DP for the project shall be computed by accumulating the mix design I/DP's and the joint density I/DP's. The accumulated quantities of materials for each element must be the same at the end of I/DP calculations for the project.

Delete subsection 106.05 and replace with the following:

106.05 Sampling and Testing of Hot Mix Asphalt. All hot mix asphalt, Item 403, except Hot Mix Asphalt (Patching) and temporary pavement shall be tested in accordance with the following program of process control testing and acceptance testing:

The Contract will specify whether process control testing by the Contractor is mandatory or voluntary.

(a) *Process Control Testing.*

1. Mandatory Process Control. When process control testing is mandatory the Contractor shall be responsible for process control testing on all elements and at the frequency listed in Table 106-1. Process control testing shall be performed at the expense of the Contractor.

   After completion of compaction, in-place density tests for process control shall be taken at the frequency shown in Table 106-1. The results shall be reported in writing to the Engineer on a daily basis. Daily plots of the test results with tonnage represented shall be made on a chart convenient for viewing by the Engineer. All of the testing equipment used for in-place density testing shall conform to the requirements of acceptance testing standards, except nuclear testing devices need not be calibrated on the Department's calibration blocks.

   For elements other than in-place density, results from quality control tests need not be plotted, or routinely reported to the Engineer. This does not relieve the Contractor from the responsibility of performing such testing along with appropriate plant monitoring as necessary to assure that produced material conforms to the applicable specifications. Quality control test data shall be made available to the Engineer upon request.

2. Voluntary Process Control. The Contractor may conduct process control testing. Process control testing is not required, but is recommended on the elements and at the frequency listed in Table 106-1.

   All of the testing equipment used for in-place density testing shall conform to the requirements of acceptance testing standards, except nuclear testing devices need not be calibrated on the Department's calibration blocks.

(b) *Acceptance Testing.* Acceptance testing is the responsibility of the Department. For acceptance testing the Department will determine the locations where samples or measurements are to be taken and as designated in Section 403. The maximum quantity of material represented by each test result, the elements, the frequency of testing and the minimum number of test results will be in accordance with Table 106-1. The location or time of sampling will be based on the stratified random procedure as described in CP 75. Acceptance sampling and testing procedures will be in accordance with the Schedule for Minimum Materials Sampling, Testing and Inspection in the Department's Field Materials Manual. Samples for project acceptance testing shall be taken by the Contractor in accordance with the designated method. The samples shall be taken in the presence of the Engineer. Where appropriate, the Contractor shall reduce each sample to the size designated by the Engineer. The Contractor may retain a split of the each sample which cannot be included as part of the Contractor's process control testing. Dispute of the acceptance test results in accordance with CP-17 will not be allowed unless a provision for check testing has been included in the Contract and it has been successfully completed. All materials being used are subject to inspection and testing at any time prior to or during incorporation into the work.

Table 106-1
SCHEDULE FOR MINIMUM SAMPLING AND TESTING

Element	Process Control	Acceptance
Asphalt Content	1/500 tons & 1/day	1/1000 tons & 1/day
Theoretical Maximum Specific Gravity	1/1000 tons, minimum 1/day	1/1000 tons, minimum 1/day
Gradation	1/Day (1)	1/day
In-Place Density	1/lift/repair location	2/day minimum
Joint Density	1 transverse and 1 longitudinal core/100 ton	1 transverse and 1 longitudinal core/100 ton
Aggregate Percent Moisture (3)	1/Day	1/week
Percent Lime (3) (4)	1/Day	1/week

Notes:
(1) The minimum number of in-place density tests for acceptance will be 5.
(2) Not to be used for incentive/disincentive pay. Test according to CP 60B and report results from Form 106 or Form 565 on Form 6.
(3) Verified per Contractor's QC Plan.

(c) *Reference Conditions.* Three reference conditions can exist determined by the Moving Quality Level (MQL). The MQL will be calculated in accordance with the procedure in CP 71 for Determining Quality Level (QL). The MQL will be calculated using only acceptance tests. The MQL will be calculated on tests 1 through 3, then tests 1 through 4, then tests 1 through 5, then thereafter on the last five consecutive test results. The MQL will not be used to determine pay factors. The three reference conditions and actions that will be taken are described as follows:

1. Condition green will exist for an element when an MQL of 90 or greater is reached, or maintained, and the past five consecutive test results are within the specification limits.

2. Condition yellow will exist for all elements at the beginning of production or when a new process is established because of changes in materials or the job-mix formula, following an extended suspension of work, or when the MQL is less than 90 and equal to or greater than 65. Once an element is at condition green, if the MQL falls below 90 or a test result falls outside the specification limits, the condition will revert to yellow or red as appropriate.

3. Condition red will exist for any element when the MQL is less than 65. The Contractor shall be notified immediately in writing and all work shall be suspended until the Contractor provides a remediation plan in writing to the DEN project manager. Production shall resume upon approval form the DEN project manager.

   If gradation is the element with MQL less than 65, the Department will test one randomly selected sample in the next days production produced in condition red. If this test result is outside the tolerance limits, production will be suspended. (This test result will not be included as an acceptance test.)

   After condition red exists, a new MQL will be started. Acceptance testing will stay at the frequency shown in Table 106-1. After three acceptance tests, if the MQL is less than 65, production will be suspended.

   Production will remain suspended until the source of the problem is identified and corrected. Each time production is suspended, corrective actions shall be proposed in writing by the Contractor and approved in writing by the Engineer before production may resume.

   Upon resuming production, the process control sampling and testing frequency for the elements causing the condition red shall remain as outlined in table 106-1. If the QL for the next five process control tests is below 65, production will be suspended again. If gradation is the element with MQL less than 65, the Department will test one randomly selected sample in the next days production produced in condition red. If this test result is outside the tolerance limits, production will be suspended.

(d) *Mix Verification Testing.* After the mix design has been approved and production commences, the Department will perform a minimum of three volumetric verification tests for each of the following elements to verify that the field produced hot mix asphalt conforms to the approved mix design:

(1) Air Voids
(2) Voids in Mineral Aggregate (VMA).
(3) Asphalt Content (AC).

The test frequency shall be one per day unless altered by the Engineer.

The test results will be evaluated and the Contractor shall make adjustments if required in accordance

with the following:

1. Target Values. The target value for VMA will be the average of the first three volumetric field test results on project produced hot mix asphalt or the target value specified in Table 403-1 and Table 403-2 of the specifications, whichever is higher. The target value for VMA will be set no lower than 0.5 percent below the VMA target on Form 43 prior to production. The target values for the test element of air voids and AC shall be the mix design air voids and mix design AC as shown on Form 43.

2. Tolerance Limits. The tolerance limits for each test element shall be:

AC	± 0.3 percent
Air Voids	± 1.2 percent
VMA	± 1.2 percent

3. Quality Levels. Calculate an individual QL for each of the elements using the volumetric field verification test results. If the QL for VMA or AC is less than 65 or if the QL for air voids is less than 70, the production shall be halted and the Contractor shall submit a written proposal for a mix design revision to the Engineer. Production shall only commence upon receipt of written approval from the Engineer of the proposed mix design revision.

   After a new or revised mix design is approved, three additional volumetric field verification tests will be performed on asphalt produced with the new or revised mix design. The test frequency shall be one per day unless altered by the Engineer.

   If the QL for VMA or AC is less than 65 or the QL for the test element of air voids is less than 70, then production shall be halted until a new mix design has been completed in accordance with CP 52 or CP 54, a new Form 43 issued, and the Contractor demonstrates that he is capable of producing a mixture meeting the verification requirements in accordance with A or B below:

   A. The Contractor shall produce test material at a site other than a CDOT project. The Contractor shall notify the Engineer a minimum of 48 hours prior to the requested test. The location and time of the test are subject to the approval of the Engineer, prior to placement. Three samples will be tested for volumetric properties. If the QL for VMA or AC is equal or greater than 65 and the QL for the element of air voids is equal or greater than 70, full production may resume or;

   B. The test strip for the project shall be all pavement repairs made on the first day of production. Three samples from the first day's repairs will be tested for volumetric properties. After construction of the test section, production shall be halted until the testing is complete and element QLs are calculated. If the QL for VMA or AC is equal or greater than 65 or the QL for the element of air voids is equal or greater than 70, full production may resume. If the QL for VMA or AC is less than 65 or the QL for the element of air voids is less than 70, the material shall be removed and replaced at no cost to the Department. The time count will continue, and any delay to the project will be considered to have been caused by the Contractor and will not be compensable.

   The costs associated with mix designs shall be solely at the Contractor's expense.

   If the Contractor fails to verify the new mix design in accordance with A or B, then production shall be halted until a new mix design has been completed in accordance with CP 52 or CP 54, a new Form 43 issued, and the Contractor demonstrates they are capable of producing a mixture meeting the verification requirements in accordance with A or B.

4. New or Revised Mix Design. Whenever a new or revised mix design is used and production resumes, three additional volumetric field verification tests shall be performed and the test results evaluated in accordance with the above requirements. The test frequency shall be one per day unless altered by the Engineer.

(e) *Stability Verification Testing.* After the mix design has been approved and production commences, the Department will perform a minimum of three stability verification tests to verify that the field produced HMA conforms to the approved mix design:

The test frequency shall be one per day unless otherwise directed by the Engineer.

The test results will be evaluated and the Contractor shall make adjustments if required in accordance with the following:

1. The minimum value for stability will be the minimum specified in Table 403-1 of the specifications. There will be no tolerance limit.

2. Quality Level. Calculate a QL for stability. If the QL for stability is less than 65, then production shall be halted and the Contractor shall submit a written proposal for a mix design revision to the Engineer. The Engineer shall give written approval to the proposed mix design revision before production continues.

   After a new or revised mix design is approved, three additional stability tests will be performed on asphalt produced with the new or revised mix design. The test frequency shall be one per day unless altered by the Engineer.

   If the stability QL is less than 65, then production shall be halted until a new mix design has been completed and approved using plant produced material or the Contractor shall submit a written proposal for a mix design revision to the Engineer. The Engineer shall give written approval to the proposed mix design revision before production continues.

3. New or Revised Mix Design. Whenever a new or revised mix design is used and production resumes, three additional stability field verification tests shall be performed and the test results evaluated in accordance with the above requirements. The test frequency shall be one per day unless altered by the Engineer.

End of Section

Revision of Section 409
Micro-Surfacing

Section 409 of the Standard Specifications is hereby revised for this project to include the following:

DESCRIPTION

This work consists of furnishing and placing a micro-surfacing seal coat which is a mixture of cationic polymer modified asphalt emulsion, mineral aggregate, mineral filler, water, and other additives proportioned, mixed and spread on the paved surface in conformance to the Contract and to the dimensions as shown on the plans.

MATERIALS

409.02 Materials for the micro-surfacing seal coat shall meet the following requirements*:*

(a) *Emulsified Asphalt.* The emulsion shall be Emulsified Asphalt (CQS-1hP) conforming to the requirements in subsection 702.02(c) Table 702-4.

The modified asphalt shall be formulated such that when the paving mixture is applied, it will cure sufficiently that traffic can be allowed on the roadway at the time designated in the Contract, without any damage to the micro-surfacing. Any damage to the micro-surfacing seal coat caused by early traffic shall be repaired by the Contractor, at no additional cost to the Department.

(b) *Mineral Aggregate.* The mineral aggregate shall be 100 percent crushed, natural aggregate from a sand and gravel or quarry source and shall conform to the gradation and stockpile tolerance ranges given in Table 409-1 and meet the following requirements:

The job mix (target) gradation (including the mineral filler) shall be within the specified gradation band. The mix design gradation shall not vary by more than the stockpile tolerance and shall also remain within the gradation band.

Acceptance of the aggregate will be determined at the job location stockpile. The aggregate shall be available for testing two full working days prior to use. The aggregate shall be tested according to the schedule in the Field Materials Manual for Item 409 and acceptance will be determined in accordance with Section 105. If tests show the aggregate does not conform to the gradation requirements, the material shall not be used.

(c) *Stockpiling and Storage.* The mineral aggregate shall be stored or stockpiled at a site acceptable to the Engineer in such a manner as to prevent segregation and contamination. The aggregate shall be sieved on a 3/8 inch scalping screen immediately prior to transfer to the micro-surfacing mixing machine.

Table 409-1

Sieve Size	Type II Percent Passing	Type III Percent Passing	Stockpile Tolerance
9.5 mm (3/8")	100	100	
4.75 mm (#4)	90 – 100	70 – 90	±5%
2.36 mm (#8)	65 – 90	45 – 70	±5%
1.18 mm (#16)	45 – 70	28 – 50	±5%
600 µm (#30)	30 – 50	19 – 34	±5%
300 µm (#50)	18 – 30	12 – 25	±4%
150 µm (#100)	10 – 21	7 – 18	±3%
75 µm (#200)	5 – 15	5 – 15	±2%

The mineral aggregate shall meet the quality test requirements as indicated in Table 409-2:

Table 409-2

Property	Test	Specification
Sand Equivalent, % minimum	CP-37	65
Soundness, % maximum	AASHTO T104 using Sodium Sulfate and 5 cycles	15
Abrasion (before crushing), % maximum	AASHTO T96	30
Methylene Blue Value, max	ISSA, TB 145	15
Note: ISSA TB = International Slurry Surfacing Association Technical Bulletin		

(d) *Water.* The water shall be potable and shall be free of harmful soluble salts.

(e) *Mineral Filler.* A mineral filler shall be introduced into the mineral aggregate and shall be a non-air entrained portland cement or hydrated lime that is free of lumps. It may be accepted upon supplier certification and visual inspection to ensure the filler is free of lumps. Hydrated lime shall conform to subsection 712.03. Portland cement shall conform to subsection 701.01. The amount of mineral filler needed shall be determined by the laboratory mix design and will be considered as part of the material gradation requirement and, as such, shall not be used as a field control for reaction retardant.

(f) *Micro-surfacing Mix Stability and Field Control Additive.* The micro-surfacing mixture shall be homogeneous during mixing and spreading. The micro-surfacing mix shall be sufficiently stable so that premature breaking of the material in the spreader box does not occur. To maintain proper mixture stability, a field control additive may be introduced to provide effective control of the required quick-set properties. If used, this additive shall be included as part of the mix design and a sample shall be provided by the chemical supplier or emulsion manufacturer and certified as being compatible with the mixture.

409.03 Mix Design. A minimum of two weeks before work commences, the Contractor shall submit a complete mix design using the materials (aggregates, emulsion, and mineral fillers) to be supplied on the project to the Engineer. Construction shall not commence until a job mix formula (Form 43) is issued. This mix design shall be performed by a qualified laboratory acceptable to the Engineer. The mix design shall be made with the same aggregate and gradation that the Contractor will provide on the project. Once materials are approved, no substitutions will be permitted unless first tested by the laboratory preparing the mix design and approved by the Engineer.

The mix design shall determine optimum asphalt content and confirm compatibility of all the ingredients.

The complete mix design shall include all the requirements of Tables 409-1, 409-2, and 409-3 and shall include Certified Test Reports (CTR) for all properties in these tables.

Table 409-3

Property	Test	Specification
Wet Stripping Test, min.	ISSA TB-114	90%
Lateral Displacement by LWT, max.	ISSA TB-147 Method A	5%
Wet Cohesion, minimum @ 30 minutes, min. (set) @ 60 minutes, min. (traffic)	ISSA TB-139	 12 kg-cm cohesion torque 20 kg-cm cohesion torque
Excess Asphalt by LWT, max.	ISSA TB-109	50 g/sq. ft.
Wet Track Abrasion Loss, maximum One hour soak	ISSA TB-100	50g/ft^2
Wet Track Abrasion Loss, maximum Six day soak	ISSA TB-100	75g/ft^2
Classification Compatibility, min.	ISSA TB-144	11 points
Mix Time @ 25 ºC (77 ºF), min.	ISSA TB-113	120 seconds
Boiling Compatibility	ISSA TB 149	Report
Note: ISSA TB = International Slurry Surfacing Association Technical Bulletin		

The percentages of each material used in the mix design shall be shown in the laboratory report. Adjustments may be required during construction based on field conditions and are subject to approval by the Engineer. The approximate range of water and control additives shall be shown on the mix design. The maximum limits of these ingredients shall also be listed.

The component materials shall be within the following limits:

Component Materials	Limits
Residual Asphalt	5.5 – 10.5 % ♦
Mineral Filler	0.0 – 3.0 % ♦
Polymer Content	Minimum of 3.0% solids based on bitumen weight content
Additives	As needed
Water ●	As needed to achieve proper mix consistency●
♦ Based on dry weight of Aggregate ● Total mix liquids should not exceed the loose aggregate voids. ISSA T106 shall be used to check optimum liquids.	

Master Range for Rate of Aggregate Application

AGGREGATE TYPE	MASTER RANGE LIMITS
Type II or Type III	15-30 lb/sq. yd.

Application rates are based on the weight of dry aggregate in the mixture

(a) *Quality Assurance Training.* The Contractor shall provide a minimum two-hour orientation session for project personnel, covering the construction process, materials control, and materials measurement by truck weight delivered vs. machine dial gauge readings.

The Contractor shall provide to the Engineer, on a daily basis, the quantity of material delivered versus material placed through the micro-surfacing mixer based on dial gauge readings. The Engineer will independently verify all dial gauge readings, and material weights delivered. This information will be used for a check against the mix design proportions.

CONSTRUCTION REQUIREMENTS

409.04 Micro-surfacing Seal Coat shall be constructed in accordance with the following requirements;

(a) *Test Strip.* The Contractor shall construct a test strip 1,000 feet long, and it shall consist of all the application courses specified. It will be considered as part of the project. The test strip shall be constructed at the same time of day or night as the full production will be applied. For a wearing course, the Engineer will evaluate the completed test strip after 1 hour of traffic to determine acceptability of the mix and the Contractor's operation. Full production may begin after the Engineer accepts the test strip.

(b) *Weather Limitations.* The material shall be spread only when the road surface and ambient temperatures are at least 50 ºF and rising, the weather is not foggy or rainy, and there is no forecast of temperatures below 40 ºF within 24 hours from the time of placement of the mixture. The Contractor

shall complete work for each day in sufficient time for the material to cure before traffic is restored in accordance with the requirements of the Traffic Control Plan.

409.05 Mixing Equipment. All equipment for the handling of all materials and mixing and placing of the mixture shall be maintained in good repair and operating condition and subject to approval of the Engineer. Any equipment found to be defective or potentially detrimental to the quality of the paving mixture shall be replaced.

The material shall be mixed by a self-propelled, self-contained micro-surfacing mixing machine. This machine shall be a continuous flow mixing unit able to accurately proportion the aggregate, emulsified asphalt, mineral filler and water and deliver these ingredients to a revolving multi-blade mixer and discharge the mixed product on a continuous flow basis.

The mixing machine shall have sufficient storage capacity for aggregate, emulsified asphalt, mineral filler and water to maintain an adequate supply to the proportioning devices. The machine shall be equipped to allow the operator to have full control of the forward and reverse speed during the application of the micro-surfacing material.

The mixing machine shall be equipped with self-loading devices which provide for the loading of all materials while continuing to place micro-surfacing, thereby minimizing construction joints. The machine shall be equipped with opposite side driving stations to optimize longitudinal alignment.

The mixing machine shall be equipped with individual volume or weight controls for proportioning each material in the mix. Each material control device shall be calibrated and properly marked.

The aggregate feed to the mixer shall be equipped with a revolution counter or similar device so the amount of aggregate used may be determined at any time.

The emulsion pump shall be a positive displacement type and shall be equipped with a revolution counter or similar device so that the amount of emulsion used may be determined at any time.

The mixing machine shall be equipped with a water pressure system and nozzle type spray bar to provide a water spray immediately ahead of and outside the spreader box to moisten the pavement.

The mixing machine shall be equipped with an approved fines feeder that shall provide a uniform, accurately metered, predetermined amount of the specified mineral filler.

409.06 Spreading Equipment. The paving mixture shall be spread uniformly by means of a mechanical type spreader box attached to the paver, equipped with auger paddles to agitate and spread the materials throughout the box. A front seal shall be provided to insure no loss of the mixture at the road contact surface. The rear seal shall act as a final strike off and shall be adjustable. The mixture shall be spread to fill cracks and minor surface irregularities and to leave a uniform skid resistant application of micro-surfacing on the surface. The spreader box and rear strike-off shall be so designed and operated that a uniform consistency is achieved to produce a free flow of material to the rear strike-off. The seam where

two spreads meet, shall be neat and uniform. A secondary strike-off shall be attached to the spreader box when the surface course is applied.

At the direction of the Engineer, before the final surface course is placed, preliminary micro-surfacing material shall be placed to fill ruts and depressions in the existing surface. Ruts shall be filled independently with a special rut filling spreader box of 5 to 6 feet in width.

Ruts over 1-¼ inch in depth shall be filled using multiple passes of the rut box with no more than a ¾ inch lift thickness in a single pass.

409.07 Machine Calibration. Each mixing unit to be used in performance of the work shall be calibrated in the presence of the Engineer, prior to construction. Calibration shall include the individual calibration of aggregate, mineral filler, and emulsion at various settings, which can be related to the machine proportioning devices to verify the application rate and mix design compliance.

409.08 Workmanship. Excessive build-up, uncovered areas or unsightly appearance will not be permitted on longitudinal or transverse joints.

(a) *Longitudinal Joints.* Longitudinal joints shall be placed on lane lines where possible. Where not possible, longitudinal joint placement shall be per the Engineer's approval. Excessive overlap will not be permitted. Care shall be taken to insure straight lines along the roadway centerline, lane lines, shoulder or curb lines. The edge shall not vary by more than 3 inches in a 100 foot section.

(b) *Scratch Marks.* The finished micro-surfacing shall have a uniform texture free from excessive scratch marks. Excessive scratch marks are defined as 4 or more marks that are at least 1/2 inch wide and at least 6 inches in length per 40 square yards, or any mark 1 inch wide or wider and at least 4 inches in length. The micro-surfacing shall adhere fully to the underlying pavement prior to placing traffic on it. The cured mixture shall provide a uniform skid resistant surface.

(c) *Surface Preparation.* The area to be micro-surfaced shall be thoroughly cleaned to the Engineer's approval.

(d) *Manholes and Valves*. All manholes and valves shall be clean when work is completed. They shall be covered in a suitable manner prior to micro-surfacing, and the covering shall be removed immediately after micro-surfacing.

(e) *Handwork.* Areas which cannot be reached with a mixing machine shall be surfaced using hand tools to provide complete and uniform coverage. The area to be worked by hand shall be lightly dampened prior to mix placement. Handwork shall not result in any unsightly appearance. Handwork shall be completed at the time of the machine applying process.

Areas deficient in quality of workmanship shall be patched by overlay with the full width paving box. Individual hole patching is not permitted. Patching must be completed in such a manner as to leave the roadway with a uniform appearance, texture, and skid resistant surface, free of segregation and flushing. Micro-Surfacing material required to repair deficiencies due to unsatisfactory workmanship will not be paid for but shall be entirely at the Contractor's expense.

METHOD OF MEASUREMENT

Micro-surfacing seal coat will be measured by the ton. The total tonnage of the micro-surfacing will be calculated by adding the accepted quantity of aggregate and emulsion only.

BASIS OF PAYMENT

Payment will be made under:

Pay Item		Pay Unit
409-09000	Micro-Surfacing Seal Coat	Ton

All materials, emulsion, mineral filler, additives, water, haul, labor, tools, equipment, placement, and all other work necessary to complete each of the pay items will not be measured and paid for separately, but shall be included in the work.

End of Section

Revision of Section 409
Slurry Seal

Section 409 of the Standard Specifications is hereby revised for this project to include the following:

DESCRIPTION

This work consists of furnishing and placing a mixture of an approved emulsified asphalt, mineral aggregate, water, and specified additives, proportioned, mixed and uniformly spread in conformance to the Contract and to the dimensions as shown on the plans. The completed slurry seal shall leave a homogeneous mat and adhere firmly to the underlying pavement.

MATERIALS

Bituminous Material. Bituminous material shall be CQS-1hL and shall conform to the requirements in subsection 702.02, Table 702-4. The emulsion shall be capable of being pumped and shall be suitable for use in slurry seal mixing, spreading and application using slurry seal equipment and a distributor truck.

Slurry Aggregate. Slurry aggregate shall be washed, hard, durable, clean rock, free from coatings or deleterious material. The aggregate shall be manufactured crushed stone such as granite, slag, limestone, or other high-quality material. To ensure that the material is totally crushed, 100 percent of the parent aggregate shall be larger than the largest stone in the gradation to be used. The target mix design aggregate gradation, including mineral filler, shall conform to the following:

Slurry aggregate shall conform to the following:

Quality Tests:
(a) Percentage of Wear, Los Angles Abrasion Test (AASHTO T96), Shall not be more than 25
(b) Soundness, AASHTO T104 using sodium sulfate, shall have a 15 percent maximum.
(c) Sand Equivalent, AASHTO T176, shall be 45 minimum.

Gradation for Slurry Aggregate:

Sieve Size	Type II Percent Passing	Type III Percent Passing	Stockpile Tolerance
9.5 mm (3/8”)	100	100	± 5%
4.75 mm (#4)	90 – 100	70 - 90	± 5%
2.36 mm (#8)	65 – 90	45 - 70	± 5%
1.18 mm (#16)	45 – 70	28 - 50	± 5%
600 µm (#30)	30 – 50	19 - 34	± 5%
300 µm (#50)	18 – 30	12 - 25	± 4%
150 µm (#100)	10 – 21	7 - 18	± 3%
75 µm (#200)	5 – 15	5 – 15	± 2%

The target gradation for the project shall establish a single percentage of aggregate passing each required sieve size. This shall be the project aggregate gradation specification and the percent passing each sieve on subsequent tests shall not vary by more than the stockpile tolerance and shall still remain within the gradation band.

Aggregate shall be screened at the stockpile, just prior to loading to eliminate oversize. If oversize or clay balls are detected in the aggregate, the slurry operation shall stop until corrective actions are taken, as approved by the Engineer.

Mineral Filler. Mineral filler shall conform to the requirements of subsection 703.06.

Water. All water used in making the slurry shall be potable. The moisture content of the aggregate being used, and the effect this moisture content has on the specific weight of the aggregate, shall be taken into account in calibrating the machine to deliver asphalt in the correct proportion.

Additives. Additives may be used to accelerate or retard the break-set of the slurry seal or to improve the resulting finished surface. The use of additives in the slurry mix shall be made initially in quantities predetermined by the mix design. Field adjustments, if required, shall be as approved by the Engineer.

Mix Design. Before work begins, the Contractor shall submit to the Engineer for approval a signed, certified mix design covering the specific materials to be used on the project. This mix design shall be prepared and signed by a laboratory that has experience in designing Emulsified Asphalt Slurry Seal Surfacing. The Contractor shall certify the materials and the laboratory shall certify the design. Compatibility of the aggregate, emulsion, mineral filler, and other additives shall be verified by the mix design. The mix design shall be made with the same aggregate gradation that the Contractor proposes to use on the project.

Tests and required values to be used in preparing mix design shall be as follows:

ISSA Test	Description	Specification
TB 106	Slurry Seal Consistency	
TB 139	Wet Cohesion (30 minutes) minimum (Set) Wet Cohesion (60 minutes) minimum (Traffic)	12 kg-cm minimum 20 kg-cm minimum
TB 109	Max. Excess Asphalt by LWT Sand Adhesion	50 g/ft^2
TB 114	Wet Stripping	90% Min. Pass
TB 100■	Wet-tack Abrasion Loss, One-hour Soak	75 g/ft^2
TB 113♦	Mix Time	Controllable to 180 seconds Min.
♦ The mixing test and set-time test should be performed at the highest temperatures expected during construction. ■ The Wet-tack Abrasion test is performed is to determine the minimum asphalt content of the slurry system.		

The mixing test is used to predict how long the material can be mixed in the machine before it begins to break.

The laboratory shall also report the quantitative effects of moisture content on the unit weight of the aggregate (bulking effect). The report shall clearly show the proportions of aggregate, mineral filler (minimum and maximum), water (minimum and maximum), additive(s) (usage), and asphalt emulsion based on the dry weight of the aggregate.

All the component materials used in the mix design shall be representative of the materials proposed by the contractor to be used on the project.

The percentages of each individual material required shall be shown in the laboratory report. Adjustments may be required during construction, based on field conditions. All proposed adjustments must be approved by the Engineer prior to implementing.

Work shall not begin until written approval of the mix design and all slurry materials has been received from the Engineer

The component materials shall be within the following limits:

Component Materials	Limits
Residual Asphalt	6.5 – 12.0 % ♦
Mineral Filler	0.0 – 3.0 % ♦
Additives	As needed
Water ●	As needed to achieve proper mix consistency●
♦ Based on dry weight of Aggregate ● Total mix liquids should not exceed the loose aggregate voids. ISSA T106 shall be used to check optimum liquids.	

Master Range for Rate of Aggregate Application

AGGREGATE TYPE	MASTER RANGE LIMITS
Type II or Type III	15-22 lb/sq. yd.

Application rates are based on the weight of dry aggregate in the mixture

Tolerances. Tolerances for individual materials as well as the slurry seal mixture are as follow:

After the designed residual asphalt content is determined, a plus or minus one percentage point variation will be permitted.

The percentage of aggregate passing each sieve shall be within stockpile tolerance range as described above

The percentage of aggregate passing shall not go from the high end to the low end of the specified range of any two successive sieves.

The slurry consistency shall not vary more than ± 0.2 inches (ISSA TB-106) from the job mix formula after field adjustments.

The rate of slurry application shall not vary more than ± 2 pounds per square yard from the designated target value. The ± 2 pound limit shall be within the Master Range limits.

Equipment. All equipment, tools, and machines used in performance of this work shall be maintained in satisfactory working condition at all times to ensure a high-quality product.

(a) Mixing Equipment*:* The machine shall be specifically designed and manufactured to lay slurry seal. The material shall be mixed by a self-propelled, slurry seal mixing machine of truck-mounted or continuous -run design. The machine shall have sufficient storage capacity for, and be able to accurately deliver and proportion the aggregate, emulsified asphalt, mineral filler, control setting additive, and water to a revolving mixer and to discharge the mixed product on a continuous-flow basis.

(b) Proportioning Devices**:** Individual volume or weight control devices for proportioning each material to be added to the mix shall be provided and properly marked. These devices shall provide information so that material output can be determined at any time. The contractor shall provide the Engineer this information and access to the devices at the Engineers request.

(c) Spreading Equipment: The mixture shall be spread uniformly by means of a conventional surfacing spreader box attached to the mixer and equipped to agitate and spread the material evenly throughout the box. A front seal shall be provided to insure no loss of the mixture at the at the road contact point.

The rear seal shall act as final strike-off and shall be adjustable. The spreader box and rear strike-off shall be so designed and operated that a uniform consistency is achieved to produce a free flow of material to the rear strike-off. The spreader box shall have suitable means provided to side shift the box to compensate for variations in the pavement geometry. A burlap drag or other approved screed shall be attached to the rear of the spreader box to provide a uniform, highly textured mat. A drag stiffened by hardened slurry is ineffective and shall be replaced immediately.

Calibration. Each mixing unit to be used in performance of the work shall be calibrated in the presence of the Engineer prior to construction. The Engineer may, at his option, use previous calibration documentation from the current calendar year and covering the exact materials to be used on this project. No machine will be allowed to work on the project until the calibration has been completed and/or accepted.

CONSTRUCTION REQUIREMENTS

Immediately prior to applying the slurry seal, the surface shall be cleared of all loose material, oil spots, vegetation and other objectionable material. Any standard cleaning method will be acceptable. If water is used, cracks shall be allowed to dry thoroughly before slurry surfacing. The Project Manager shall approve the surface preparation prior to surfacing.

The slurry seal shall not be applied if either the pavement or air temperature is below 50ºF and falling, but may be applied when both pavement and air temperatures are above 45ºF and rising. No slurry seal shall be applied when there is the possibility of freezing temperatures at the project location within 24 hours after application.

The slurry seal shall be of the desired consistency upon leaving the mixer. A sufficient amount of material shall be carried in all parts of the spreader at all times so that a complete coverage is obtained. Overloading of the spreader shall be avoided.

No lumping, balling, or unmixed aggregate shall be permitted.

Approved hand squeegees, with burlap drags, shall be used to spread Slurry in areas not accessible to the Slurry spreader box. Care shall be exercised in leaving no unsightly appearance from handwork.

No streaks, such as those caused by oversized aggregate, shall be left in the finished surface. If, in the opinion of the Engineer, excess oversize develops, the job will be stopped until the contractor has corrected his aggregate pre-screening operation to eliminate the oversize.

Areas receiving slurry seal will be allowed to cure from three to five hours or until the treated pavement will not be damaged by traffic. The Contractor shall protect the area with suitable barricades or markers for the full curing period. Areas damaged within 24 hours of application of slurry, or prior to moving to new work locations, shall be repaired by the Contractor at their expense.

Manholes, Valves, and Inlets. Manholes, valve boxes, and inlets shall be covered and or protected with an approved material during the operation and shall be removed immediately after the street has been sealed. The Contractor is responsible for locating all exposed manholes, valve boxes and inlets prior to construction.

Joints. No excess buildup, uncovered areas, or unsightly appearance shall be permitted on longitudinal or transverse joints. Longitudinal joints shall be placed on lane lines. Half passes and odd-width passes will be used only when approved by the Engineer. The half or odd-width passes shall not be the last pass of any paved area.

Mix Stability. The slurry seal shall possess sufficient stability so that premature breaking of the material in the spreader box does not occur. The mixture shall be homogeneous and free of excess water and emulsion, with no segregation of the emulsion and aggregate fines from the coarser aggregate during and following mixing and spreading.

METHOD OF MEASUREMENT

Slurry seal will be measured by the ton. The total tonnage of the slurry seal will be calculated by adding the accepted quantity of aggregate and emulsion only.

BASIS OF PAYMENT

Payment will be made under:

Pay Item		Pay Unit
410-00001	Slurry Seal Coat	Ton

All materials, emulsion, mineral filler, additives, water, haul, labor, tools, equipment, placement, and all other work necessary to complete each of the pay items will not be measured and paid for separately, but shall be included in the work.

End of Section

Division 2 - CDOT Standard Special Provisions

Revision of Section 101 and 630
Construction Zone Traffic Control

Sections 101 and 630 of the Standard Specifications are hereby revised for this project as follows:

In subsection 101.01 add the following:

MASH Manual for Assessing Safety Hardware

In subsection 630.01, delete the first paragraph and replace with the following:

630.01 This work consists of furnishing, installing, moving, maintaining, and removing temporary traffic signs, advance warning arrow panels, flashing beacon (portable), barricades, channelizing devices, delineators, temporary traffic signals, mobile pavement marking zones, masking and unmasking existing signs in construction zones, and concrete barriers as required by the Manual on Uniform Traffic Control Devices for Streets and Highways and the Colorado Supplement thereto, in accordance with the Contract. Devices shall comply with the performance criteria contained in NCHRP Report 350 (only applicable for devices developed prior to 2011) or MASH (acceptable for all devices). Devices temporarily not in use shall, as a minimum, be removed from the shoulder area. Moving will include devices removed from the project and later returned to use.

In subsection 630.02, delete the second paragraph, and replace with the following:

Temporary sign support assembly shall be timber, perforated square metal tubing inserted into a larger base post or slip base or perforated metal U-channel with a slip base. The temporary sign support assembly shall conform to NCHRP (only applicable for sign support assemblies developed prior to 2011) or MASH (acceptable for all sign support assemblies), and AASHTO requirements regarding temporary sign supports during construction.

Subsection 630.02 shall include the following:

If a timber post is selected, it shall conform to the requirements of subsection 614.02.

In subsection 630.07(a), delete the first paragraph and replace with the following:

(a) *Stackable Vertical Panels***.** Stackable vertical panels shall comply with the crash test requirements contained in NCHRP Report 350 (only applicable for vertical panels developed prior to 2011) or MASH (acceptable for all vertical panels) and shall meet MUTCD requirements for vertical panels. Vertical panels shall be retroreflectorized with Type IV sheeting, in accordance with subsection 630.02. The stackable vertical panels shall have the following properties:

In subsection 630.07(b), delete the first paragraph and replace with the following:

(b) *Stackable Tubular Markers.* Stackable tubular markers shall comply with the crash test requirements contained in NCHRP Report 350 (only applicable for stackable tubular markers developed prior to 2011) or MASH (acceptable for all stackable tubular markers) and shall conform to MUTCD requirements for Tubular Markers. The stackable tubular markers shall have the following properties:

In subsection 630.09, delete the second and third paragraphs, and replace with the following:

Work zone devices designated by FHWA as Category I, II, or III, shall comply with the performance criteria contained in NCHRP Report 350 (only applicable for devices developed prior to 2011) or MASH (acceptable for all devices). Devices designated as Category IV, including but not limited to portable or trailer-mounted devices such as flashing arrow panels, temporary traffic signals, area lighting supports, and changeable message signs are not required to meet NCHRP 350 or MASH requirements.

Except for Category IV devices, the Contractor shall obtain and present to the Engineer the manufacturer's written NCHRP 350 (only applicable for devices developed prior to 2011) or MASH (acceptable for all devices) certification for each work zone device before it is first used on the project.

In subsection 630.10(a) (3) (iii), delete the third paragraph, and replace with the following:

Groups 1 and 2 shall each be equipped with a truck-mounted Advance Warning Flashing or Sequencing Arrow Panel (C Type), and a truck mounted impact attenuator. The impact attenuator shall be located on the rearmost vehicle of each group. A separate vehicle for this attenuator may be used. Each truck-mounted impact attenuator shall be certified by the manufacturer to be able to withstand a 62 MPH impact in accordance with NCHRP 350, Test Level 3 (only applicable for truck-mounted impact attenuators developed prior to 2011) or MASH, Test Level 3 (acceptable for all truck-mounted impact attenuators). The cone setting truck and the cone pickup truck shall not be the same vehicle.

In subsection 630.16, delete the 5th paragraph.

End of Section

Revision of Section 105 and 106
Conformity to the Contract of Hot Mix Asphalt (Voids Acceptance)

Sections 105 and 106 of the Standard Specifications are hereby revised for this project as follows:

Delete subsection 105.05 and replace with the following:

105.05 Conformity to the Contract of Hot Mix Asphalt. Conformity to the Contract of all Hot Mix Asphalt, Item 403, except Hot Mix Asphalt (Patching) and temporary pavement will be determined by tests and evaluations of elements that include asphalt content, voids in the mineral aggregate, air voids, in-place density, and joint density in accordance with the following:

All work performed and all materials furnished shall conform to the lines, grades, cross sections, dimensions, and material requirements, including tolerances, shown in the Contract.

For those items of work where working tolerances are not specified, the Contractor shall perform the work in a manner consistent with reasonable and customary manufacturing and construction practices.

When the Engineer finds the materials or work furnished, work performed, or the finished product are not in conformity with the Contract and has resulted in an inferior or unsatisfactory product, the work or material shall be removed and replaced or otherwise corrected at the expense of the Contractor.

Materials will be sampled randomly and tested by the Department in accordance with subsection 106.05 and with the applicable procedures contained in the Department's Field Materials Manual. The approximate maximum quantity represented by each sample will be as set forth in subsection 106.05. Additional samples may be selected and tested at the Engineer's discretion.

A process will consist of either a test value or a series of test values resulting from related tests of an element of the Contractor's work and materials. An element is a material and/or workmanship property that can be tested and evaluated for quality level by the Department approved sampling, testing, and analytical procedures. All materials produced will be assigned to a process of each element being tested and evaluated. A change in process is defined as a change that affects the element involved. A process for any element normally will include all produced materials associated with that element prior to a change in the job mix formula (Form 43) with the exception of the process for joint density element. For joint density, a new process will be established for each new layer of pavement or for changes in joint construction. In-place density measurements taken within each compaction test section will be a separate process. The Engineer may separate a process in order to accommodate small quantities or unusual variations.

Evaluation of materials for pay factors (PF) will be done using only the Department's acceptance test results. Each process will have a PF computed in accordance with the requirements of this Section. Test results determined to have sampling or testing errors will not be used.

Except for in-place density measurements taken within a compaction test section, any test result for the asphalt content, in-place density and/or joint density element greater than the distance 2 x V (see Table 105-2) outside the tolerance limits will be designated as a separate process and the quantity it represents will be evaluated in accordance with subsection 105.05(a). An element pay factor less than zero shall be zero. The calculated PF will be used to determine the Incentive/Disincentive Payment (I/DP) for the process in accordance with 105.05(e) Evaluation of Work.

Any test result for the air voids or VMA elements greater than the distance 2 x V (see Table 105-2) outside the tolerance limits will be designated as a separate process and the quantity it represents shall be

removed and replaced with specification material at the Contractor's expense.

In the case of in-place density or joint density, the Contractor will be allowed to core the exact location (or immediately adjacent location for joint density) of a test result more than 2 x V outside the tolerance limit. The core must be taken and furnished to the Engineer within eight hours after notification by the Engineer of the test result. The result of this core will be used in lieu of the previous test result. Cores not taken within eight hours after notification by the Engineer will not be used in lieu of the test result. All costs associated with coring will be at the Contractor's expense.

(1) *Representing Small Quantities.* When it is necessary to represent a process by only one or two test results, PF will be the average of PFs resulting from the following:

If the test result is within the tolerance limits then PF = 1.00. If the test result is above the maximum specified limit, then

$$PF = 1.00 – [0.25(T_0 - T_U)/V]$$

If the test result is below the minimum specified limit, then

$$PF = 1.00 – [0.25(T_L - T_0)/V]$$

Where: PF = pay factor.
V = V factor from Table 105-2.
T_0 = the individual test result.
T_U = upper specification limit.
T_L = lower specification limit.

If the pay factor of any of the above calculations is less than 0.75 for any element, the acceptance of the work will be evaluated according to subsection 105.05(e).

(2) *Determining Quality Level.* Each process with three or more test results will be evaluated for a quality level (QL) in accordance with Colorado Procedure 71.

(3) *Joint Density Element.* Joint density will be tested according to subsection 401.17.

(4) *Process Pay Factor.* Using the calculated QL for the process, compute the PF as follows: The final number of random samples (Pn) in each process will determine the final pay factor. As test values are accumulated for each process, Pn will change accordingly. When the process has *been* completed, the number of random samples it contains will determine the computation of PF, based on Table 105-3 and formula (1) below. When Pn is from 3 to 9, or greater than 200, PF will be computed using the formulas designated in Table 105-3. Where Pn is equal to or greater than 10 and less than 201, PF will be computed by formula (1):

$$(1)\ PF = \frac{(PF_1 + PF_2)}{2} + \left[\frac{(PF_2 + PF_3)}{2}\right]\left[\frac{(PF_1 + PF_2)}{2}\right]\left[\frac{(Pn_2 - Pn_X)}{(Pn_2 - Pn_3)}\right]$$

Where, when referring to Table 105-3:

PF_1= PF determined at the next lowest Pn formula using process QL
PF_2= PF determined using the Pn formula shown for the process QL
PF_3= PF determined at the next highest Pn formula using process QL
Pn_2= the lowest Pn in the spread of values listed for the process Pn formula
Pn_3= the lowest Pn in the spread of values listed for the next highest Pn formula
Pn_X= the actual number of test values in the process

When evaluating the item of Furnish Hot mix asphalt, the PF for the element of In-Place Density shall be 1.0.

Regardless of QL, the maximum PF in relation to Pn is limited in accordance with Table 105-3.

As test results become available, they will be used to calculate QL and PF numbers for each process. The process I/DP's will then be calculated and accumulated for each element and for the item. The test results and the accumulated calculations will be made available to the Contractor upon request.

Numbers from the calculations will be carried to significant figures and rounded according to AASHTO Standard Recommended Practice R-11, Rounding Method.

(5) *Evaluation of Work.* When the PF of a process is 0.75 or greater, the finished quantity of work represented by the process will be accepted at the appropriate pay factor. If the PF for the air voids or VMA elements within *any* process is less than 0.75, the Contractor shall remove and replace the material with specification material at the Contractor's expense. If PF for any other element within any process is less than 0.75, the Engineer may:

1. Require complete removal and replacement with specification material at the Contractor's expense,

Or

2. Where the finished product is found to be capable of performing the intended purpose and the value of the finished product is not affected, permit the Contractor to leave the material in place. If the material is permitted to remain in place, the PF for the process shall not be greater than 0.75. The Region Materials Engineer (RME) will be consulted prior to determining the material will be allowed to remain in place. The RME will also be consulted to assist in determining an appropriate pay factor.

When condition red, as described in subsection 106.05(g), exists for any element, resolution and correction will be in accordance with subsection 106.05(g). Material that the Engineer determines is defective may be isolated and rejected without regard to sampling sequence or location within a process.

If removal and replacement is required because the joint density PF for a process is below 0.75, the Contractor shall remove and replace the full lane width adjacent to and including at least six inches beyond the visible joint line for the entire length of joint representing the process. If the lane removed is adjacent to another joint, that joint shall also be removed to a point six inches beyond the visible joint line. When a single joint density core is more than 2V outside the tolerance limits, the removal and replacement limits shall be identified by coring the failing joint at 25 foot intervals until two successive

cores are found to be 1V or less.below the minimum tolerance limit. If removal and replacement is required, the Contractor shall submit documentation identifying the process to be used to correct the area in question. The process will be approved by the Engineer before commencing the corrective work

Table 105-2
"W" AND "V" FACTORS FOR VARIOUS ELEMENTS

Element	V Factor	W Factor
Asphalt Content	0.20	10
Voids in the Mineral Aggregate	0.60	10
Air Voids	0.60	30
In-place Density	1.10	35
Joint Density	1.60	15

Table 105-3
FORMULAS FOR CALCULATING PF BASED ON PN

Pn	When Pn as shown at left is 3 to 9, or greater than 200, use designated formula below to calculate Pay Factor, PF = ..., when Pn is 10 to 200, use formula (1) above:	Maximum PF
3	$0.31177 + 1.57878 (QL/100) - 0.84862 (QL/100)^2$	1.025
4	$0.27890 + 1.51471 (QL/100) - 0.73553 (QL/100)^2$	1.030
5	$0.25529 + 1.48268 (QL/100) - 0.67759 (QL/100)^2$	1.030
6	$0.19468 + 1.56729 (QL/100) - 0.70239 (QL/100)^2$	1.035
7	$0.16709 + 1.58245 (QL/100) - 0.68705 (QL/100)^2$	1.035
8	$0.16394 + 1.55070 (QL/100) - 0.65270 (QL/100)^2$	1.040
9	$0.11412 + 1.63532 (QL/100) - 0.68786 (QL/100)^2$	1.040
10 to 11	$0.15344 + 1.50104 (QL/100) - 0.58896 (QL/100)^2$	1.045
12 to 14	$0.07278 + 1.64285 (QL/100) - 0.65033 (QL/100)^2$	1.045
15 to 18	$0.07826 + 1.55649 (QL/100) - 0.56616 (QL/100)^2$	1.050
19 to 25	$0.09907 + 1.43088 (QL/100) - 0.45550 (QL/100)^2$	1.050
26 to 37	$0.07373 + 1.41851 (QL/100) - 0.41777 (QL/100)^2$	1.055
38 to 69	$0.10586 + 1.26473 (QL/100) - 0.29660 (QL/100)^2$	1.055
70 to 200	$0.21611 + 0.86111 (QL/100)$	1.060
$\geq$ 201	$0.15221 + 0.92171 (QL/100)$	1.060

(6) Process I/DP Computation.

$$I/DP = (PF - 1)(QR)(UP)(W/100)$$

Where:
- I/DP = Incentive/Disincentive Payment
- PF = Pay Factor
- QR = Quantity in Tons of HMA Represented by the Process
- UP = Unit Bid Price of Asphalt Mix
- W = Element Factor from Table 105-2

When AC is paid for separately UP shall be:

$$UP = [(Ton_{HMA})(UP_{HMA}) + (Ton_{AC})(UP_{AC})]/Ton_{HMA}$$

Where:
- Ton_{HMA} = Tons of Asphalt Mix
- UP_{HMA} = Unit Bid Price of Asphalt Mix
- Ton_{AC} = Tons of Asphalt Cement
- UP_{AC} = Unit Bid Price of Asphalt Cement

For the Joint Density element:

$$UP = UP_{HMA}$$

Where: UP_{HMA} is as defined above.

When AC is paid for separately UP shall be:

$$UP = [(BTon_{HMA})(BUP_{HMA}) + (BTon_{AC})(BUP_{AC})]/BTon_{HMA}$$

Where:	$BTon_{HMA}$	=	Bid Tons of Asphalt Mix
	BUP_{HMA}	=	Unit Bid Price of Asphalt Mix
	$BTon_{AC}$	=	Bid Tons of Asphalt Cement
	BUP_{AC}	=	Unit Bid Price of Asphalt Cement

(7) *Element I/DP.* The I/DP for an element shall be computed by accumulating the process I/DP for that element.

(8) *I/DP for a Mix Design.* The I/DP for a mix design shall be computed by accumulating the process I/DP's for the asphalt content, voids in the mineral aggregate, air voids, and in-place density elements for that mix design. The accumulated quantities of materials for each element must be the same at the end of I/DP calculations for a mix design.

(9) *Project I/DP.* The I/DP for the project shall be computed by accumulating the mix design I/DP's and the joint density I/DP's. The accumulated quantities of materials for each element must be the same at the end of I/DP calculations for the project.

Delete subsection 106.05 and replace with the following:

106.05 Sampling and Testing of Hot Mix Asphalt. All HMA, Item 403, except HMA (Patching) and temporary pavement shall be tested in accordance with the following program of process control testing and acceptance testing:

(a) *Process Control Testing*. The Contractor shall be responsible for process control testing on all elements listed in Table 106-1. Process control testing shall be performed at the expense of the Contractor. The Contractor shall develop a quality control plan (QCP) in accordance with the following:

1. Quality Control Plan. For each element listed in Table 106-1, the QCP must provide adequate details to ensure that the Contractor will perform process control. The Contractor shall submit the QCP to the Engineer at the preconstruction conference. The Contractor shall not start any work on the project until the Engineer has approved the QCP in writing.

   A. Frequency of Tests or Measurements. The QCP shall indicate a random sampling frequency, which shall not be less than that shown in Table 106-1. The process control tests shall be independent of acceptance tests.

   B. Worksheets, Forms, and Charts. The Contractor shall submit examples of worksheets, test result forms, and test results charts in accordance with CP 12 as part of the QCP.

   C. Test Result Chart. Each process control test result, the appropriate tonnage and the tolerance limits shall be plotted. For in-place density tests, only results after final compaction shall be shown. The chart shall be posted daily at a location convenient for viewing by the Engineer.

   D. Quality Level Chart. The Quality Level (QL) for each element used to calculate incentive or

disincentive in Table 106-1 and each required sieve size shall be plotted. The QL will be calculated in accordance with the procedure in CP 71 for Determining Quality Level (QL). The QL will be calculated on tests 1 through 3, then tests 1 through 4, then tests 1 through 5, then thereafter the last five consecutive test results. The tonnage of material represented by the last test result shall correspond to the QL. For in-place density tests, only results after final compaction shall be shown. The chart shall be posted daily at a location convenient for viewing by the Engineer.

2. Elements Not Conforming to Process Control. The QL of each discrete group of five test results, beginning with the first group of five test results, shall be a standard for evaluating material not conforming to process control. When the group QL is below 65, the process shall be considered as not conforming to the QCP. In this case, the Contractor shall take immediate action to bring the process back into control. Except where the cause of the problem is readily apparent and corrected without delay, production shall be suspended until the source of the problem is determined and corrected. A written explanation of actions taken to correct control problems shall accompany the test data and be submitted to the Engineer on the day the actions are taken.

3. Point of Sampling. The material for process control testing shall be sampled by the Contractor using approved procedures. Acceptable procedures are Colorado Procedures, AASHTO and ASTM. The order of precedence is Colorado Procedures, AASHTO procedures and then ASTM procedures. The location where material samples will be taken shall be indicated in the QCP.

4. Testing Standards. The QCP shall indicate which testing standards will be followed. Acceptable standards are Colorado Procedures, AASHTO and ASTM. The order of precedence is Colorado Procedures, AASHTO procedures and then ASTM procedures.

5. Testing Supervisor Qualifications. The person responsible for the process control sampling and testing shall be identified in the QCP and be qualified according to the requirements of CP 10

6. Technician Qualifications. Technicians taking samples and performing tests must be qualified according to the requirements of CP 10.

7. Testing Equipment. All of the testing equipment used to conduct process control testing shall conform to the standards specified in the test procedures and be in good working order. Nuclear testing devices used for process control testing of in-place density do not have to be calibrated on the Department's calibration blocks.

8. Reporting and Record Keeping. The Contractor shall report the results of the process control tests to the Engineer in writing at least once per day. The Contractor shall assemble a Quality Control (QC) notebook and update it daily. This notebook shall contain all worksheets, test results forms, test results charts and quality level charts for each of the elements listed in Table 106-1. The Contractor shall submit the QC notebook to the Engineer for review once a month on the date agreed to at the Pre-Paving Conference. The QC notebook will be returned to the Contractor within one working day after submittal. The Engineer will notify the Contractor in writing of any deficiencies in the QC notebook, including the failure to submit the notebook on time or an absence of the required reports. Upon the second failure to submit the complete QC notebook on time or with an absence of the required reports, the Engineer will notify the Contractor, and the pay estimate will be withheld until the Contractor submits, in writing, a report detailing the cause for the failure to submit the complete QC notebook on time or the cause for the absence of required reports. The report shall include how the Contractor plans to resolve the failures. Additional failures to submit the QC notebook on time or absent the required reports will result in a delay of the pay estimate until the Contractor has identified and resolved the failure along with revising and resubmitting his QCP to address these issues. Once the Engineer has reviewed and approved the

revised QCP the estimate may be paid. Upon submittal of the QC notebook for the semi-final estimate, the QC notebook shall become the property of the Department. The Contractor shall make provisions such that the Engineer can inspect process control work in progress, including QC notebook, sampling, testing, plants, and the Contractor's testing facilities at any time.

(b) Acceptance Testing. Acceptance testing is the responsibility of the Department and shall not be addressed in the QCP. The Department will determine the locations where samples or measurements are to be taken and as designated in Section 403. The maximum quantity of material represented by each test result and the minimum number of test results will be in accordance with Table 106-1. The location or time of sampling will be based on a stratified random procedure. Acceptance sampling and testing procedures will be in accordance with the Schedule for Minimum Materials Sampling, Testing and Inspection in the Department's Field Materials Manual. Samples for project acceptance testing shall be taken by the Contractor in accordance with the designated method. The samples shall be taken in the presence of the Engineer. Where appropriate, the Contractor shall reduce each sample to the size designated by the Engineer. The Contractor may retain a split of each sample which cannot be included as part of the QCP.

If the Contractor elects to question the Hot Mix Asphalt (HMA) acceptance test results, the steps outlined in CP 17 shall be followed. The results from the CP 17 resolution process shall be binding on both the Department and the Contractor. Requests for CP 17 process for all elements except density shall be submitted in writing to the Engineer within five working days from the date the Contractor receives acceptance test data from the Engineer. The specific element questioned shall be identified in writing. All requests for the CP 17 process for the density element shall be submitted in writing to the Engineer within 24 hours of receiving test data from the Engineer. The Contractor shall choose either the CDOT Materials and Geotechnical Branch or a consultant laboratory not associated with the project to perform the third party testing. The Contractor shall document his choice in writing at the Pre-Paving Conference. If a consultant laboratory is chosen, the CDOT Materials and Geotechnical Branch will determine the consultant that will be used from a pre-established list and ensure there is no conflict of interest. If third party testing is required, the responsibility for the testing expenses shall be assigned in accordance with CP 17. The costs for testing are shown in CP 17, Table 17-2.

All materials being used are subject to inspection and testing at any time prior to, during, or after incorporation into work. Acceptance tests will be made by and at the expense of the Department, except when otherwise provided.

(c) *Check Testing Program (CTP).* Prior to or in conjunction with placing the first 500 tons of asphalt pavement, under the direction of the Engineer, a CTP will be conducted between acceptance testing and process control testing programs. The CTP will consist of testing for asphalt content, theoretical maximum specific gravity, voids in the mineral aggregate, air voids, in-place density, and joint density in accordance with CP 13 of the Department's Field Materials Manual. The CTP will be continued until the acceptance and process control test results are within the acceptable limits shown in Table 13-1 of CP 13. For joint density, the initial check test will be a comparison of the seven cores tested by CDOT and the seven cores tested by the Contractor. These are the cores from the compaction test section used for nuclear gauge calibration and test section payment.

During production a split sample check will be conducted at the frequency shown in Table 106-1. The split samples will be from an acceptance sample obtained in accordance with subsection 106.05(b). Except for joint density, the split samples will be from an acceptance sample obtained in accordance with subsection 106.05(b). The acceptance test result will be compared to the process control test result obtained by the Contractor using the acceptable limits shown in Table 13-1 of CP 13. For joint density, the comparison sample material for testing by the Contractor will be obtained by taking a second core adjacent to the joint density acceptance core. The acceptance test result will be

compared to the process control test result obtained by the Contractor using the acceptable limits shown in the above table and following the check testing procedure given in CP 13.

If production has been suspended and then resumed, the Engineer may order a CTP between process control and acceptance testing persons to assure the test results are within the acceptable limits shown in Table 13-1 of CP 13. Check test results shall not be included in process control testing. The Region Materials Engineer shall be called upon to resolve differences if a CTP shows unresolved differences beyond the values shown in Table 13-1 of CP 13.

(d) Stability Verification Testing. After the mix design has been approved and production commences, the *Department* will perform a minimum of three stability verification tests to verify that the field produced Hot mix asphalt conforms to the approved mix design:

The test frequency shall be one per day unless altered by the Engineer.

The test results will be evaluated and the Contractor shall make adjustments if required in accordance with the following:

1. The minimum value for stability will be the minimum specified in Table 403-1 of the specifications. There will be no tolerance limit.

2. Quality Level. Calculate a QL for stability.

If the QL for stability is less than 65, then production shall be halted and the Contractor shall submit a written proposal for a mix design revision to the Engineer. The Engineer shall give written approval to the proposed mix design revision before production continues.

After a new or revised mix design is approved, three additional stability tests will be performed on asphalt produced with the new or revised mix design. The test frequency shall be one per day unless altered by the Engineer.

If the stability QL is less than 65, then production shall be halted until a new mix design has been completed and approved using plant produced material or the Contractor shall submit a written proposal for a mix design revision to the Engineer. The Engineer shall give written approval to the proposed mix design revision before production continues.

3. New or Revised Mix Design. Whenever a new or revised mix design is used and production resumes, three additional stability field verification tests shall be performed and the test results evaluated in accordance with the above requirements. The test frequency shall be one per day unless altered by the Engineer.

4. Field Verification Process Complete. When the field verification process described above is complete and production continues, the sample frequency will revert back to 1/10,000 tons.

(e) Target Values for VMA. After the mix design has been approved and production commences, the first three *acceptance* tests for Voids in Mineral Aggregate (VMA) will be analyzed to verify and establish a target value for VMA. The Contractor shall make adjustments if required in accordance with the following: The target value for VMA will be the average of the first three volumetric field verification test results on project produced hot mix asphalt or the target value specified in Table 403-1 and Table 403-2 of the specifications, whichever is higher. The target value for VMA will be set no lower than 1.0 percent below the VMA target on original Form 43.

Whenever a new or revised mix design is used and production resumes, the next three acceptance

tests will be evaluated and a target value for VMA will be established in accordance with the above requirements.

(f) Independent Assurance Testing. Independent assurance testing for Asphalt Content and In-Place Density will be in accordance with the Department's Field Materials Manual. Independent assurance testing for *Voids* in the Mineral Aggregate and Air Voids will be performed by the Department's Flexible Pavement laboratory on samples sent from the field at a frequency of one per 10 000 tons.

(g) Reference Conditions. Three reference conditions can exist determined by the Moving Quality Level (MQL). The *MQL* will be calculated in accordance with the procedure in CP 71 for Determining Quality Level (QL). The MQL will be calculated using only acceptance tests. The MQL will be calculated on tests 1 through 3, then tests 1 through 4, then tests 1 through 5, then thereafter on the last five consecutive test results. The MQL will not be used to determine pay factors. The three reference conditions and actions that will be taken are described as follows:

1. Condition green will exist for an element when an MQL of 90 or greater is reached, or maintained, and the past five consecutive test results are within the specification limits.

2. Condition yellow will exist for all elements at the beginning of production or when a new process is established because of changes in materials or the job-mix formula, following an extended suspension of work, or when the MQL is less than 90 and equal to or greater than 65. Once an element is at condition green, if the MQL falls below 90 or a test result falls outside the specification limits, the condition will revert to yellow or red as appropriate.

3. Condition red will exist for any element when the MQL is less than 65. The Contractor shall be notified immediately in writing and the process control sampling and testing frequency increased to a minimum rate of 1/250 tons for that element. The process control sampling and testing frequency shall remain at 1/250 tons until the process control QL reaches or exceeds 78. If the QL for the next five process control tests is below 65, production will be suspended.

   After condition red exists, a new MQL will be started. Acceptance testing will stay at the frequency shown in Table 106-1. After three acceptance tests, if the MQL is less than 65, production will be suspended. Production will remain suspended until the source of the problem is identified and corrected. Each time production is suspended; corrective actions shall be proposed in writing by the Contractor and approved in writing by the Engineer before production may resume.

   Upon resuming production, the process control sampling and testing frequency for the elements causing the condition red shall remain at 1/250 tons. If the QL for the next five process control tests is below 65, production will be suspended again.

(h) Correction Factor. In determining the air voids and VMA in the materials compacted with the SuperPave Gyratory *Compactor* (SGC), the following correction for bulk specific gravity shall be performed during the CTP:

1. The difference in the average value of bulk specific gravity between the process control testing SGC and acceptance testing SGC will be determined and used as a correction factor for the process control bulk specific gravity.

2. This correction factor shall be used to correlate the process control SGC to the acceptance testing SGC for comparison of air voids and VMA during the CTP and full project production. Values in Table 13-1 of CP 13 apply to SGC comparison after correction factor has been applied.

3. This correction factor shall be applied in correlating the SGC's air voids and VMA test results from

process control and acceptance testing to produce comparable data. Any changes in SGC equipment or in the mix design properties, specifically the number of gyrations, asphalt binder grade, aggregate gradation, combination of aggregates, and aggregate sources shall require a new correction factor to be determined under a CTP.

Example: If for the five CTP tests on split samples the process control SGC averages bulk specific gravity of 2.391 and the acceptance SGC averages 2.382, the correction factor would be –0.009 (2.382-2.391) to the process control bulk specific gravities. Each of the five process control CTP bulks would be decreased by 0.009 before CTP result comparison of voids and VMA is made. If the volumetric results satisfy Table 13-1 of CP 13, use corrected bulks to calculate voids and VMA for process control testing program.

If process control and acceptance SGCs are not from the same equipment manufacturer, project-specific material shall be used to perform the CTP and generate the correction factor.

Table 106-1
SCHEDULE FOR MINIMUM SAMPLING AND TESTING

Element	Process Control	Acceptance[3]	Check (CTP)
Determining Asphalt Content of Hot Bituminous Mixtures	1/500 tons	1/1000 tons[1]	1/10,000 tons
Theorectical Maximum Specific Gravity	1/1000 tons, minimum 1/day	1/1000 tons, minimum 1/day	1/10,000 tons
Voids in the Mineral Aggregate	1/1000 tons	1/1000 tons[1]	1/10,000 tons
Air Voids	1/1000 tons	1/1000 tons[1]	1/10,000 tons
Hveem Stability	1/10,000 tons	1/10,000 tons[2]	Not applicable.
Resistance to Moisture Damage (Lottman)	1/10,000 tons	According to subsection 401.02	Not applicable.
Gradation	1/10,000 tons	1/10 000 tons[2]	Not applicable.
Determining Percent Relative Compaction of Bituminous Pavement	1/500 tons[1]	1/500 tons[1]	1/5000 tons
Joint Density	1 core/2500 linear feet of joint	1 core/5000 linear feet of joint[1]	1 core/50,000 linear feet of joint
Aggregate Percent Moisture (4)	1/2000 T or 1/Day if less than 2000 T	1/2000 T	Not applicable
Percent Lime (4) (5)	**1/Day**	Not applicable	Not applicable

Notes for Table 106-1:

(1) The minimum number of acceptance tests will be at least 5 asphalt content, 5 voids in the mineral aggregate, 5 air voids, 10-in-place density and 5 joint densities for all projects.

(2) For information only. These elements are not used to calculate pay factors.

(3) When unscheduled job mix formula changes are made (Form 43) acceptance of the elements, except for in-place density, will be based on the actual number of samples that have been selected up to that time, even if the number is below the minimum listed in Table 106-1. At the Engineer's discretion, additional random in-place density test may be taken in order to meet scheduled minimums, provided the applicable pavement layer is available for testing under safe conditions. Beginning with the new job mix formula, the quantity it will represent shall be estimated. A revised schedule of acceptance tests will be based on that estimate.

(4) Not to be used for incentive/disincentive pay. Test according to CP-60B and report results from Form 106, Form 565 or Form 6.

(5) Verified per Contractor's QC Plan.

End of Section

Revision of Section 106, 627, and 713
Glass Beads for Pavement Marking

Sections 106, 627, and 713 are hereby revised for this project as follows:

Subsection 106.11 shall include the following:

All post-consumer and industrial glass beads for pavement marking shall have been manufactured from North American glass waste streams in the United States of America. The bead manufacturer shall submit a COC in accordance with subsection 106.12 confirming that North American glass waste streams were used in the manufacture of the glass beads.

Subsection 627.06 (c) shall include the following:

Glass beads shall be applied into the thermoplastic pavement marking by means of a low pressure, gravity drop bead applicator.

In subsection 713.08, delete the first and third paragraphs and replace with the following:

713.08 Glass Beads for Pavement Marking. Glass beads for pavement marking shall conform to AASHTO M 247, except for the following:

(1) Gradation:

U.S. Mesh	Microns	% Passing	
		Epoxy and MMA	Waterborne, Low VOC and High Build
16	1180	90-100	100
18	1000	65-80	97-100
20	850		85-100
30	600	30-50	50-70
40	425		10-35
50	300	0-5	0-10
80	180		0-5

(2) Roundness: All beads shall meet a minimum of 80 percent true spheres in accordance with the Office of Federal Lands Highways FLH T520 or a computerized optical testing method.

(3) Color / Clarity: Beads shall be colorless, clear, and free of carbon residues.

(4) Refractive Index: Minimum 1.51 by oil immersion method.

(5) Air Inclusions: Less than 5 percent by visual count.

(6) Coatings: Per manufacturer's recommendation for optimum adhesion and embedment.

(7) Chemical Resistance: Beads shall be resistant to hydrochloric acid, water, calcium chloride, and sodium sulfide as tested per methods outlined in sections 4.3.6 to 4.3.9 of the TT-B Federal Spec.1325D.

(8) For Epoxy Pavement Marking, a minimum of 40 percent of the total weight shall be manufactured using a molten kiln direct melt method. For Waterborne and Low VOC Paint, a minimum of 15 percent of the total weight shall be manufactured using a molten kiln direct melt method. All molten kiln direct melt glass beads shall be above the 600 µm (#30) sieve.

(9) Glass beads used for any type of pavement marking shall not contain more than 75 parts per million (ppm) arsenic, 75 ppm antimony and 100 ppm lead, as tested in accordance with EPA methods 3052 and 6010C, or other approved testing method

End of Section

Revision of Section 202, 627, And 708
Pavement Marking Paint

Sections 202, 627 and 708 of the Standard Specifications are hereby revised for this project as follows:

In subsection 202.05, delete the third paragraph and replace with the following:

(a) *Removal of temporary pavement marking on final alignment.* Temporary pavement marking paint on the approved final alignment shall be removed completely from the roadway surface at locations of permanent pavement markings as shown on the plans. The ground location shall be clean, dry and free of laitance, oil, dirt, grease, paint or other foreign contaminants prior to application of final pavement marking. The Contractor shall not remove more pavement marking paint than what can be replaced with permanent pavement marking during the same working day or working period. If an event occurs that precludes the contractor from completing the work during the placement of permanent marking, the Contractor shall halt the removal operation and raised flexible pavement markers shall be placed at locations that have been removed but not marked while the pavement is drying prior to the marking application. Marking application shall resume when pavement is dry and has had no moisture for a minimum of 24 hours. Raised flexible pavement markers shall be installed with one marker at 40-foot centers.

(b) *Removal of temporary pavement marking on transitions.* Removal of pavement marking paint on temporary transitional alignments shall be performed by grinding or water-blasting. The removal shall result in 100 percent removal of the paint and a wide swath of ground pavement surrounding the former location of the temporary paint. The width of the swath shall be as follows; the center of the swath shall be the location of the paint line:

Width of Pavement Marking to be removed	Width of Swath
≤ 8 inches	12 inches
> 8 inches	15 inches

Subsection 202.11 shall include the following:

Removal of temporary pavement marking on transitions will be measured as the actual square feet of the swath constructed for the required width. Removal of pavement marking for the permanent alignment will be measured as the actual number of square feet removed.

Subsection 202.12 shall include the following:

Payment will be made under:

Pay Item	**Pay Unit**
Removal of Pavement Marking	Square Foot
Removal of Pavement Marking (12 Inch)	Square Foot
Removal of Pavement Marking (15 Inch)	Square Foot

Raised pavement markings shall be at the Contractor's expense.

In subsection 627.04, delete the first paragraph and replace with the following:
627.04 Pavement Marking with Low Temperature Acrylic Paint and High Build Acrylic Paint. Striping shall be applied when the air and pavement temperatures are no less than 45 °F for waterborne and high-

build paint, and 35°F for low temperature waterborne paint on asphalt or portland cement concrete pavements. The pavement surface shall be dry and clean, and free of all latent materials, in accordance with manufacturer recommendations. Weather conditions shall be conducive to satisfactory results.

Glass beads shall be applied into the paint by means of a low pressure, gravity drop bead applicator.

In subsection 627.04 delete the table and replace it with the following:

Description		Pavement Marking Paint	
		Low Temp	High Build
Alignment	Lateral Deviation	2.0 inch per 200 foot Max	
Coverage Rate	Sq. Ft. per Gallon	89-93	67-70
Thickness	Mil	17-18	23-24
Width	Inches	Per Plans +/- 0.25	Per Plans +/- 0.25
Dry Time	Minutes	5-10	7-12
Beads	Application Rate, lbs./gal	7-8	9-10

Subsection 627.13 shall include the following:

Pay Item	**Pay Unit**
Pavement Marking Paint (High Build)	Gallon
Pavement Marking Paint (Low Temperature)	Gallon

Delete subsection 708.05 and replace with the following:

708.05 Pavement Marking Materials. All pavement marking materials shall be selected from the Department's Approved Products List (APL). Prior to start of work, a Certificate of Compliance (COC) for all pavement marking materials shall be submitted in accordance with subsection 106.13.

(a) Color. The pavement marking paint, without drop-on beads, shall correspond following requirements:

White – Federal Standard No. 595B-17925. The Yellowness Index (YI) of white shall not exceed 8.0 per ASTM E-313-10 initially. The color after drying shall be a flat-white, free from tint, and shall provide the maximum amount of opacity and visibility under both daylight and artificial light.

Yellow – Materials for pavement markings shall meet the initial daytime chromaticity that fall within the box created by the following corner points:

Initial Daytime Chromaticity Coordinates (Corner Points)

	1	2	3	4
x	0.530	0.510	0.455	0.472
y	0.456	0.485	0.444	0.400

(b) Low Temperature Acrylic Waterborne Paint. Low Temperature Acrylic Waterborne Paint binder (nonvolatile portion of vehicle) shall be 100 percent XSR acrylic polymer, by weight, as determined by

infrared analysis or other chemical analysis available to the Department.

(c) *High Build Acrylic Waterborne Paint.* High build acrylic waterborne paint binder (nonvolatile portion of vehicle) shall be 100 percent HD 21 acrylic cross linking polymer, by weight, as determined by infrared analysis or other chemical analysis available to the Department.

Low Temperature Acrylic Waterborne Paint, and High Build Acrylic Waterborne paint shall meet the following requirements:

Performance Requirements: The paint shall be water resistant and shall show no softening or blistering.

Table 708-1
LOW TEMPERATURE WATERBORNE AND HIGH BUILD ACRYLIC WATERBORNE PAINT

Property	**White**	**Yellow**	**Test Method**
Nonvolatile portion of vehicle (white and yellow), %	43.0 (min)	43.0 (min)	ASTM D 2205
Pigment Composition			
Percent by weight♦	60.0	60.0	ASTM D 4451 ASTM D 3723
Paint			
Titanium Dioxide Content, lb./gal	1.0 (min)		ASTM D 5381
Properties of the Finished Paint			
Total Non-volatiles, (solids) % by weight	77.0 (min)	77.0 (min)	FTMS 141C - Method 4053.1, ASTM D 2369, or ASTM D 4758
Density, lbs./gal	14.0-14.6	13.7-14.3	ASTM D 2205
Consistency (Viscosity) White and Yellow, Krebs-Stormer Units	85-95	85-95	ASTM D 562
Freeze Thaw Stability	Shall complete 5 or more test cycles successfully		ASTM D 2243
Fineness of Grind, Cleanliness Rating B, minimum	3	3	ASTM D 1210
Scrub Resistance	800	800	ASTM D2486
Directional Reflectance: [15 mil Wet Film]	88 (min)	50 (min)	ASTM E 1347
Dry Opacity (Contrast Ratio): [5 mil Wet Film]	0.95 (min)	0.95 (min)	ASTM D 2805
♦Percent by weight shall include percent of organic yellow pigment.			

End of Section

Revision of Section 401
Compaction of Hot Mix Asphalt

Section 401 of the Standard Specifications is hereby revised for this project as follows:

In subsection 401.17, delete the first paragraph and replace with the following:

401.17 Compaction. The hot mix asphalt shall be compacted by rolling. Both steel wheel and pneumatic tire rollers will be required. The number, weight, and type of rollers furnished shall be sufficient to obtain the required density while the mixture is in a workable condition. Compaction shall begin immediately after the mixture is placed and be continuous until the required density is obtained. When the mixture contains unmodified asphalt cement (PG 58-28 or PG 64-22) or modified (PG 58-34), and the surface temperature falls below 185 °F, further compaction effort shall not be applied unless approved, provided the Contractor can demonstrate that there is no damage to the finished mat. If the mixture contains modified asphalt cement (PG 76-28, PG 70-28 or PG 64-28) and the surface temperature falls below 230 °F, further compaction effort shall not be applied unless approved, provided the Contractor can demonstrate that there is no damage to the finished mat.

Warm Mix Asphalt compaction requirements shall conform to CP 59.

In subsection 401.17, delete the third paragraph and replace with the following:

SMA shall be compacted to a density of 93 to 97 percent of the daily theoretical maximum specific gravity, determined according to CP 51. All other HMA shall be compacted to a density of 92 to 96 percent of the daily theoretical maximum specific gravity, determined according to CP 51. If more than one theoretical maximum specific gravity test is taken in a day, the average of the theoretical maximum specific gravity results will be used to determine the percent compaction. Field density determinations will be made in accordance with CP 44 or 81.

In subsection 401.17, second to last paragraph, delete the first sentence and replace with the following:

After production paving work has begun, a new Roller Pattern shall be demonstrated when a change in the compaction process is implemented.

End of Section

Revision of Section 401
Compaction Pavement Test Section (CTS)

Section 401 of the Standard Specifications is hereby revised for this project as follows:

In subsection 401.17, delete the fifteenth paragraph and replace with the following:

Two sets of random cores shall be taken within the last 200 tons of the CTS. Each set shall consist of seven random cores. The Engineer will determine the coring locations using a stratified random sampling process. The locations of these cores will be such that one set can serve as a duplicate of the other. One set of these cores shall be immediately submitted to the Engineer. This set will be used for determining acceptance of the CTS and determining density correction factors for nuclear density equipment. Densities of the random samples will be determined by cores according to CP 44. Density correction factors for nuclear density equipment will be determined according to CP 81. Coring shall be performed under CDOT observation. Coring will not be measured and paid for separately but shall be included in the work. For SMA, a CTS is not used. The Contractor shall follow the requirements for the demonstration control strip in accordance with the Revision of Section 403, Stone Matrix Asphalt Pavement.

End of Section

Revision of Section 401
Composition of Mixtures – Voids Acceptance

Section 401 of the Standard Specifications is hereby revised for this project as follows:

Subsection 401.02(a) shall include the following:

On projects with voids acceptance of hot mix asphalt, mix designs based on a theoretical rejection of baghouse fines may be used when necessary to meet CDOT mix design requirements if the following additional requirements are met. Written approval for use of theoretical rejection of baghouse fines mixture design shall be obtained before production of project material.

(1) Price adjustment for the hot mix asphalt shall be made based on voids acceptance criteria as prescribed in the latest version of the Standard Special Provision, Revision of Sections 105 and 106, Conformity to the Contract of Hot Mix Asphalt (Voids Acceptance). All costs associated with theoretical rejection of baghouse fines mix design, production, and acceptance shall be at the Contractor's expense.

(2) The Contractor shall submit a separate Quality Control (QC) plan for handling the rejection of baghouse fines. The plan shall identify the plan, equipment, and procedures that will be used for the rejection of baghouse fines. The plan shall include detailed information on baghouse control systems and actual data demonstrating consistent system functionality. The QC plan shall be approved in writing prior to production.

(3) The Contractor shall demonstrate that the material can be produced in accordance with one of the two procedures listed below. The Contractor shall supply project aggregate material for use in establishing acceptance testing equipment correction factors. Aggregate samples that have been produced according to CP-L 5117 to represent plant-produced material shall be provided by the mix design lab.

(i) The Contractor shall produce a minimum of 3000 tons of material. This material shall be placed on non thru lanes or offsite in locations approved by the Engineer. A minimum of 3 samples will be tested for AC content, air voids and VMA. QL's for each element will be determined in accordance with the contract documents. If the QL is equal to or greater than 65 for VMA and Asphalt Cement Content and the QL for the element of air voids is equal to or greater than 70, full production may commence. This material may be considered a separate process and price adjustment will be in accordance with subsection 105.05 or;

(ii) The Contractor shall construct a 500-ton test strip on the main line on the project. Tonnage other than 500 tons may be produced only if approved. Three samples in the last 200 tons will be tested for volumetric properties. After construction of the test section, production shall be halted until the testing is complete and element QL's are calculated. If the QL is equal to or greater than 65 for VMA and Asphalt Cement Content and the QL for the element of air voids is equal to or greater than 70, full production may commence. If the TQL is less than 65 or the QL for the element of air voids is less than 70, the material shall be removed and replaced at the Contractor's expense.

End of Section

Revision of Section 401
Plant Mix Pavements

Section 401 of the Standard Specifications is hereby revised for this project as follows:

Subsection 401.02(b) shall include the following:

After the Form 43 is executed, and all ingredients are available on the project, the Contractor shall notify the Engineer a minimum of one working day in advance of beginning production of the hot mix asphalt. Any changes in the Form 43 will require the same notification unless otherwise approved by the Engineer.

End of Section

Revision of Section 401
Reclaimed Asphalt Pavement

Section 401 of the Standard Specifications is hereby revised for this project as follows:

Subsection 401.02(b) shall include the following:

Reclaimed Asphalt Pavement (RAP) is allowed in hot mix asphalt (HMA) up to a maximum binder replacement of 23 percent for all lifts, provided all specifications for HMA are met. Fine Aggregate Angularity requirements shall apply only to the virgin fraction of the fine aggregate. The RAP shall not contain clay balls, vegetable matter, or other deleterious substances, and must meet the uniformity requirements as outlined below.

HMA Project Verification Testing for asphalt content and gradation will be performed at the frequencies listed in the Field Materials Manual in accordance with CP-L 5120.

The Contractor shall have an approved mix design for the amount of RAP to be used. The AC content of the RAP utilized in the Contractor RAP mix design shall be the average AC content determined in accordance with 1B or 1C, below, or alternatively, a minimum of five samples of the Contractors RAP stockpile may be sampled and the average AC content of the RAP be determined using AASHTO T-164, Method A or B, or in accordance with 1C below. The Contractor shall determine the total binder replaced by the binder in the RAP pursuant to the following equation:

Total Binder Replaced = (A x B) x 100/E
Where:
A = RAP % Binder Content *
B = RAP % in Mix *
E = Total Effective Binder Content *
* in decimal format (i.e. 2% is 0.02)

The Total Binder Replaced by the binder in the RAP shall not exceed 23 percent of the effective binder content of either the mix design or the produced mix.

The use of RAP shall be controlled in accordance with subsections 105.05 and 106.05. If the Contractor elects to use RAP, the following additional conditions shall apply:

1. The Contractor shall have an approved Quality Control (QC) Plan that details how the RAP will be processed and controlled. The QC plan shall address the following:

   A. RAP Processing Techniques. This requires a schematic diagram and narrative that explains the processing (crushing, screening, and rejecting) and stockpile operation for this specific project.

   B. Control of RAP Asphalt Binder Content (AASHTO T-164, Method A or B). RAP Asphalt Binder Content may also be determined in accordance with CP-L 5120, provided an RAP AC content correction factor is determined through correlation testing with AASHTO T-164, Method A or B. The correction factor shall be determined by performing correlation testing on the first five samples of the RAP AC content, then at a frequency of one for every five AC content tests thereafter. The correction factor shall be determined by calculating the average difference in AC content between CP-L 5120 and AASHTO T-164, Method A or B, and applying the correction to the AC content determined in accordance with CP-L 5120 :
   Frequency: 1/1000 tons of processed RAP material (minimum five tests)

C. (Alternate) The Contractor may propose a RAP asphalt content correction factor to be used in conjunction with CP-L 5120. The proposed CP-L 5120 RAP asphalt content correction factor shall be used with all RAP asphalt contents tested for the mixture design and quality control sampling and testing. The methodology of the proposed CP-L 5120 RAP asphalt content correction factor shall be outlined in detail in the approved RAP QC Plan. At a minimum, the proposed CP-L 5120 correction factor shall identify the principal source locations of the RAP aggregate, gradation of the material tested, and specific ignition oven serial number used in all the RAP asphalt content testing. The RAP source locations, material gradation, and specific equipment used shall substantiate the CP-L 5120 asphalt content correction factor used for the testing. The substantiation must be from data gathered from historical information or specific asphalt content correction data obtained from tests performed on similar virgin aggregate sources, virgin material gradations, and the specific equipment used.

D. Control of RAP Gradation (CP31 or AASHTO T-30):
Frequency: 1/1000 tons of processed RAP material (minimum three tests)

E. Process Control Charts shall be maintained for binder content and each screen listed in subsection 401.02(b), during addition of any RAP material to the stockpile. The Contractor shall maintain separate control charts for each RAP stockpile. The control charts shall be displayed and shall be made available, along with RAP AC extraction testing laboratory reports to the Engineer upon request

2. The processed RAP must be 100 percent passing the 31.5 mm (1¼ inch) sieve. The aggregate obtained from the processed RAP shall be 100 percent passing the 25.0 mm (1 inch) sieve. The aggregate and binder obtained from the processed RAP shall be uniform in all the measured parameters in accordance with the following:

UNIFORMITY*

Parameter	Standard Deviation
Binder Content	0.5
Percent Passing 19 mm (¾")	4.0
Percent Passing 12.5 mm (½")	4.0
Percent Passing 9.5 mm (⅜")	4.0
Percent Passing 4.75 mm (#4)	4.0
Percent Passing 2.36 mm (#8)	4.0
Percent Passing 600 μm (#30)	3.0
Percent Passing 75 μm (#200)	1.5
*Uniformity is the Maximum allowable Standard Deviation of test results of processed RAP.	

If RAP millings generated are incorporated in the same project, in accordance with CPL 5145 the Contractor shall pave with a virgin mix design until sufficient amount of processed RAP has been stockpiled and tested to allow full production of a RAP HMA mix.

End of Section

Revision of Section 401
Temperature Segregation

Section 401 of the Standard Specifications is hereby revised for this project as follows:

In subsection 401.16 delete the twelfth (last) paragraph and replace it with the following:

The Engineer may evaluate the HMA for low density due to temperature segregation any time industry best practices, as detailed on Form 1346, are not being followed or the Engineer suspects temperature segregation is occurring. The Engineer will first meet with the Contractor to discuss the paving practices that are triggering the temperature investigation. Areas across the mat, excluding the outside 1 foot of both edges of the mat, that are more than 25 °F cooler than other material across the width may be marked for density testing. Material for temperature comparison will be evaluated in 3-foot intervals behind the paver across the width of the mat. The material shall be marked and tested in accordance with CP 58. If four or more areas within a lot of 500 tons have densities of less than 93 percent of the material's maximum specific gravity for SMA mixes or less than 92 percent of the material's maximum specific gravity for all other HMA mixes, a 5 percent price disincentive will be applied to the 500 ton lot. The 500 ton count begins when the Engineer starts looking for cold areas, not when the first cold area is detected. This price disincentive will be in addition to those described in Sections 105 and 106. Only one area per delivered truck will be counted toward the number of low density areas. Temperature segregation checks will be performed only in areas where continuous paving is possible.

End of Section

Revision of Section 401
Tolerances for Hot Mix Asphalt (Voids Acceptance)

Section 401 of the Standard Specifications is hereby revised for this project as follows:

In subsection 401.02(b) delete Table 401-1, including the footnotes, and replace with the following:

Table 401-1
Tolerances for Hot Bituminous Pavement

Element	Tolerance
Asphalt Cement Content	± 0.3 %
Voids in the Mineral Aggregate (VMA)	± 1.2 %
Air Voids	± 1.2 %

End of Section

Revision of Section 401 and 412
Safety Edge

Sections 401 and 412 of the Standard Specifications are hereby revised for this project as follows:

Subsection 401.10 shall include the following:

The paver shall include an approved longitudinal paver wedge system to create a sloped safety edge as shown on the plans. The wedge system shall be attached to the screed and shall compact the HMA to a density at least as dense as the compaction imparted to the rest of the HMA layer by the paving screed. The system shall provide a sloped Safety Edge equal to 32 degrees plus or minus 5 degrees measured from the pavement surface cross slope extended. The use of a single plate strike off is not permitted. The system shall be adjustable to accommodate varying paving thicknesses. The Engineer may allow the Contractor to use handwork for short sections or to saw cut the sloped Safety Edge after paving operations are completed in areas such as transitions at driveways, intersections, interchanges.

The Contractor shall submit the proposed system for approval at the Preconstruction Conference. The Engineer may require proof that the system has been used on previous projects with acceptable results or may require a test section constructed prior to the beginning of work to demonstrate that it creates an acceptable wedge shape and compaction. Paving shall not begin until the system is approved in writing by the Engineer. The Safety Edge may be constructed on each lift of HMA or on the full specified plan depth on the final lift. The finished shape of the Safety Edge shall extend for the full depth of the asphalt pavement or for the top 5 inches whichever is less.

Subsection 401.22 shall include the following:

All costs associated with the construction of the Safety Edge will not be paid for separately, but shall be included in the work.

Subsection 412.07 shall include the following:

The Contractor shall use an approved longitudinal paver wedge system to create a sloped Safety Edge. The Contractor shall modify the paver screed to create a Safety Edge that meets the final cross-section shown on the plans. The system shall provide a sloped Safety Edge equal to 32 degrees plus or minus 5 degrees measured from the pavement surface cross slope extended. There may be areas where it is not possible to place the Safety Edge in conjunction with mainline paving but where the Safety Edge is required, such as transitions at driveways, intersections, interchanges, etc. In these areas the Engineer may allow the Contractor to use handwork for short sections or to saw cut the sloped Safety Edge after paving operations are completed.

The Contractor shall submit the proposed system for approval at the Preconstruction Conference. The Engineer may require proof that the system has been used on previous projects with acceptable results or may require a test section constructed prior to the beginning of work to demonstrate that it creates an acceptable wedge shape. Paving shall not begin until the system is approved in writing by the Engineer. The finished shape of the Safety Edge shall extend for the full depth of the concrete pavement or for the top 5 inches whichever is less.

Subsection 412.23 shall include the following:

Concrete Safety Edge will be measured by the actual number of linear feet that are installed and accepted.

Subsection 412.24 shall include the following:

Pay Item	**Pay Unit**
Concrete Safety Edge	Linear Foot

Payment for concrete safety edge will be full compensation for all work and materials required to complete the item.

End of Section

Revision of Section 614 and 713
Sign Panel Sheeting

Sections 614 and 713 of the Standard Specifications are hereby revised for the project as following:

Delete subsection 614.04 and replace with the following:

614.04 Sign Panels. Sign panel materials shall conform to Section 713 and to the details shown on the plans. Sign panels shall be produced in accordance with the retroreflective sheeting manufacturer's recommendations. Layout and font design shall conform to the "Standard Highway Signs" published by FHWA. Font selection for guide sign legends shall conform to the most recent version of the "CDOT Sign Design Manual". Sign layouts for special signs shall be in accordance with the detailed sign layouts proved in the plans or by the Engineer.

Silk screen and digital process figures shall be in accordance with the plans and series figures described in the current editions of "Standard Highway Signs", published by the FHWA, and the "Colorado Supplement to Standard Highway Signs".

All exposed lockbolt fastener heads on the faces of the sign panels shall be covered with material matching the background of the panel.

All sign panels shall be identified with the month and year that the sign was manufactured. The date shall be located on the lower right side of the back of the sign panel and shall be approximately ¼ inch high. The date shall be stamped or adhered onto the sign panel material for a permanent record. This work will be paid for as part of the Item.

In subsection 713.01, delete Table 713-1 and replace with the following:

Table 713-1

	Aluminum		Steel
Application	**ASTM Designation**	**Allow No.**	**ASTM Designation**
Sign panels	B 449[1] B 921[1]	6061-T6 5052-H36 5052-H38	A 653[2]
Traffic controller cabinets	B 209	6061-T6	A 709 Grade 36
Clip bolts	B 211	2024-T4	
Locknuts or steel nuts and bolts	B 211	2014-T4	A 307
Clips and backing angles	B 221	6061-T6	

[1]In lieu of ASTM treatment, aluminum sign blanks shall receive a Class 2 anodized coating prior to the placement of retroreflective sheeting.
[2] Steel sheets shall have a Z600 zinc coating in accordance with ASTM A 653 and a light phosphate coating. Phosphate coating of 3.5 oz./sq. ft. will be required for application with reflective sheeting. Nuts and bolts shall be galvanized or cadmium plated.

Delete subsection 713.04 and replace with the following:

713.04 Sign Message Materials. The legend, border, and overlay shall be used in accordance with the sheeting manufacturer's recommendation. Retroreflective sheeting background material shall be approved in the Department's Approved Product List; and the retroreflective sheeting background material shall be the type as specified on the plans. At a minimum, ASTM 4956 Type IV shall be used for ground mount signs. ASTM D4956 Type XI shall be used for Class III overhead signs.

For Class III overhead signs, the legend and borders shall be ASTM D4956 Type XI sheeting.

All reflective sheeting shall be sealed at the seams and edges as recommended by the manufacturer.

Delete subsection 713.06 and replace with the following:

713.06 (unused)

End of Section

Revision of Section 630 and 713
Retroreflective Sign Sheeting

Section 630 and 713 of the Standard Specifications is hereby revised for this project as follows:

In subsection 630.02, delete the sixth and seventh paragraphs, including Table 630-1, and replace them with the following:

Retroreflective sheeting for all signs requiring an orange background shall be Fluorescent.

Table 630-1

RETROREFLECTIVE SHEETING TYPES

Sheeting	Type IV	Type VI (Roll-up sign material)	Fluorescent[1]
Application	Work Zone	Work Zone	Work Zone
All Orange Construction Signs			X
Orange Construction Signs that are used only during daytime hours for short term or mobile operations		X[4]	X
Barricades (Temporary)	X		X
Vertical Panels	X		X
Flaggers Stop/Slow Paddle	X		X
Drums and Tubular Markers[2]	X[6]		X
Non-orange Fixed Support signs with prefix "W"	X		
Special Warning Signs			X
STOP sign (R1-1) YIELD sign (R1-2) WRONG WAY sign (R5-1a) DO NOT ENTER sign (R5-1) EXIT sign (E5-1a)	X		
DETOUR sign (M4-9) or (M4-10)			X
All other fixed support signs[3]	X		X
All other signs used only during working hours	X		X
All other signs that are used only during daytime hours for short term or mobile operations	X	X[5]	X

1 Fluorescent sheeting shall be of a brand that is on the CDOT Approved Products List.
2 Drum and Tubular Marker sheeting shall be manufactured for flexible devices, and sheeting materials shall conform to Section 713.
3 Fixed support signs are defined as all signs that must remain in use outside of working hours. They shall be mounted in accordance with Standard Plan S-630-1.
4 RS 24 only.
5 White only.
6 For projects advertised prior to September 1, 2017, Type IV or Fluorescent sheeting will be permitted. For projects advertised on or after September 1, 2017, only Fluorescent sheeting will be permitted.

In subsection 630.07 (b), delete the first sentence of the second paragraph and replace it with the following:

Tubular Markers shall be retroreflectorized as shown in Table 630-1.

Delete Subsection 713.10(b) and replace with the following:

(b) *Retroreflective Sheeting.* Reflective sheeting for traffic control devices shall be listed on the CDOT Approved Products List, and conform to the requirements of ASTM D 4956.

1. Retroreflective Quality Requirements

A. Drums and Tubular Markers. Retroreflective sheeting shall conform to ASTM D4956 Type IV, with the following modifications:

The Minimum Coefficient of Retroreflection (R_A) shall conform to the following minimum values.

Observation Angle	Entrance Angle	Minimum Coefficient of Retroreflection (R_A) [cd/fc/ft^2 (cd/lx.m^2)]	
		White	Fluorescent Orange
0.2º	-4º	500	200
0.2º	30º	200	80
0.5º	-4º	225	90
0.5º	30º	85	34

2. Daytime Color

A. Drums and Tubular Markers. All fluorescent orange sheeting shall meet the color requirements of ASTM D4956, with the following modifications:

The chromaticity coordinates and total luminance factor shall conform to the requirements as described in 23 CFR Part 655 Appendix to Subpart F.

The Fluorescence Luminance Factor (Y_F) shall conform to the following minimum values.

Color	Y_F Initial Requirement	Y_F Minimum Requirement
Fluorescent Orange	20	15

End of Section

Revision of Section 702
Bituminous Materials

Section 702 of the Standard Specifications is hereby deleted for this project and replaced with the following:

702.01 Asphalt Cements.

(a) *Superpave Performance Graded Binders.* Superpave Performance Graded Binders shall conform to the requirements listed in Table 702-1. (Taken from AASHTO M 320)

Asphalt cement shall not be acid modified or alkaline modified.

Asphalt cement shall not contain any used oils that have not been re-refined. Modifiers that do not comply with environmental rules and regulations including 40 CFR Part 261.6(a) (3) (IV), and part 266/Subpart C shall not be added. Modifiers shall not be carcinogenic.

The supplier of the PG binder shall be certified in accordance with CP 11.

Table 702-1
SUPERPAVE PERFORMANCE GRADED BINDERS

Property	Requirement for PG Binder						AASHTO Test No.
	58-28	58-34	64-22	64-28	70-28	76-28	
Original Binder Properties							
Flash Point Temp., °C, minimum	230	230	230	230	230	230	T 48
Viscosity at 135 °C, Pa●s, maximum	3	3	3	3	3	3	T 316
Dynamic Shear, Temp. °C, where G*/Sin δ @ 10 rad/s ≥ 1.00 kPa	58	58	64	64	70	76	T 315
Ductility, 4 °C (5 cm/min.), cm minimum	-	-	-	50		-	T 51
Toughness, joules (inch-lbs)	-	-	-	12.4 (110)		-	CP-L 2210
Tenacity, joules (inch-lbs)	-	-	-	8.5 (75)		-	CP-L 2210
Acid or Alkali Modification (pass-fail)	Pass	Pass	Pass	Pass	Pass	Pass	CP-L 2214
RTFO Residue Properties							CP-L 2215
Mass Loss, percent maximum	1.00	1.00	1.00	1.00	1.00	1.00	CP-L 2215
Dynamic Shear, Temp. °C, where G*/Sin δ @ 10 rad/s ≥ 2.20 kPa	58	58	64	64	70	76	T 315
Elastic Recovery, 25 °C, percent min.	-	-	-	-	50	50	T 301
Ductility, 4 °C (5 cm/min.), cm minimum	-	-	-	20	-	-	T 51
PAV Residue Properties, Aging Temperature 100 °C							R 28
Dynamic Shear, Temp. °C, where G*●Sin δ @ 10 rad/s ≤ 5000 kPa	19	16	25	22	25	28	T 315
Creep Stiffness, @ 60 s, Test Temperature in °C	-18	-24	-12	-18	-18	-18	T 315
S, maximum, MPa	300	300	300	300	300	300	T 313
m-value, minimum	0.300	0.300	0.300	0.300	0.300	0.300	T 313

Acceptance Samples of the PG binder will be taken on the project in accordance with the Schedule in the Field Materials Manual.

The Department will test for acid modification and alkaline modification during the binder certification process. Thereafter, the Department will randomly test for acid modification and alkaline modification.

(b) Damp proofing. Asphalt for damp proofing shall conform to the requirements of ASTM D 449, and the asphaltic primer shall conform to the requirements of ASTM D 41.

702.02 Emulsified Asphalts. Emulsified asphalts shall conform to AASHTO M 140 or M 208 for the designated types and grades. Emulsified asphalt and aggregate used for surface seals shall be sampled and will be tested for information only in accordance with CP-L 2213.

Emulsified asphalt (HFMS-2S) with a residual penetration greater than 300 dmm shall conform to all properties listed in AASHTO M 140, Table 1 except that ductility shall be reported for information only.

(a) *Emulsion for Tack and Fog Coats.* Emulsions for tack and fog coats shall conform to the requirements listed in Table 702-2 or 702-3, prior to dilution.

Table 702-2
TACK AND FOG COAT EMULSIONS

Property		CSS-1h	SS-1h	AASHTO Test No.
Tests on Emulsion:				
Viscosity, at 25 ºC, Saybolt-Furol, s	*min*	20	20	T 59
	max	100	100	
Storage stability, 24 hr, % max[1]		1.0	1.0	T 59
Particle charge test		Positive		T 59
Sieve test, % max		0.10	0.10	T 59
Oil Distillate by volume, % max		3.0	3.0	T-59
Residue by distillation/ evaporation, % min[3]		57[3]	57[3]	T 59/ CP-L 2212[2]
Tests on residue:				
Penetration, 25 ºC, 100g, 5s, min, dmm		40	40	T 49
Penetration, 25 ºC, 100g, 5s, max, dmm		120	120	
Ductility, 25 ºC, 5 cm/min, cm, min		40	40	T 51
Solubility, in trichloroethylene% min		97.5	97.5	T 44

[1]If successful application is achieved in the field, the Engineer may wave this requirement.

[2] CP-L 2212 is a rapid evaporation test for determining percent residue of an emulsion and providing material for tests on residue. CP-L 2212 is for acceptance only. If the percent residue or any test on the residue fails to meet specifications, the tests will be repeated using the distillation test in conformance with AASHTO T-59 to determine acceptability.

[3] For polymerized emulsions the distillation and evaporation tests will in be in conformance with AASHTO T-59 or CP-L 2212 respectively with modifications to include 205 ± 5 ºC (400 ± 10 ºF) maximum temperature to be held for 15 minutes.

(b) *Emulsion for Chip Seals* Polymerized emulsions for chip seals shall conform to the requirements listed in Table 702-3. Emulsion for chip seals shall be an emulsified blend of polymerized asphalt, water, and emulsifiers. The asphalt cement shall be polymerized prior to emulsification and shall contain at least 3 percent polymer by weight of asphalt cement. The emulsion standing undisturbed for a minimum of 24 hours shall show no white, milky separation but shall be smooth and homogeneous throughout. The emulsion shall be pumpable and suitable for application through a distributor.

Table 702-3
POLYMERIZED EMULSIONS FOR CHIP SEALS

Property		CRS-2	CRS-2P	CRS-2R	HFMS-2P	AASHTO Test No.
Tests on Emulsion:						
Viscosity, at 50 ºC, Saybolt-Furol, s	*min*	50	50	50	50	T 59
	max	450	450	450	450	
Storage stability, 24 hr, % max		1.0	1.0	1.0	1.0	T 59
Particle charge test		Positive	Positive	Positive		T 59
Sieve test, % max		0.10	0.10	0.10	0.10	T 59
Demulsibility[1], % min		40	40	40		T 59
Oil Distillate by volume, % max or range		3.0	3.0	3.0	3.0	T-59
Residue by distillation/ evaporation, % min[3]		65[3]	65[3]	65[3]	65[3]	T 59/ CP-L 2212[2]
Tests on residue:						
Penetration, 25 ºC, 100g, 5s, min, dmm		70	70	70	70	T 49
Penetration, 25 ºC, 100g, 5s, max, dmm		150	150	150	150	
Ductility, 25 ºC, 5 cm/min, cm, min		40			75	T 51
Ductility, 4 ºC, 5 cm/min, cm, min				40		
Solubility, in trichloroethylene% min[4]		97.5[4]	97.5[4]	97.5[4]	97.5[4]	T 44
Elastic Recovery, 25 ºC min					58	T 301
Float Test, 60 ºC, s min					1200	T 50
Toughness, in-lbs, min			70	90		CP-L 2210
Tenacity, in-lbs, min			45	45		CP-L 2210

[1]If successful application is achieved in the field, the Engineer may waive this requirement.

[2] CP-L 2212 is a rapid evaporation test for determining percent residue of an emulsion and providing material for tests on residue. CP-L 2212 is for acceptance only. If the percent residue or any test on the residue fails to meet specifications, the tests will be repeated using the distillation test in conformance with AASHTO T-59 to determine acceptability.

[3] For polymerized emulsions the distillation and evaporation tests will in be in conformance with AASHTO T-59 or CP-L 2212 respectively with modifications to include 205 ± 5 ºC (400 ± 10 ºF) maximum temperature to be held for 15 minutes.

[4] Solubility may be determined on the base asphalt cement prior to polymer modification.

(c) *Emulsion for Slurry Seals and Micro-Surfacing.* Emulsions for slurry seals and micro-surfacing shall conform to the requirements listed in Table 702-4. The modified emulsion shall contain a minimum of 3 percent polymer, SBR latex, or natural latex by weight.

Table 702-4
SLURRY SEAL AND MICRO-SURFACING EMULSIONS

Property		CQS-1hL	CQS-1hP	AASHTO Test No.
Tests on Emulsion:				
Viscosity, at 25 ºC, Saybolt-Furol, s	*min*	15	15	T 59
	max	100	100	
Storage stability, 24 hr, % max[1]		1.0	1.0	T 59
Particle charge test		Positive	Positive	T 59
Sieve test, % max		0.10	0.10	T 59
Oil Distillate by volume, % max		0.5	0.5	T-59
Residue by distillation/ evaporation, % min[3]		62[3]	62[3]	T 59/ CP-L 2212[2]
Tests on residue:				
Penetration, 25 ºC, 100g, 5s, min, dmm		40	40	T 49
Penetration, 25 ºC, 100g, 5s, max, dmm		150	150	
Ductility, 25 ºC, 5 cm/min, cm, min		50	50	T 51
Solubility, in trichloroethylene% min		97.5	97.5	T 44

[1]If successful application is achieved in the field, the Engineer may wave this requirement.

[2] CP-L 2212 is a rapid evaporation test for determining percent residue of an emulsion and providing material for tests on residue. CP-L 2212 is for acceptance only. If the percent residue or any test on the residue fails to meet specifications, the tests will be repeated using the distillation test in conformance with AASHTO T-59 to determine acceptability.

[3] For polymerized emulsions the distillation and evaporation tests will in be in conformance with AASHTO T-59 or CP-L 2212 respectively with modifications to include 205 ± 5 ºC (400 ± 10 ºF) maximum temperature to be held for 15 minutes.

(d) *Emulsion for Prime Coat.* Emulsion for prime coat shall conform to the requirements of Table 702-5. Circulate before use if not used within 24 hours.

Table 702-5
ASPHALT EMULSION FOR PRIME COAT (AEP)

Property	Requirement	AASHTO Test No.
Viscosity, Saybolt Furol, at 50 °C (122 °F), s	20-150	T 59
% Residue	65% min.	T 59 to 260 °C (500 °F)
Oil Distillate by Volume, %	7% max.	T59
Tests on Residue from Distillation:		
Solubility in Trichloroethylene, %	97.5 min.	T 44

(e) *Recycling Agent.* Recycling Agent for Item 406, Cold Bituminous Pavement (Recycle), shall be either a high float emulsified asphalt (polymerized) or an emulsified recycling agent as follows:

1. High Float Emulsified Asphalt (Polymerized). High Float Emulsified Asphalt (Polymerized) for Cold Bituminous Pavement (Recycle) shall be an emulsified blend of polymer modified asphalt, water, and emulsifiers conforming to Table 702-6 for HFMS-2sP. The asphalt cement shall be polymerized prior to emulsification, and shall contain at least 3 percent polymer.

   The emulsion standing undisturbed for a minimum of 24 hours shall show no white, milky separation, and shall be smooth and homogeneous throughout.

   The emulsion shall be pumpable and suitable for application through a pressure distributor.

Table 702-6
HIGH FLOAT EMULSIFIED ASPHALT
(POLYMERIZED) (HFMS-2sP)

Property	Requirement		AASHTO Test
	Minimum	Maximum	
Tests on Emulsion:			
Viscosity, Saybolt Furol at 50 °C (122 °F), sec	50	450	T 59
Storage Stability test, 24 hours, %		1	T 59
Sieve test, %		0.10	T 59
% Residue[1]	65		T 59
Oil distillate by volume, %	1	7	T 59
Tests on Residue:			
Penetration, 25 °C (77 °F), 100g, 5 sec	150	300[2]	T 49
Float Test, 60 °C (140 °F), sec	1200		T 50
Solubility in TCE, %	97.5		T 44
Elastic Recovery, 4 °C (39.2 °F), %	50		T 301

[1]400 ± 10° F maximum temperature to be held for 15 minutes.
[2]When approved by the Engineer, Emulsified Asphalt (HFMS-2sP) with a residual penetration greater than 300 dmm may be used with Cold Bituminous Pavement (Recycle) to address problems with cool weather or extremely aged existing pavement. Emulsified Asphalt (HFMS-2sP) with a residual penetration greater than 300 dmm shall meet all properties listed in Table 702-4 except that Elastic Recovery shall be reported for information only.

2. *Emulsified Recycling Agent.* Emulsified Recycling Agent for use in Cold Bituminous Pavement (Recycle) shall conform to the requirements in Table 702-7.

Table 702-7
EMULSIFIED RECYCLING AGENT

Property	Requirement		Test
	Minimum	Maximum	
Tests on Emulsion:			
Viscosity @ 25 °C, SFS	20	200	ASTM D 244
Pumping Stability	Pass		GB Method[1]
Sieve Test, %w		0.1	ASTM D 244[2]
Cement Mixing, %w		2.0	ASTM D 244
Particle Charge	Positive		ASTM D 244
Conc. Of Oil Phase	64		ASTM D 244[3]
Tests on Residue:			
Viscosity @ 60 °C , CST	2000	4000	ASTM D 2170
Flash Point, COC, °C (° F)	232		ASTM D 92
Maltenes Dist. Ratio[4] $\frac{PC+A_1}{S+A_2}$	0.3	0.6	ASTM D 2006
PC/S Ratio	0.4		ASTM D 2006
Asphaltenes, % max.		11.0	ASTM D 2006

[1]Pumping stability is determined by charging 450 ml of emulsion into a one liter beaker and circulating the emulsion through a gear pump (Roper 29.B22621) having a 6.3 mm (1/4 inch) inlet and outlet. The emulsion passes if there is no significant separation after circulating ten minutes.
[2]Test procedure identical with ASTM D 244 except that distilled water shall be used in place of 2 percent sodium oleate solution.
[3]ASTM D 244 Evaporation Test for percent of residue is modified by heating 50 gram sample to 149°C (300 °F) until foaming ceases, then cooling immediately and calculating results.
[4]In the Maltenes Distribution Ratio Test by ASTM Method D 2006.

PC = Polar Compounds S = Saturates
A_1 = First Acidaffin A_2 = Second Acidaffins

(f) Asphalt Rejuvenating Agents. Asphalt rejuvenating agents (ARA) shall be composed of a petroleum resin-oil base uniformly emulsified with water and shall conform to the physical and chemical requirements of Table 702-8 or ASTM D 4552.

Table 702-8
ASPHALT REJUVENATING AGENT

Property	Test Method	Requirement
Viscosity, S.F., @ 25 °C (77 °F), s	ASTM D 244	20-40
[1]Residue, % min.	ASTM D 244	60-65
[2]Miscibility Test	ASTM D 244	No coagulation
[3]Sieve Test, % max.	ASTM D 244	0.10
Particle Charge Test	ASTM D 244	Positive
ASTM D244 (Mod):		
Viscosity, 60 °C (140 °F), mm^2/s	ASTM D 445	100 - 200
Flash Point, COC, °C, min.	ASTM D 92	196
Asphaltenes, % max.	ASTM D2006	1.0
[4]Maltenes Dist. Ratio $\frac{PC+A_1}{S+A_2}$	ASTM D 2006	0.3-0.6
Saturated Hydrocarbons, %	ASTM D 2006	21-28

[1] ASTM D244 Modified Evaporation Test for percent of residue is made by heating 50-gram sample to 149 °C (300 °F) until foaming ceases, then cooling immediately and calculating results.
[2] Test procedure identical with ASTM D244 except that 0.02 Normal Calcium Chloride solution shall be used in place of distilled water.
[3] Test procedure identical with ASTM D244 except that distilled water shall be used in place of 2% sodium oleate solution.
[4] In the Maltenes Distribution Ratio Test by ASTM Method D4124:

PC = Polar Compounds S = Saturates
A_1 = First Acidaffin A_2 = Second Acidaffins

For hot-in-place recycling ARA-1P is an acceptable alternative to ARA. ARA-1P shall meet the requirements below:

Emulsified Polymer Modified Asphalt Rejuvenating Agent (ARA-1P) for use in hot-in-place recycling of bituminous pavements shall be modified with a minimum of 1.5 percent styrene-butadiene solution polymer. The finished product shall conform to the physical requirements listed in Table 702-9 below.

Table 702-9
ARA-1P

Property	Test Method	Min	Max
Test on Emulsion			
Viscosity, Saybolt-Furol @ 77 ºF, s	ASTM D 244		100
Residue @ 350 ºF, %	ASTM D 244 Mod	60	
Sieve Test, %	ASTM D 244		0.10
Oil distillate, %	ASTM D 244		2.0
Test on Residue			
Penetration @ 39.2 ºF, 100g, 5s, dmm	ASTM D-5 Modified	150	250
Asphaltenes, %	ASTM D 4124		15

702.03 (unused)

702.04 Hot Poured Joint and Crack Sealant. Hot poured material for filling joints and cracks shall conform to the requirements of ASTM D 6690, Type II or Type IV. The concrete blocks used in the Bond Test shall be prepared in accordance with CP-L 4101.

Sealant material shall be supplied pre-blended, pre-reacted, and prepackaged. If supplied in solid form the sealant material shall be cast in a plastic or other dissolvable liner having the capability of becoming part of the crack sealing liquid. The sealant shall be delivered in the manufacturer's original sealed container.

Each container shall be legibly marked with the manufacturer's name, the trade name of the sealer, the manufacturer's batch or lot number, the application temperature range, the recommended application temperature, and the safe heating temperature.

The sealant shall be listed in CDOT's Approved Products List prior to use.

End of Section

Revision of Section 703
Aggregate for Hot Mix Asphalt

Section 703 of the Standard Specifications is hereby revised for this project as follows:

Delete subsection 703.04 and replace with the following:

703.04 Aggregates for Hot Mix Asphalt. Aggregates for hot mix asphalt (HMA) shall be of uniform quality, composed of clean, hard, durable particles of crushed stone, crushed gravel, natural gravel, or crushed slag. Excess of fine material shall be wasted before crushing. A percentage of the aggregate retained on the 4.75 mm (No. 4) sieve for Gradings S, SX and SG— and on the 2.36 mm (No. 8) sieve for Gradings SF and ST—shall have at least two mechanically induced fractured faces when tested in accordance with Colorado Procedure 45. This percentage will be specified in Table 403-1, as revised for the project in Section 403. The angularity of the fine aggregate shall be a minimum of 45.0 percent when determined according to AASHTO T 304. Grading SF mixes, when determined by RME, may not require fine aggregate angularity of 45.0 percent. Aggregate samples representing each aggregate stockpile shall be non-plastic if the percent of aggregate passing the 2.36 mm (No. 8) sieve is greater than or equal to 10 percent by weight of the individual aggregate sample. Plasticity will be determined in accordance with AASHTO T 90. The material shall not contain clay balls, vegetable matter, or other deleterious substances.

The aggregate for Gradings ST, S, SX and SG shall have a percentage of wear of 45 or less when tested in accordance with AASHTO T 96.

Table 703-4
MASTER RANGE TABLE FOR HOT MIX ASPHALT

Sieve Size	Percent by Weight Passing Square Mesh Sieves				
	Grading SF**	Grading ST	Grading SX	Grading S	Grading SG
37.5 mm (1½″)					100
25.0 mm (1″)				100	90 – 100
19.0 mm (¾″)			100	90 – 100	
12.5 mm (½″)		100	90 – 100	*	*
9.5 mm (⅜″)	100	90 – 100	*	*	*
4.75 mm (#4)	90 – 100	*	*	*	*
2.36 mm (#8)	*	28 – 58	28 – 58	23 – 49	19 – 45
1.18 mm (#16)	30 – 54				
600 μm (#30)	*	*	*	*	*
300 μm (#50)					
150 μm (#100)					
75 μm (#200)	2 – 12	2 – 10	2 – 10	2 – 8	1 – 7

* These additional Form 43 Specification Screens will initially be established using values from the As Used Gradation shown on the Design Mix.
**SF applications are limited and the CDOT Pavement Design Manual should be referenced, prior to use.

Aggregates for stone matrix asphalt (SMA) shall be of uniform quality, composed of clean, hard, durable particles of crushed stone, crushed gravel, or crushed slag. A minimum of 90 percent of the particles retained on the 4.75 mm (No. 4) sieve shall have at least two mechanically induced fractured faces when tested in accordance with Colorado Procedure 45. The particles passing the 4.75 mm (No. 4) sieve shall be the product of crushing rock larger than 12.5 mm (½ inch) and shall be non-plastic when tested in accordance with AASHTO T 90.

Additionally, each source of aggregate for SMA shall meet the following requirements:

(1) No more than 30 percent when tested in accordance with AASHTO T 96 Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine.

(2) No more than 12 percent when tested in accordance with AASHTO T 104 Soundness of Aggregate by Use of Sodium Sulfate.

The aggregate for Hot Mix Asphalt (HMA) shall meet the requirements of Table 703-4A when tested in accordance with CP-L 4211 Resistance of Coarse Aggregate to Degradation by Abrasion in the Micro-Deval Apparatus. The Contractor shall be assessed a price reduction of $1000 for each production sample of the combined aggregate with a value greater than 20 according to CP-L 4211.

Table 703-4A

AGGREGATE DEGRADATION BY ABRASION

IN THE MICRO-DEVAL CP-L 4211

	Not to exceed
Combined Aggregate (Mix Design)	18
Combined Aggregate (1/10,000 tons, or fraction thereof during production)	20

End of Section