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DIVISION OF ENGINEERING SERVICES
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METHOD OF TEST FOR OPERATION OF CALIFORNIA HIGHWAY PROFILOGRAPH AND EVALUATION OF PROFILES

A. SCOPE

This test method describes the procedures for:

1. Operation and calibration of the profilograph.

2. Determining the profile index (PI) from a profile trace (called a "profilogram") of the pavement.

3. Locating individual high points in excess of 0.3 in.

B. EQUIPMENT

1. California Profilograph consists of a frame 25 ft in length supported upon wheels at both ends. The California Profilograph is fabricated with a truss structure for stability (Figure 1). Beams or other systems are not permitted.

   The profilograph records the roadway surface profile from the vertical movement of a wheel attached to the frame at mid-point (profile wheel) and is in reference to the mean elevation of the points of contact with the road surface established by the support wheels.

   The profilograph may use a mechanical or an electronic recording device.

2. Motive Power may be provided manually or by propulsion unit provided it can operate at the slow rate required and it does not adversely affect the operation or function of the profilograph in any manner. The propulsion unit must not be used to push the profilograph from behind.

3. Data Recording Devices:

   a. Mechanical recorder – collects data by measuring distance and bumps resulting from the vertical movement of the profile with a pen-recording device on a paper reel.

   b. Electronic recorder – collects data by means of a digital response resulting from the vertical movement of the profile wheel.

   Profilographs must accurately record both horizontal and vertical movement. Both must be able to produce a profilogram. The record of the roadway surface is recorded as follows:

   a. Mechanical recorder – on a scale of 1 in. = 25 ft longitudinally and 1 in. = 1 in. vertically (full scale).

b. Electronic recorder – records the data digitally and must be able to produce a hard copy profilogram on a scale of 1 in. = 25 ft longitudinally and 1 in. = 1 in. vertically (full scale).

C. OPERATION OF THE PROFILOGRAPH

The instructions for assembling the profilograph are contained in a booklet supplied for each unit by the manufacturer.

The profilograph should be moved at a speed no greater than a walk, approximately 2 to 3 mph, so as to eliminate as much bounce as possible. Higher speeds can result in a profilogram with excessive spikes (chatter) that is difficult to evaluate.

D. CALIBRATION AND REPEATABILITY OF THE PROFILOGRAPH

The profilograph must be calibrated both horizontally and vertically per the manufacturer's recommendations. These calibrations and the profilograph repeatability should be evaluated prior to use in the project, weekly during use, and at times the Engineer determines verification is necessary. Records of calibrations are a chart for the mechanical recorders or a printed document for the electronic recorders.

Vertical calibration is required after every profile wheel change and each reassembly of the profilograph. The air pressure of the profile wheel must be checked daily to make sure it is within the manufacturer's recommendation.

The following records must be produced and maintained with the profilograph and in the project records:

- Vertical and horizontal calibration following assembly and prior to use, weekly during use, and when rerun at the request of the Engineer or Contractor.

- Daily tire pressure checks and the associated calibration information if tire pressure changed beyond the manufacturer's recommendation.

1. Horizontal Calibration

   The horizontal calibration standard is a straight, flat roadway section at least 528 ft (0.1 mi) long measured accurately to within 1 ft (or 0.2 %) of the length. The roadway test section must be measured by a measuring tape or wheel.

   Horizontal calibration requires the following procedures:

   a. For mechanical profilographs, determine the scale factor by dividing the length of the test section, in feet, by the length of the recording on the chart, measured to the nearest 0.10 in. The resulting factor must be 25.0 ± 0.2 (or 0.8 %).

   b. For electronic profilographs, the distance measured digitally must be 528 ft ± 4.20 ft.

NOTE: The distance counts for a 628 ft segment should be approximately 119 counts per ft for 200 pulse encoders and 357 counts per ft for 600 pulse encoders.

2. Vertical Calibration

Vertical calibration requires the following procedures:

a. Use vertical deflection standards that are flat plates of known thickness or a single device with graduated thickness. The thickness of the initial plate or initial step of the graduated device must not exceed 1.0 in.

b. Place the profilograph on a flat, level area. Raise the profile wheel and place it on the initial plate or initial step of the graduated device. Ensure that the initial plate or graduated device is firmly seated. This will place the profile wheel on a flat surface and establish a baseline value from which to measure subsequent elevations. Mark the recorder pen elevation on the mechanical profilograph or record the elevation displayed on the electronic profilograph.

c. Raise the profile wheel again and insert another plate on top of the initial baseline plate or slide the graduated device to the next elevation. Ensure that the graduated device is firmly seated. Mark the recorder pen elevation on the mechanical profilograph or record the displayed elevation on the electronic profilograph. Perform this step for at least a 1 in. and 2 in. change in elevation from the initial elevation.

NOTE: Recorded elevations must be accurate to within 0.01 in. of the known thickness of the plates or graduations.

d. Reverse the process by removing the 2 individual plates 1 at a time or stepping down the graduated device and marking or recording the change in elevation after the removal of each successive plate.

e. The calibration is considered complete if the marking pen or recorded elevation returns to within ± 0.03 in. of the original starting position (i.e., the first position of the profile wheel on the initial plate or initial step of the graduated device).

f. Adjust chart deviations in excess of 0.03 in. according to the manufacturer's recommendations.

NOTE: Vertical encoder must have counts that fall within the range of 210 to 230 at 2 in. for automated profilographs.

3. Repeatability

The profilograph must be able to demonstrate acceptable repeatability. Acceptable repeatability is defined as "after 3 tests, the difference in the measured PI must not exceed a PI of 1 between any 2 tests."

The pavement surface used for the repeatability test must have a PI value of 15 or less.

In cases of dispute, all model test results must correlate to those generated by the Department's profilograph to within a PI of 1. The pavement surface used for the dispute resolution must have a PI value of 15 or less.

E. DETERMINATION OF THE PROFILE INDEX

"Profile Index" (PI) is defined as – inches per 0.1 mile in excess of a zero (null) blanking band.

"Zero (null) blanking band" is defined as – a reference line that balances the profile above and below it.

The PI can be determined from the data collected by a profilograph using mechanical or electronic recording devices. Both models must be able to create a profile trace (profilogram). The profilogram indicates the PI for the required distance as well as the location of all scallops.

1. Mechanical Profilograph

   The PI from the mechanically generated profile trace can be determined by using a scanning device or by a manual count.

   To determine the PI manually, use a plastic scale 1.70 in. × 21.12 in. representing a pavement length of 528 ft (0.1 mi) at a scale of 1 in. to 25 ft.

   In the center there is a horizontal line (reference line or zero blanking band). On either side of the reference line are scribed lines 0.1 in. apart and parallel to the zero blanking band. When the scale is located properly on the manually generated profile trace, these lines are used to measure deviations (or excursions) of the graph (trace) from the reference line. The deviations are called "scallop."

2. Electronic Profilograph

   A software program capable of generating a computerized profile trace must process the collected data. The computer software must be set with the following data filter settings.

   - Filter Type: 3rd Order Butterworth
   - Filter Length: 2.0 ft
   - Filter Grain: 1.00
   - Blanking Band: Zero
   - Bump Locator: On
   - Bump Checkbox: Check
   - Dip Checkbox: Check
   - Bottom Bump: Off

3. Method of Counting

   Place the plastic scale over the profile in such a way as to "balance" profile deviations above and below the reference line as much as possible. Scallops

above and below the zero blanking band should be approximately balanced (Figure 2).

The profile trace will move from a generally horizontal position when going around super elevated curves making it impossible to balance the deviations of the trace without shifting the scale. When such conditions occur, the profile should be broken into short sections and the zero blanking band repositioned on each section while counting (Figure 3).

Starting at the right end of the scale, measure and total the height of all the scallops appearing both above and below the zero blanking band, measuring each scallop to the nearest 0.05 in. Write this total on the profile sheet near the left end of the scale together with a small mark to align the scale when moving to the next section. Short portions of the profile line may project 0.03 in. or more, but unless they extend longitudinally for 2 ft (0.08 in. on the profilogram) or more, they are not included in the count. See Figure 2 for illustration of these special conditions.

When scallops occurring in the first 0.1 mi are totaled, slide the scale to the left, aligning the right end of the scale with the small mark previously made and proceed with the counting in the same manner. The last section counted may or may not be an even 0.1 mi. If not, its length should be scaled and the counts proportioned to an equivalent 0.1 mi section. For example, 9 counts in 0.07 mi = 12.9 or 13 per 0.1 mi.

4. Limitations of Count in 0.1 Mile Sections

When the specifications limit the amount of roughness in "any 0.1 mile section," the scale is moved along the profile and counts made at various locations to find those sections, if any, that do not conform to specifications. The limits are then noted on the profile and can be later located on the pavement preparatory to grinding.

5. Limits of Counts – Joints

When counting profiles, a day's paving is considered to include the last portion of the previous day's work which includes the daily joint. The last 15 to 30 ft of a day's paving cannot usually be obtained until the following day. In general, the paving contractor is responsible for the smoothness of joints if pavement is placed on both sides of the joint. On the other hand, the contractor is responsible only for the pavement placed by the same contractor if the work abuts a bridge or pavement placed under another contract. When approaching such joints, profilograph readings should be taken in conformance with current specifications.

F. DETERMINATION OF HIGH POINTS IN EXCESS OF 0.3 INCH

Use a plastic template having a line 1 in. long scribed on one face with a small hole or scribed mark at either end, or a slot 0.3 in. from and parallel to the scribed line (Figure 3). The 1 in. line corresponds to a horizontal distance of 25 ft on the pavement.

1. Locating High Points in Excess of 0.3 in.

   At each prominent peak or high point on the profile trace, place the template so that the small holes or scribe marks at each end of the scribed line intersect the profile trace to form a chord across the base of the peak or indicated bump. The line on the template need not be horizontal. With a sharp pencil draw a line using the narrow slot in the template as a guide. Any portion of the trace extending above this line will indicate the approximate length and height of the deviation in excess of 0.3 in.

   There may be instances where the distance between easily recognizable low points is less than 1 in. In such cases a shorter chord length must be used in aligning the scribed line on the template tangent to the trace at the low points.

   NOTE: It is the intent of this requirement that the baseline for measuring the height of bumps will be as near to 1 in. as possible, but will in no case exceed this value. When the distance between prominent low points is greater than 1 in., make the ends of the scribed line intersect the profile trace when the template is in a nearly horizontal position. Examples of the possible positions are shown in Figure 3.

G. HEALTH AND SAFETY

It is the responsibility of the user of this test method to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use. Prior to handling, testing or disposing of any materials, testers must be knowledgeable about safe laboratory practices, hazards and exposure, chemical procurement and storage, and personal protective apparel and equipment.

Caltrans Laboratory Safety Manual is available at:

http://www.dot.ca.gov/hq/esc/ctms/pdf/lab_safety_manual.pdf

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(California Test 526 contains 9 Pages)

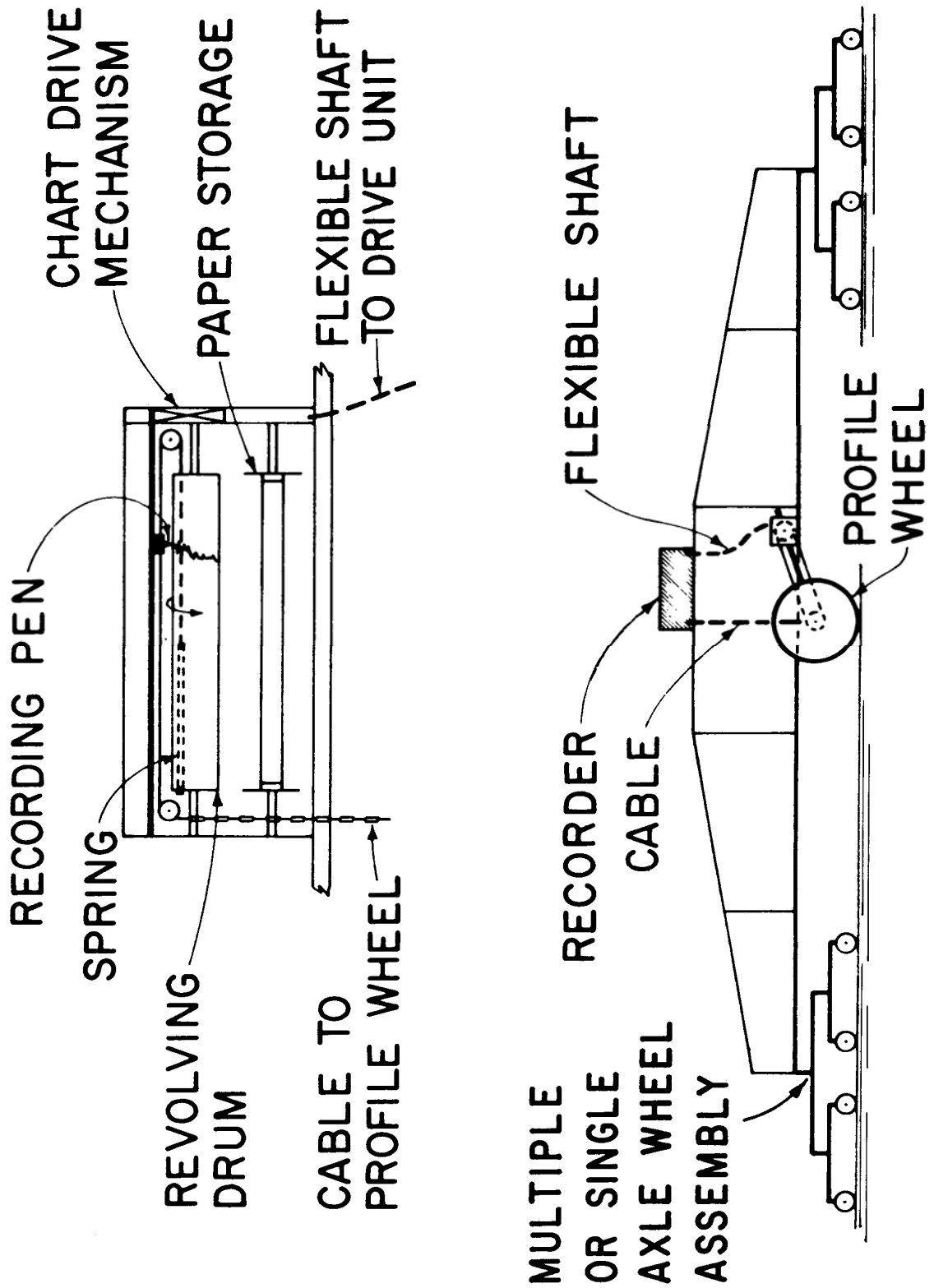
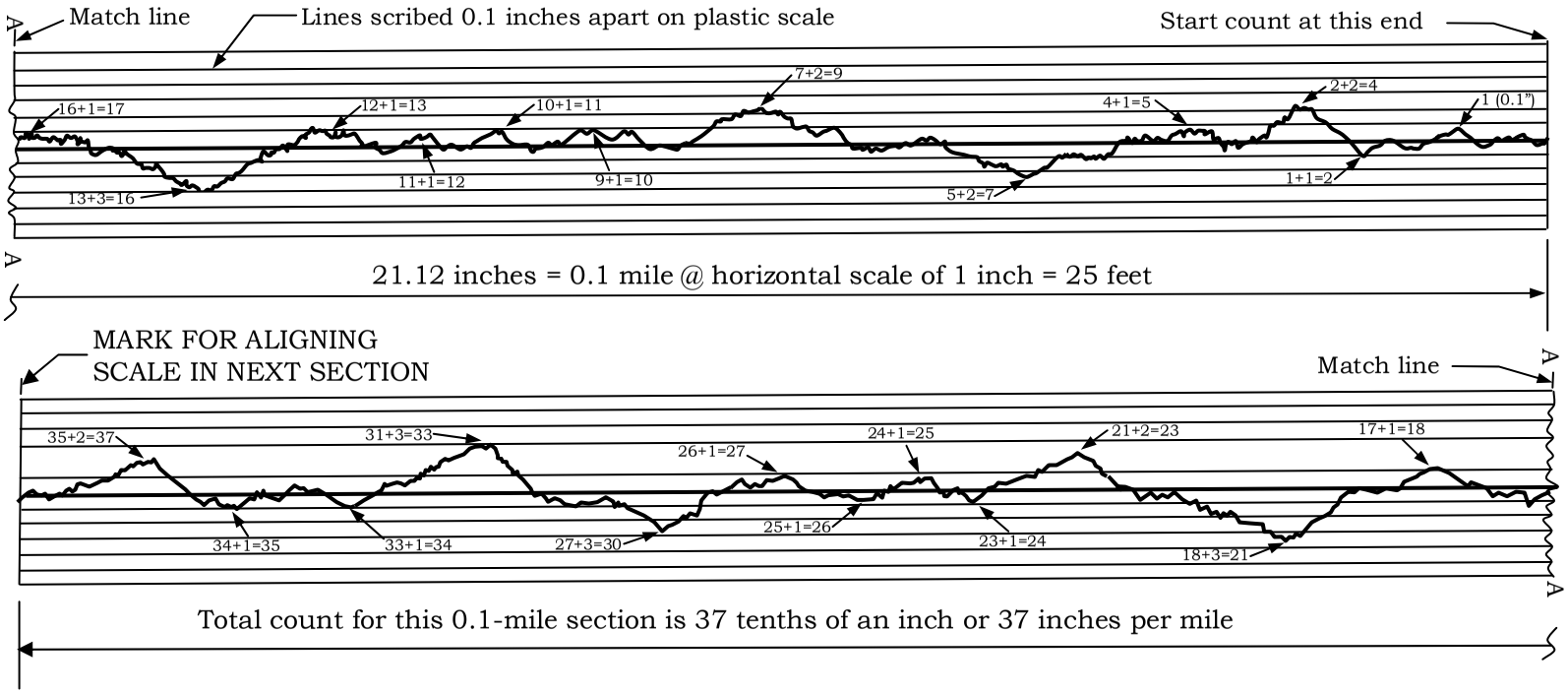


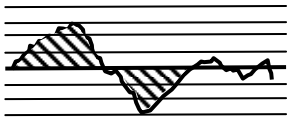
FIGURE 1. California Profilograph

EXAMPLE SHOWING METHOD OF DERIVING PROFILE INDEX FROM PROFILOGRAMS

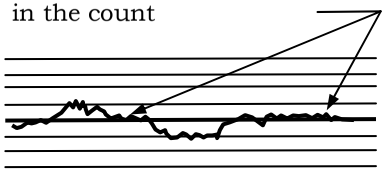


TYPICAL CONDITIONS

Scallops are areas enclosed by profile line and blanking band (Shown crosshatched in this sketch)

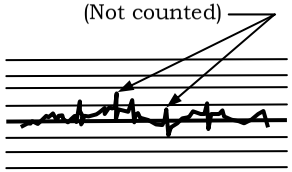


Small projections not included in the count

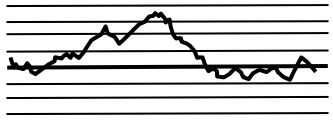


SPECIAL CONDITIONS

Rock or dirt on the pavement (Not counted)



Double peaked scallop (Only highest part counted)



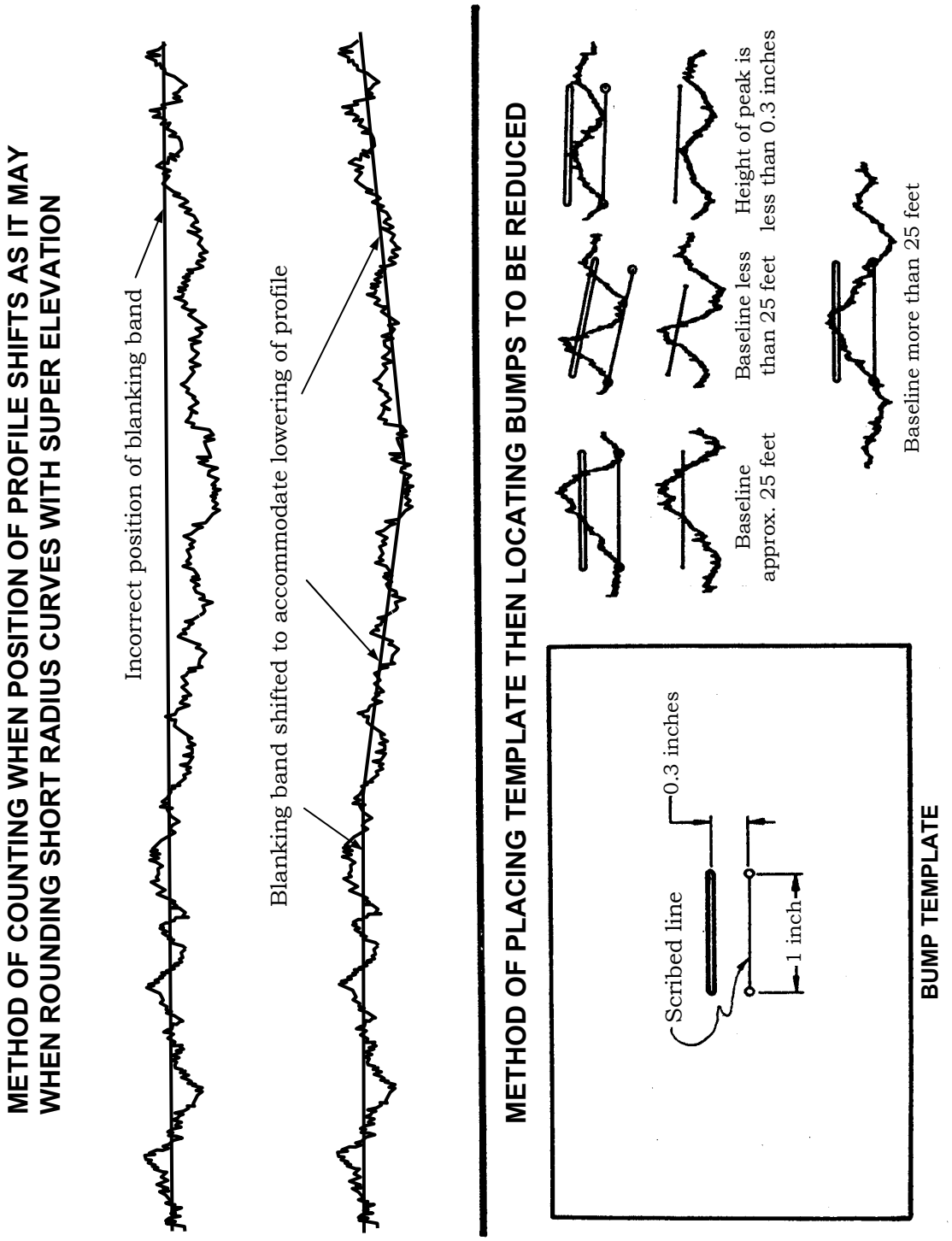


FIGURE 3. Special Conditions for Method of Counting