

July 1, 2024

**Revision of Section 105
Pavement Smoothness**

Notice

The Standard Special Provision (SSP) on the following page revises or modifies CDOT's *Standard Specifications for Road and Bridge Construction*. The Construction Engineering Services Branch has reviewed, approved, and issued it. Use as written without change. Do not use modified versions of it on CDOT construction projects. Do not use the following special provision on CDOT projects in a manner other than specified in the instructions without approval by CDOT's Standards and Specifications Unit. The instructions for use appear below.

Other agencies using the *Standard Specifications for Road and Bridge Construction* to administer construction projects may use this special provision appropriately and at their own risk.

Instructions for use on CDOT construction projects:

Use the following standard special provision on all projects placing asphalt or concrete pavement. The designer will contact the Regional Materials Engineer to specify the roadway pavement smoothness category in the General Notes. The instructions for determining the pavement smoothness category are in Design Bulletin dated July 1, 2024.

Not to be used on projects bid prior to July 1, 2024.

Note: This specification requires a Planned Project Expense item for incentive payment.

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Revise Section 105 of the Standard Specifications for this project as follows:

Delete subsection 105.07 and replace with the following:

105.07 Conformity to Roadway Smoothness Criteria. Roadway smoothness testing and corrective work shall be performed as described below. The pavement smoothness category shall be MRI Category A unless shown otherwise on the plans.

At least two weeks prior to the Pre-paving Conference the Contractor may request a change to the pavement smoothness category based on the [CDOT's Design Bulletin guidelines](#) for assigning pavement smoothness categories. The Contractor shall not assume a change will be granted and shall be prepared to build the pavement according to the assigned smoothness category. Once paving operations have been started, a change in pavement smoothness category will not be made.

(a) Smoothness Process Control Testing.

1. The Contractor shall perform Smoothness Process Control (SPC) testing. The test results shall be submitted to the Engineer within 48 hours of completion. SPC test results shall show the Mean Roughness Index (MRI) for each 0.10 mile.

All traffic control costs associated with SPC testing will be paid for in accordance with Section 630.

SPC testing shall be performed on the first 2,000 tons for the final layer of HMA or each day's paving within 24 hours after the concrete has achieved sufficient strength for PCCP. SPC testing on SMA will be tested after the sheen has been worn off. The Contractor may continue paving at his own risk. The Contractor shall not perform the SPC testing until after the concrete has attained a compressive strength of 1,000 psi if a lightweight profiler is used or 2,000 psi if a high speed profiler is used.

SPC testing shall be performed using the Contractor's inertial profiler, pursuant to the methods described in subsection 105.07(b). The Contractor's Inertial Profiler and Operator shall be certified according to CP 78. See CDOT's list of [certified profilers and operators](#).

Production shall be suspended if SPC testing indicates that corrective work is required in accordance with subsection 105.07(e). If the SPC data becomes available after production has started for the day, suspension will begin at the end of that production day for HMA. Production will remain suspended until the problem is identified and corrected. Each time production is suspended, corrective actions shall be proposed in writing by the Contractor. Production shall not resume until the proposed corrective actions have been accepted by the Engineer in writing.

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When production resumes, the Contractor shall profile the first 2,000 tons of HMA or each day's paving within 24 hours after the concrete has achieved sufficient strength for PCCP. The conditions described above for suspension of work will apply.

Corrective work may be performed by the Contractor prior to initial SA testing.

2. The finished transverse and longitudinal surface elevation of the pavement shall be measured using a 10-foot straightedge. Areas to be measured will be directed by the Engineer. The Contractor shall furnish an approved 10-foot straightedge, depth gauge, and operator to aid the Engineer in testing the pavement surface. Areas showing high spots of more than 3/16 inch in 10 feet shall be marked and diamond ground until the high spot does not exceed 3/16 inch in 10 feet.

(b) Initial Smoothness Acceptance Testing. The Contractor shall perform Smoothness Acceptance Testing (SA) which will be used for locating corrective work. If no corrective work is required, it will be considered the final SA testing and shall be used for acceptance and calculation of incentive adjustments.

The Contractor shall submit a Method for Handling Traffic (MHT) to the Engineer for approval at least five days in advance of SA testing. The MHT shall detail the methods for traffic control that will allow for continuous non-stop profiling of each lane to be profiled at a minimum speed of 15 mph and for the placement of triggers. The Contractor shall provide the traffic control in accordance with the approved MHT. SA testing shall not be performed without traffic control using the approved MHT.

The Contractor shall notify the Engineer in writing and the Department by e-mail at DOT_Profiles@state.co.us at least five working days in advance of his intention to perform SA testing. The Contractor shall profile the project within 14 days after the completion of paving operations. The Department will determine if Smoothness Verification Testing (SV) will be performed. If SV testing will be performed, it will be performed at the same time as the SA testing.

The Engineer will witness the SA profiling. Within 24 hours after each profile is collected, the Contractor shall submit the data electronically along with a SA data submittal form to the Department at DOT_Profiles@state.co.us, and to the Engineer.

All traffic control costs associated with SA testing will be paid for in accordance with Section 630.

Pavement surfaces shall be tested and accepted for longitudinal smoothness as described herein.

1. Testing Procedure (General). The longitudinal surface smoothness of the final pavement surface shall be tested by the Contractor in accordance with CP 74 and

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using the Contractor's inertial profiler (profiler). The Contractor's Profiler and Operator shall be certified according to CP 78. See CDOT's list of [certified profilers and operators](#).

The profiler's instrumentation shall be verified in accordance with CP 74 prior to measurements. The Contractor shall lay out a distance calibration site. The distance calibration site shall be located no more than 10 miles from the project limits. The distance calibration site shall be 1056.0 feet long and shall be on a relatively flat, straight section of pavement as approved by the Engineer. The site shall have a speed limit equal to the project's highest speed limit that allows for the profiler to operate uninterrupted. The limits of the site shall be clearly marked, and the distance shall be measured to an accuracy of +/- 1 inch. The Contractor shall provide in writing the site location to the Engineer. The cost of the distance calibration site will not be measured and paid for separately but shall be included in the work.

The entire length of each through lane, climbing lane and passing lane including bridge approaches, bridge decks and intersections from the beginning to the end of the project shall be profiled in their planned final configuration and direction. Shoulders with a width of 12 feet or greater, ramps, tapers, turn slots, acceleration lanes and deceleration lanes shall be profiled, but will not be subject to incentive adjustments. The profile of the entire length of a lane shall be taken at one time. However, a lane profile may be broken into sections to accommodate project phasing. At the Pre-paving Conference, the Contractor shall submit a plan for breaking the project profiling into phases for approval by the Engineer.

Shoulders less than 12 feet in width and medians will not be profiled and will not be subject to incentive adjustments. Shoulders less than 12 feet in width and medians constructed as part of the project shall be measured in accordance with subsection 105.07(a).

Pavement 25 feet outside of a traffic circle and traffic circles will not be profiled and will not be subject to incentive adjustments. Traffic circles shall be measured in accordance with subsection 105.07(a).

A sufficient distance shall be deleted from the profile to allow the profiler to obtain the testing speed, plus a 300 foot distance to stop and start when required. The distance deleted from a profile shall be minimized by reducing testing speed as necessary. Incentive adjustments will not be made for this area. The final surface of these areas shall be tested in accordance with subsection 105.07(a).

The profile shall include transverse joints when pavement is placed on both sides of the joint. When pavement is placed on only one side of the joint, the profile shall start and stop 25 feet outside project paving limits.

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The section of pavement 25 feet outside the paving limits to 5 feet inside the paving limits will be evaluated in accordance with subsection 105.07(a) and will not be subject to incentive adjustments.

The profile of the area 25 feet each side of every expansion joint, railroad crossing, cattle guard, bus pad, manhole, gutter pan and intersection (where there is a planned breakpoint in the profile grade line in the direction of traffic) shall be deleted from the profile before the MRI is determined. Incentive adjustments will not be made for these areas. Areas deleted from the profile shall be tested in accordance with subsection 105.07(a).

The profile of the area 25 feet each side of the bridge deck shall be deleted from the profile before the MRI is determined. Incentive adjustments will not be made for this area. When both pavement and a bridge or bridge pavement are being constructed on the project, areas deleted from the profile shall be tested in accordance with subsection 105.07(a). Corrective work required in these areas will not be measured and paid for separately but shall be included in the work. For all other projects, the profile of the area 25 feet each side of the bridge deck shall be deleted from the profile before the MRI is determined. If the Engineer determines that corrective work is required in this area, payment will be made in accordance with subsection 109.04.

2. Smoothness Testing Procedures. The Contractor shall mark the profiling limits and excluded areas. The Engineer will verify that the Contractor's marks are located properly. The Contractor shall use traffic cones with reflective tape or reflective tape on the pavement at the beginning and end of each lane for triggering the start and stop locations on the profiler and at any other location, where portions of the profile are being excluded. GPS triggering shall not be used. These locations shall be marked with temporary paint so that the final SA testing uses the same triggering locations.

The ambient temperature shall be at least 34 °F for the profiler to operate.

The Contractor shall clear the lanes to be tested of all debris before profiling.

Each lane shall be profiled at least once. Profiling shall be at a constant speed (+/- 5 mph of the distance calibration speed) with a minimum speed of 15 mph and a maximum speed of 70 mph. Shoulders with a width of 12 feet or more, ramps, tapers, turn slots, acceleration lanes and deceleration lanes shall be profiled once. The profile shall be taken in the planned direction of travel. The left and right wheel paths shall be profiled simultaneously. Triggers for the start of the profile, the end of the profile and the locations of each exclusion shall be collected during each run. The collected profiles shall be electronically submitted to the Department and Engineer to be analyzed using CP 74.

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The Department will determine an MRI for each 0.1-mile section or fraction thereof of completed pavement. Sections will terminate at the beginning of an exclusion and a new section starts at the end of exclusion. The MRI consists of the left and right wheel path's profile passed through the International Roughness Index (IRI) filter. The IRI for the left and right wheel paths are averaged to determine MRI.

The Contractor's SA test results will be available within ten working days of the completion of SA testing. The Engineer will give the Contractor a report that will include the lane profiled, the MRI in 0.10-mile increments and a summary of areas requiring corrective work. Areas requiring corrective work shall be addressed per 105.07(e) and the entire length of the lane(s) identified with corrective work shall be re-profiled and re-submitted as outlined in this section.

Areas requiring corrective work will be determined according to subsection 105.07(e).

Sections less than 0.005 miles in length shall not be subject to corrective work as specified by Table 105-10. Sections less than 0.005 miles in length shall be evaluated in accordance with subsection 105.07(a).

(c) *MRI Category D.* For MRI Category D pavements, the following shall be used for acceptance:

An MRI for each 0.1-mile section shall be determined on the original pavement surface prior to beginning the work in accordance with subsection 105.07(b) without exclusions.

An MRI for each 0.1-mile section shall be determined on the pavement surface after the work is complete in accordance with subsection 105.07(b) without exclusions.

The original and final profile lengths shall have a difference in the length of each lane less than 0.2 percent. When the profile length difference exceeds 0.2 percent, the final testing shall be repeated.

When a 0.1-mile section has a final MRI greater than 92.0 inches/mile and the final MRI is greater than the MRI prior to performing the work, that 0.1-mile section shall be corrected by a method approved in writing by the Engineer. Corrective work shall be such that the resulting final MRI is equal to or less than the initial MRI or 92.0 in/mile, whichever is greater. All costs associated with corrective work shall be at the Contractor's expense, including but not limited to traffic control, additional hot mix asphalt, grinding and milling.

When the Contractor fails to collect the profile of the original pavement surface prior to beginning the work, the final pavement surface will be evaluated for corrective work in accordance with the criteria for Category C pavement smoothness.

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Incentive adjustments for smoothness will not be made for MRI Category D.

Pavements evaluated for MRI Category D that will be overlaid with a surface seal shall be evaluated for pavement smoothness prior to application of the surface seal (e.g., chip seal).

(d) *Acceptance and Incentive Adjustments.* Acceptance and incentive adjustments for pavement smoothness will be made on a square yard basis in accordance with the following:

Incentive adjustments will be based on the MRI for each 0.1-mile section or fraction thereof. Incentive adjustments for Pavement Smoothness will be made in accordance with Table 105-12 or 105-13. No incentive payments will be made until all sections requiring corrective work have been completed.

Final acceptance and incentive adjustments for pavement smoothness will be made on a square yard basis based on the MRI for each 0.1-mile section or fraction thereof from the Contractor’s Final SA testing. Those sections requiring corrective work adjustments indicated by the initial SA testing will be re-evaluated.

**Table 105-12
HMA Pavement Smoothness (Inches/Mile)
Mean Roughness Index**

Pavement Smoothness Category	Maximum Incentive Payment (\$/sq.yd.)	Incentive Payment (\$/sq.yd.)	No Incentive	Corrective Work Required (0.10-mile sections)
A	MRI ≤ 40.0 I = \$1.28	MRI > 40 and < 55.0 I = 4.6933 - 0.0853*MRI	MRI ≥ 55.0 and ≤ 70.0	MRI > 70.0
B	MRI ≤ 45.0 I = \$1.28	MRI > 45.0 and < 60.0 I = 5.1200 - 0.0853*MRI	MRI ≥ 60.0 and ≤ 75.0	MRI > 75.0
C	MRI ≤ 50.0 I = \$1.28	MRI > 50.0 and < 65.0 I = 5.5467 - 0.0853*MRI	MRI ≥ 65.0 and ≤ 80.0	MRI > 80.0

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**Table 105-13
PCCP Smoothness (Inches/Mile)
Mean Roughness Index**

Pavement Smoothness Category	Maximum Incentive Payment (\$/sq.yd.)	Incentive Payment (\$/sq.yd.)	No Incentive	Corrective Work Required (0.10-mile sections)
A	MRI ≤ 40.0 I = \$2.80	MRI > 40 and < 55.0 I = 10.2670 - 0.1867 * MRI	MRI ≥ 55.0 and ≤ 70.0	MRI > 70.0
B	MRI ≤ 45.0 I = \$2.80	MRI > 45.0 and < 60.0 I = 11.2000 - 0.1867 * MRI	MRI ≥ 60.0 and ≤ 75.0	MRI > 75.0
C	MRI ≤ 50.0 I = \$2.80	MRI > 50.0 and < 65.0 I = 12.1330 - 0.1867 * MRI	MRI ≥ 65.0 and ≤ 80.0	MRI > 80.0

**Table 105-14
Corrective Work Criteria (Inches/Mile)
0.005 To 0.10 Mile Sections
Mean Roughness Index**

Pavement Smoothness Category	Corrective Work Required D = Section Length (miles)
A	MRI = 106.84 - 368.42 * D
B	MRI = 114.87 - 394.74 * D
C	MRI = 122.11 - 421.05 * D

(e) *Corrective Work.* The Department will analyze the initial and final SA testing for acceptance and indicate areas requiring corrective work in accordance with subsection 105.07(b). Corrective work shall be proposed in writing by the Contractor. Corrective work shall not be performed until approved in writing by the Engineer. The Contractor shall perform corrective work in the areas indicated by the SA testing.

The criteria for determining if a 0.1-mile section requires corrective work is specified in Table 105-12 or 105-13. The criteria for determining if a section less than 0.10-miles in

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length and greater than 0.005 miles in length requires corrective work is specified in Table 105-14.

Shoulders with a width of 12 feet or more, ramps, tapers, turn slots, acceleration lanes and deceleration lanes will be evaluated for MRI and shall require corrective work if a 0.10-mile section exceeds an MRI greater than 100.0 in/mile. Sections greater than 0.005 mile, but less than 0.1 miles shall not exceed $MRI = 152.63 - 526.32 * D$, where D is section length in miles.

Corrective work shall consist of diamond grinding, an approved overlay, or removal and replacement. Corrective work shall conform to one of the following conditions:

1. **HMA Removal and Replacement.** The pavement requiring corrective work shall be removed, full width of the lane and the full thickness of the layer in accordance with subsection 202.09.

The removal area shall begin and end with a transverse butt joint, which shall be constructed with a transverse saw cut perpendicular to centerline. Replacement material shall be placed in sufficient quantity, so the finished surface conforms to grade and smoothness requirements. Sections removed and replaced shall be at least 0.20 miles in length.

2. **HMA Overlay.** The overlay shall cover the full width of the pavement including shoulders and adjacent lanes. The area overlaid shall begin and end with a transverse butt joint, which shall be constructed with a transverse saw cut and asphalt removal. All material shall be approved hot bituminous mixtures that meet all contract requirements. The overlay shall be placed so that the finished surface conforms to grade and smoothness requirements. The overlay area shall be compacted to the specified density. The overlay thickness shall be equivalent to that of the final layer in accordance with the Contract. Sections overlaid shall be at least 0.20 miles in length.
3. **Diamond Grinding.** Grinding shall be performed using diamond blades mounted on a self-propelled machine designed for grinding and texturing pavement. The equipment shall weigh a minimum 17,000 pounds including the grinding head and be of a size that will grind a strip at least 3 feet wide in a single pass. The effective wheelbase of the machine shall be at least 12 feet. Grinding equipment that causes raveling, aggregate fractures or disturbance to the joints shall not be permitted. The equipment shall be maintained to ensure it is in proper working order, including the roundness of the match and depth of control wheels. Any wheels found to be out of round shall be immediately replaced. The Engineer may approve smaller equipment for areas that the above equipment cannot reach.

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Grinding equipment that causes raveling, aggregate fractures or disturbance to the joints shall not be permitted.

All grinding shall be parallel to the longitudinal joints. Adjacent passes shall be overlapped by a maximum of 2 inches.

The grinding process shall produce a pavement surface that is true to grade and uniform in appearance. The grooves shall be evenly spaced. Any ridges on the outside edge next to the shoulder, auxiliary, or ramp lanes greater than 3/16-inch high shall be feathered out to the satisfaction of the Engineer in a separate, feather pass operation. No adverse drainage conditions shall be caused by the grinding operations.

Grinding shall not reduce planned pavement thickness by more than 0.3 inches. Diamond grinding shall be the full width of a wheel path. The wheel path is from the stripe to the center of the lane.

The pavement surface after grinding shall have no depressions or misalignment of slope in the longitudinal direction exceeding 1/8 inch in 12 feet when measured with a 12-foot straightedge placed parallel to the centerline. All areas of deviation shall be reground at no additional cost.

The equipment shall have a positive means of vacuuming the grinding residue from the pavement surface, leaving the surface in a clean, near-dry condition. The slurry and residue resulting from the grinding operation shall not be allowed to flow across lanes occupied by the traffic and shall be continuously removed during the grinding operation, leaving the pavement in a clean condition. The Contractor shall haul the grinding residue to a suitable location at an approved location at no additional cost.

Cores shall be taken to verify that minimum pavement thicknesses have been maintained. A minimum of one core shall be taken every 100 cumulative feet or fraction thereof per lane of diamond grinding, as directed by the Engineer. Coring shall be at the Contractor's expense.

For HMA pavements, the entire ground area of the final pavement surface shall be covered with a Tack Coat conforming to Section 407 (CSS-1h at 0.1 gallons per square yard of diluted emulsion; the emulsion shall be diluted with water at the rate of 50 percent water and 50 percent emulsion) when grinding is complete after corrective work has been completed.

When any grinding on concrete pavement occurs where a core for determining pavement thickness has been previously taken, another core shall be taken after the grinding has been completed and shall replace the original core in the calculation of pavement thickness incentive and disincentive. Joint sealant that has been damaged

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by grinding on concrete pavement shall be repaired or replaced at the Contractor's expense in accordance with Standard Plan M-412-1 and subsection 412.18.

For PCCP, diamond ground surface texture will be considered acceptable when the average texture depth (ATD) of the panel is greater than 0.05 inch. The Contractor will perform surface texture testing in accordance with CP 77 Method B. Each area in a lane that required diamond grinding will be tested at least once. Areas in a lane with more than 500 continuous feet of grinding will be tested at a frequency of one test per 500 linear feet. Areas with deficient surface texture shall be diamond ground and retested.

- (f) *Final Smoothness Acceptance Testing.* After the Contractor has completed all required corrective work, the Contractor shall retest the pavement in accordance with subsection 105.07(b). Final SA testing shall only be required on lanes with sections requiring corrective work. Final SA testing shall start and stop at the same locations as the Initial SA testing. If additional corrective work is identified in the Final SA testing, the Contractor shall perform the corrective work and perform additional Final SA Testing. Time count will be charged pursuant to contract requirements during the time period required for all Final SA Testing. Delays associated with additional Final SA Testing will be considered non-excusable and non-compensable.

The Contractor shall notify the Engineer and the Department by e-mail at DOT_Profiles@state.co.us at least 5 working days in advance of his intention to perform final SA testing. The Department will determine if Smoothness Verification Testing (SV) will be performed. If SV testing will be performed, it will be performed at the same time as the SA testing.

The Initial SA and Final SA profile lengths shall have a difference in the length of each lane less than 0.2 percent. When the profile length difference exceeds 0.2 percent, the Final SA testing shall be repeated.

- (g) *Department Smoothness Verification Testing (SV).* The Department may elect to perform smoothness verification testing using the Department's inertial profiler, with the methods described in subsection 105.07(b). The Engineer will notify the Contractor of the Department's intention to perform SV testing. The Contractor shall coordinate with the Department and his profiler to schedule SA and SV to occur at the same time.

The Department will randomly select scheduled Contractor Smoothness Acceptance Testing to verify. A minimum of 25 percent of each scheduled Contractor Smoothness Acceptance Testing by an individual profiler will be verified. The Engineer may also request verification for any Smoothness Acceptance Testing.

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The Contractor's SA test results will be compared to the Department's SV test results. The Contractor's SA test results will be considered acceptable and will be used for incentive payment if the following criteria are met:

- (1) The difference in MRI for a 1/10-mile section is less than 6.1 inches/mile for a minimum of 90 percent of the 1/10-mile sections for each lane.
- (2) The difference in average MRI for each lane is less than 6.1 inches/mile.
- (3) The difference in the length of each lane is less than 0.2 percent.

When the Contractor's SA test results are not considered acceptable, the Department's SV test results will be used for incentive payment and the Contractor's profiler certification will be suspended and evaluated pursuant to CP 78. The Contractor shall schedule with the Department within 10 working days to perform this evaluation or the profiler will be required to be re-certified in accordance with CP 78.