



Standard Test Procedures Manual

Section: ASPHALT MIXES

Subject: ASPHALT CONTENT BY NUCLEAR GAUGE

1. SCOPE

1.1. Description of Test

The method described is a procedure to determine the asphalt content of asphalt-aggregate mixtures using nuclear devices.

1.2. Application of Test

The asphalt content of asphalt-aggregate mixtures as determined by the described test method, is used for product acceptance, quality assurance, process quality control and research activities.

1.3. Units of Measure

The final asphalt content is reported as a percent by dry weight of aggregate corrected for the moisture content.

2. APPARATUS AND MATERIALS

2.1. Equipment Required

Campbell Pacific AC-2 nuclear asphalt content gauge.
Standard volume compactor (see Figure 1).
Laboratory oven/stove, 150°C oven capacity.
Laboratory balance, 16 kg capacity & 0.1 g accuracy.
Laboratory thermometer, 250°C capacity and 1°C accuracy.

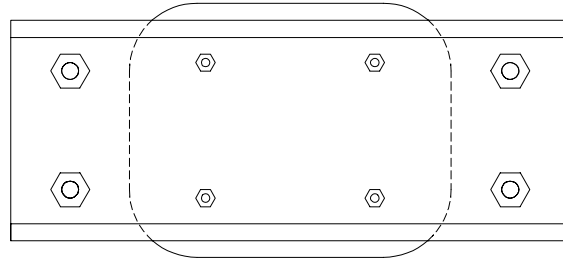
** 1 or more large mixing bowls/pans.

Smalltrowel.
Scoop.
Oven gloves.

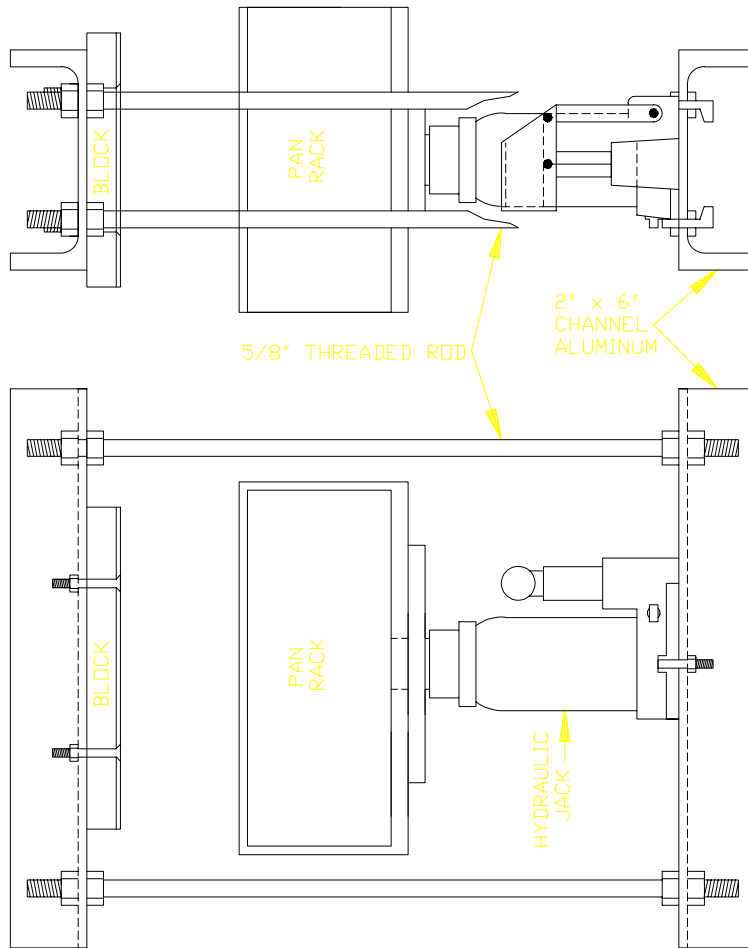
*The CP AC-2 reference manual should be reviewed prior to proceeding with calibration or testing.

**Mixing bowls/pans are required for calibration testing only.

FIGURE 1



TOP VIEW



SIDE VIEW

FRONT VIEW

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2.2. Materials Required

2.2.1. Materials Required for Calibration

The following materials are required for calibration:

2 L of the same asphalt type that is to be used in the project. For emulsions, the calibration samples should also be from the same supplier.

30 kg representative sample of the blended aggregate that is to be used in the project.

Aggregate samples will be collected in accordance with STP 105 - SAMPLING FINE AND COARSE AGGREGATES.

For conventional asphalt plants, use aggregate that has been through the dryer but has no asphalt added.

For road mix or drum mix plants, use materials from the aggregate source.

2.2.2. Materials Required for Test Procedure

The following material is required for testing:

10 kg representative sample of asphalt-aggregate mixture (increase to 20 kg if quality assurance testing (check test) is to be completed).

Asphalt-aggregate mix samples will be collected in accordance with STP 103 - SAMPLING ASPHALT MIXES. Contrary to STP 103, samples are not to be taken from the roadway after compaction.

2.3. Calibration/Test Data Required

See calibration data requirements on Form MR-60: Nuclear Asphalt Content Gauge Calibration Form.

See test data requirements on Forms MR-70 or EPS70: Quality Control Testing Form.

3. PROCEDURE

3.1. Equipment Preparation

Tare the gauge sample pans if a zero reset is not available on the laboratory balance.

3.2. Sample Preparation

3.2.1. Sample Preparation for Correlation

Oven dry the aggregate samples at 110 °C for several hours(or overnight) to drive off the moisture.

Heat the aggregate to the desired mixing temperature just prior to the mixing of the asphalt and aggregate samples. The desired mixing temperature should be close to, but lower than, the anticipated asphalt-aggregate mix discharge temperature of the plant. Refer to the appropriate SHT Standard Specification for the specified plant discharge temperatures.

Heat the asphalt cement to the desired mixing temperature just prior to the mixing of the asphalt and aggregate samples. The desired mixing temperature should be close to, but lower than, the anticipated asphalt-aggregate mix discharge temperature of the plant. Refer to the appropriate SHT Standard Specification for the specified plant discharge temperatures.

Cutbacks and emulsions are not to be heated prior to the mixing of the asphalt and aggregate samples. The desired mixing temperature for cutbacks and emulsions should be sufficiently below the plant discharge temperature to ensure that heating of the field test samples is not required to obtain the same temperature as that of the calibration samples.

NOTE: The desired mixing temperature should never exceed 150°C as asphalt-aggregate mix temperatures above this may damage the circuitry of the nuclear gauge.

3.2.2. Sample Preparation for Testing Procedure

The asphalt-aggregate mix temperature must be within $\pm 5^{\circ}\text{C}$ of the same temperature as the calibration samples, so heating or cooling may be required. Cutback or emulsion mixes are not to be reheated as reheating will drive off the cutter/moisture still contained in the mix.

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3.3. Equipment Calibration

The CP AC-2 gauge must be calibrated for each asphalt-aggregate mixture to be tested, to obtain accurate and meaningful test results. The calibration process to be used is outlined in the following steps:

Step 1 - Set CP AC - 2 for Calibration

Step 1.1 Standard Count

A standard count should be completed prior to every calibration unless several calibrations are being done on the same day. A standard count is also to be completed every day or after each time the gauge is moved or its surroundings are changed. This process will take about 17 minutes. Ensure the test chamber is completely empty. To complete a standard count, press STD, STEP until the term "NEW STD?" is displayed and then ENTER. When the standard count has been completed the gauge will beep twice and display the current standard count. Once the standard count has been displayed the Chi Ratio must be checked to ensure that it is acceptable. To do this, press ENTER twice and the term "CHI _." should be displayed.

If the number displayed is ≥ 0.75 and ≤ 1.25 , press ENTER or CLEAR. If the number displayed is < 0.75 or > 1.25 , the Chi Ratio obtained is unacceptable and the standard count must be repeated to obtain an acceptable Chi Ratio. If the second Chi Ratio is also outside the specified limits but is outside the opposite limit to which it was previously outside, repeat the standard count until an acceptable Chi Ratio is obtained. If two successive Chi Ratios are obtained which are both < 0.75 or > 1.25 , the gauge has internal circuitry problems and will require repair by the manufacturer.

NOTE: Unacceptable Chi Ratios may also be obtained if the gauge test chamber is not completely empty or clean while completing each standard count.

Step 1.2 Calibration Number

Forty Eight (48) calibration curves may be stored in the CP AC-2. To set the calibration curve number, press CALIB, ENTER, the calibration curve number assigned (1-48), ENTER and then STEP. The term "SELF CAL" should appear.

Step 1.3 Count Time

The count time for calibration is to be set at 16 minutes. With the term "SELF CAL" displayed, press ENTER and then STEP until the term "TIME 16" is displayed. Press ENTER. The term "P1 0.0" should be displayed. The gauge is now ready to measure and store calibration data.

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Step 2 - Asphalt-Aggregate Mix Calibrations

Prepare a test sample containing the design asphalt content of the asphalt-aggregate mixture to be tested. Mix thoroughly while heating to the desired mixing temperature.

Avoiding segregation, fill the CP AC-2 sample pan with $5.5 \text{ kg} \pm 1 \text{ g}$ of material. Place the sample and container in the standard volume compactor and compact the material until the pan rack contacts the top channel or the material will not compact any further with the hydraulic jack.

Place the prepared sample in the CP AC-2 test chamber. With the term "P1 0.0" displayed, enter the asphalt content of the sample and press ENTER to store this data. The term "C1 0.0" should be displayed. Press START to begin the count. The gauge will beep twice and the count will be displayed once it is completed. For example, the following count may be displayed: "C1 18021". C1 refers to the first correlation point and 18021 refers to the actual count for the sample in units of CPM. Once the count has been completed and displayed for the sample, record the data and press ENTER to store the count data. The term "NEW PAN?" should be displayed. Press ENTER and the term "P2 0.0" should be displayed. The unit is now ready to measure and store calibration data for the second sample.

Prepare a minimum of two additional samples of asphalt-aggregate mix and repeat the process previously described in this step. The two samples should contain asphalt contents of approximately $\pm 1\%$ from the design asphalt content. If time allows, it is preferable to prepare several calibration samples at different asphalt contents around the design asphalt content.

Upon storing the last correlation count and with the term "NEW PAN?" displayed, press STEP. The term "DATA OK" should be displayed. Press ENTER. The term "COMPUTE" will be displayed until the regression coefficient is calculated and displayed. A regression coefficient ≥ 0.995 and ≤ 1.000 must be obtained to proceed with any testing of asphalt-aggregate mix samples. If an acceptable regression coefficient is not obtained, repeat the calibration process or make a new calibration curve by testing one new calibration sample and manually entering the old calibration data (asphalt contents and gauge counts). Asphalt contents and gauge counts which appear to be incorrect should not be re-entered. The calibration data may be manually entered by repeating Steps 1.2 and 1.3. When the term "P1 0.0" is displayed, enter the asphalt content of the sample and press ENTER to store this data. The term "C1 0.0" should be displayed. Enter the count time previously obtained and press ENTER to store the count data. The term "P2 0.0" should now be displayed. Repeat this process for each set of asphalt contents and gauge counts to be manually entered.

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Once an acceptable regression coefficient has been obtained, the calibration coefficients can be obtained and recorded. Obtain the calibration coefficient A, by pressing ENTER. Obtain the calibration coefficient B, by pressing ENTER. Obtain the calibration coefficient C, by pressing ENTER. Press ENTER and CLEAR to return to the "READY" mode.

For cutback and emulsion mixes only, the mixing procedure needs to be slightly changed to account for the cutter/moisture which is lost during heating and mixing. Therefore, slightly more emulsion/cutback (recommend +0.5% cutback or 2% emulsion) are required to be added to the calibration sample. For example, if mix requires 4.5% asphalt, mix samples should be prepared by adding 5.0% cutback or 7% emulsion. For cutback mixes, 1.5% water should also be added to the calibration mix samples to simulate the aggregate moisture conditions found in the field. Prior to mixing the cutback/emulsion with the aggregate, weigh the sample pan, aggregate and trowel together. Add the weight of the emulsion/cutback asphalt to this number to arrive at a combined weight before mixing. After the sample has been heated and mixed, reweigh the sample pan, asphalt-aggregate mixture and trowel. Calculate the actual cutback/emulsion asphalt weight and content by using the differences in these total weights. This will give a true asphalt content uncorrected (uncorrected asphalt content includes residual asphalt and H₂O/cutter). To obtain the asphalt content(residual asphalt), a moisture sample must be tested as per STP 204-1 - MOISTURE TEST BY OVEN DRYING.

3.4. Test Procedure

Step 1. Check/Set Gauge Display/Output of CP AC-2

The display/output of the gauge may be in either %AC or CPM(counts per minute). Ensure the output/display is set to %AC. This can be checked by pressing UNIT. If the term "%AC" is displayed, press ENTER or CLEAR and proceed to Step 2. If the term "CPM" is displayed, press STEP and then ENTER. The display/output of the gauge will now be in percent asphalt.

Step 2. Check/Set Gauge Count Time

The count time of the gauge should be checked by pressing TIME. If the desired count time is not displayed, press STEP until it is displayed. Press ENTER. The recommended count time is 16 minutes.

Step 3. Check/Set Calibration Reference

As up to 48 calibrations may be stored within a gauge, one must ensure that the correct calibration is being used. The current calibration may be checked by pressing CALIB. If the displayed calibration number is not correct, press ENTER and key in the desired calibration number. Press ENTER. Press STEP to ensure the correct calibration data and

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coefficients are currently stored under the calibration desired. The term "SELF CAL" should appear. Press STEP to view or change the calibration coefficients A, B and C. Each coefficient may be viewed by pressing ENTER. Each coefficient may also be changed by manually entering a value when it is viewed.

Step 4. Measurement of Asphalt Content

Place and compact a sample of asphalt-aggregate mixture in the CP AC-2 sample pan as described in Section 3.3-Step 2. The sample mass, temperature and preparation procedure used, are to be the same as that used in the calibration process (Section 3.3-Step 2). The test sample mass is to be within ± 1 g of the calibration sample mass.

Place the sample in the CP AC-2 test chamber and take the reading by pressing START. Once the count has been completed the gauge will beep twice and display the uncorrected asphalt content. To return to the "READY" mode press ENTER.

The asphalt content obtained will be uncorrected because the nuclear gauge will read any moisture/cutter present as asphalt. To obtain the asphalt content(residual), a moisture sample must be tested as per STP 204-1: MOISTURE TEST BY OVEN DRYING and the moisture/cutter content subtracted from the uncorrected asphalt content.

3.5. Quality Assurance Testing

Quality assurance testing should be completed to minimize errors. A minimum of two companion samples per week should be tested for asphalt content using STP 204-2: ASPHALT CONTENT BY CENTRIFUGE EXTRACTION. The size of the asphalt-aggregate samples taken, must be increased to account for a field and/or district lab extraction test.

4. RESULTS AND CALCULATIONS

4.1. Collection of Test Results

The following test results are to be collected:

Moisture Content of the asphalt-aggregate mix as determined by STP 204-1 - MOISTURE CONTENT BY OVEN DRYING.

See reporting results described in Section 4.3.

4.2. Calculations

$$\text{Uncorrected Asphalt Content (\%)} = \frac{\text{Wt. Asphalt Mix} - \text{Wt. Dry Agg}}{\text{Wt. of Dry Aggregate}} \times 100$$

Asphalt Content(%) = Uncorrected Asphalt Content(%) - Moisture Content(%)
(Residual)

4.3. Reporting Results

Report calibration information on Form MR-60: Nuclear Asphalt Content Gauge Calibration Form.

Report the percent moisture and percent asphalt on Form MR-70 or EPS70: Quality Control Testing Form.

Asphalt Content (%) = Uncorrected Asphalt Content (%) - Moisture Content
(Residual)

5. EQUIPMENT PRECISION, TEST REPEATABILITY AND SOURCES OF ERROR

5.1. Precision of Gauges

CP AC-2 Precision:

Count time	Precision(%Asphalt)
0.5	+0.113
1	+0.080
2	+0.057
4	+0.040
8	+0.028
16	+0.020

5.2. Sources of Error

The asphalt-aggregate mix samples are not representative of the materials being produced.

The asphalt-aggregate test samples are not compacted to the same density as the calibration samples.

The calibration samples are not composed of the same asphalt and/or aggregate as that of the mixture being tested.

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Items/people which are in close proximity or on top of the gauge may effect the counting process. Take a standard count any time the surrounding conditions have changed. After the standard count has been taken, do not change the surrounding conditions. While a standard, test or calibration count is being taken, operating personnel should step at least 1 m away from the gauge.

Errors can occur if a constant moisture content/correction is assumed and there are variations in the moisture content of the asphalt-aggregate mixture being tested/produced.

Heating of emulsion and cutback asphalt-aggregate test samples can increase errors if the water/cutter is driven off and not accounted for.

Errors are increased if the counting time is reduced for calibration or testing.

Errors are increased with fewer calibration counts. A minimum of three calibration counts are required.

For best accuracy, the three calibration samples should be composed of the design asphalt content and $\pm 1\%$.

Errors can occur if the sample pans become dented after calibration or if sample pans of a different style or size are used during the calibration and testing.

Errors are increased if standard counts are not completed when required. A standard count is to be completed prior to every calibration unless several calibrations are being done on the same day. A standard count is also to be completed every day and after each time the gauge is moved or it's surroundings are changed.

Errors will result if the gauge test chamber is not completely empty or clean while completing each standard count.

Asphalt/moisture has a tendency to accumulate/condense on the detector surface. To reduce errors, ensure all chamber surfaces are clean prior to every standard, calibration or test count.

6. ADDITIONAL INFORMATION

6.1. General Safety

While a standard, test or calibration count is being taken, operating personnel should step at least 1 m away from the gauge.

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Do not set hands inside the test chamber unless necessary, and when required, only for as short a time as possible.

Use a long (200 mm) handle brush to clean the test chamber.

The Director of Geotechnical and Materials Branch or designate has the overall responsibility and authority for safety regulations regarding the nuclear gauges. This includes updating the licenses.

The District Materials Engineer or designate has the responsibility and authority for ensuring that these regulations are followed for the gauges within their district.

Only authorized personnel are to operate or handle nuclear gauges.

When not in use, gauges are to be padlocked and if the period is longer than 1 week the gauge should be padlocked and placed inside the locked carrying case.

Radiation hazard markings on the gauge and carrying case are to be kept clean and visible at all times. Vehicles used for transportation will be clearly marked on all 4 sides using the magnetic signs provided in the carrying case. The signs will be removed from the vehicle when the gauge is elsewhere. Field laboratories will be signed in a manner similar to vehicles transporting gauges.

The gauge is not to be dismantled for any reason without prior instruction from the District Materials Engineer. At no times should the source be removed from the gauge.

During long term storage or charging of the batteries, keep the gauge in an isolated area marked with radiation hazard signs.

The gauge is always on as far as radiation is concerned. The switch only controls the electronic readout and even the electronics remain on at all times.

Exposure depends on time; therefore complete your work as quickly as possible.

Radiation decreases as the square of distance; by doubling the distance, you get one quarter the amount of radiation. There is no need for the operator to hover over the gauge during the test.

Always transport the gauge in it's shipping case in the vehicle trunk, truck box or field laboratory.

Personnel are required to wear film badges when operating or handling the nuclear gauges.

6.2. Emergency Procedures

6.2.1. Moderate Damage

If the gauge is superficially damaged, dented, flooded, or otherwise injured from a drop, minor run over, etc. but the enclosure is in one piece with a minor break or two in the sheet metal or casting and the source location is not torn apart:

- 1) Do not walk through the site material where the gauge was pushed or pulled. Turn the gauge to view the source area, if necessary. Examine the gauge with care at ARM's length to ensure that there is no damage to the source casing and mounting. Do not touch the source casing. Keep hands at least 15 cm away from the source casing.
- 2) If the source casing and mounting is intact, place the gauge in its shipping case in the best way possible and transport to its usual overnight storage area.
- 3) Keep everyone at least 3 m from the gauge as much as possible. Use gloves to pick up the damaged unit or any part of the damaged unit and place any loose pieces in a container, preferably inside a plastic bag. After handling, place the gloves inside the bag and close it. If you must leave the area, have someone guard the area in order to discourage entry.
- 4) Call the Central Lab in Regina at (306) 787-4914 for further instructions. If no one can be reached at the Central Lab number, call the RADIATION SAFETY OFFICER (RSO) at (306) 787-4838 or (306) 787-4486. If the RSO cannot be reached, call the Atomic Energy Control Board (AECB) in Ottawa at (613) 995-0479 to provide further assistance. The AECB must be contacted within 24 hours.

6.2.2. Major Damage

If the gauge is broken apart, severely burned, severely crushed with parts strewn around or the source area is visually damaged:

- 1) Do not walk in the area and do not touch or move the gauge.
- 2) Freeze the site. Rope off the damage site for 3 m around the gauge and any loose pieces. Stop all vehicles which could have

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collided with the gauge or which could have picked up radiation on its tires, cleats or tracks. Call the RCMP at the closest location if traffic control is required.

- 3) Call the Central Lab in Regina at (306) 787-4914 for further instructions. If no one can be reached at the Central Lab number, call the RADIATION SAFETY OFFICER (RSO) at (306) 787-4838 or (306) 787-4486. If the RSO cannot be reached, call the Atomic Energy Control Board (AECB) in Ottawa at (613) 995-0479 to provide further assistance. The AECB must be contacted within 24 hours.

6.2.3. Lost or Stolen Gauges

Notify the RCMP at the closest location. Notify the Central Lab in Regina at (306)787-4914.

6.3. Maintenance of Nuclear Gauges

Radiation leak tests will be conducted once a year by the Laboratory Supervisors in each District.

The gauge chamber should be kept clean of asphalt, debris and loose aggregate. Use a long (200 mm) handle brush to clean the chamber.

If a cleaning solution is required to clean the chamber surfaces, only SafeSolve D'limonen should be used.

When operating the nuclear gauges, display buttons should be operated by finger tips rather than sharp objects such as pens. Sharp objects can cause the circuit board to short.

Do not place asphalt-aggregate mix samples which are greater than 150°C in the nuclear gauge as the gauge circuits could be damaged by the heat.

The area where the gauge is operated should be kept as dust free as possible to prevent the accumulation of dust in/on the electronic components.

The CP AC-2 gauge should not be switched on and off rapidly since the transients created could potentially disrupt memory. A minimum of 5 seconds should be allowed between switching on and off. It is not necessary to shut the gauge off to conserve power since the gauge automatically powers itself down after about 1 minute of inactivity. The switch should be left on at all times unless the gauge is to be stored or not used for several days or more.

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6.4. Charging of Batteries in CP AC-2

The life of the expensive nicad batteries can be greatly increased by using proper charging procedures. Some of the procedures which should be followed are listed below:

Charge the batteries only when the term "READY LO" is displayed. If the gauge beeps when the keys are pressed in this mode there is less than 20% power remaining. If there is no beep when the keys are pressed in this mode then the battery has no power.

When the gauge is being charged, the term "READY CH" will be displayed. Charge the gauge until such time that only the term "READY" is displayed. If the gauge is not being used while charging, the batteries will be recharged in about 14 hours.

Do not charge gauges using contractor's power supply. Use normal domestic power supply.

Do not charge batteries when the ambient temperature exceeds 38 °C.

For long term storage, the gauge should be charged before it is placed in storage and then recharged every 3 months.

6.5. References

Instruction manual for CP AC-2 Nuclear Asphalt Content Gauge.

ASTM D-4125 : STANDARD METHOD OF TEST FOR ASPHALT CONTENT OF BITUMINOUS MIXTURES BY THE NUCLEAR METHOD

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APPROVAL SHEET

New Revision Date of Previous Document 82-04-01

Effective Date: 92-04-01

Description of Revision (Reason for Revision):
Re-designed the standard volume compactor.

Review/Implementation Process:
Lab Supervisors Committee

Other Manuals/Policies Affected:
Nil

Follow Up/Training Required:
Nil

Comments/Concerns/Implications (Budget/Environment/Stakeholders):

Prepared and Recommended by D. MacLeod 92-03-26
Quality Control Engineer Date

Approval Recommended by R.A. Widger 92-04-03
Date

Approval Recommended by A.R. Gerbrandt 92-04-07
Dir., Technical Standards & Policies Br. Date

Approved by D.G. Metz 92-04-09
Assistant Deputy Minister, Infrastructure Date

Electronic File Updated 92-04-30
Update Mailed --