Section 2316. Pavement Smoothness

2316.01 DESCRIPTION.

A. Apply this specification when Section 2317 does not apply.

B. Test and evaluate pavement smoothness. Perform surface correction if required.

2316.02 TESTING AND EVALUATION.

A. General.

1. Evaluate pavement smoothness for all Interstate and Primary main line pavement surfaces, and all other road surfaces included on Primary projects, except when specifically excluded or modified by the contract documents. Main line pavement is defined as all permanent pavement for traffic lanes, including:
- Tapers to parallel lanes or through lanes at intersections,
- Tapers to climbing lanes, and
- Tapers to ramps and loops.

2. Evaluate pavement smoothness for all interchange ramps and loops.

3. For non-Primary projects, do not evaluate pavement smoothness unless specified in the contract documents.

4. If this specification is required by contract documents on non-Primary projects let by the Department, it will be added in its entirety. Selected portions of the specification will not be deleted.

5. Bridge approach sections which are a part of the paving contract will be tested according to Section 2428.

6. Smoothness Requirements:
a. Apply Table 2316.02-1 to all projects when specified. Smoothness requirements in inches per mile (millimeters per kilometer) are listed in Schedules A and B.
b. For through traffic which requires matching the surface of the new pavement to the surface of an existing old pavement, an Average Base Index (ABI) will be calculated as shown in Table 2316.02-1 on lanes wider than 8.5 feet (2.6 m). This will be the smoothness base in inches per mile (millimeters per kilometer) for payment for the new pavement unless specified otherwise. The requirements are shown in Schedule C.

Table 2316.02-1: Schedule for Identification of Pavements

Pavement	Schedule by Posted Speed (mph) (Existing or Proposed)	
	45 or less	over 45
Mainline, curbed (one or both sides of roadway	B	A
Mainline, not curbed	A	A
Ramps and Collector Distributor Roads	A[(c)]	A[(c)]
Loops	B	B
Side Roads	B	A
Grade Separations[(a)]	B	A
Pavement adjacent to existing pavement (added lane)	C[(b)]	C[(b)]
(a) Including municipal or Secondary Roads therein.		

(b) $ABI = \frac{PI + X}{2}$

where:
PI = the profile index of the edge line of the abutting lane. If the computed ABI is less than X, use an ABI equal to X

X = 7 inches/mile (110 mm/km) if Schedule A, or 22 inches/mile (345 mm/km) if Schedule B.

(c) When a ramp or collector distributor road terminates at an intersection with a traffic signal or stop sign, the 700 feet (215 m) nearest the intersection will be evaluated under Schedule B.

7. Exclusions:
- **a.** Areas excluded from smoothness testing are detour pavement, crossovers, shoulders, and sections less than 50 feet (15 m) long.
- **b.** The Engineer will check all excluded areas with a surface checker. Excluded areas are not to exceed 1/8 inch in 10 feet (3 mm in 3 m).

B. Measurement.

1. General.
- **a.** Provide and operate an Ames or California type profilograph to produce a profilogram (profile trace) of the surface tested, according to Materials I.M. 341. Other types of profilographs or profilers that produce compatible results and meet the requirements of Materials I.M. 341 may be used.
- **b.** When a pavement for which smoothness is to be tested is adjacent to an existing old pavement, smoothness must also be tested on the old pavement 3 feet (1 m) from the adjacent edge for ABI calculation. Should the surface of the old pavement be specified for correction, perform smoothness testing for ABI calculation after correction.
- **c.** Remove all objects and foreign material on the pavement surface, including protective covers if used, prior to testing. If appropriate, properly replace protective covers after testing.
- **d.** Produce a profilogram for each segment of 50 feet (15 m) or more. Include the 16 feet (5 m) beyond the ends of the section in the profilogram.

2. Pavements.
- **a.** The pavement surface will be divided into sections that represent continuous placement.
- **b.** A section will terminate at a day's work joint (header), a bridge, similar interruption, or when continuous placement crosses to a section with a different smoothness designation.
- **c.** Sections longer than 778 feet or 0.147 miles (240 m) placed without interruption will be separated into segments of 0.1 mile (160 m). The terminating segment may be shorter than 0.1 mile (160 m) and greater than 250 feet (80 m) and still be considered a segment. A segment is to be in only one traffic lane. Each traffic lane will be tested and evaluated separately. Gaps for temporary crossings or similar construction sequencing which are placed in otherwise continuous sections will be tested, when placed, and included in the adjacent section evaluation.

3. Bridge Approach Sections.
Bridge approach sections will not be considered a part of a pavement segment, section, or project.

C. Profilograph Testing.
Perform testing and provide the Engineer with the profilogram results. Ensure testing and evaluation are done by a trained and certified person. Ensure the evaluation is certified according to Materials I.M. 341.

1. Test each segment within 48 hours following placement. Provide the Engineer the index for each segment of paving by the end of the next day worked following the placement until there has been 3 consecutive days of paving where the index for all segments would result in 100% payment or better.

2. Should any following day be evaluated to receive less than 100% payment, immediately notify the Engineer, and take corrective action to modify paving methods and equipment to achieve 100% payment or better.

3. Submit all final profilograph test reports and profile traces to the Engineer within 14 calendar days following completion of paving on the project. Selected reports and traces may be requested by the Engineer in advance of paving completion for purposes of validating the Contractor's test results. Incentive payments for qualifying segments will be made following receipt of appropriate documentation of certified smoothness results.

4. The Engineer will perform verification testing to validate the contractor's certified quality control testing. If the Engineer's verification test results validate the Contractor's test results, the Contractor's results will be used for acceptance. Disputes between the Contractor's and Engineer's test results will be resolved according to Materials I.M. 341. The Engineer may test the entire project length if it is determined that the Contractor certified test results are inaccurate, and the Contractor will be charged for this work at a rate of $400.00 per mile ($250.00 per kilometer), per profile track, with a minimum charge of $800.00. Furnishing inaccurate tests may result in decertification of the Contractor's certified operator.

D. Profile Index.

1. Calculate a profile index for each segment from the profilogram, according to Materials I.M. 341, except for:
   - **a.** Side road connections less than 600 feet (180 m) in length.
   - **b.** Single lift pavement overlays 2 inches (50 mm) or less in thickness unless the existing surface has been corrected by milling or scarification.
   - **c.** Storage lanes and turn lanes.
   - **d.** Pavement less than 8.5 feet (2.6 m) in width.
   - **e.** The 16 feet (5 m) at the ends of the section when the Contractor is not responsible for the adjoining surface.
   - **f.** Runout tapers on HMA overlays at existing pavement, bridges, or bridge approach sections when the thickness is less than the design thickness.

2. If there is a segment 250 feet or 0.047 mile (80 m) long or less at the end of a section, include the profilograph measurements for that segment in the evaluation of the adjacent segment in that section.

3. Identify bumps and dips separately on all profilograms. These appear as high or low points on the profilogram and correspond to high points (bumps) or low points (dips) on the pavement surface. They are identified by locating vertical deviations exceeding 0.5 inches for a 25 foot (12.7 mm for a 7.6 m) span for both bumps and dips as indicated on the profilogram.

2316.03 SURFACE CORRECTION.

A. General.

1. Surface correction for pavement smoothness may be required, which includes bumps or dips. Complete the correction before the determination of pavement thickness.

2. Perform bump, dip, and smoothness correction work for the full lane width of the paved surface.

3. Obtain the Engineer's approval for all correction work. After all required correction work is completed, determine the final profile index.

B. Pavements.

1. **Portland Cement Concrete Pavement.**
   - **a.** Accomplish PCC pavement surface correction by grinding the pavement with a diamond grinder, by PCC resurfacing, or by replacement.
   - **b.** Use grinding and texturing equipment that meets the requirements of Section 2532. Use a cutting head that is a minimum of 24 inches (600 mm) wide.

c. Perform surface correction parallel to lane lines or edge lines as directed by the Engineer. Make each pass parallel to the previous passes. Ensure the ground surface is of a uniform texture.

d. Do not allow adjacent passes to overlap more than 1 inch (25 mm) or have a vertical difference of more than 1/8 inch (3 mm) as measured from bottom of groove to bottom of groove.

e. Begin and end smoothness correction at lines normal to the pavement lane lines or edge lines within any one corrected area. Proceed from the center line or lane line toward the pavement edge to maintain pavement cross slope.

2. Hot Mix Asphalt Pavements.

a. Accomplish asphalt pavement surface correction by:

- Diamond grinding,
- Overlaying the area,
- Replacing the area, or
- Inlaying the area.

b. For diamond grinding, perform the same work and use the same equipment specified for PCC pavement. Cover the surface that has been ground with a seal coat according to Section 2307 with the following modifications:

- The binder bitumen may be the same material used for tack coat, applied at a rate of 0.10 gallon per square yard (0.45 L/m^2). Hand methods may be used for spraying.
- Apply a cover aggregate consisting of sand at a rate of 10 pounds per square yard (5 kg/m^2). Hand methods may be used for spreading. Apply the sand slightly damp, but with no free moisture, as determined by visual inspection. Embed with at least one complete pneumatic roller coverage.
- This seal coat is intended to be placed immediately after the diamond grinding is completed in the travel lane. Complete this work when the road surface temperature is above 60ºF (16ºC).
- Labor, equipment, and materials used for this seal coat will not be paid for separately, but are incidental to the items for which correction is required.

c. If the surface is corrected by overlay, replacement, or inlay, begin and end the surface correction with a transverse saw cut normal to the pavement lane lines or edge lines within any one area. Ensure the profile of the surface is smooth with no bumps or dips at the beginning or end of correction. Overlay correction must be for the entire pavement width. Maintain pavement cross slope through the corrected areas.

C. Bumps and Dips.

Evaluate bumps and dips, including those at headers, on all pavements for which pavement smoothness is designated. Correction work will be required according to the criteria in Paragraphs 1, 2, and 3 below. For areas excluded from profilograph testing, correct deviations exceeding 1/8 inch in 10 feet (3 mm in 3 m).

1. Bumps.

a. For all pavements evaluated, if the Engineer does not assess a price adjustment, correct all bumps exceeding 0.5 inch (12.7 mm) within a 25 foot (7.6 m) span, as indicated on the profilogram, except as stated in Article 2316.03, C, 3.

b. Corrected bumps will be considered satisfactory when measurement by the profilograph shows that the bumps are 0.3 inch (8 mm) or less in a 25 foot (7.6 m) span.

c. When a through traffic lane over 8.5 feet (2.6 m) wide is constructed adjacent to an existing old pavement, bump correction or price adjustment to the Contractor for a bump will not apply if a bump exists at that location in the adjacent existing old pavement.

2. Dips.

a. On all pavements, if the Engineer does not asses a price adjustment, correct dips of 0.5 inch to 1.0 inch (12.7 mm to 25 mm) in a 25 foot (7.6 m) span, as indicated on the profilogram, except as stated in Article 2316.03, C, 3. Replace the pavement in areas with dips over 1.0 inch (25 mm). Corrected dips will be considered satisfactory when the profilogram shows the dips are less than 0.3 inch (8 mm) in a 25 foot (7.6 m) span.

b. When a lane over 8.5 feet (2.6 m) wide is constructed adjacent to an existing old pavement, correction of a dip or price adjustment to the Contractor for a dip will not be required if a dip exists at that location in the adjacent existing old pavement.

3. **Exceptions.**
When the Contractor is not responsible for the adjoining pavement, the Engineer will evaluate bumps and dips exceeding 0.5 inches (12.7 mm) located within 16 feet (5 m) either side of the end of a section. The Contractor will not be price adjusted for bumps and dips in this area. When the Engineer instructs to repair these bumps and dips, the Contractor will be paid according to Article 1109.03, B.

2316.04 SMOOTHNESS.

Pavement smoothness will be compensated by adding to (incentive) or subtracting from (price reduction) the price bid for pavement a determined amount for each segment. These amounts are identified in the appropriate schedule of Article 2316.05.

A. Pavement Where Schedule A Smoothness is Required.

1. For the appropriate categories of highway, as shown in Schedule A, incentives for pavement smoothness will be paid for each segment of pavement with an initial index per mile (kilometer) per segment of 3.0 inches (48 mm) or less.
2. For segments with an initial index of 7.1 to 10.0 inches per mile (111 mm/km to 160 mm/km), the Contractor will be assessed a price reduction.
3. For segments with an index of 10.1 inches per mile (161 mm/km) and greater, grind the surface to a final index of 7.0 inches per mile (110 mm/km) or less.

B. Pavement Where Schedule B Smoothness is Required.

1. For all highways, incentives for pavement smoothness will be paid for each segment of pavement with an initial index of 12 inches per mile (190 mm/km) per segment or less.
2. For all segments with an initial index of 22.1 to 30.0 inches per mile (346 mm/km to 475 mm/km), the Contractor will be assessed a price reduction.
3. For segments with an index of 30.1 inches per mile (476 mm/km) and greater, grind the surface to a final index of 22.0 inches per mile (345 mm/km) or less.

C. Pavement Adjacent to Existing Pavement.

1. Smoothness will be evaluated by the Average Base Index (ABI) as defined in Article 2316.02, A, 6 or 7, for each segment of new pavement 8.5 feet (2.6 m) wide or more, and over 600 feet (180 m) in length, which is to be matched to the surface of an existing pavement.
2. Surface correction is required for smoothness exceeding ABI + 12 (190) when Schedule A is required and exceeding ABI + 30 (470) when Schedule B is required. Payment will be based on results after correction according to Schedule C.
3. Longitudinally check areas not included in the profilograph test with a 10 foot (3 m) straight edge. Ensure the surface does not deviate from a straight line by more than 1/8 inch in 10 feet (3 mm in 3 m). Meet requirements of Article 2316.03 for all corrections needed.

D. Bridge Approach Sections.
Smoothness of bridge approach sections will not be used in the calculations for incentive or price reduction of pavement segments, sections, or the project.

2316.05 SCHEDULE OF PAYMENT.

A. For each traffic lane of main line pavement and each traffic lane of interchange ramps and loops evaluated for smoothness, as defined in Article 2316.02, A, the Engineer will determine the length of each segment in miles (kilometers).

B. For roadways, the Contractor may receive an incentive payment or be assessed a price reduction based on the number of qualifying segments and the initial profile index.

C. Pavement segments excluding repair work that are subject to profilograph testing, as defined in Article 2316.02, D, will be considered for additional payment as a smoothness incentive or price reduction. For a segment to be qualified for incentive, there must be no grinding within that segment.

D. Surface correction (grinding) of bridge approach sections, and as stated in Article 2316.03, C, 3, will not count as surface correction on adjacent pavement segments and will not detract from possible incentive payments on those segments.

E. Single lift pavement resurfacing 2 inches (50 mm) thick or more that has milling or scarification of the original pavement will be rated using the multi-lift schedules.

F. A $900 price adjustment will be assessed for each dip not corrected in each pavement lane under Schedule A and B, except as stated in Article 2316.03, C, 3. In addition, a $900 price adjustment will be assessed for each bump not corrected under Schedule A and B, except as stated in Article 2316.03, C, 3. Bumps and dips not corrected will also be included in the evaluation for the segment smoothness.

G. The cost of certified smoothness and associated traffic control is incidental to the cost of the pavement.

H. These payments or assessments will be based on the following schedules:

1. **Schedule A Smoothness Requirements.**
   Pavement segments which are designated for Schedule A smoothness will be evaluated for incentive or price reduction assessments as follows:

Table 2316.05-1: Incentives for Pavement Smoothness

Initial Profile Index	Single Lift Pavements		Multi-Lift Pavements	
Inches Per Mile (mm / km) Per Segment [(a)]	Primary	Non-Primary	Primary	Non-Primary
	Dollars Per Segment	Dollars Per Segment	Dollars Per Segment	Dollars Per Segment
0-1.0 (0-16) 1.1-2.0 (17-32) 2.1-3.0 (33-48) 3.1-7.0 (49-110)	700 600 450 Unit Price	300 250 200 Unit Price	250 200 150 Unit Price	125 100 50 Unit Price
[(a)] For each segment of pavement that has an initial index, within the limits listed, with no grinding, the Contractor will receive an incentive payment as shown in the tabulation for the appropriate category.				

Table 2316.05-2: Price Reduction for Pavement Smoothness

Initial Profile Index	Single Lift Pavements		Multi-Lift Pavements	
Inches Per Mile (mm / km) Per Segment [(a)]	Primary	Non-Primary	Primary	Non-Primary
	Dollars Per Segment	Dollars Per Segment	Dollars Per Segment	Dollars Per Segment
3.1-7.0 (48-110) 7.1-10.0 (111-160) 10.1 & Over[(a)] (161 & Over)[(a)]	Unit Price 200 Grind Only	Unit Price 100 Grind Only	Unit Price 100 Grind Only	Unit Price 50 Grind Only
[(a)] For segments with an initial index of 10.1 (161) and over, grind the surface to a final index of 7.0 (110) or better. In lieu of grinding the surface to a final index of 7.0 (110) or better, the Contractor may elect to replace part or all of the segment.				

2. **Schedule B Smoothness Requirements.**
   a. Pavement segments designated for Schedule B smoothness and indexed in segments greater than 50 feet (15 m) will be evaluated for incentive or price reduction as shown in Tables 2316.05-3 and 2316.05-4.
   b. No price reduction assessment will be made for individual segments shorter than 50 feet (15 m) properly corrected if required.

Table 2316.05-3: Incentives for Pavement Smoothness

Initial Profile Index	New Pavements	Resurfaced Pavements
Inches Per Mile (mm / km) Per Segment [(a)]	Dollars Per Segment	Dollars Per Segment
0-4.0 (0-65) 4.1-8.0 (66-130) 8.1-12.0 (131-190) 12.1-22 (191-345)	600 500 400 Unit Price	300 250 200 Unit Price
(a) For each segment of pavement that has an initial index, within the limits listed, with no grinding, the Contractor will receive an incentive payment as shown in the tabulation for the appropriate category.		

Table 2316.05-4: Price Reduction for Pavement Smoothness

Initial Profile Index	New Pavements	Resurfaced Pavements
Inches Per Mile (mm / km) Per Segment [(a)]	Dollars Per Segment	Dollars Per Segment
12.1-22.0 (191-345) 22.1-30.0 (346-475) 30.1 & Over (476 & Over) [(a)]	Unit Price Grind Grind Only	Unit Price Grind Grind Only
(a) For segments with an initial index of 30.1 (476) and over, grind the surface to a finish index of 22.0 (345) or better. In lieu of accepting a price reduction and grinding the surface to a final index of 22.0 (345) or better the Contractor may elect to replace part or all of the segment.		

3. **Schedule C Smoothness Requirements (Pavement Adjacent to Existing Pavement).**
   For new pavement which has been matched to an existing old pavement for which an Average Base Index (ABI) was calculated, the pavement will be evaluated for a price reduction for each segment based on Schedule A or Schedule B payment.

Table 2316.05-5: Initial Profile Index or Profile Index after Correction

Schedule A Inches Per Mile (mm / km) Per Segment	Schedule B Inches Per Mile (mm / km) Per Segment	Dollars Per Segment
0 to ABI ABI + 0.1 (1) to ABI +4 (65) incl. ABI + 4.1 (66) to ABI +8.0 (130) incl. ABI + 8.1 (131) to ABI +12 (190) incl. Greater than AGI + 12 (190)	0 to ABI ABI + 0.1 (0.1) to ABI + 10 (160) incl. ABI + 10.1 (161) to ABI + 20 (315) incl. ABI + 20.1 (316) to ABI + 30 (475) incl. Greater than ABI + 30 (470)	0 300 500 800 Grind Only

4. **Bridge Approach Sections.**
   Correct bridge approach sections for smoothness as specified in Section 2428.