**Delete Subsection 105.06 and replace with the following:**

**105.06 Conformity to the Contract of Portland Cement Concrete Pavement.** Conformity to the Contract of all Portland Cement Concrete Pavement, Item 412, will be determined per the following:

When the Engineer finds that the materials furnished, the work performed, or the finished product does not conform to the Contract, or the Pay Factor (PF) for an element’s process is less than 0.75 but that reasonably acceptable work has been produced, the Engineer will determine the extent of the work that will be accepted and remain in place. The Engineer will use a Contract Modification Order to document the justification for allowing the work to remain in place and the price adjustment that will be applied.

When the Engineer finds the materials furnished, work performed, or the finished product is not in conformity with the Contract, or the PF for an element’s process is less than 0.75 and has resulted in an inferior or unsatisfactory product, the work or material shall be removed and replaced or otherwise corrected by and at the expense of the Contractor. When the PF for any process is 0.75 or greater, the finished quantity of work represented by the process will be accepted at the calculated pay factor.

Materials will be sampled and tested by the Contractor and the Department per subsection 106.06 and with procedures contained in the Department’s Field Materials Manual. The approximate quantity represented by each sample will be as set forth in subsection 106.06, Table 106-3. Additional samples may be selected and tested at the Engineer’s discretion.

1. Incentive and Disincentive Payments (I/DP) will be made based on a statistical analysis that yields Pay Factors (PF) and Quality Levels (QL). The PF and QL will be made based on test results for the elements of compressive strength and pavement thickness.

The QL will be calculated for the elements of compressive strength and pavement thickness on a process basis. A process will consist of the test results from a series of random samples. Test results determined to have sampling or testing errors will not be used. All materials produced will be assigned to a process. Changes in mix design, design pavement thickness, or a break of more than 120 working days between placements will create a new process. The following is provided to clarify changes in processes for each element:

* 1. Construction of mainline pavement, including the shoulders if placed with the mainline, is a single process for the compressive or flexural strength element, when the mix design does not change and there is not a break of more than 120 days between placements.
  2. Construction of mainline pavement, including the shoulders if placed with the mainline, is a single process for the thickness element, when the planned thickness does not change and there is not a break of more than 120 days between placements.
  3. Construction of ramps, acceleration and deceleration lanes and shoulders placed separately are considered separate processes.
  4. Changes in paving equipment, changes in placement method, changes in hauling equipment, adjustments to mix designs that do not require a new mix design, changes in weather conditions, and changes in production rate shall not create a new process in the strength or thickness elements.

The Contractor and Engineer will determine element processes and what distinguishes them as processes during the Pre-pave meeting before concrete placement.

1. When it is necessary to represent material by one or two tests, each individual test shall have a PF computed per the following:

If the value of the test is at or above the lower tolerance limit, then PF = 1.000. If the value of the test is below the lower tolerance limit, then:

PF = 1.00 – [0.25(TL -T0)/V]

Where PF = pay factor.

V = V factor from Tables 105-10

T0 = the individual test value.

TL= lower tolerance limit.

1. The following procedures will be used to compute Incentive and Disincentive Payments (I/DP), quality levels (QL), and pay factors (PF) for processes represented by three or more tests:
   1. Quality Level (QL) will be calculated according to CP-71.
   2. Compute the PF for the process. When the process has been completed, the number of tests (Pn) it includes shall determine the formula to be used to compute the final pay factor per the following:

A. For pavement thickness:

When 3 ≤ Pn ≤ 5

If QL ≥ 85, then PF = 1.00 + (QL - 85)0.001333

If QL < 85, then PF = 1.00 + (QL - 85)0.005208

When 6 ≤ Pn ≤ 9

If QL ≥ 90, then PF = 1.00 + (QL - 90)0.002000

If QL < 90, then PF = 1.00 + (QL - 90)0.005682

When 10 ≤ Pn ≤ 25

If QL ≥ 93, then PF = 1.00 + (QL - 93)0.002857

If QL < 93, then PF = 1.00 + (QL - 93)0.006098

When Pn ≥ 26

If QL ≥ 95, then PF = 1.00 + (QL - 95)0.004000

If QL < 95, then PF = 1.00 + (QL - 95)0.006757

B. For compressive strength:

When 3 ≤ Pn ≤ 5

If QL ≥ 85, then PF = 1.00 + (QL - 85)0.002000

If QL < 85, then PF = 1.00 + (QL - 85)0.005208

When 6 ≤ Pn ≤ 9

If QL ≥ 90, then PF = 1.00 + (QL - 90)0.003000

If QL < 90, then PF = 1.00 + (QL - 90)0.005682

When 10 ≤ Pn ≤ 25

If QL ≥ 93, then PF = 1.00 + (QL - 93)0.004286

If QL < 93, then PF = 1.00 + (QL - 93)0.006098

When Pn ≥ 26

If QL ≥ 95, then PF = 1.00 + (QL - 95)0.006000

If QL < 95, then PF = 1.00 + (QL - 95)0.006757

3. Compute the I/DP for the process:

I/DP = (PF-1)(QR)(UP)

where: QR = Quantity Represented by the process.

UP = Unit Price bid for the Item.

The total I/DP for an element shall be computed by accumulating the individual I/DP for each process of that element.

1. As acceptance test results become available, they will be used to calculate accumulated QL and Incentive and Disincentive Payments (I/DP) for each element and for the item. The Contractor’s test results and the accumulated calculations shall be made available to the Engineer upon request. The Engineer’s test results and the calculations will be made available to the Contractor as early as reasonably practical. Numbers from the calculations shall be carried to significant figures and rounded according to AASHTO Standard Recommended Practice R-11, Rounding Method.

I/DP will be made to the Contractor per subsection 412.24(a). During production, interim I/DP will be computed for information only. The Pn will change as production continues and test results accumulate. The Pn at the time and I/DP is computed shall determine the formula to be used.

1. The Contractor shall not have the option of accepting a price reduction or disincentive in lieu of producing specification material. Continued production of non-specification material will not be permitted. Material that is obviously defective may be isolated and rejected without regard to sampling sequence or location within a process.
2. The Contractor may take cores at his own expense and per Colorado Procedure 65 to provide an alternative determination of strength to replace acceptance test results with a compressive strength less than **TL**. The core compressive strength shall be used for I/DP regardless of result..

**Table 105-10**

**“V” FACTORS AND INCENTIVE PAYMENTS**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Element** | **V factor** | **Maximum Incentive Payment** | **Lower Tolerance Limit,** **TL** | **Plan Value** |
| Compressive Strength | 400 psi | 3.00 % | 4200 psi | 4500 psi |
| Pavement Thickness | 0.4 inch | 2.00 % | Plan Thickness  -0.4 inch | Plan Thickness |

1. *Sand Equivalence*. The sand equivalence (SE) as determined by CP 37 will be considered acceptable when the running average of three consecutive tests is greater than 80 percent and no individual test result is less than 75 percent. When the running average of three consecutive SE tests falls below 80 percent or an individual SE test result falls below 75 percent, paving operations shall be suspended. The Contractor shall submit a written plan to correct the low SE test results to the Engineer for approval. The Contractor shall not continue paving operations until the Engineer approves the plan in writing and three SE test results from random samples in the stockpile are above 80 percent.
2. *Pavement Surface Texture.* The Contractor shall perform process control (PC) testing for the pavement surface texture depth per CP 77 Method B. All PC results for surface texture depth measurements shall be included in the Contractor’s QC notebook. The start of PC testing for texturing depth shall be completed within 24 hours after the first 500 linear feet of textured pavement is placed for each lane. Paving shall not proceed until results are accepted by the Engineer.

Surface texture will be considered acceptable when the average texture depth (ATD) of the panel is greater than 0.05 inch. When the ATD is less than 0.05 inches, the Contractor shall determine the area represented by this test. The area shall be determined by taking additional tests at 15-foot intervals parallel to the centerline in each direction from the affected location until two consecutive tests are found to be within the specified limits. Any surface with unacceptable texturing exceeding 25 linear feet in any lane or shoulder greater than 8 feet wide shall be diamond ground full width of the lane. Upon the second unacceptable test result, the Contractor shall notify the Engineer, in writing, of the action taken to provide an acceptable surface texture.

The Department will perform surface texture acceptance testing per CP 77 Method B. The Department will determine the panel locations where acceptance test measurements are to be taken. One stratified random acceptance test per 2,500 linear feet or fraction thereof in each lane and shoulder wider than 8 feet shall be taken with a minimum of one test per day when the Contractor is paving.

When the Department locates areas of surface texture that do not meet the minimum ATD, the Contractor will be notified and the Contractor shall identify the limits of the deficient texture depth. After the Engineer approves the limits, the Contractor shall correct the deficient surface texture by diamond grinding full lane width to provide an ATD greater than 0.05 inch at no additional cost to the project. The Contractor shall correct surface texture deficiencies before pavement smoothness testing and pavement thickness determinations.

**Delete Subsection 106.06 and replace with the following:**

**106.06 Sampling and Testing of Portland Cement Concrete Paving**. All Portland Cement Concrete Pavement, Item 412, shall be tested per the following process control and acceptance testing procedures:

1. *Process Control Testing*. The Contractor shall be responsible for process control testing of all elements listed in Table 106-3. Process control testing shall be performed at the expense of the Contractor. The Contractor shall develop a process control plan (PCP) per the following:
   1. Process Control Plan. For each element listed in Table 106-3, the PCP must provide adequate details to ensure that the Contractor will perform process control. The Contractor shall submit the PCP to the Engineer at the Pre- construction Conference. The Contractor shall not start any work on the project until the Engineer has approved the PCP in writing.
      1. Frequency of Tests or Measurements. The PCP shall indicate a random sampling frequency, which shall be equal to or more frequent than that shown in Table 106-3. The process control tests shall be independent of acceptance tests.
      2. Test Result Chart. Each process control test result, the appropriate area, volume, and the tolerance limits shall be plotted. The chart shall be posted daily at a location convenient for viewing by the Engineer.
      3. Quality Level Chart. The QL for each element in Table 106-3 shall be plotted. The QL shall be calculated per the procedure in CP 71 for Determining Quality Level. The QL shall 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 area of material represented by the last test result shall correspond to the QL.
   2. Point of Sampling. The material for process control testing shall be sampled by the Contractor using CP 61. The location where material samples will be taken shall be indicated in the PCP.
   3. Testing Standards. The PCP 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.

The compressive strength test for process control will be the average strength of two test cylinders cast in plastic molds from a single sample of concrete, cured under standard laboratory conditions, and tested three to seven days after molding.

* 1. Testing Supervisor Qualifications. The person in charge of and responsible for the process control testing shall be identified in the PCP. This person shall be present on the project and possess one or more of the following qualifications:
     1. Registration as a Professional Engineer in the State of Colorado.
     2. Registration as an Engineer in Training in the State of Colorado with two years of paving experience.
     3. A Bachelor of Science in Civil Engineering or Civil Engineering Technology with three years of paving experience.
     4. National Institute for Certification in Engineering (NICET) certification at level III or higher in the subfields of Transportation Engineering Technology, Highway Materials, or Construction Materials Testing Engineering Technology, Concrete and four years of paving experience.
  2. Technician Qualifications. Technicians performing tests shall meet the requirements of Colorado Procedure 10.
  3. 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., For projects with greater than 50,000 SY of PCCP or projects that do not have a certified lab within 40 miles of the project limits then the Contractor shall provide the following equipment and supplies, which will not be paid for separately but shall be included in the work:
     1. A separate, temperature-controlled facility of at least 300 square feet usable space. This facility shall be used exclusively for the molding, storage and testing of concrete test specimens as required. This facility shall be provided in addition to other facilities required in Section 620. The storage facility shall have sufficient water storage capacity for curing all required test specimens. The storage facility shall provide separate storage tanks for each type of required testing. Each storage tank shall have a continuously recording thermometer and sufficient blank charts for the project. Temperatures of each storage tank shall be recorded for the duration of the project.
     2. A machine for testing compressive strength of concrete specimens. The machine shall meet the requirements of ASTM C39 and shall have a minimum capacity of 250,000 lbs. The machine shall have a digital monitor capable of displaying load rate and total load. The following or an approved equal by the Region Materials Engineer may be used:
        1. Forney 250 series compression machine with digital monitor.
        2. Humboldt HCM-2500 series with an i7 Digital Indicator.
        3. Gilson MC-250 series with a Pro Controller.
        4. Test Mark Industries CM-2500 series with an i720 Digital Indicator.

Both the Contractor and the Engineer may use this machine for testing concrete specimens. After the machine has been certified and accepted by the Engineer it shall not be moved until all portland cement concrete paving and compressive strength acceptance tests have been completed.

* + 1. The Contractor shall supply an MIT Scan T2 or MIT Scan T3 and the associated test plates when pavement thickness acceptance is based on magnetic pulse induction (MPI).
  1. Reporting and Record Keeping. The Contractor shall report the results of the tests to the Engineer electronically at least once per day.

The Contractor shall assemble a process control (PC) 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 106-3. The Contractor shall submit examples of worksheets, test result forms and test results charts per CP 12B as part of the Contractor’s Process Control Plan (PCP). The Contractor shall submit the PC notebook electronically to the Engineer for review once a month on the date agreed to at the Pre-construction Conference.

A list of recognized deficiencies will be returned to the Contractor within two workdays after submittal. Deficiencies may include, but are not limited to, the failure to submit the notebook on time or an absence of the required reports. For any month that deficiencies are identified, the PC notebook will be submitted for review two weeks after the PC notebook is returned. Upon the second recognized deficiency the Engineer will notify the Contractor, and the pay estimate shall be withheld until the Contractor submits, in writing, a report detailing the cause for the recognized deficiency. The report shall include how the Contractor plans to resolve the deficiencies. Additional recognized deficiencies will result in a delay of the pay estimate until the Contractor has identified and resolved the deficiency along with revising and resubmitting his PCP to address these issues. Once the Engineer has reviewed and approved the revised PCP the estimate may be paid. Upon submittal of the PC notebook for the semi-final estimate, the PC 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 PC notebook, sampling, testing, plants, and the Contractor’s testing facilities at any time.

* 1. PC Stockpile Management. For Projects greater than 25,000 SY of PCCP,the contractor shall perform PC Testing for each aggregate source. All aggregates furnished for the project shall conform to the range of tolerances listed in Table 106-2 when compared to the approved mix design gradations. Individual gradation testing shall be at a minimum frequency of 1/day or 1/1,000 tons, whichever is greater, as aggregate is delivered to the batch plant and incorporated into the stockpile. If material does not meet the listed tolerances, the area of the stockpile represented by the sample may be remixed and retested. If material fails to meet the tolerances a second time, it shall be rejected. If multiple batch plants are being utilized, aggregates at each plant shall be tested separately. Testing and Tracking methods shall be included in the Contractor’s Process Control Plan.

**Table 106-2**

**Individual Aggregate Gradation Tolerances**

|  |  |
| --- | --- |
| Sieve Size | Tolerance (%) |
| ≥No. 4 | ±6 |
| No.8 – No. 30 | ±4 |
| No. 50 | ±3 |
| No. 100 | ±2 |
| No. 200 | ±1 |

* 1. Optimized Gradation. The Contractor shall perform PC testing of the combined aggregate gradation (CAG) when an Optimized Gradation (OG) is used for Class P Concrete. A sample of the combined aggregate from the first 100 cubic yards of concrete shall be tested; then one test per 750 cubic yards shall be performed. The frequency shall be a minimum of one per day if production is less than 750 cubic yards per day.

The Department will perform one gradation test each day that may be a split of one of the PC samples. This data will not be used to determine acceptability of the material but as information only.

The Contractor’s gradation test data will be used to evaluate the gradation optimization based on the mix design optimization.

When the Contractor’s gradation test results fail to meet their optimization range, the Contractor shall immediately make corrections to bring the aggregate gradation optimization into range and notify the Engineer. If two or more consecutive test results for any single day or two successive days are found to fall outside the optimization range, the Contractor shall immediately suspend production and provide a written corrective plan to the Engineer for approval before resuming production.

Upon being allowed to resume production, the Contractor shall follow the daily sampling frequency. If the next two consecutive gradation tests indicate that they meet the optimization range, the Contractor may continue production. If the first two aggregate samples do not meet the optimization range, production shall be suspended.

Before resuming production, the Contractor shall sample the individual aggregate stockpiles at two or more locations to determine the range of variability within each stockpile, make appropriate adjustments to the percentages for each aggregate component, and discharge and sample the combined aggregates. The combined aggregate gradation shall be tested to determine if the optimization range is met. Production can resume if the optimization range is met.. Production will continue to be suspended for additional evaluation of stockpiles and aggregate feed rates until gradation sampling and testing indicate the optimization range is met.

All gradation test information during production shall be provided to the Engineer daily. The Contractor shall immediately report all gradation test data to the Engineer for evaluation during periods when production is suspended or upon resuming production. The Contractor will be notified in writing in all cases when production may resume or shall remain suspended.

* 1. **Aggregate Moisture Content**. An aggregate moisture content sample from the first 100 cubic yards of concrete shall be tested; then one test per 750 cubic yards shall be performed. The frequency shall be a minimum of one per day if production is less than 750 cubic yards per day. The moisture content sample maybe the same sample used for gradation PC testing. Moisture content of each aggregate shall be tested per CP 33. As they become available, results shall be immediately input into the batching computer and reflected on batch tickets.

11. Concrete Test Reports. The Contractor shall distribute electronically to the concrete supplier all compressive- strength PC data for the concrete supplied to the project. The Contractor shall distribute the PC compressive strength data within two business days of the 7-day and 28-day compressive strength testing. The data shall include the compressive strength and batch ticket number at a minimum.

1. *Acceptance Testing.* Acceptance testing frequencies will follow the Schedule (Owner Acceptance) in the Department’s Field Materials Manual. Acceptance sampling and testing procedures will be per the Department’s Field Materials Manual with the following exceptions and inclusions:

A split sample from an acceptance test shall not be used for a process control test. The Engineer will designate the location where samples are to be taken. Samples shall be taken by the Contractor per CP 61. The Engineer will be present during the sampling and take possession of all acceptance samples. Samples transported in different containers will be combined and mixed before molding specimens. All materials are subject to inspection and testing at all times.

Pavement thickness acceptance will be determined by cores or magnetic pulse induction (MPI).

Acceptance tests for thickness using MPI shall be the Contractor’s process control tests. MPI testing shall be per AASHTO T359.

When compressive strength testing is specified, the Engineer will distribute electronically to the concrete supplier all compressive strength Owner Acceptance (OA) data for the concrete supplied to the project. The Engineer will distribute the OA compressive strength data within two business days of the 7-day and 28-day compressive strength testing. The data will include the compressive strength and batch ticket number at a minimum. The Contractor shall not have a valid dispute or claim as a result of any action or inaction by the Department related to the distribution of test results.

The compressive strength test for acceptance will be the average compressive strength of three test cylinders cast in plastic molds from a single sample of concrete and cured under standard laboratory conditions before testing. If the compressive strength of any one specimen differs from the average by more than 10 percent, that specimen will be deleted and the average strength will be determined using the remaining two specimens. If the compressive strength of more than one specimen differs from the average by more than 10 percent, the average strength will be determined using all three specimens. Each set of three cylinders will be tested at 28 days after molding.

1. *Check Testing.* The Contractor and the Engineer shall conduct a check testing program (CTP) before the placement of any concrete pavement. The check testing program will include a conference directed by the Region Materials Engineer, the Contractor’s testers, and the Department’s testers concerning methods, procedures and equipment for compressive strength testing. Check testing shall be completed before any portland cement concrete pavement (PCCP) is placed. A set of three cylinders will be molded by both the Contractor’s and the Department’s project testers from a split sample. The specimens will be sampled, molded and cured for seven days and tested for compressive strength according to the procedures of Section 106. The Department’s Independent Assurance Tester will also mold, cure and test a set of three cylinders, but the Independent Assurance Test results will not be entered in the check testing analysis. If the results of the check tests do not meet the following criteria, then the check testing will be repeated until the following criteria are met:
2. The average of the Contractor’s test results and the average of the Department’s test results shall be within 10 percent of the average of all test results.
3. Each specimen test result shall be within 15 percent of the average of all test results.

When compressive strength criteria is indicated, a check test must also be conducted on the sand equivalent test. A set of 5 sand equivalents will be run by both the Contractor’s and the Department’s project tester, from a split sample. The average of the absolute differences between tests taken by the process control personnel and the acceptance testing personnel will be compared to the acceptable limits shown in Table 13-1 of CP 13. The CTP will be continued until the acceptance and process control test results are within the permissible ranges shown in Table 13-1 of CP 13.

During production, split samples of randomly selected acceptance tests will be compared to the permissible ranges shown in Table 13-1 of CP 13. The minimum frequency will be as shown in Table 106-3.

If production has been suspended and then resumed, the Engineer may order a CTP between tests taken by process control and acceptance testing persons to assure the test results are within the permissible ranges 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 ranges shown in Table 13-1 of CP 13.

1. *Independent Assurance Testing*. The sample for the IAT will be a split sample of the Contractor’s process control test. The Department’s representative performing verification tests shall also use a split sample of the Contractor’s process control test and participate in the IAT.
2. *Testing Schedule.* All samples used to determine Incentive or Disincentive payment by quality level formulas per Section 105 will be selected by a stratified random process.



**Table 106-3**

**PC TESTING SCHEDULE - ITEM 412 PORTLAND CEMENT CONCRETEPAVEMENT**

|  |  |
| --- | --- |
| **Element** | **Minimum Testing Frequency**  **Contractor’s Process Control** |
| Aggregate Gradation each source or combined gradation | Minimum of 1/day, then 1 per 2500 cu. yds.  When an OG is used, follow 106.06(a) 9 |
| Slump and Air Content | First three loads each day, then as needed for control |
| Compressive Strength, Slump  Air Content, Yield, and Sand Equivalent | Minimum of 1/day, then 1/2500 sq. yds. |
| Pavement Thickness | Per subsection 412.21 |
| Pull Test Joints | Minimum of six transverse and six longitudinal joint locations for the first 2,500 linear feet, then three transverse and three  longitudinal joints thereafter |
| Load Transfer Dowel  Bar Placement | Per subsection 412.13(b)2 |
| Average Texture Depth | 1 per 528 linear feet in each lane and shoulder wider than 8 feet |
| Water Cement Ratio | First three loads each day, then 1/500 cu. yds. |
| Aggregate Moisture Content | Per subsection 106.06(a) 10 |

**In Subsection 412.24, delete** “All costs associated with developing correlation curves used to evaluate low flexural strength results per the Contract, or as requested by the Engineer, shall be included in the work. This shall include all materials, forms, testing, equipment and labor.”

**In Subsection 601.02 Class P, delete** “(1) The Required Field Flexural Strength shall be 650 psi.”

**Subsection 601.02 shall include the following:**

When an optimized gradation is used for any class of concrete, the Shilstone, Tarantula or Power-45 optimization method shall be used.