KANSAS STATE UNIVERSITY | Salina

Profilograph Workbook

Certified Inspector Training Program

AD ASTRA PER ASPERA

Kansas Department of Transportation

Profilograph Operator Workbook

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GENERAL INFORMATION

INTRODUCTION

Smoothness is a measure of the level of comfort experienced by the traveling public while riding over a pavement surface. As an important indicator of pavement performance, smoothness is used interchangeably with roughness as an expression of the deviation of a surface from a true planar surface and is often cited as the most important indicator of user satisfaction. However, smoothness also imparts a number of other benefits, including improved pavement performance and service life, improved safety, and reduced fuel and vehicle maintenance cost. In recognition of the importance of pavement smoothness, many highway agencies employ specifications to control initial pavement smoothness during construction and then monitor it over time as an indicator of performance and as a trigger for maintenance or rehabilitation.

EQUIPMENT FOR MEASURING PAVEMENT SMOOTHNESS

A number of different devices have been used over the years for measuring pavement smoothness, from simple straightedges that indicate localized deviations in the surface to inertial profilers equipped with laser sensors that record actual elevation measurements along the pavement.

For monitoring of initial smoothness on new pavement construction, the profilograph has a long history of service, but the use of lightweight inertial profilers has become increasingly common in the last two decades. The latter is particularly attractive because it is compatible with the high-speed profiling devices that highway agencies use to monitor pavement smoothness at the network-level, thereby promoting the use of a single technology for measuring smoothness of a pavement structure from cradle to grave.

PROFILOGRAPHS

Profilographs were widely implemented by State Highway Agencies in the 1980s/1990s exclusively for measuring and controlling initial pavement smoothness. Profilographs are low-speed profile measurement systems (2 to 5 mi/hr [3 to 8 km/hr]) that consist of a rigid frame, a center profiling wheel, and a system of support wheels to provide a datum. Originally, profilographs mechanically recorded data on a strip chart recorder that was linked to the profile wheel, but today most profilographs are computerized and record data electronically.

DEFINITIONS

PROFILOGRAPH TESTING accurately measures surface roughness through a computerized or manual recorder capable of graphing a pavement profile both vertically and horizontally. The

information it collects is used to calculate the International Roughness Index (IRI), which is expressed in units of inches/mile or millimeters/meters.

There are several **methods** currently available **to measure** the **roughness** of a **surface**, these include contact stylus tracing, laser reflectivity, non-contact laser stylus metrology.

Road Roughness is a condition parameter used to measure deviations from the intended longitudinal profile of a **road** surface, with characteristic dimensions that affect vehicle dynamics, ride quality and dynamic pavement loading.

CALIFORINA TYPE PROFILOGRAPH

A. Personnel, Transportation and Assembly:
    1. Normally, two people are required to assemble and operate the 25 ft profilograph. For the high speed profilograph general only one person is needed to operate. Additional people may be necessary to provide signing and flagging protection.
    2. The 25 feet profilograph consists of a lightweight aluminum truss which easily separates into three or more sections by the use of quick-acting clamps. These sections will fit into a pickup truck and require about 15 minutes assembly time. The sections are match marked to assure correct assembly. The recorder is mounted on the profilograph and is connected to the distance measuring wheel through a drive chain and gearbox assembly for longitudinal movement, and a control cable for vertical movement.
    3. The recorder box should always be transported inside the vehicle cab to protect it from the weather and kept covered to protect it from dust when not in use.
    4. Blanking bands will warp from heat and scratch easily. Either leave them in the office or cover with cloth and keep out of sunlight when transporting.
B. Traffic Control
    1. If testing is performed under traffic, follow standard KDOT Traffic Control requirements.
    2. Remember that these are minimal traffic control layouts and that additional signing or more elaborate traffic control such as a complete lane closure may be needed.
    3. Safety first! No test result is worth an accident, personal injury or fatality.
C. Maintenance
    1. The truss is aluminum and will not rust but should be stored inside during the winter.
    2. The quick-acting clamps are steel and may require a light application of oil for smooth operation. The averaging wheels should be lubricated at least once per year. Do not over lubricate as this will create a mess and collect dirt. Follow the manufactures recommendations. (This is true for all types of profilographs.)
    3. Clean and repaint steel parts and clean and wax aluminum and chrome parts each winter.

4. Check distance measuring tire pressure before each trace to ensure that it is identical to the pressure established during calibration.
5. Do not force the steering wheel since the gears can be stripped or the cable broken. The steering box or linkage may become still in cold weather and this is generally when damage occurs.
6. Do not hit curb, drive over drop-off, ect., that could damage the machine while maneuvering. (This is true of all profilograph machines.)
7. Do not tow or push the 25 ft profilograph with a vehicle since the small averaging wheels at both ends of the machine can be damaged.
8. The Research Unit of the KDOT Bureau of Research should be contacted if repair is needed on KDOT owned profilographs.
9. All profilographs must be recertified if any repairs are made to the unit or the vehicle that they are certified in, or the unit is moved to another vehicle.
10. The contractor's profilograph must be calibrated and certified each year by the Research Unit of the KDOT Bureau of Research.

SPECS

SECTION 503

PORTLAND CEMENT CONCRETE PAVEMENT SMOOTHNESS

503.1 DESCRIPTION

Determine the smoothness of the pavement surface. Correct the smoothness deficiencies discovered in the pavement surface.

BID ITEM	UNITS
Concrete Pavement Smoothness	Lump Sum

503.2 MATERIALS - None specified.

503.3 CONSTRUCTION REQUIREMENTS

a. General. Determine the pavement smoothness by profiling the pavement surface of through traffic lanes and ramps. Excluded from profilograph testing, and not eligible for pay adjustments, on all projects are:

- bridge decks;
- acceleration and deceleration lanes of at-grade intersections;
- turning lanes;
- shoulders;
- pavement on horizontal curves with centerline radius of curvature of less than 1000 feet, and pavement within the superelevation transition of such curves;
- individual sections of pavement less than 50 feet in length;
- sideroads less than 250 feet in length; and
- the first (or last) 15 feet of a pavement section where the Contractor is not responsible for the adjoining surface
- county secondary projects

b. Equipment. Use a California type profilograph, prequalified by the Bureau of Construction and Materials, to determine the pavement profile. If approved by the Bureau of Construction and Materials, other types of profilographs that produce results compatible to the California type profilograph may be used. If the profilograph has a mechanical recorder, provide a ProScan electronic scanner with motorized paper transport to reduce the trace. Use the motorized paper transport when scanning the profilograph traces. The Bureau of Construction and Materials can provide the information necessary for the Contractor to obtain a ProScan electronic scanner. If approved by the Bureau of Construction and Materials, other types of automated trace reduction equipment may be used. If the profilograph has a computerized recorder, the trace produced is evaluated without further reduction.

Provide a self-propelled grinding machine specifically designed to grind and texture portland cement concrete pavement using diamond blades mounted on a multi-blade arbor. The arbor must contain enough blades to provide at least a 36-inch wide cutting head and provide 55 to 60 evenly spaced grooves per foot.

Do not use equipment that causes excessive ravels, aggregate fractures or spalls. Use equipment that provides a flat plane surface without crown and a uniform texture for the full width of the lane. Grind a nominal depth of 3/16 inch.

When grinding is performed, use vacuum equipment or other continuous methods to remove grinding slurry and residue. Remove from the project and properly dispose of the material. Do not allow the grinding slurry to flow across lanes being used by traffic, onto shoulder slopes, into streams, lakes, ponds or other bodies of water, or gutters or other drainage facilities. Do not place grinding slurry on foreslopes.

Bush hammers or other impact devices will not be permitted.

c. Profilograph Operation. Provide an operator for the profilograph certified according to KT-46, Part V.

Determine the pavement profiles for each lane according to the procedures for 1 lane shown in Kansas Test Method KT-46. Additional profiles may be taken only to define the limits of an out-of-tolerance surface variation. The

Engineer may use a 10-foot straightedge (or other means) to detect irregularities outside the required trace paths. The Engineer may also use the straightedge to delineate the areas that require corrective action.

Determine a profile index (in./mi.) for each pavement section of finished pavement. A pavement section is a continuous area of pavement surface 0.1 mile long by 1 lane wide (12 feet nominal). A partial pavement section resulting from an interruption (such as a bridge) of the continuous pavement surface is subject to the same testing and evaluation as a whole section.

During the initial paving operations (and after long shutdown periods), profile the pavement as soon as the concrete has cured sufficiently to permit testing. The Engineer and the Contractor will use the results of the initial testing to evaluate the paving methods and equipment. If the initial paving operation produces acceptable results, the Contractor may continue paving. Repair or replace any PCCP curing medium that is damaged or removed during the testing.

On surfaces excluded from profilograph testing, the Engineer will determine the pavement smoothness using a 10-foot straightedge. The Engineer will select the locations to be tested. The variation of the surface from the testing edge of the straightedge shall not exceed ⅛ inch between any 2 contacts, longitudinal or transverse.

Correct all irregularities exceeding the specified tolerance using equipment and methods approved by the Engineer. After the irregularities are corrected, the Engineer will retest the area to verify compliance with the specified tolerance.

d. Profilograph Evaluation and Corrective Actions. Evaluate the profilograph results according to KT-46. Provide the Engineer with the profilograms and their evaluation within 2 working days after placement of the pavement.

Determine and evaluate the profile index (in./mi.) for each trace and the average profile index (in./mi.) for each section to identify required corrective action.

Determine the daily average profile index (in./mi.) for each day's paving operation. A day's paving operation is the pavement placed in a day (a minimum of 1 pavement section).

- If less than 1 pavement section is placed in a day, the day's production is grouped with the next day's production.
- If the production of the last day of project paving is less than 1 pavement section, it is grouped with the previous day's production.
- The Contractor has the option of profiling the final portion of a day's production (not to exceed 5 sections) the first working day that paving is continued in the same lane. If the Contractor opts to profilograph the final portion of a day's paving the next working day that paving is continued in the same lane, those results (the final portion of the previous day's paving) are grouped with the day's paving as the lane is continued.

Make the required corrections for pavement smoothness before making the pavement thickness determinations. Take the required corrective actions according to **TABLE 503-1**.

TABLE 503-1: PCCP SURFACE CORRECTIONS		
Pavement Surface Tolerances (in./mi.)		Required Corrective Action
Through Lanes Speed Limit Greater than 45 mph	Acceleration Lanes[1] Deceleration Lanes[1] Ramps[1] Through Lanes Speed Limit 45 mph or Less	
Profile Index per Section of 30 or less for an individual trace	Profile Index per Section of 40 or less for an individual trace	Correct all bumps and dips[2]
Profile Index per Section of greater than 30for an individual trace		Correct the Profile Index of each individual trace to 30 or less per section[3]
	Profile Index per Section of greater than 40 for an individual trace	Correct the Profile Index of each individual trace to 40 or less per section[3]
Daily Average Profile Index greater than 40	Daily Average Profile Index greater than 65	Suspend the paving operations until corrective actions are taken to improve the paving operations

[1]Acceleration/deceleration lanes include the taper. Acceleration lanes that become through lanes are limited to 500 feet from the noes of the ramp. Ramps are from the nose to the intersection of the adjoining road.
[2]Correct all areas within each section having high points (bumps) with deviations in excess of 0.3 inches in a length of 25 feet or less regardless of the profile index value.
[3] Contractor has the option to replace the section when the Profile Index per Section is greater than 65.

After the profilograph traces have been evaluated, make corrections according to **TABLE 503-2.**

TABLE 503-2: GRINDING REQUIREMENTS	
Condition	Action*
Greater than 25% (132 feet) of the 0.1 mi. section requires correction	Continuously grind the entire 0.1 mi. section.**
Greater than 25% (1320 feet) of 1.0 mi. segment require correction	Continuously grind the entire 1.0 mi. segment, when the areas requiring correction are dispersed throughout the 1.0 mi. segment. If the areas requiring correction are isolated to 1/3 or ½ mi. within the 1.0 mi. segment, then only grind that 1/3 or ½ mi.

* Continuously grinding requires a minimum of 98% of the pavement be ground.
**If the skip length between areas to be ground (either within a 0.1 mi. section or between 0.1 mi. sections) is less than either grind length, combine the grinds so the area between is also ground. This additional ground area (area between) will apply to the computation of the 25% of the 0.1 mi. section.

If the Contractor elects or is required by **TABLE 503-2** to continuously grind the entire project, the following apply:

- the areas excluded in **subsection 503.3a.** are not required to be ground;
- at intersections constructed with multiple transitions for drainage (especially in urban areas), if smoothness meets **SECTION 503**, the intersection is not required to be ground; and
- when transitioning from a ground area to an unground area, feather the grinding a uniform distance throughout the project.

Grind and texture the entire surface of the pavement in the longitudinal direction. Provide positive lateral drainage by maintaining a constant cross slope between grinding passes in each lane.

Maintain a uniform transverse slope that matches the existing cross slope to the extent possible with no depressions or humps greater than 1/4 inch in 12 feet when tested with a string line or straightedge. Do not exceed by more than 1/16 inch the vertical alignment between adjacent passes of the cutting head. Begin and end grinding lines

normal to the direction of vehicle travel. Grind the surface so corrugations are parallel to the pavement edge with ridges 1/16 inch, ±1/32 inch higher than the valleys of the corrugations.

Use the following methods for corrections:

- Diamond grinding or other profiling devices approved by the Engineer,
- Remove and replace the entire pavement thickness

Apply the corrective measure to the full lane width of the pavement. The corrected areas shall have uniform texture and appearance. The beginning and ending of the corrected areas shall be squared normal to centerline of the paved surface.

e. Profilograms. After pavement sections are corrected, re-profile the pavement surface to verify compliance with the specified pavement smoothness. Provide the Engineer with the profilograms and their evaluation within 2 working days after correcting the pavement surface.

The Engineer may perform profilograph testing on the pavement surface for monitoring and comparison purposes. If the Engineer determines that the Contractor's certified test results are inaccurate, the Engineer may choose to test the entire project length. The Engineer will charge the Contractor for such testing at the rate of $500 per mile per profile track, with a minimum charge of $1000. Providing inaccurate test results may result in de-certification of the Contractor's certified operator.

503.4 MEASUREMENT AND PAYMENT

Pay adjustments will be based on the initial average profile index determined for the "sections" prior to performing any corrective work, unless the surface of the entire project is continuously ground.

If the Contractor elects or is required by **TABLE 503-2** to continuously grind the entire project, pay adjustments will be based on the average profile index determined after all grinding is performed.

If the Contractor elects to remove and replace the sections, the Contractor will be paid the price adjustment that corresponds to the initial average profile index obtained on the pavement sections after replacement.

The Engineer will apply the contract price adjustment according to **TABLE 503-3.**

Payments made for "Concrete Pavement Smoothness" will be shown as an added item to the contract.

TABLE 503-3: CONCRETE PAVEMENT SMOOTHNESS PAY ADJUSTMENT NEW CONSTRUCTION

Average Profile Index (in./mi. per lane per 0.1 mi. section)	Contract Price Adjustment (per 0.1 mi. section per lane)
6.0 or less	+$1000.00
6.0 to 10.0	+$835.00
10.1 to 15.0	+$625.00
15.1 to 18.0	+$310.00
18.1 to 30.0	0.00
30.1 to 40.0	0.00*
40.1 or more	-$615.00*

*Correct to 30.0 inch/mile (40.0 in./mi. as noted in **TABLE 503-1**).

The pay adjustments in **TABLE 503-3** are for 12-inch thick hot mix asphalt and 8-inch thick portland cement concrete pavements. Pay adjustments for pavements of different thicknesses will be reduced or increased proportionally, based on the typical section for the extent. (i.e. pay adjustment for a 12-inch portland cement concrete pavement is equal to the adjustment from the TABLE multiplied by 1.5).

KANSAS DEPARTMENT OF TRANSPORTATION
SPECIAL PROVISION TO THE
STANDARD SPECIFICATIONS, EDITION 2015

Delete SECTION 603 and replace with the following:

SECTION 603

ASPHALT PAVEMENT SMOOTHNESS

603.1 DESCRIPTION

Determine the smoothness of the pavement surface and correct the deficiencies as specified in the Contract Documents.

For the purposes of this specification, define new construction to mean construction where pavement did not exist before, and where existing pavement is removed down to the base or subgrade.

All other conditions should be considered rehabilitation construction.

When projects contain both new and rehabilitation construction, follow appropriate guidelines for each type.

BID ITEM	UNITS
Asphalt Pavement Smoothness	Lump Sum

603.2 MATERIALS - None specified.

603.3 CONSTRUCTION REQUIREMENTS

a. Profilograph Testing. Determine the pavement smoothness by profiling the pavement surface of through traffic lanes and ramps. Excluded from profilograph testing, and not eligible for pay adjustments, on all projects are:

- bridge decks
- acceleration and deceleration lanes of at-grade intersections
- turning lanes
- shoulders
- pavement on horizontal curves with centerline radius of curvature of less than 1000 feet, and pavement within the superelevation transition of such curves
- individual sections of pavement less than 50 feet in length
- the first (or last) 15 feet of a pavement section where the Contractor is not responsible for the adjoining surface
- side roads less than 250 feet in length
- county secondary projects
- existing roadways that are surfaced with a plan thickness of less than 4 inches of hot mix asphalt (HMA)
- chip seals
- microsurfacing
- ultrathin bonded asphalt surface (UBAS)

Profile and correct, if necessary, the following categories of asphalt surfacing. These are not eligible for pay adjustments:

- existing roadways that are milled, then surfaced with a plan thickness of less than 4 inches of hot mix asphalt (HMA).
- existing roadways that are surfaced with a plan thickness of less than 4 inches of HMA that is placed in 2 or more lifts.

- existing roadways that are cold in-place recycled (CIR) with a plan depth of 2 inches or more, then surfaced with a plan thickness of less than 4 inches of HMA.
- existing roadways that are hot-in-place recycled (HIR) with a plan depth of 1 ½ inches or more, then surfaced with a plan thickness of less than 4 inches of HMA.

In addition to the asphalt surfacing above, profile and correct, if necessary, the following categories of asphalt base, prior to placement of the surface course. These are not eligible for pay adjustments:

- CIR pavement with a plan thickness of 2 inches or more.
- HIR pavement with a plan thickness of 1 ½ inches or more.
- HMA Base with a plan thickness of less than 4 inches when the surface course is UBAS. Profile and correct HMA base prior to placing UBAS.

b. Equipment. Use a California type profilograph, prequalified by the Bureau of Construction and Materials, to determine the pavement profile. If approved by the Bureau of Construction and Materials, other types of profilographs that produce results compatible to the California type profilograph may be used. If the profilograph has a mechanical recorder, provide a ProScan electronic scanner with motorized paper transport to reduce the trace. Use the motorized paper transport when scanning the profilograph traces. The Bureau of Construction and Materials can provide the information necessary for the Contractor to obtain a ProScan electronic scanner. If approved by the Bureau of Construction and Materials, other types of automated trace reduction equipment may be used. If the profilograph has a computerized recorder, the trace produced is evaluated without further reduction.

c. Profilograph Operation. Provide an operator for the profilograph certified according to KT-46, Part V.

Determine the pavement profiles for each lane according to the procedures for 1 lane shown in Kansas Test Method KT-46. Additional profiles may be taken only to define the limits of an out-of-tolerance surface variation. The Engineer may use a 10-foot straightedge (or other means) to detect irregularities outside the required trace paths. The Engineer may also use the straightedge to delineate the areas that require corrective action.

Determine a profile index (in./mi.) for each pavement section of finished pavement. A pavement section is a continuous area of pavement surface 0.1 mile long by 1 lane wide (12 feet nominal). A partial pavement section resulting from an interruption (such as a bridge) of the continuous pavement surface is subject to the same testing and evaluation as a whole section.

Profile the pavement after final rolling, and within 72 hours of completing the asphalt paving on the project. At the Engineer's discretion, the Contractor will profile the pavement after final rolling, and within 24 hours of placement of the pavement.

If the Contractor elects to test intermediate lifts with the profilograph, make the profilograms available to the Engineer to review for evaluating the paving methods and equipment.

On surfaces excluded from profilograph testing, the Engineer will determine the pavement smoothness using a 10-foot straightedge. The Engineer will select the locations to be tested. The variation of the surface from the testing edge of the straightedge shall not exceed ⅛ inch between any 2 contacts, longitudinal or transverse.

Correct all irregularities exceeding the specified tolerance using equipment and methods approved by the Engineer. After the irregularities are corrected, the Engineer will retest the area to verify compliance with the specified tolerance.

d. Profilograph Evaluation and Corrective Actions. Evaluate the profilograph results according to KT-46. Provide the Engineer with the profilograms and their evaluation the first working day after profiling the roadway.

Determine and evaluate the profile index (in./mi.) for each trace and the average profile index (in./mi.) for each section to identify where corrective action is needed.

Determine the daily average profile index (in./mi.) for each day's paving operation. A day's paving operation is the pavement placed in a day (a minimum of 1 pavement section).

- If less than 1 pavement section is placed in a day, the day's production is grouped with the next day's production.
- If the production of the last day of project paving is less than 1 pavement section, it is grouped with the previous day's production.
- The Contractor has the option of profiling the final portion of a day's production (not to exceed 5 sections) the first working day that paving is continued in the same lane. If the Contractor opts to

profilograph the final portion of a day's paving the next working day that paving is continued in the same lane, those results (the final portion of the previous day's paving) are grouped with the day's paving as the lane is continued.

(1) For new construction bid items in **SECTION 602,** take the required corrective actions according to **TABLE 603-1**.

TABLE 603-1: ASPHALT PAVEMENT SURFACE TOLERANCES, NEW CONSTRUCTION SECTION 602 BID ITEMS

Pavement Surface Tolerances (in./mi.)		Required Corrective Action
Through Lanes Speed Limit Greater than 45 mph	**Acceleration Lanes* Deceleration Lanes* Ramps* Through Lanes Speed Limit 45 mph or Less**	
Profile Index per Section of 30 or less for an individual trace	Profile Index per Section of 40 or less for an individual trace	Correct all bumps and dips**.
Profile Index per Section greater than 30 for an individual trace		Correct the Profile Index of each individual trace to 30 or less per section**.
	Profile Index per Section greater than 40 for an individual trace.	Correct the Profile Index of each individual trace to 40 or less per section**.
Daily Average Profile Index greater than 40	Daily Average Profile Index greater than 65	Suspend the paving operations until corrective actions are taken to improve the paving operations.

*Acceleration/deceleration lanes include the taper. Acceleration lanes that become through lanes are limited to 500 feet from the nose of the ramp. Ramps are from the nose to the intersection of the adjoining road.
**Correct all areas within each section having high or low points (bumps or dips) with deviations in excess of 0.3 inches in a length of 25 feet or less regardless of the profile index value.

(2) For all other rehabilitation construction bid items in **DIVISION 600**, take the required corrective actions according to **TABLE 603-2**.

TABLE 603-2: ASPHALT PAVEMENT SURFACE TOLERANCES, REHABILITATION DIVISION 600 BID ITEMS (EXCEPT SECTION 602, NEW CONSTRUCTION)		
Pavement Surface Tolerances (in./mi.)		**Required Corrective Action**
Through Lanes	**Acceleration Lanes* Deceleration Lanes* Ramps* ≥ 1 ½" Surface Recycled Asphalt/Hot In-place Recycled Asphalt Pavement ≥ 2" Cold Recycle Asphalt Construction**	
Profile Index per Section of 30 or less for an individual trace	Profile Index per Section of 40 or less for an individual trace	Correct all bumps and dips**.
Profile Index per Section greater than 30 for an individual trace		Correct the Profile Index of each individual trace to 30 or less per section**.
	Profile Index per Section greater than 40 for an individual trace.	Correct the Profile Index of each individual trace to 40 or less per section**.
Profile Index per Section greater than 40 for an individual trace	Profile Index per Section greater than 50 for an individual trace.	Suspend the paving operations until corrective actions are taken to improve the paving operations.

*Acceleration/deceleration lanes include the taper. Acceleration lanes that become through lanes are limited to 500 feet from the nose of the ramp. Ramps are from the nose to the intersection of the adjoining road.
**Correct all areas within each section having high or low points (bumps or dips) with deviations in excess of 0.4 inches in a length of 25 feet or less regardless of the profile index value.

e. Corrections. Make the required corrections for pavement smoothness before making the pavement thickness determinations. Use these methods for corrections:

- diamond grinding when the layer is the final riding surface
- when the layer will be covered with a chip seal or microsurfacing
  - micro-milling or fine-lace milling (minimum of 60 teeth per foot) may be done in a continuous 100-foot segment provided there is at least 400 feet of the surface adjacent to the segment that is not milled or diamond ground
  - diamond grind when more than 100 feet within a 400-foot segment requires correction. The Engineer may permit micro-milling if in the opinion of the Engineer the resulting surface is not detrimental to the functionality of the chip seal or the microsurfacing
- milling if the layer will be covered by UBAS or a layer of HMA.
- remove and replace the entire pavement thickness
- remove the surface by milling, and replace the specified surface course
- overlay (not patch) with the specified surface course
- other methods that are approved by the Engineer

Apply the corrective measure to the full-lane width of the pavement. The corrected areas shall have uniform texture and appearance. The beginning and ending of the corrected areas shall be squared normal to centerline of the paved surface.

When grinding is performed, use vacuum equipment or other continuous methods to remove grinding slurry and residue. Remove from the project and properly dispose of the material. Do not allow the grinding slurry to flow across lanes being used by traffic, onto shoulder slopes, into streams, lakes, ponds or other bodies of water, or gutters or other drainage facilities. Do not place grinding slurry on foreslopes.

f. New Construction Bid Items in SECTION 602, and Eligible for Pay Adjustments. After the profilograph traces have been evaluated, make corrections according to **TABLE 603-3.**

TABLE 603-3: GRINDING REQUIREMENTS	
Condition	**Action***
Greater than 25% (132 feet) of the 0.1 mi. section requires correction	Continuously grind the entire 0.1 mi. section.**
Greater than 25% (1320 feet) of 1.0 mi. segment require correction	Continuously grind the entire 1.0 mi. segment, when the areas requiring correction are dispersed throughout the 1.0 mi. segment. If the areas requiring correction are isolated to 1/3 or ½ mi. within the 1.0 mi. segment, then only grind that 1/3 or ½ mi.

* Continuously grinding requires a minimum of 98% of the pavement be ground.

**If the skip length between areas to be ground (either within a 0.1 mi. section or between 0.1 mi. sections) is less than either grind length, combine the grinds so the area between is also ground. This additional ground area (area between) will apply to the computation of the 25% of the 0.1 mi. section.

If the Contractor elects or is required by **TABLE 603-3** to continuously grind the entire project, the following apply:

- the areas excluded in **subsection 603.3a.** are not required to be ground;
- at intersections constructed with multiple transitions for drainage (especially in urban areas), if smoothness meets **SECTION 603**, the intersection is not required to be ground; and
- when transitioning from a ground area to an unground area, feather the grinding a uniform distance throughout the project.

Grind and texture the entire surface of the pavement in the longitudinal direction. Provide positive lateral drainage by maintaining a constant cross slope between grinding passes in each lane.

Maintain a uniform transverse slope that matches the existing cross slope to the extent possible with no depressions or humps greater than 1/4 inch in 12 feet when tested with a string line or straightedge. Do not exceed by more than 1/16 inch the vertical alignment between adjacent passes of the cutting head. Begin and end grinding lines normal to the direction of vehicle travel. Grind the surface so corrugations are parallel to the pavement edge with ridges 1/16 inch, ±1/32 inch higher than the valleys of the corrugations.

g. Profilograms. After pavement sections are corrected, re-profile the pavement surface to verify compliance with the specified pavement smoothness. Provide the Engineer with the profilograms and their evaluation within 2 working days after correcting the pavement surface.

The Engineer may perform profilograph testing on the pavement surface for monitoring and comparison purposes. If the Engineer determines that the Contractor's certified test results are inaccurate, the Engineer may choose to test the entire project length. The Engineer will charge the Contractor for such testing at the rate of $500 per mile per profile track, with a minimum charge of $1000. Providing inaccurate test results may result in de-certification of the Contractor's certified operator.

603.4 MEASUREMENT AND PAYMENT

a. General. The Engineer will base the pay adjustment for pavement smoothness on the initial average profile index of the pavement section before any corrective work is performed. If the Contractor elects to remove and replace a pavement section, the Engineer will base the pay adjustment for pavement smoothness on the initial average profile index of the pavement section after the replacement.

For reconstruction projects, if the Contractor elects or is required by **TABLE 603-3** to continuously grind the entire project, pay adjustments will be based on the average profile index determined after all grinding is performed.

b. New Construction, Bid Items in SECTION 602, Eligible for Pay Adjustments. The Engineer will apply the contract price adjustment according to **TABLE 603-4**. Payments for "Asphalt Pavement Smoothness" are an added item to the contract.

TABLE 603-4: ASPHALT PAVEMENT SMOOTHNESS PAY ADJUSTMENT NEW CONSTRUCTION	
Average Profile Index (in./mi. per lane per 0.1 mi. section)	**Contract Price Adjustment (per 0.1 mi. section per lane)**
6.0 or less	+$1000.00
6.0 to 10.0	+$835.00
10.1 to 15.0	+$625.00
15.1 to 18.0	+$310.00
18.1 to 30.0	0.00
30.1 to 40.0	0.00*
40.1 or more	-$615.00*

*Correct to 30.0 in./mi. (40.0 in./mi. as noted in **TABLE 603-1**).

The pay adjustments in **TABLE 603-4** are for 12" thick hot mix asphalt and 8" thick portland cement concrete pavements. Pay adjustments for pavements of different thicknesses will be reduced or increased proportionally, based on the typical section for the extent. (i.e. pay adjustment for a 9" hot mix asphalt pavement is equal to the adjustment from the **TABLE 603-4** multiplied by 0.75).

c. Rehabilitation Construction, for all Other Bid Items in DIVISION 600 and Eligible for Pay Adjustments, Take the Required Corrective Actions According to TABLE 603-5. The Engineer will apply the contract price adjustment according to **TABLE 603-5**. Payments for "Asphalt Pavement Smoothness" are an added item to the contract.

TABLE 603-5 ASPHALT PAVEMENT SMOOTHNESS PAY ADJUSTMENT REHABILITATION CONSTRUCTION	
Average Profile Index (in./mi. per lane per 0.1 mi. section)	**Contract Price Adjustment (per 0.1 mi. section per lane)**
7.0 or less	+$152.00
7.1 to 10.0	+$76.00
10.1 to 30.0	0.00
30.1 to 40.0	0.00*
40.1 or more	-$203.00*

*Correct to 30.0 in./mi. (40.0 in./mi. as noted in **TABLE 603-2**).

03-07-16 C&M (LAL)
Jul-16 Letting

КТ-46

5.9.46 DETERMINATION OF PAVEMENT PROFILE WITH THE PROFILOGRAPH
(Kansas Test Method KT-46)

1. SCOPE

This method of test covers the procedure for determining the smoothness, i.e. profile index, of both concrete and asphalt pavement using the California type 25-foot (7.6 mm), profilograph or equivalent.

2. APPARATUS

2.1. California type, 25-foot (7.6 mm), profilograph or equivalent **Figure 1**, with pointer. The 25-foot (7.6 mm) profilograph is a rolling straight edge; which measures vertical deviations from a moving 25-foot (7.6 mm) reference plane. The pavement profile is graphically recorded on a profilogram with scales of 300:1 longitudinally and 1:1 vertically.

2.2. Blanking band which is a plastic scale 1.70 inch (43 mm) wide and 21.12 inch (333 mm) long representing a pavement length of 528 ft (100 m) or 0.1 mile (0.1 km) at a scale of 1 inch = 25 feet. Near the center of the scale is a dashed line extending the entire length of the plastic scale. On either side of this dashed line are scribed lines 0.1 inch (2 mm) apart, parallel to the dashed line. These lines serve as a convenient scale to measure deviations of the profile trace above or below the dashed reference line. These deviations are called "scallops".

2.3. Scale graduated in 0.1 inch or 1 mm.

2.4. Medium point ballpoint pen with red ink or other color contrasting to the profile trace.

2.5. Electronic calculator.

2.6. Plain recording chart paper as specified by the manufacturer of the profilograph.

2.7. Bump template which is a plastic template having a marked length 1 inch (25 mm) long on one face, and a slot (or edge) parallel to the marked length. A distance equal to the maximum bump specified separates the two reference lengths **Figure 2**. The 1 inch (25 mm) line corresponds to a longitudinal distance of 25 feet (7.5 m) on the longitudinal scale of the profilogram.

3. CALIBRATION

3.1. All profilographs used on KDOT projects must be calibrated at least annually. Calibration must be checked any time the profilograph has been altered or repaired. The certification includes establishing the proper tire inflation pressure, checking the trueness of the tire travel, checking the chart scale factor, and checking vertical displacement of the sensing wheel.

3.2. Each District and contractor using a profilograph shall establish a 500 to 1000 ft. (100 to 300 m) distance calibration test section on or near each project. This test section should be fairly straight, relatively flat and used periodically to check the longitudinal calibration and trace reproduction.

3.3. Longitudinal calibration consists of pushing the profilograph at walking speed approximately 3 mph (approximately 5 km/h), over a pre-measured test distance 500 to 1000 ft. (100 to 300 m) and determining the chart scale factor. Dividing the premeasured test distance in inches (mm) by the profilogram trace length, for the test distance, in inches (mm) will determine the scale factor. This factor shall be 300 $\pm$ 0.5.

If the profilograph produces charts with a different scale factor, adjustment of the profilograph must be made to bring the scale factor within the tolerances specified above.

3.4. Vertical calibration consists of placing the center recording wheel of the profilograph on a base plate and recording the base elevation. Two plates 0.5 inches (12.5 mm) thick each are added under the center wheel one at a time and the change in elevation noted. The two plates are removed one at a time and the change in elevation noted. Each step in the process shall show a change in height of 0.5 inches ± 0.01 inch (12.5 mm $\pm$ 1.0 mm). If the profilograph produces results not conforming to the above limits, it must be adjusted to within the tolerance specified.

3.5. The automatic trace reduction capability of a machine so equipped shall be checked by comparing the machine's results to the results obtained through manual trace reduction. The comparison shall be made for the trace obtained at the Materials and Research test section and for each project, at the project test section. The results of the comparison may not differ by more than 2.0 inches/mile (30 mm/km). All calibration traces and calculations shall be submitted to the Materials and Research Center or to the appropriate construction office to become part of the project file.

4. TEST PROCEDURE

4.1. The profilograph is propelled at walking speed approximately 3 mph (approximately 5 km/h) in the paths indicated for each section of pavement **Figure 1**. Propulsion may be provided by manually pushing or by a suitable propulsion unit such as a garden tractor. **DO NOT** push or pull a profilograph with a vehicle. More than one person may be required to hold the back end of the profilograph exactly in the required path on superelevated or sharp horizontal curves.

4.2. Use of the pointer to maintain the required trace path is mandatory

4.3. If excessive "spikes" are encountered, decrease the rate of travel. An excessive number of "spikes" on a trace make it difficult to evaluate and may affect test results.

4.4. If possible, assemble the profilograph ahead of the location on the pavement where testing is to start. With the distance measuring wheel down and the pen in place on the trace paper, push the machine to the start position in the direction the test will be conducted. The center wheel should be the reference wheel. While the profilograph is stationary at the start location, move the cable attached to the pen thus creating a spike mark on the trace and label that mark as the start location. Using this procedure at the beginning and end of each trace will ensure that all systems are working properly, that slack has been removed from the drive chains, and will clearly define the start and end location. Also mark which direction is up on the trace and the direction the profilograph was pushed.

4.5. Push the profilograph in the same direction when recording each trace for a given section of pavement.

4.6. Indicate stationing on the profilogram at least every 500 feet (100 m), using the procedure outlined in **Section 4.4** of this test method. More frequent station references of every 100 feet (25 m) or every 200 feet (50 m) are highly desirable where possible. Station referencing on the trace is used to accurately locate 0.40 inch (10 mm) bumps. Notation of landmarks, roadway signs, etc. should also be made on the trace for additional referencing.

4.7. Completely label both ends of the profilogram with the project number, stationing represented on the roll and name of profilograph operators. Fill out a report form and secure it around the trace roll. This report ensures that the person reducing the trace and reporting results will have all necessary information.

4.8. A little dirt or debris will spike out and not effect the profilograph readings, however, excessive mud or caked mud must be removed prior to testing. Anything on the pavement surface longer than 2 to 3 inches (50 to 75 mm) may not be considered a spike when reducing the trace and should be removed.

4.9. When operating the profilograph, all wheels should always be on the pavement for which the contractor is responsible. Test from header to header whenever possible.

4.10. Pavement not tested at the end of a day's run due to barrier fences, machinery or other obstructions shall be included in a subsequent test run.

5. TRACE REDUCTION AND BUMP/DIP LOCATING PROCEDURE

5.1. Using a red (or other contrasting color), medium point, ballpoint pen; retrace the profilogram through the middle of any spikes. This outlining procedure removes spikes and minor deviations and generally smooths the trace for easier reduction and analysis.

5.2. Use a bump template (scribed side down) to locate bumps/dips for removal. At each prominent bump/dip or high/low point on the profile trace, place the template so that the scribe marks at each end of the scribed line intersect the profile trace to form a chord across the base of the peak/valley or indicated bump/dip. The line on the template need not be horizontal. With a sharp pencil, draw a line using the narrow slot in the template (or edge) as a guide. Any portion of the trace extending above/below this line will indicate the approximate length and height of the bump/dip in excess of the specification.

There may be instances where the distance between easily recognizable low/high points is less than 1 inch (25 mm). In such cases a shorter chord length shall be used in making the scribed line on the template tangent to the trace at the low/high points. It is the intent, however, of this requirement that the baseline for measuring the height of bumps (or depth of dips) will be as nearly 1 inch (25 mm) as possible, but in no case to exceed this value. When the distance between prominent low/high points is greater than 1 inch (25 mm), make the ends of the scribed line intersect the profile trace when the template is in a nearly horizontal position. A few examples of the procedure are shown in **Figure 2**.

After marking the bump/dip on the profilogram, determine the station number of the center of the bump/dip by scaling from the nearest reference mark. Record the track identification and station of the bump/dip.

5.3. Place the blanking band (scribed side down) over the profile with the dashed reference line as nearly centered on the profile trace as possible.

The profile trace may move from a generally horizontal position when going around superelevated curves making it impossible to follow the central portion of the trace without shifting the blanking band. When such conditions occur, the profile should be broken into short sections and the blanking band repositioned on each section as shown in the upper part of **Figure 2**.

Indicate the beginning and ending of superelevated curves on the profilogram at the time the profile trace is being made.

5.4. Begin evaluating each trace from the same point on the road so that sections representing the same length of road can be aligned on the test report form. Measure and total the height of all the scallops appearing both above and below the dashed reference line, measuring each scallop to the nearest 0.05 inch (1 mm). Do not count a scallop as 0.05 inch (1 mm) just because you see the profile line or there is space under the line. Short sections of the profile line may be visible above or below the dashed reference line, but unless they project 0.03 inch (0.7 mm) or more vertically and extend longitudinally for 0.08 inch (2 mm)

or more on the profilogram, they are not included in the count. Spikes are not counted. Double-peaked scallops are only counted once as the highest peak **Figure 3**.

Write the total count in inches (mm) on the profilogram above the profile line (toward the center of the section) and circle it. Outline the position of the blanking band when reducing the trace for later repositioning to check trace reduction procedure. Rotate the blanking band about the previous end position when evaluating the next section **Figure 4.**

When a scallop occurs at the end of the blanking band, count the scallop only once. Place the scallop in the 0.1 mile (0.1 km) section where the peak is highest **Figure 4**.

Always use the measured trace length in computations. This length may not agree exactly with distance by subtracting stationing. Always use ± after the total length on the report.

Enter the measured roughness for each 0.1 mile (0.1 km) section and for each track into the worksheet shown in **Figure 6.** Enter the profile index into **KDOT Form 242**.

5.5. The last section counted is generally not an even 0.1 mile (0.1 km). If not, its length should be scaled to determine its length in miles (km) (Calculated to three decimal places). For the example shown below, the last section measures 7.60 inches (193 mm) in length.

English

$$\frac{(7.60 \text{ in})(25 \text{ ft/in})}{5{,}280 \text{ ft/mile}} = 0.036 \text{ miles}$$

Metric

$$\frac{(193 \text{ mm})(300)}{1{,}000{,}000 \text{ mm/km}} = 0.0579 \text{ km} = 0.058 \text{ km}$$

If the last section is less than or equal to 250 ft (0.047 mile) (0.05 km [50 m]), it is added to and included with the previous 0.1 mile (0.1 km) section to determine compliance with the profile index. If the last section is more than 250 ft (0.047 mile) [0.05 km (50 m)], it is treated as a separate section.

When the profilograph must be picked up or partially disassembled and moved around an unpaved area or structure, a new section will be started.

The profile index is determined as inches/mile (mm/km) using the "zero" blanking band but is simply called the profile index. The procedure for converting counts inches of roughness (mm of roughness) to profile indices is illustrated in **Figure 5**. For 0.1 mile (0.1 km) sections, the profile index can be determined from the counts (inches of roughness (mm of roughness)) by moving the decimal point one position to the right. For odd length sections, the profile index is determined by dividing the counts (inches of roughness (mm of roughness)) by the section length in miles (km). The weighted average for a day's run is determined by dividing the total counts (inches of roughness (mm of roughness)) for the day's run by the total length (in miles (in km)) of the day's run. **See Figure 6**.

6. REPORT

6.1. Contractors shall furnish and certify profilograph test reports, **KDOT Form No.242,** Figure 6.

6.2. All profile traces (profilograms) become part of the Engineer's permanent project records.

7. OPERATOR CERTIFICATION

7.1. Basis of operator certification is attendance at an approved training school and comprehension of the material presented, or by having proof of certification by another agency with requirements similar to KDOT.

7.2. A contractor's personnel may be decertified if the test results vary from the KDOT results by more than what is regarded as normal test variation.

7.3. When a contractor's personnel are decertified to issue profilograph reports, such reports will not be recognized until corrections in testing, trace reduction and reporting are made to the satisfaction of the Engineer.

LOCATION OF PROFILE WHEEL

------------------------ LANE EDGE OR CONSTRUCTION JOINT (PAINT STRIPE)
- - - - - - - - - - - - - - - TRACE 3 ft FROM LANE EDGE

- - - - - - - - - - - - - - - TRACE 3 ft FROM CONSTRUCTION JOINT
------------------------ CONSTRUCTION JOINT OR LANE EDGE

PROFILOGRAPH

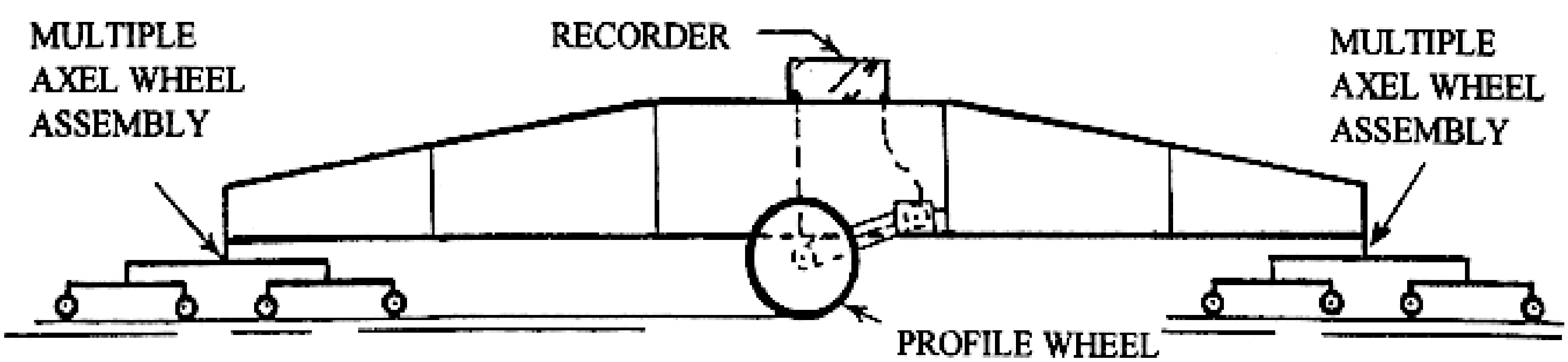


Figure 1.

Figure 2

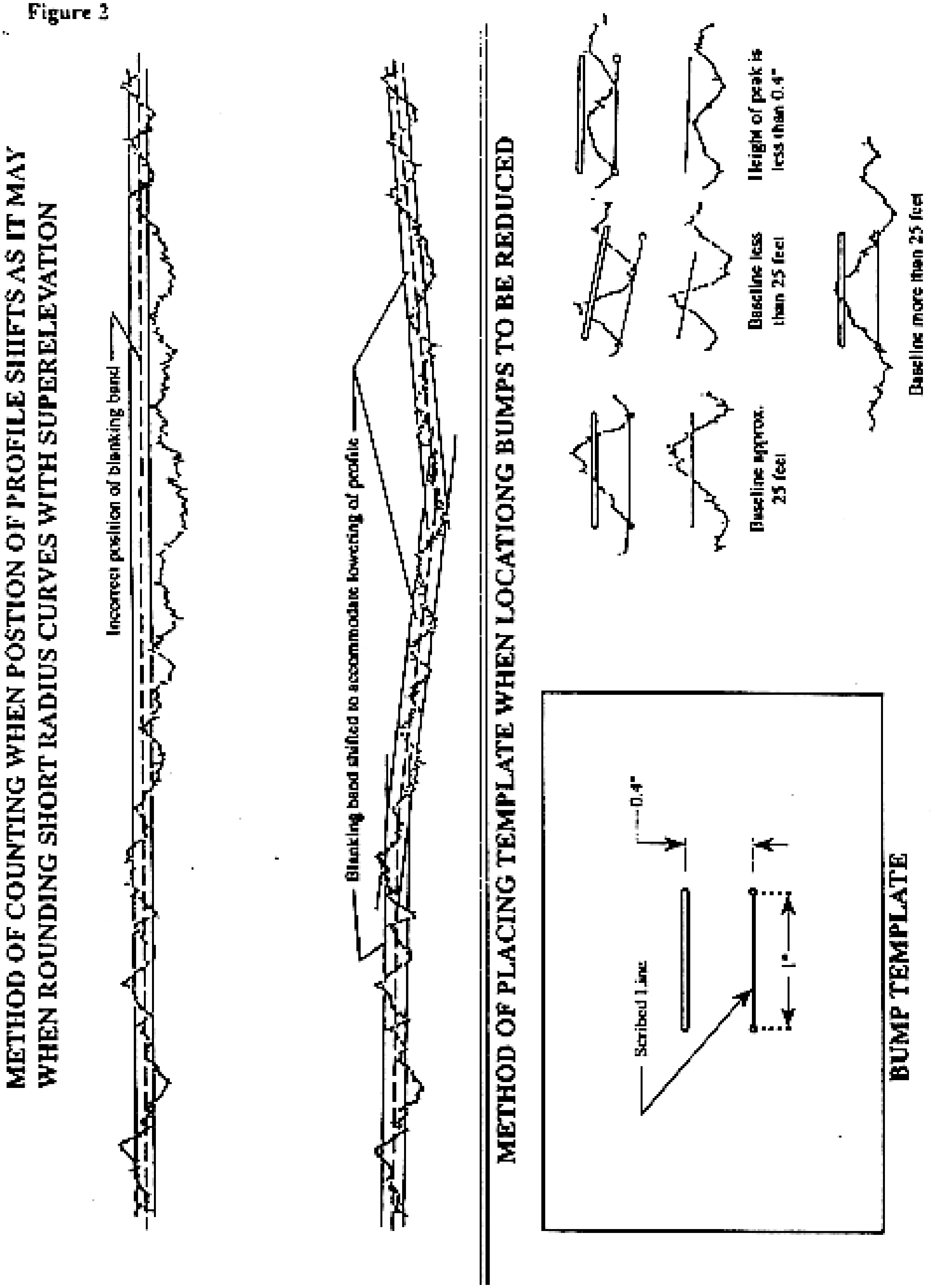
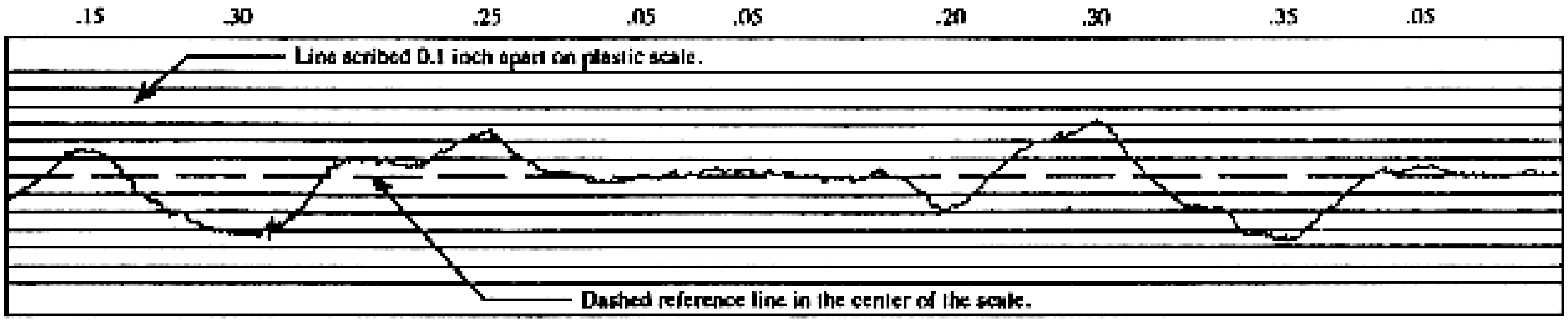

METHOD OF COUNTING WHEN POSTION OF PROFILE SHIFTS AS IT MAY
WHEN ROUNDING SHORT RADIUS CURVES WITH SUPERELEVATION
Incorrect position of blanking band
Blanking band shifted to accommodate lowering of profile
METHOD OF PLACING TEMPLATE WHEN LOCATIONG BUMPS TO BE REDUCED
Baseline approx. 25 feet
Baseline less than 25 feet
Height of peak is less than 0.4"
Baseline more than 25 feet
Scribed Line
0.4"
1"
BUMP TEMPLATE

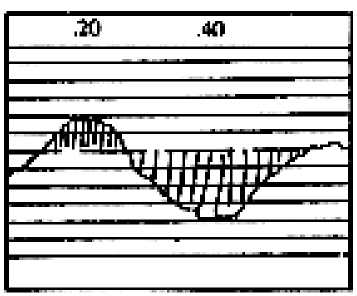
Figure 3

Example Showing Method of Deriving Profile Index From Profilogram



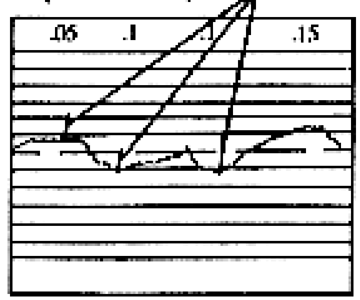
Total count for this 0.1 mile section is 1.70 inches (1.70 tenths of an inch).
Profile index for this 0.1 mile section is 1.70 inches per mile. (1.70 ÷ 0.1 = 17.0)

Scallops are areas enclosed by profile line and dashed reference line



Small projections which are not counted

Spikes caused by dirt or rock on the pavement (not counted)



Double scallop - only count the highter peak

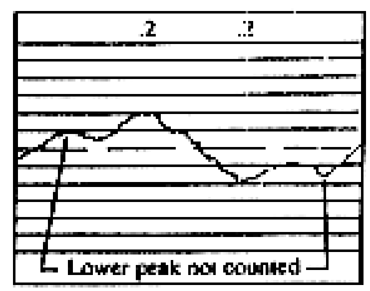
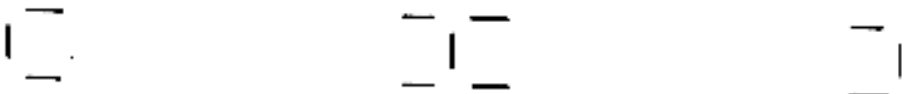


Figure 4

ROTATING BLANKING BAND ABOUT
LAST END POINT

This



Not This

SCALLOPS OCCURRING AT END
OF BLANKING BAND

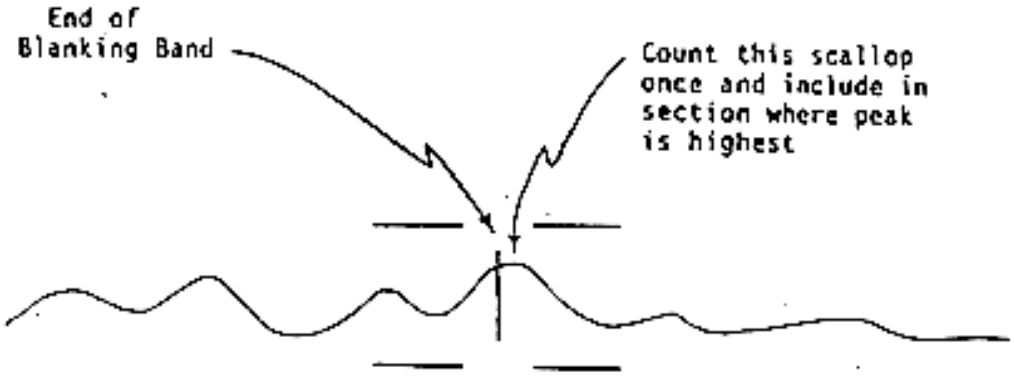


Figure 5

Procedure for Determining Profile Index

Segment Length (miles)	Inches of Roughness Shown on Trace	Reported Roughness (inches/mile)
Example A		
0.1	1.35	13.5
0.1	1.15	11.5
0.1	0.25	2.5
0.1	0.85	8.5
0.1	0.30	3.0
0.1	0.80	8.0
0.1	0.35	3.5
0.1	0.35	3.5
0.055 *	0.20	3.6(1)
0.855	5.60	6.5(2)

$$(1)\ \frac{0.20}{0.055} = 3.6$$

$$(2)\ \frac{5.60}{0.855} = 6.5$$

Example B		
0.1	0.80	8.0
0.1	0.40	4.0
0.1	0.35	3.6(1)
0.037 *	0.15	----
0.337	1.70	5.0(2)

$$(1)\ \frac{0.35 + 0.15}{0.1 + 0.037} = 3.6$$

$$(2)\ \frac{1.70}{0.337} = 5.0$$

* See section (e)(5) of this test method.

Figure 6.

___ Information
_X_ Initial
___ Intermediate
___ Final

PROFILOGRAPH REPORT OF PAVEMENT SMOOTHNESS

Project No. 75-98 K 1234-01 County Trego

Contractor John Doe Construction Company Pavement Type PCC

Station 153+00 to Station 168+00 Traffic Direction EB

No. of Lanes 2 Direction of Paving EB

Date Placed (corrected) 8-9-94 Date Tested 8-10-94

Tested and Evaluated by Norman Lee

Paving Action 9 inch Reinforced PCC

Length (Miles)	Track 1 Measured Roughness (Inches)	Track 1 Profile Index (In./Mi.)	Track 2 Measured Roughness (Inches)	Track 2 Profile Index (In./Mi)	Track 3 Measured Roughness (Inches)	Track 3 Profile Index (In./Mi.)	Average Profile Index (In./Mi)
0.1	0.75	7.5	0.65	6.5			7.0
0.1	0.35	3.5	0.40	4.0			3.8
0.084	0.95	11.3	0.80	9.5			10.4
0.284	2.05	7.2	1.85	6.5			6.9 Weighted Daily Average

Wheighted Daily Average Computation

2.05
1.85
3.90 inches / 2 tracks = 1.95 inches / 0.284 mile = 6.9 Average inches/mile

Bump Locations Track 2-None; Track 1-None

Certified by: Norman Lee

Title Chief Profilograph Pusher

Org'n John Doe Const. Co.

Figure 7.

PROFILOGRAPH REPORT OF PAVEMENT SMOOTHNESS

KDOT Form 242 Back Side

This form shall be prepared and submitted, along with the profilogram, within two working days of the placement or correction of concrete pavement or one working day for bituminous pavement.

The type of report is as follows:

Information - For check testing by Ks DOT and other situations not required to have testing.

Initial - All required testing of pavement for the first time (may be the only one).

Intermediate - After some corrective action that has not yet been completed.

Final - After all corrective action has been completed.

Pavement Type - PCC, HR, BM-1, etc.

Traffic Direction and direction of paving - NB, SB, EB, or WB depending on the design traffic flow of the numbered route.

Number of Lanes - the number of lanes placed at one time.

Paving Action - Mill (2"), Hot Recycle (2"), BM-1 (1 1/2"), etc.

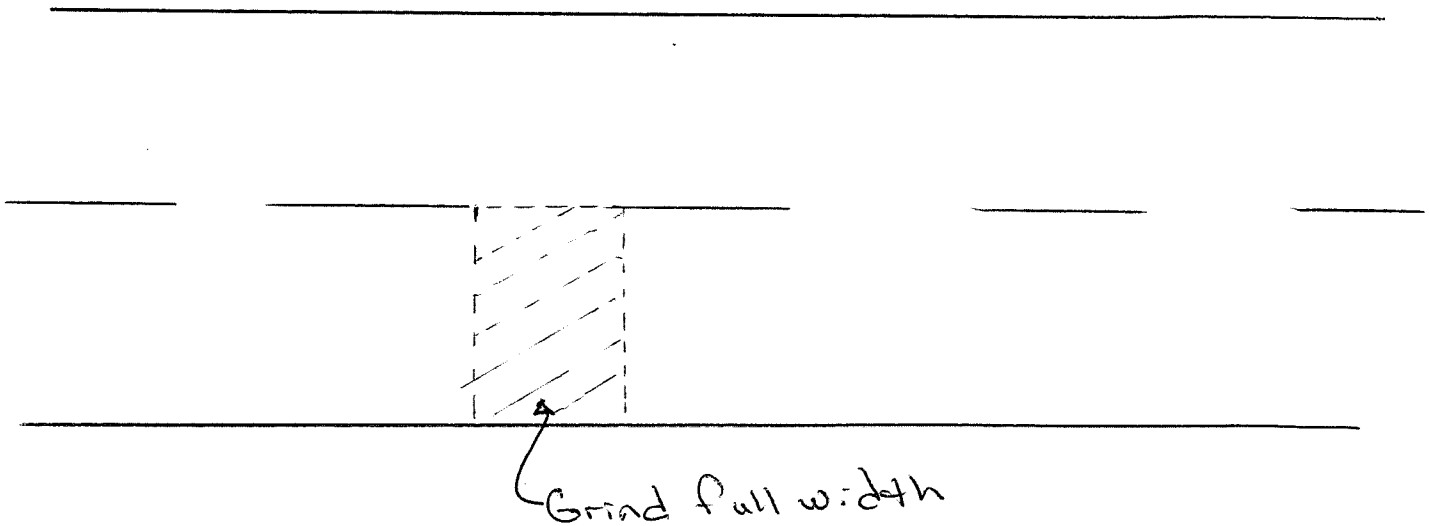
Always compute a weighted daily average Wdt Daily Avg =

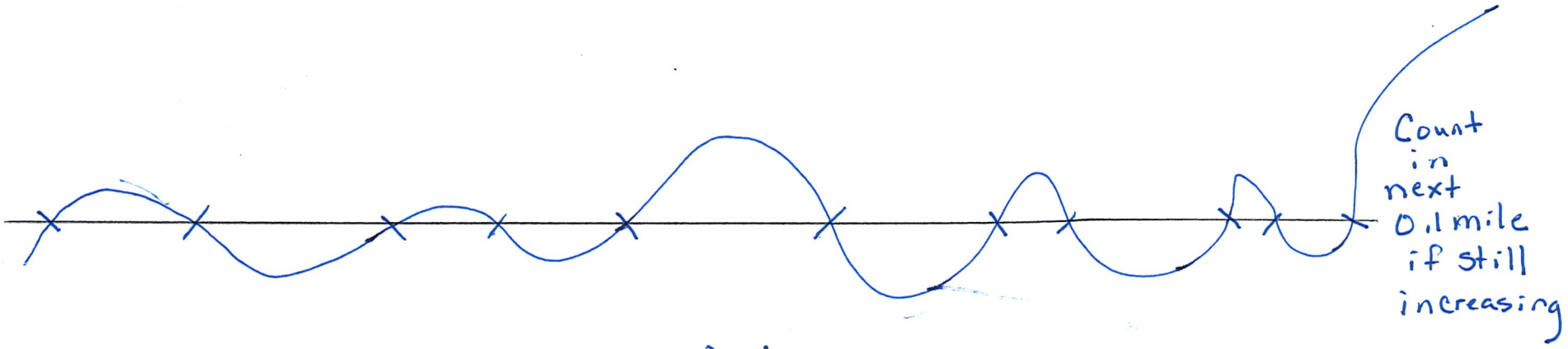
$$\frac{\text{Total count in inches}}{\text{No. of tracks x length}}$$

Bump locations are by station.

Distribution
Field Office (1)
District Office (1)
Bureau of Const. & Maint. (1)
Pavement Surface Research Engineer (1)

EXAMPLES


Grind full width



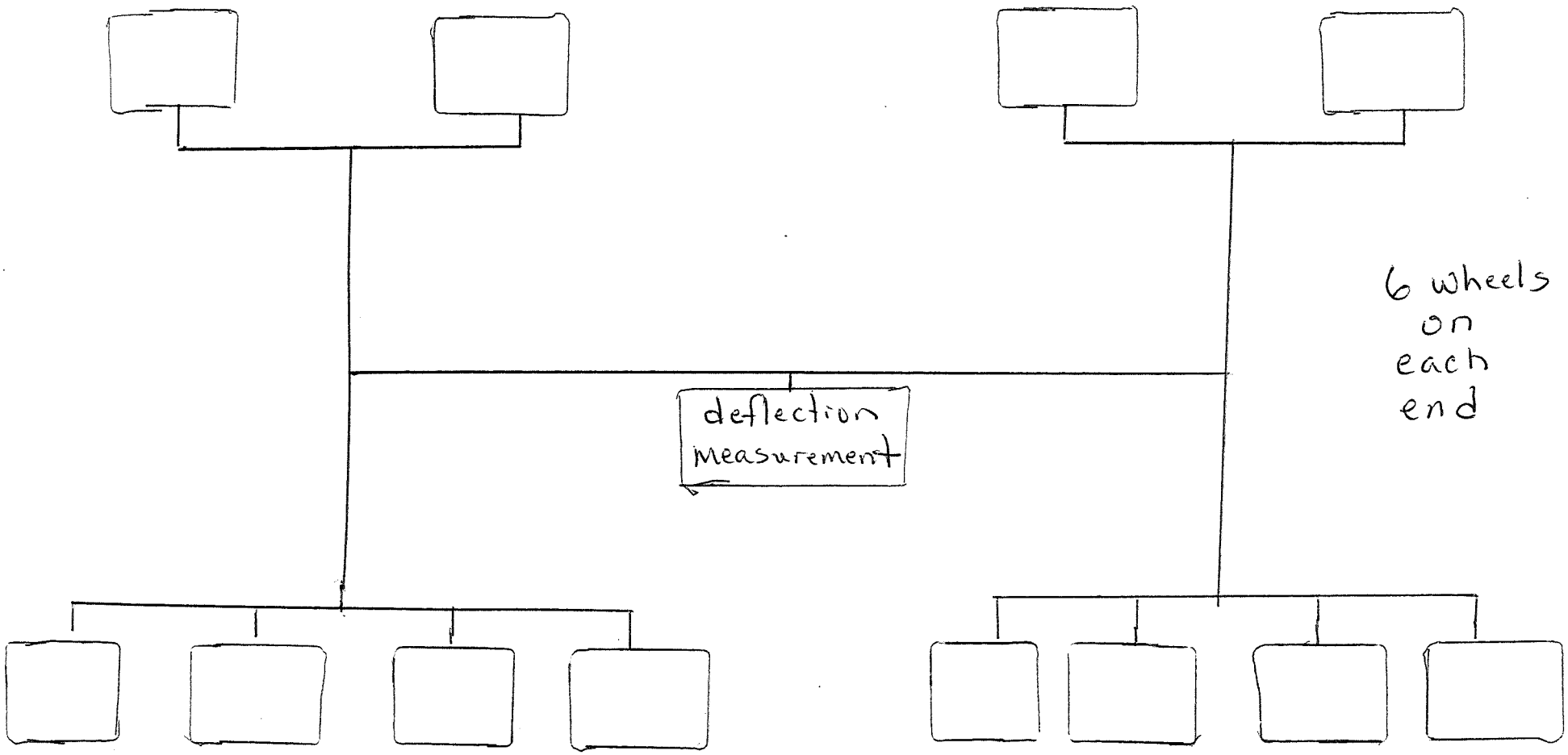
Add bumps and dips

divide by length

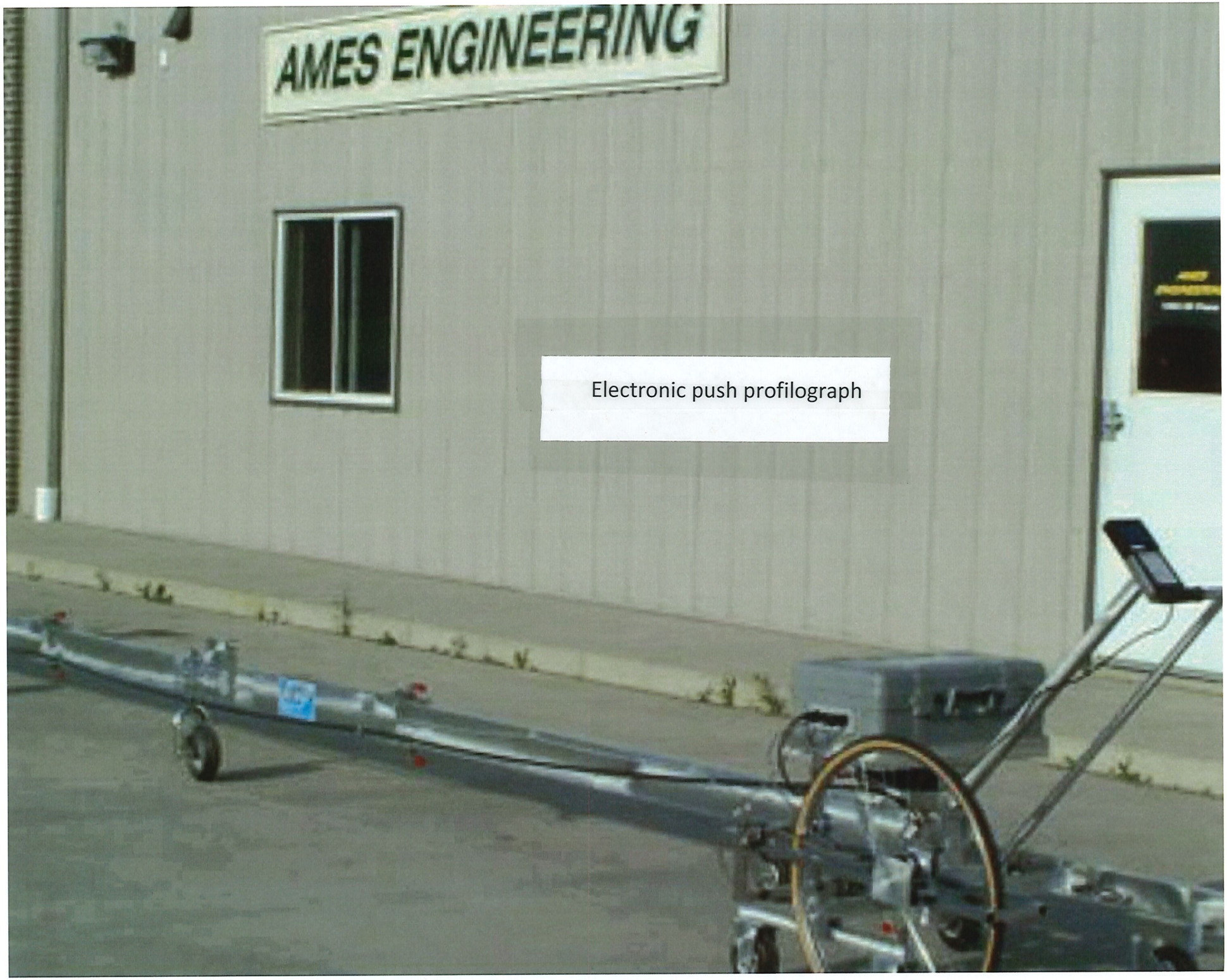
0.1 mile segments

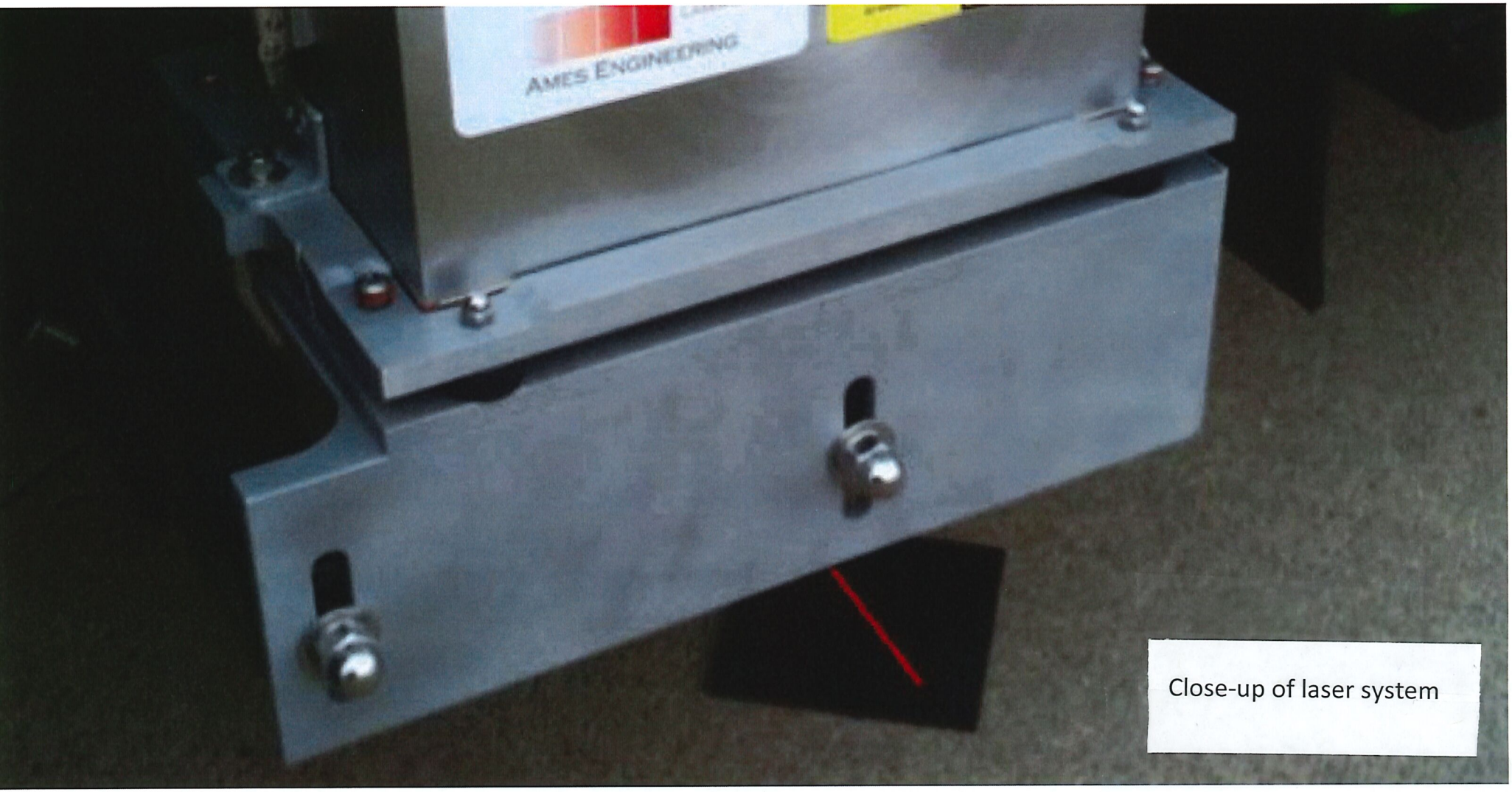
Profile Index

Count	Dist	=	Profile Index
2.6	0.1		26.0 in/mi


deflection
measurement
6 wheels
on
each
end

High speed profilograph

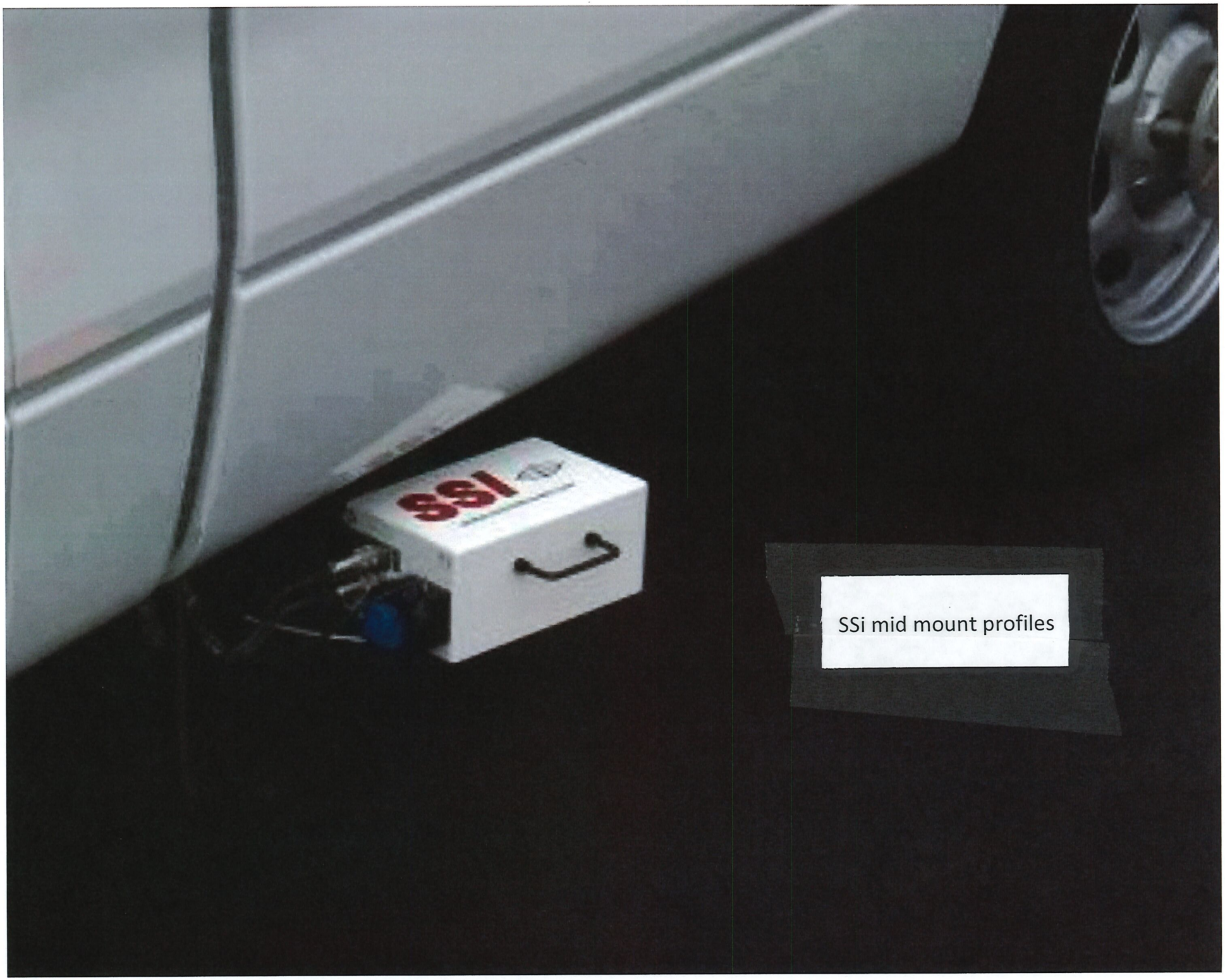

AMES ENGINEERING
Electronic push profilograph



Close-up of laser system


Lightweight profilograph
ENGINEERING
ement Profiler


SSi push type profilograph


SSI
SSi mid mount profiles

Ames Engineering
Profiler
Software Version 6.1.1.122
SERIAL # 830718
MODEL # Model_8300

Company = Hamm, inc
Operator =
Certification # = 830-718
Certification date = 06182018
Project =
Job = 470
County = Sh
Division =
Resident =
Highway =
Lane =
Lane Location =
Pass = 0
Comments =

FILE
C:\Jobs\470 NB\470 Ramps8.ard

CALPRO SETTINGS
Band width(in.) = 0.001
Min. scallop width(ft.) = 2.00
Min. scallop height(in.) = 0.030
Scallop rounding(in.) = 0.01
Count scallops once = False
Butterworth filter(ft.) = 15.00

BUMP SETTINGS
Bump Height(in.) = 0.40
Bump Width(ft.) = 25.00
Bump Detection = On
Dip Detection = On

ANALYSIS SETTINGS
Low-pass Filter(ft.) = 0.00
High-pass Filter(ft.) = 300.00
Reduction Length(ft.) = 528
Horizontal Scale = 300 To 1
Vertical Scale = 1 To 1
Paper Factor = 1.800

SENSOR SETTINGS
Sample rate = 12 samples/ft
Collection Speed(mph) = 42.42
Horizontal Cal. Divisor = 21
Horizontal Calibration = 48.768
Pre\Post Run Length = 500.00 ft

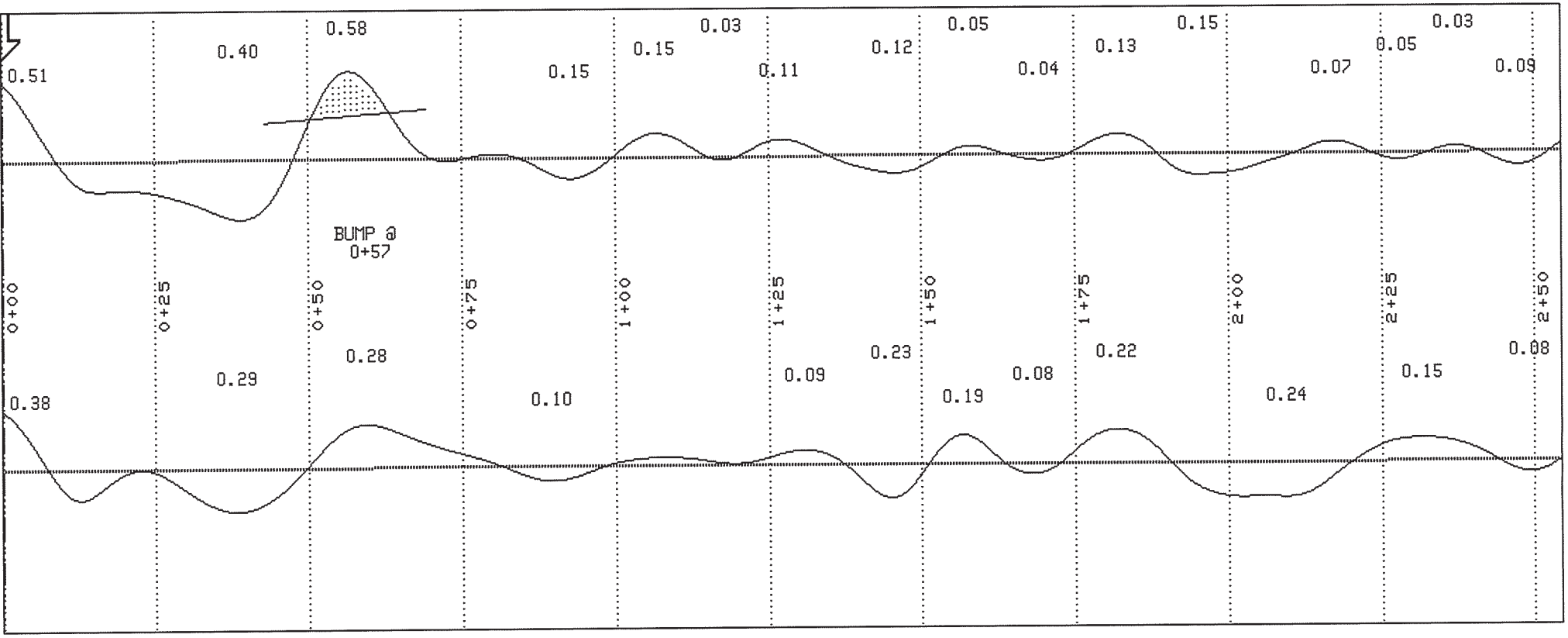
LEFT SENSOR FILTERS
Collection Filter (ft.) = 3,921.01
Analog Filter = 0.10 rad.
Anti-Aliasing Filter = 0 Hertz

RIGHT SENSOR FILTERS
Collection Filter (ft.) = 3,921.01
Analog Filter = 0.10 rad.
Anti-Aliasing Filter = 0 Hertz

--Collection Time and Date--
Time: 07:07:12
Date: 07-29-2019

--Printed Time and Date--
Time: 07:09:11
Date: 07-29-2019

470 Ramps8
7/29/2019
7:07 AM



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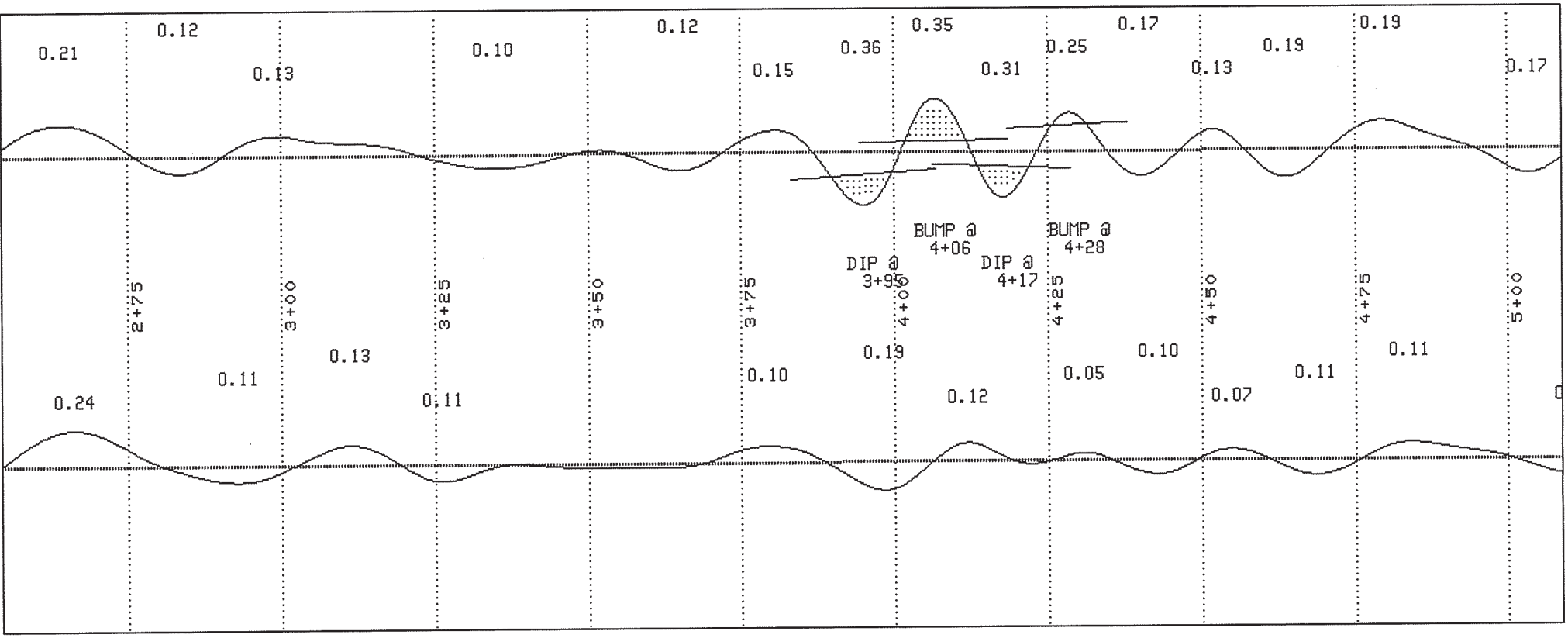
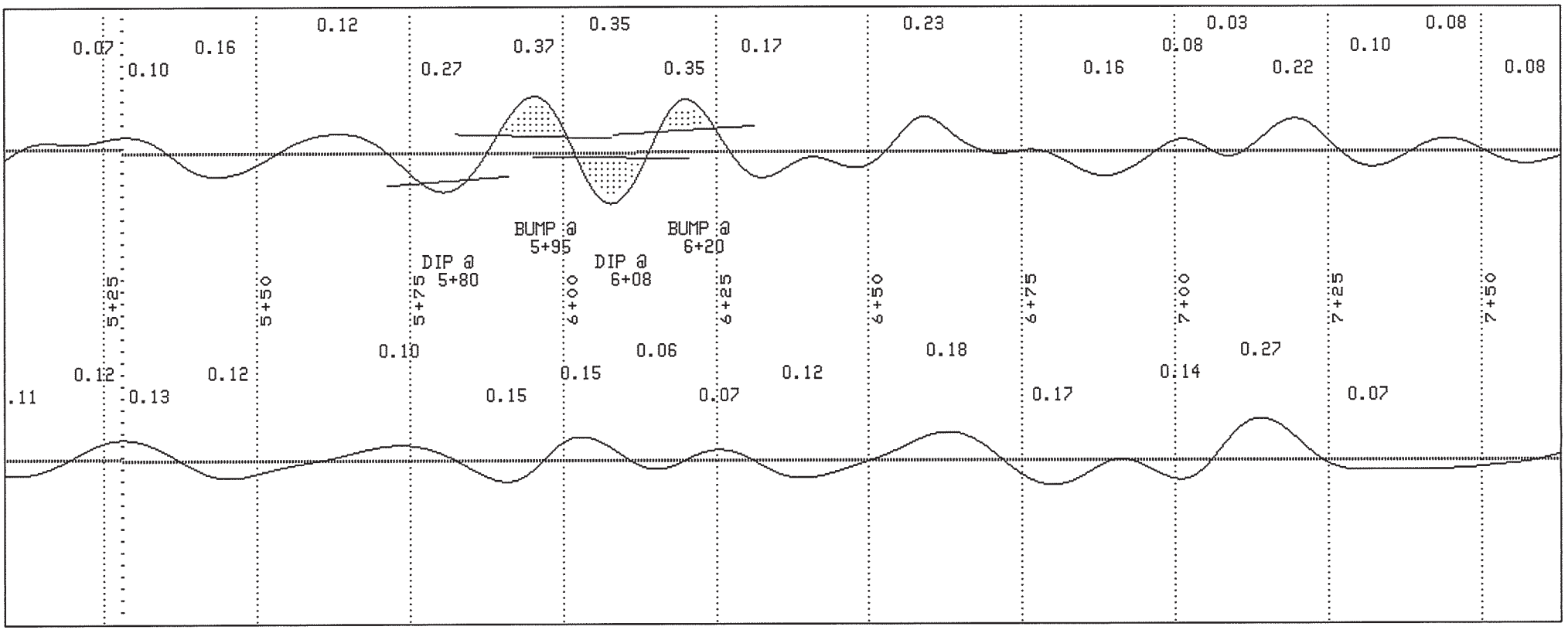
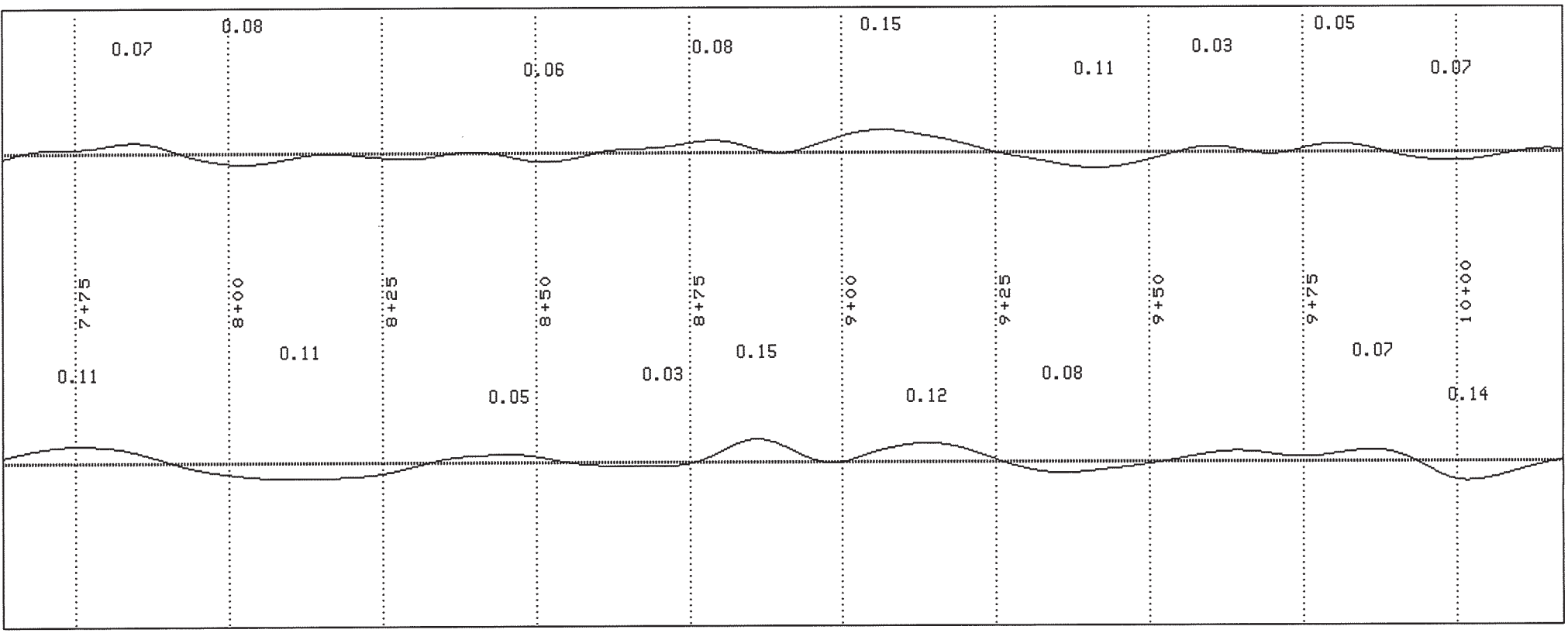
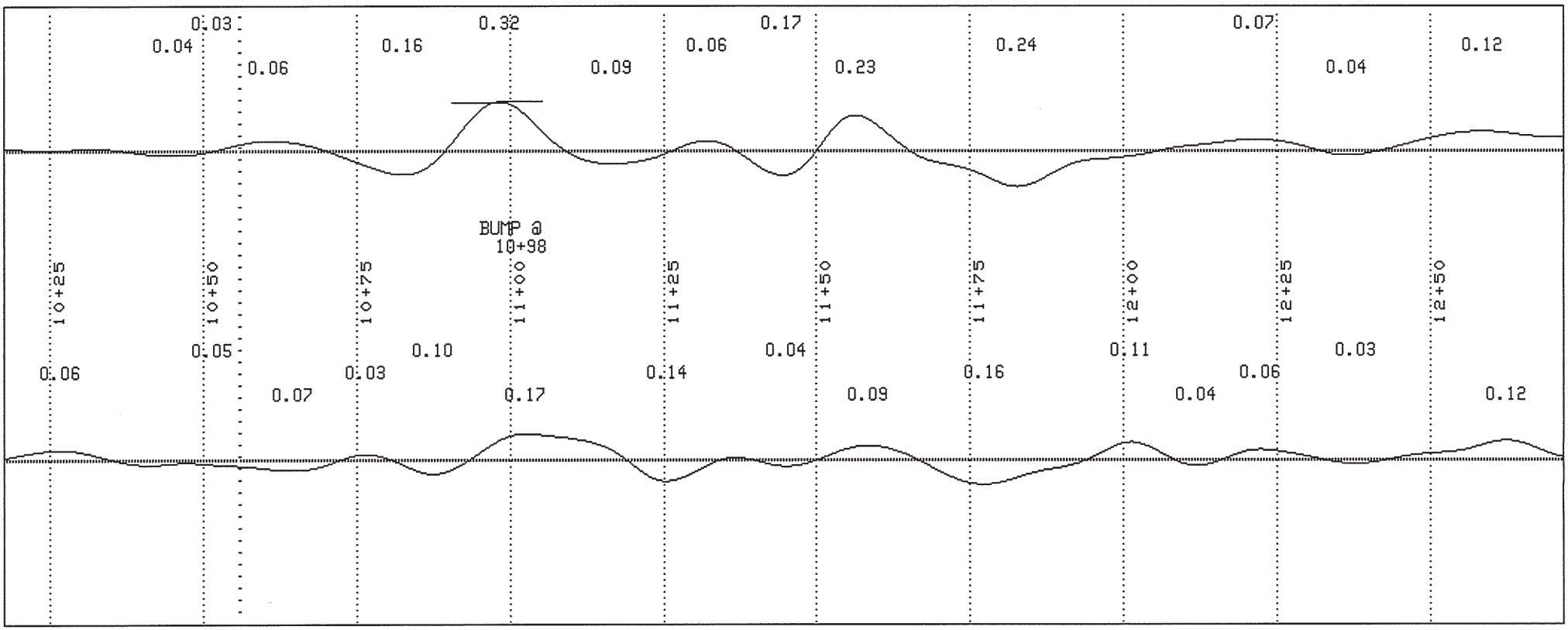
7/29/2019
7:07 AM



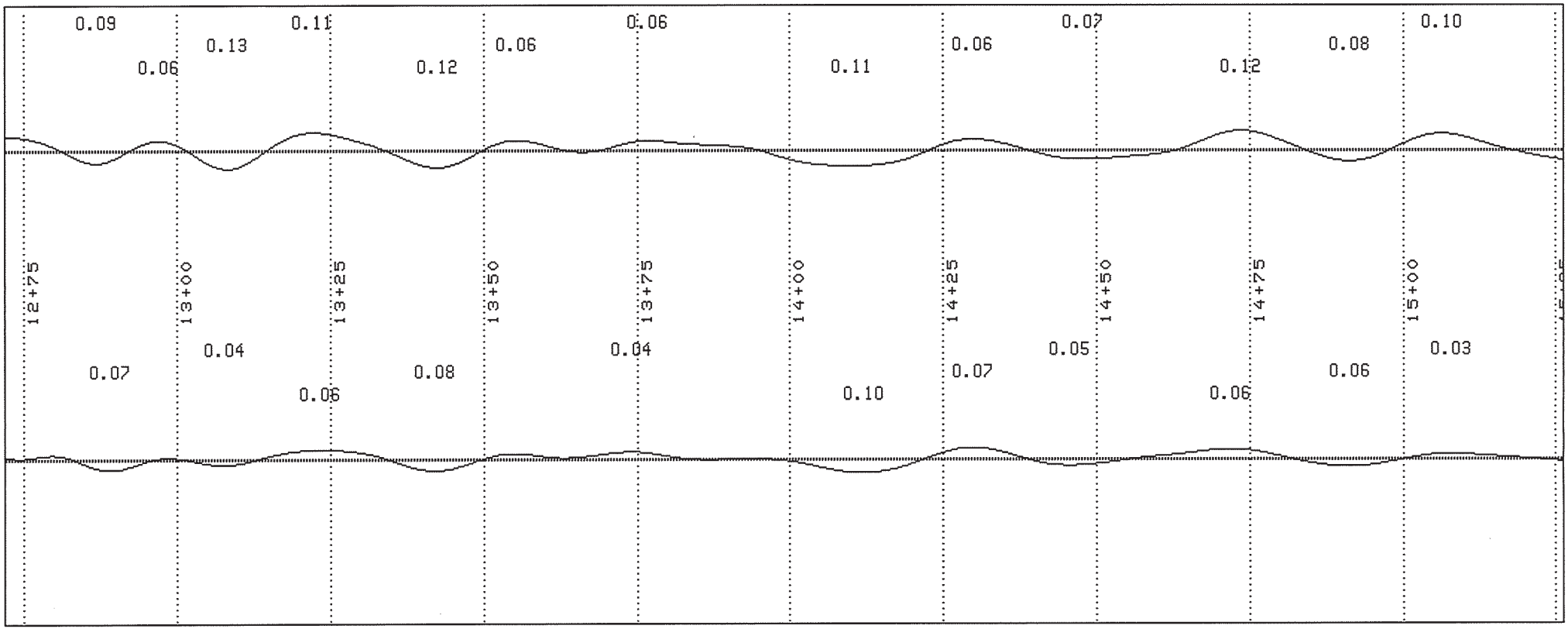


Beginning Station-> 0+00.0
Ending Station-> 5+28.0
Distance(ft.)-> 528.0
Scallop Sum Left (in.)-> 4.00
Scallop Sum Right (in.)-> 5.68
Profile Index Left (in./mile)-> 40.00
Profile Index Right (in./mile)-> 56.80
Average (in./mile)-> 48.40


0.07
0.08
0.06
0.08
0.15
0.11
0.03
0.05
0.07
7+75
8+00
8+25
8+50
8+75
9+00
9+25
9+50
9+75
10+00
0.11
0.11
0.05
0.03
0.15
0.12
0.08
0.07
0.14



Beginning Station-> 5+28.0
Ending Station-> 10+56.0
Distance(ft.)-> 528.0
Scallop Sum Left (in.)-> 2.70
Scallop Sum Right (in.)-> 3.64
Profile Index Left (in./mile)-> 27.00
Profile Index Right (in./mile)-> 36.40
Average (in./mile)-> 31.70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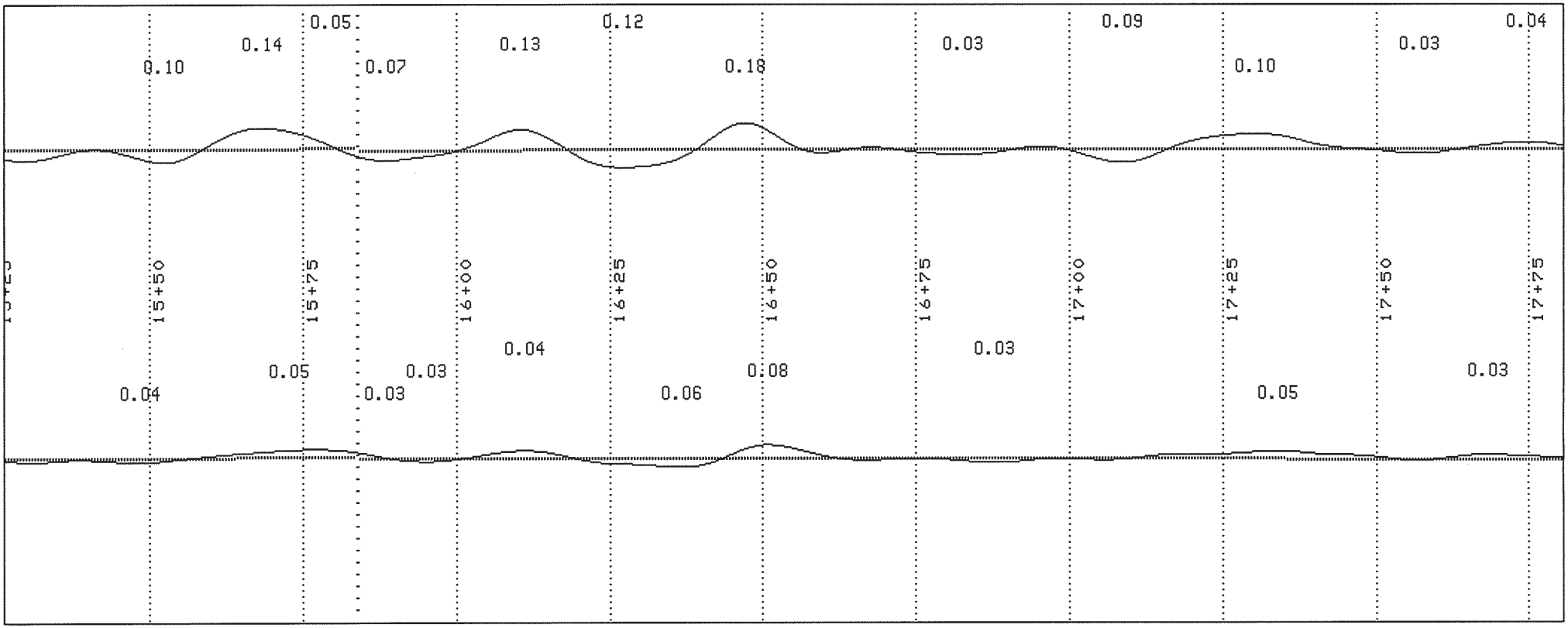
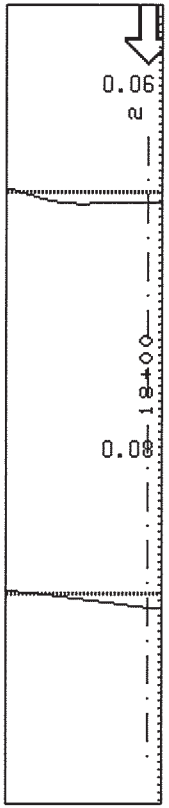
0.11
0.06
0.07
0.10
0.13
0.06
0.06
0.08
0.06
0.12
0.11
0.12
12+75
13+00
13+25
13+50
13+75
14+00
14+25
14+50
14+75
15+00
0.04
0.04
0.05
0.03
0.07
0.08
0.07
0.06
0.06
0.10
0.06



Beginning Station-> 10+56.0
Ending Station-> 15+84.0
Distance(ft.)-> 528.0
Scallop Sum Left (in.)-> 1.91
Scallop Sum Right (in.)-> 3.02
Profile Index Left (in./mile)-> 19.10
Profile Index Right (in./mile)-> 30.20
Average (in./mile)-> 24.65



Beginning Station-> 15+84.0
Ending Station-> 18+00.5
Distance(ft.)-> 216.5
Scallop Sum Left (in.)-> 0.43
Scallop Sum Right (in.)-> 0.85
Profile Index Left (in./mile)-> 10.49
Profile Index Right (in./mile)-> 20.73
Average (in./mile)-> 15.61

Beginning Station-> 10+56.0
Ending Station-> 18+00.5
Distance(ft.)-> 744.5
Scallop Sum Left (in.)-> 2.34
Scallop Sum Right (in.)-> 3.87
Profile Index Left (in./mile)-> 16.59
Profile Index Right (in./mile)-> 27.45
Average (in./mile)-> 22.02

Final Analysis
Beginning Station-> 0+00.0
Ending Station-> 18+00.5
Total Distance(ft.)-> 1800.5
Total Scallop Sum Left (in.)-> 9.04
Total Scallop Sum Right (in.)-> 13.19
Total PI 1 (in./mile)-> 26.51
Total PI 2 (in./mile)-> 38.68
Average PI (in./mile)-> 32.59

<- Bump/Dip Locations Track 1 ->

Type	From(ft.)	Peak	To	Height(in)

<- Bump/Dip Locations Track 2 ->

Type	From(ft.)	Peak	To	Height(in)
Bump	0+50.2	0+57.0	0+61.9	0.27
Dip	3+90.4	3+95.0	3+99.5	0.21
Bump	4+01.8	4+06.0	4+11.1	0.28
Dip	4+13.5	4+17.0	4+21.2	0.20
Bump	4+25.8	4+28.0	4+30.5	0.08
Dip	5+78.8	5+80.0	5+83.8	0.05
Bump	5+89.8	5+95.0	6+00.5	0.27
Dip	6+02.4	6+08.0	6+13.2	0.31
Bump	6+15.6	6+20.0	6+24.0	0.20
Bump	10+98.0	10+98.0	10+98.0	0.01

<- Event Summary ->

1. Start of Run Station: 0+00.0
Manual

2. End of Run Station: 18+00.5
Manual

<- CalPro Summary Track 1 ->

From(ft.)	To	Dist	Count	PI(in/mi)
0+00.0	5+28.0	528.0	4.00	40.00
5+28.0	10+56.0	528.0	2.70	27.00
10+56.0	15+84.0	528.0	1.91	19.10
15+84.0	18+00.5	216.5	0.43	10.49
10+56.0	18+00.5	744.5	2.34	16.60
Total		1800.5	9.04	26.51

<- CalPro Summary Track 2 ->

From(ft.)	To	Dist	Count	PI(in/mi)
0+00.0	5+28.0	528.0	5.68	56.80
5+28.0	10+56.0	528.0	3.64	36.40
10+56.0	15+84.0	528.0	3.02	30.20
15+84.0	18+00.5	216.5	0.85	20.73
10+56.0	18+00.5	744.5	3.87	27.45
Total		1800.5	13.19	38.68

<- CalPro Summary Average ->

From(ft.)	To	Dist	Count	PI(in/mi)
0+00.0	5+28.0	528.0	4.84	48.40
5+28.0	10+56.0	528.0	3.17	31.70
10+56.0	15+84.0	528.0	2.47	24.65
15+84.0	18+00.5	216.5	0.64	15.61
10+56.0	18+00.5	744.5	3.11	22.06
Total		1800.5	11.11	32.59