1. SCOPE

1.1 Description of Test

The profilograph is a "rolling straight-edge" that measures a pavement's longitudinal profile. As the unit is pushed along a roadway, it provides a trace of the road profile as well as locates, measures and records any bumps or depressions in the pavement surface onto a paper chart known as a profilogram.

1.2 Application of Test

The profilogram is used to calculate the smoothness of a road.

Smoothness is a Pay Adjustment consideration in the Department's Specification for Asphalt Concrete Pavements.

1.3 Units of Measure

The smoothness of a road is measured in terms of Profile Index and bump or depression magnitude.

1.3.1 Profile Index

The Profile Index, PrI, is the sum of the vertical deviations outside the null band (normally 5 mm), in millimetres, that a roadway deviates from a perfectly flat surface over a horizontal distance of 100 m.

The Profile Index measurement is conducted at 100 m intervals on the section to be tested. If the starting station is not on an even 100 m station e.g. 17+250, the next reading will be on an even 100 m e.g. 17+300 and so on. If the roadway or construction project is divided into a number of separate sections, each section will be profiled and analyzed independently.

1.3.2 Bump or Depression
The bump or depression magnitude is the vertical difference, in millimetres, measured over the length of the profilograph which is 7.6 m.

2. **APPARATUS AND MATERIALS**

2.1 **Equipment Required**

James Cox and Sons computerized profilograph Model No. CS 8200, transport and safety vehicle, electric generator and accessory equipment.

2.2 **Materials Required**

Surveyor's chain, spray paint or keel, data sheets (Profile Index Summary report form).

2.3 **Sample to be Tested**

A sublot as defined in the contract (normally 100 m of the finished surface, one lane width wide).

2.4 **Data Required**

The location of the sublot and location of an unacceptable area (bumps and dips) determined after measurement.

3. **PROCEDURE**

3.1 **Description of Equipment Preparation**

After a test section is identified, drive over the section and become familiar with the area. Note all curves, hills, and potentially unsafe areas.

Ensure that the current safety regulations are followed as outlined in the Traffic Control Devices Manual For Work Zones and the Safety Manual. This includes the correct placement of signs, the wearing of hard hats or high visibility hats, vests and overalls.
Carefully unload the profilograph sections, wheels and microcomputer. Assemble the profilograph as directed in Equipment Section. Set power switch to ON, as shown in Figure 1, and enter the following parameters.

The front panel display has a four line by 20 character liquid crystal display (LCD) with the top line providing the vertical position of the measuring wheel, the current operating mode, and the odometer. The second line shows the beginning and ending station for automatic measurement. The third line gives the document number and the pass number. The fourth line is selected with the up and down arrow buttons and can display any one of the 20 parameters listed below. The fourth line is also used to show the status of the PRINT and PRINT SUMMARY keys.

### PROFILOGRAPH PARAMETERS

- **1. ODOMETRE**: -3.7
- **2. BEGIN**: 15000.0

**FIGURE 1**

Date: 2001 10 31  
Page: 3 of 16
3   END                  21000.0
4   DOCUMENT #             0
5   PASS #                  690
6   ENCODER                -365
7   DOOM FACTOR             9910
8   NULL FILTER             80
9   DATA FILTER             8000
10  REDUCT LEN              100
11  BLANK WID                .50
12  BUMP HT                 .80
13  BUMP WID                  7.6
14  TIME                    16:55
15  DATE                   9/04/90
16  ROUTE                313000
17  PAVEMENT            4000028
18  DISTRICT          5 090052
19  BUMP LOCATOR             ON
20  BOTTM BUMPS            ON

(1) The ODOMETER field displays the odometer distance scaled in tenths of a meter. It can be entered manually but will reset to either the begin or end distance depending on the position of the DIRECTION switch when started in automatic mode.

(2) Enter the BEGIN station of the test section of pavement to be measured.

(3) Enter the END station of the section. Note that the end station must always be larger than the begin station.

(4) The DOCUMENT number is usually reset to 1 and will increment 1 number each time the button is used.

(5) The PASS number includes a two digit operator I.D. number preceding a single digit lift number.

(6) The ENCODER is the number of pulses received from the horizontal transducer and is used to calculate the odometer position. There is no need to change or reset this number.

(7) The ODOMETER FACTOR is used to calibrate the odometer and, depending on its value, sets the profilograph in metric or imperial units.
(8) The NULL FACTOR, will be set at 80, is only activated with the NULL BAND switch set to FILTERED, for sharp vertical curves or superelevation transitions. The switch is usually set to FIXED DISTANCE where the null band is set using a regression best fit line of the data output.

(9) The DATA FILTER, will be set at 8000, filters out texture and sharp movements of the testing wheel.

(10) The REDUCTION LENGTH is used to set the interval of the outputs in automatic mode. It is normally set at 100.0, but a zero setting will put the CS8200 in manual mode.

(11) The BLANK WIDTH is the width of the null band, usually .50 cm.

(12) The BUMP HEIGHT, usually .80 cm, is the height used for the bump and dip cutting template.

(13) The BUMP WIDTH, normally 7.6 m, determines the width of the template used to mark bumps and depressions.

(14) The TIME is a 24 hour clock that can be set and is backed with an internal battery for memory.

(15) The DATE, MM/DD/YY, is also retained in memory.

(16) The ROUTE is set to include Highway, Section, Sub-Section.

(17) The PAVEMENT parameter is used to identify the wheel path and/or offset from centreline.

(18) The DISTRICT provides space for storing identifying numbers. Normally the preservation area code and the contract number are used.

(19) The BUMP LOCATOR can be turned off if there is no desire to mark bumps over specified bump height.

(20) BOTTOM BUMPS, being similar to BUMP LOCATOR, marks depressions.

Press the START button at the station where you want to begin. A header with the description of the road being tested and the calibration factors will be printed, as shown in Figure 2.
3.2 Sample Preparation

Mark the begin location of the sublot to be tested with spray paint, keel or pylon.

3.3 Test Procedure

Push the profilograph in a straight line in the wheel path of the section to be tested at a speed no greater than a moderate walk.

To protect the operator from the dangers of traffic especially from behind, a safety vehicle complete with proper warning lights should follow the profilograph operation by a constant distance of approximately 50 metres.

3.4 Documenting Reference Points

Press the DOCUMENT POINT button whenever it is necessary to locate a reference point such as joints, culverts, approaches, kilometre markers and curves. A number will appear on the printout which locates the reference point. Be sure to write on the output what you wanted to reference. The document point number automatically increases by one after each use and can not be changed during a run.

3.5 Omitting Bridges
This feature can be used to omit recording of the profilogram of a bridge or other non-measurement section when running in the AUTO PRINT mode.

Allow the printer to stop printing if there is a report in progress. The bridge feature will not function until the report is finished.

Push the BRIDGE button when the front wheels reach the beginning of the section to be omitted. This will cause the STOP LCD to be illuminated; a report will be printed. Do not pick up the measurement wheel. Push the profilograph across the section that is to be omitted.

Stop at the end of the section.

Allow the printer to stop printing if there is a report in progress.

Push the START button. The START LCD will be illuminated and measuring will continue. No header report will be written. The bridge feature results in a profilogram without the omitted section. Reports will start and end at normal 100 m intervals. There will be an additional report for the first part of the section that was interrupted and another for the section in which the bridge ended. The odometer will have the same reading as if the BRIDGE button had not been pushed.

At the completion of the section, press STOP and then PRINT SUMMARY buttons and a summary of the PrI per 0.1 km will be printed, as shown in Figure 3.

Turn the profilograph off, disassemble and load the profilograph.
FIGURE 3
PrI measurements when the starting/end station is on an even 100 m

<table>
<thead>
<tr>
<th>From</th>
<th>To</th>
<th>Distance (m)</th>
<th>PrI (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1+600</td>
<td>1+500</td>
<td>100</td>
<td>15</td>
</tr>
<tr>
<td>1+500</td>
<td>1+400</td>
<td>100</td>
<td>13</td>
</tr>
<tr>
<td>1+400</td>
<td>1+300</td>
<td>100</td>
<td>14</td>
</tr>
<tr>
<td>1+300</td>
<td>1+200</td>
<td>100</td>
<td>8</td>
</tr>
<tr>
<td>1+200</td>
<td>1+100</td>
<td>100</td>
<td>13</td>
</tr>
<tr>
<td>1+100</td>
<td>1+000</td>
<td>100</td>
<td>18</td>
</tr>
<tr>
<td>1+000</td>
<td>0+900</td>
<td>100</td>
<td>3</td>
</tr>
<tr>
<td>0+900</td>
<td>0+800</td>
<td>100</td>
<td>8</td>
</tr>
<tr>
<td>0+800</td>
<td>0+700</td>
<td>100</td>
<td>18</td>
</tr>
<tr>
<td>0+700</td>
<td>0+600</td>
<td>100</td>
<td>3</td>
</tr>
<tr>
<td>0+600</td>
<td>0+500</td>
<td>100</td>
<td>5</td>
</tr>
<tr>
<td>0+500</td>
<td>0+400</td>
<td>100</td>
<td>15</td>
</tr>
<tr>
<td>0+400</td>
<td>0+300</td>
<td>100</td>
<td>6</td>
</tr>
<tr>
<td>0+300</td>
<td>0+200</td>
<td>100</td>
<td>12</td>
</tr>
<tr>
<td>0+200</td>
<td>0+100</td>
<td>100</td>
<td>7</td>
</tr>
<tr>
<td>0+100</td>
<td>0+000</td>
<td>100</td>
<td>10</td>
</tr>
</tbody>
</table>

PrI measurements when the starting/end station is not on an even 100 m

<table>
<thead>
<tr>
<th>From</th>
<th>To</th>
<th>Distance (m)</th>
<th>PrI (mm)</th>
<th>Manually prorated PrI value over 100 meter</th>
</tr>
</thead>
<tbody>
<tr>
<td>1+625</td>
<td>1+600</td>
<td>25</td>
<td>8</td>
<td>32 (8x100/25)</td>
</tr>
<tr>
<td>1+600</td>
<td>1+500</td>
<td>100</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>1+500</td>
<td>1+400</td>
<td>100</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>1+400</td>
<td>1+350</td>
<td>50</td>
<td>10</td>
<td></td>
</tr>
</tbody>
</table>
4. RESULTS AND CALCULATIONS

4.1 Collection of Test Results

Remove the profilograms of that section from the machine and properly describe and label the roll.

4.2 Calculations
The Profile Index is normally measured in the approximate OWP, in millimetres per 0.1 km in excess of 5 mm blanking band. The Department has the option of testing anywhere within the driving lanes. The procedure for determining the profile index is as follows:

All bumps and dips on the profilograph should be checked with the bump template. An example of how the BUMP LOCATOR will indicate a bump is shown in Figure 5.

4.3 Reporting Results

Report test results on Profile Index Summary report form as shown in Figure 6.
### SASKATCHEWAN HIGHWAYS AND TRANSPORTATION

**PROFILE INDEX SUMMARY REPORT**

**CONTRACT NO.** ____________ **CONTROL SECTION** ____________ **DIRECTION** ________

**LANE** ________ **LOCATION** ____________ **TO** ________ **CONTRACTOR** ________

**INITIAL TEST** ________ **RECHECK TEST** ________ **DATE TESTED** ________

<table>
<thead>
<tr>
<th>Wheel Path</th>
<th>Lift</th>
<th>Location 0.1 km Start --&gt; End</th>
<th>Ride Index</th>
<th>Bump mm</th>
<th>Size &gt; 8mm and Sta mm</th>
<th>Sta</th>
</tr>
</thead>
</table>

**Operator:** ____________ **COX-8200:** __________________ **Date:** ____________ **Time:** ____________

**Received Results:** __________________ **Date:** ____________ **Time:** ____________

(Contractor’s Signature) __________________ **Date:** ____________ **Time:** ____________

Form EPS91

FIGURE 6

### 5. **CALIBRATIONS, CORRECTIONS, REPEATABILITY**

#### 5.1 **Equipment Calibration**
The accuracy of the profilograph should be checked when the profilogram results are in doubt.

5.1.1 Odometer (Horizontal) Calibration

Before calibrating:

a) Ensure the tire pressure is between 275 and 310 kPa (40-45 psi)

b) Check the profile wheel for roundness

Choose a paved stretch of road (or parking lot), 100 m in length. Ensure the test section is relatively flat with good visibility for oncoming traffic from both directions.

Ensure that current safety regulations are followed. This includes the correct placement of signs and the wearing of hard hats, vests and overalls.

Use spray paint or keel to mark the starting point on the pavement. Place a pylon beside the mark as a reference while chaining.

Mark the end point with spray paint or keel and place a pylon beside the mark.

Carefully unload the profilograph sections, wheels and microcomputer.

Assemble the profilograph as directed in Equipment Section.

Set the POWER SWITCH to ON, as shown in Figure 1.

Enter DIAGNOSTICS mode by holding down F1 while activating the RESET switch. Note that "DIAGNOSTICS MODE" will be displayed on the display.

Lower the recording wheel and slowly guide the profilograph so that the profile wheel is even with the starting point. To protect the operator from the dangers of traffic especially from behind, a safety vehicle complete with proper warning lights should follow the profilograph operation by a constant distance of approximately 50 metres.

Note: the recording wheel must be in the up position when the assembled profilograph is manoeuvring (making a sharp turn).
Press the START button and the encoder count will go to zero and run will be displayed on top line.

Push the profilograph to the end of the measured distance (100 m).

Push the STOP button. The bottom line of the display will freeze, STOP will be displayed on the top line and the cursor will start to flash on the bottom line.

If you desire to use this calibration to update the odometer factor, press ENTER. If not, press CLEAR. If ENTER is pressed, the value displayed on the fourth line will be stored into ODOM FACTOR and a short report will be printed documenting the date and the old and new factors. KEEP A RECORD OF THE ODOM FACTOR. If CLEAR is pressed, the cursor will stop flashing and line four will go back to normal operation.

Note: The ENCODER COUNT should be 9643 + 10% for a 100 m distance. If the count is outside the limits, there is probably an equipment malfunction.

The chainage has to match the highway’s chainage within +/- 1%, otherwise the unit must be recalibrated.

5.1.2 Vertical Calibration

The vertical calibration has been programmed into the microcomputer at the factory, and should not change. When in doubt, run the profilograph wheel over the vertical calibration block supplied with unit. Compare each measured result on the profilograph to the corresponding block thickness. If they are not the same, contact Testing Services at 1610 Park St. in Regina, phone 787-4914 for assistance.

Note: The DATA FILTER must be changed to 65535 to check the vertical calibration.

5.1.3 Front Panel Diagnostic Check

The front panel diagnostic check is performed once a month or whenever it is necessary to check the front panel buttons, switches and displays.

1. Enter DIAGNOSTICS mode by holding down F1 while activating the RESET switch.

2. Press any numeric key.
In response to this, the bottom line of the display should display three fields. The first will be either FIX or FILT depending upon the position of the NULL BAND switch. The second field will be either + or - depending upon the position of the DIRECTION switch. The third field will be blank until a keypad is pressed. When a pad is pressed, its number will be displayed in this third field. See Figure 7 for the numeric codes of the keys.

5.2 Tolerances and Repeatability

Repeatability is achieved by re-testing the sublot.

5.3 Equipment Care and Maintenance

The microcomputer unit has to be protected from moisture so that the electronics are not damaged.

Ensure that the microcomputer and generator are placed into their storage boxes after use. This will protect the equipment from damage during transport.

Regular maintenance must be maintained.
FIGURE 7

DIAGNOSTIC CODES
6. ADDED INFORMATION

6.1 References


2. TESTING MANUAL Vol. II, State of California, Business and Transportation Agency, Department of Transportation, Transportation Laboratory, 1978


4. A STUDY OF CONSTRUCTION EQUIPMENT AND INITIAL PAVEMENT ROUGHNESS AS MEASURED WITH A PROFILOGRAPH, Texas Highway Department, Departmental Research, Report #49-2

5. CONSTRUCTION CONTROL PROFILOGRAPH PRINCIPLES, Texas Highway Department, Departmental Research, Report #49-1

6. ASTM Designation E 1274-88, "STANDARD TEST METHOD FOR MEASURING PAVEMENT ROUGHNESS USING A PROFILOGRAPH"

6.2 Safety

Ensure all safety regulations are followed as outlined in the Traffic Control Devices Manual for work Zones and the Safety Manual. This includes the correct placement of signs and the wearing of hard hats, vests and overalls.

To protect the operator from the dangers of traffic especially from behind, a safety vehicle complete with proper warning lights must follow the profilograph operation by constant distance of approximately 50 metres.