CANNON INSTRUMENT COMPANY®

Thermo-Electric Bending Beam Rheometer

Instruction & Operation Manual

TE-BBR SD

44.0991

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Contact

Address:	CANNON Instrument Company®
	2139 High Tech Road
	State College PA 16803, USA
Phone:	1-814-353-8000; 1-800-676-6232
Fax:	1-814-353-8007
Website:	www.cannoninstrument.com
Email:	
Sales:	sales@cannoninstrument.com
Service:	service@cannoninstrument.com

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Introduction

This manual describes the CANNON Thermoelectric Bending Beam Rheometer and the procedures for obtaining test data. The Bending Beam Rheometer is used to make rapid determinations of the flexural-creep stiffness of asphalt binders over a temperature range of 0 °C to -36 °C.

The user of this manual and instrument should have some experience in the handling and testing of asphalt binders and should be familiar with the operation of the Windows® operating system.

Procedural Overview

A small beam of asphalt is prepared and placed horizontally on two supports which are submerged in a cold alcohol solution. A load is applied at the center of the beam and the deflection of the beam is recorded over a time span of four minutes. From this data, the stiffness modulus and the log slope of the creep curve at test temperature are calculated.

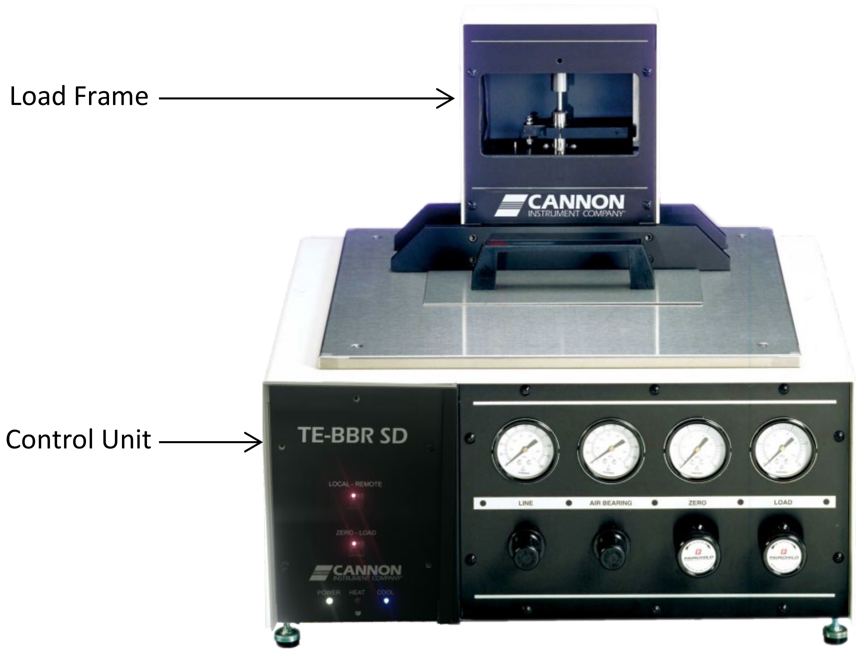


Figure 1: Thermoelectric Bending Beam Rheometer

Control Unit

The Control Unit is the base for the Bending Beam Rheometer. It contains the electronic components required to condition the signals from the Linear Variable Differential Transducer (LVDT), load cell, and temperature probe, and to communicate with the host computer via the serial port. Also included in the Control Unit are the relays, switches, and solenoid valves that control the introduction of pressurized gas to the chamber below the air bearing. The Control Unit contains pressure regulators and gages for operation of the pneumatic system. The low temperature bath is also an integral part of the Control Unit and is surrounded by thermoelectric modules to permit solid state cooling. Refer to Figure 2.

Figure 2: Front of Control Unit

Load Frame

The Load Frame rests on top of the Control Unit. The lower section is immersed in the alcohol bath. The Load Frame consists of a frame with the LVDT at the uppermost section, a shaft with an attached platform for holding weights, an air bearing through which the shaft passes, a load cell integral with the shaft below the bearing, and at the lower end is the support for the beam. The frame also contains several filters for the compressed gas and an illumination system to assist the operator in the placement of the beams on the supports.

An air chamber directly below the air bearing provides a force that counterbalances much of the load that would be applied to the specimen from the weight of the shaft. The pressure in the air chamber, or cylinder, can be adjusted - any desired load can be applied to the specimen, up to the maximum or the full weight of the shaft. Refer to Figure 3.

Figure 3: Front of Load Frame

Manual Operation

The Load Frame can be operated both manually (LOCAL) and automatically (REMOTE) as shown in Figure 4.

Figure 4: Front of Control Unit with Local and Remote Mode

The normal test procedure involves elements of both. Manual operation is used to adjust the position of the loading shaft to bring it into contact with the asphalt beam and adjust the load to be applied to the beam.

Automatic Operation

Automatic operation is controlled via the computer. The computer sends signals to the electronics system to trigger a solenoid valve which regulates the flow of pressurized air (or gas). This adjusts the net load applied to the asphalt beam. Refer to Figure 4.

Air/Water Heat Exchanger

The Air/Water Heat Exchanger consists of a radiator, fan(s), and a water pump to circulate and cool a mixture of water and ethylene glycol flowing through the hot side heat sinks surrounding the bath in the Control Unit. Circulation of the mixture removes heat from the Control Unit bath.

Specimen Molds

Each mold set consists of five rectangular metal sections, three plastic strips, and two rubber O-rings. Since tests are generally performed in duplicate, two complete specimen molds are required for each test.

Air/Nitrogen Requirements

The air bearing, and the pneumatic load chamber immediately below it, require a source of clean, dry, nonflammable gas. Compressed air is preferable if it is readily available and is clean and dry. Other acceptable gasses include nitrogen and carbon dioxide. A small compressor can be used to provide air at a suitable rate and pressure to satisfy the requirements for operation of this equipment.

Some users prefer to use cylinders of compressed gas such as nitrogen or carbon dioxide. Consult the Specifications section for air pressure and volume requirements, which vary depending on the date of manufacture for your instrument.

Computer Interface

The data acquisition system includes a personal computer, printer, and the BBRw software program for Windows®. A USB cable is provided to connect the TE-BBR to a computer.

The TE-BBR has its own microprocessor and communicates with the host computer via the USB connection to the computer connector.

Test data, including deflection of the asphalt beam, load on the beam, and temperature, are acquired by the instrument. The instrument then transmits the data to the host computer. The TE-BBR also receives commands from the host computer via the USB connection in order to control timing of the application of loads and enable the temperature control system. Testing and data acquisition control parameters are selected via the software interface.

Contact CANNON for specifications of software version and instrument type.

Safety Precautions

Notes/Cautions/Warnings

Please keep this manual near your system to easily access to the necessary information while operating or preparing for measurement.
Notes, caution, and warnings are used in the manual to call an operator's attention to important details prior to performing a procedure or step. Read and follow these important instructions. Failure to observe these instructions may void warranties, compromise operator safety, and/or result in damage to the TE-BBR.

Notes provide more information about the content that follows.

Cautions alert the operator to conditions that may damage equipment.

Warnings alert the operator to conditions that may cause injury.

It is prohibited to copy or reproduce in part or in whole this manual without authorization by copyright.
If you should find any part in this manual not clear to understand or missing article, contact your local dealer or sales representative.
Manufacturer is not liable for any loss or damage directly or indirectly caused by use of the instrument or its consequences.
This manual pertains directly to the TE-BBR. For details relating to other accessories or equipment please refer to the appropriate manufacturers supplied documentation.

Safety Precautions

Always observe these signs and instructions. You must observe cautionary messages and warnings in order to protect yourself as well as prevent others from physical injury or property damages.

- Only qualified personnel should operate the TE-BBR.

- Make sure that you read and understand all operating instructions and safety precautions listed in this manual before installing or operating your unit. If you have questions regarding instrument operation or documentation, contact Cannon Instrument Company.
- Do not deviate from the installation, operation, or maintenance procedures described in this manual. Improper use of the TE-BBR may result in a hazardous situation and may void the manufacturer's warranty.
- Handle and transport the unit with care. Sudden jolts or impacts may cause damage to components.
- Always remove liquid from the bath before moving the unit.
- Observe all warning labels. Never remove warning labels.
- Never operate damaged or leaking equipment.
- Unless procedures specify otherwise, always turn off the unit and disconnect the mains cable from the power source before performing service or maintenance procedures, or before moving the unit.
- Refer all service and repairs to qualified personnel.

Warning: Hot surface cautions may be attached on or near hot surfaces of the TE-BBR. Avoid touching hot surfaces, particularly when operating the instrument at bath temperatures exceeding 50 °C.

~MAINS	The **~MAINS** symbol indicates the connections for the AC power supply. The AC power input must match the electrical specifications of the instrument. Never operate the equipment with a damaged MAINS AC power cable. Use only the manufacturer-supplied MAINS AC power cable. This cable must be inserted into a receptacle with a protective earth ground.

(O)	The **(O)** symbol indicates the OFF position for the electrical switches for your unit.

Specifications

Table 1: CANNON TE-BBR Specifications

Specifications	Details
Model	CANNON TE-BBR Thermoelectric Bending Beam Rheometer
Methodology	ASTM D6648, AASHTO T313, SHRP Binder Provisions
Applications	Low temperature flexural creep testing of asphalt binders
Dimensions (W × D × H)	**Control Unit:** 73.7 cm × 70.1 cm × 55.9 cm (29 in × 28 in × 22 in) **Load Frame:** 58.4 cm × 48.3 cm × 68.6 cm (23 in × 19 in × 27 in) **Air/Water Heat Exchanger:** 49.5 cm × 40.6 cm × 48.3 cm (19.5 in × 16 in × 19 in) **add 15 cm (6 in) to front and rear dimensions for connection and air flow allowance*
Weight	**Control Unit:** 49.9 kg (110 lb) **Load Frame:** 15.9 kg (35 lb) **Air/Water Heat Exchanger:** 68 kg (150 lb)
Maximum Throughput	6 results per hour
Sample Capacity	1
Flexural Creep Stiffness Range	20 mPa to 1 GPa
Sample Supports	Specimen support strips 3 mm ± 0.30 mm in top radius
Bath Volume	5 L (1.33 gal)
Temperature Range	ambient to -40 °C (± 0.03 °C stability; ± 0.01 °C resolution)
Sample Dimensions	12.7 mm x 6.35 mm x 127 mm (o.5 in x 0.25 in x 5 in)
Data Output	USB

Table 1: CANNON TE-BBR Specifications

Specifications	Details
Operating Conditions	15 °C to 30 °C, 10% to 75% relative humidity (non-condensing), Installation Category II, Pollution Degree 2
Electrical Specifications	120 VAC, 50/60 Hz; 240 VAC, 50/60 Hz; 1800 watt power consumption
Compliance	CE Mark: EMC Directive (2004/108/EC); Low Voltage Directive (2006/95/EC); HI-POT (1900 V_{DC}, 60 sec.); ROHS

Ordering Information

The CANNON TE-BBR Thermoelectric Bending Beam Rheometer consists of the bending beam rheometer with load frame, air/water heat exchanger, a complete precision calibration kit, a set of six aluminum molds with Mylar separators and data storage/management software. Computer sold separately. Refer to Table 2 and Table 3 for assistance ordering desired components.

Table 2: TE-BBR Part numbers

Description	Part Number
100 VAC, 50/60 Hz	9728-V31
120 VAC, 50/60 Hz	9728-V30
240 VAC, 50/60 Hz	9728-V35

Table 3: TE-BBR Accessories and Consumables

Description	Part Number
BBR precision calibration kit (D6648 update): rugged carrying case containing a high precision gage block, precision-cut stainless steel thin beam and NIST-traceable calibration certificates	9728-V63
Complete BBR precision calibration kit: rugged carrying case containing a high precision gage block, precision cut stainless steel thin beam, ¼" compliance beam, four 100 gram weights and NIST-traceable calibration certificates.	9728-V60
Silicone rubber mold for BBR; simplifies the procedure for making asphalt beams	9728-V40
Aluminum mold for BBR: standard mold kit	44.6200
Aluminum molds (6) for BBR: standard mold kit	44.6205

Table 3: TE-BBR Accessories and Consumables

Description	Part Number
Crack seal kit: includes a set of 5 modified beam supports, thin and thick beam (for calibration), installation hardware and documentation	P44.0675
Crack seal mold for BBR	44.6262
Crack seal molds (6) for BBR	44.6263
Plastic Strip (set of 12) for aluminum molds	44.6250
O-Ring for aluminum molds	44.6235

Unpack and Install the TE-BBR

Caution: Some components, including the Control Unit and the Air/Water Heat Exchanger, are quite heavy. Avoid injury by obtaining assistance when lifting and moving the instrument and its components.
The TE-BBR is a sensitive device. Take care when handling and using the instrument to avoid accidental damage to a high precision component.

Check the shipping container(s) for external damage before opening and carefully inspect the contents after opening for evidence of damage.
Report any damage to the shipper and to Cannon Instrument Company immediately.
Take special care when unpacking the Load Frame. Foam blocks and other restraints have been used to prevent damage to the measurement system. These must be removed with care to prevent undue stress on these components.
CANNON advises that users keep the packing material and original shipping container for the Load Frame in the event that it is necessary to return the Load Frame to Cannon Instrument Company for service.
Ensure that all of the contents of each container are retained. All auxiliary items shipped with the TE-BBR are labeled. When all containers have been opened, compare the contents with the packing slip to ensure that there are no missing items.

System Components Arrangement

Control Unit

Locate the Control Unit and tilt it first to one side and then the other, extending the leveling legs as you do so by turning them counter-clockwise. Refer to Figure 5. All four leveling legs should be extended far enough to prevent the stirring motor shield at the very bottom of the unit from contacting the surface of the supporting table/bench when the unit is upright. If this shield is damaged, the stirring motor may be forced against the bottom of the tank, preventing rotation. After extending the legs, set the Control Unit on a flat, level tabletop which has access to the floor from the rear of the unit.

Figure 5: Levelling Legs

Stirring Bar Protection Sheet

Place the stirring bar protection sheet in the bottom of the bath.

Stirring Bar

Place the cross-shaped stirring bar on the stainless steel plate in the center of the bath. Place the stirring bar cover grid over the bar and make sure that the grid does not impede rotation of the stirring bar. When the bath is functioning, the speed of the stirring bar is controlled magnetically using the speed control dial on the left rear panel (as viewed from the rear) of the Control Unit. Refer to Figure 6.

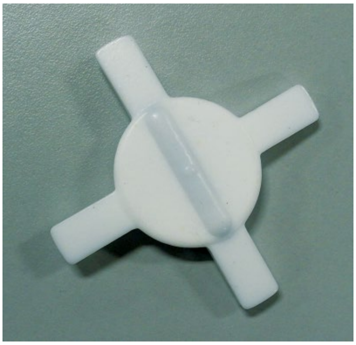


Figure 6: Stirring Bar

Load Frame

Place the Load Frame into the bath of the Control Unit by lowering the Load Frame through the larger opening in the stainless steel plate until the horizontal support member rests on the upper surface of the Control Unit. Slide the Load Frame toward the rear of the Control Unit into the smaller rectangular opening. When this component is back as far as it will go, the metal cover for the forward rectangular aperture should fit easily in the remaining space.

Level the Instrument

After the Load Frame is in the bath, place the small bubble level onthe Load Frame platform to the left of the shaft (this is where the gage block is normally placed). Adjust the four leveling legs on the Control Unit until the bubble level indicates that the unit is level. Refer to Figure 7.

Figure 7: Bubble Level for Load Frame

Computer

Place the computer adjacent to the control unit to expedite convenient serial connections.

Exchanger/Refrigeration

Place the Refrigeration Unit (BBR model) or Air/Water Heat Exchanger (TE-BBR model) on the floor below the Control Unit. Do not place the unit on the same table as the Control Unit as the fan/motor vibration can interfere with the sensitive measuring system of the Load Unit. Also, it is necessary to provide 15 cm (6") of clearance on all sides of the unit for sufficient air circulation. Clearance requirements for refrigeration units may vary depending on the model.

Note: If a compressor has been purchased to supply compressed gas, place it on the floor or at a location removed from the test apparatus to prevent the compressor vibration from interfering with the Load Frame measurements.

Electrical Connections

Load/Control Unit Connections

Connect the communication cable from the Load Frame to the Control Unit. Refer to Figure 8.

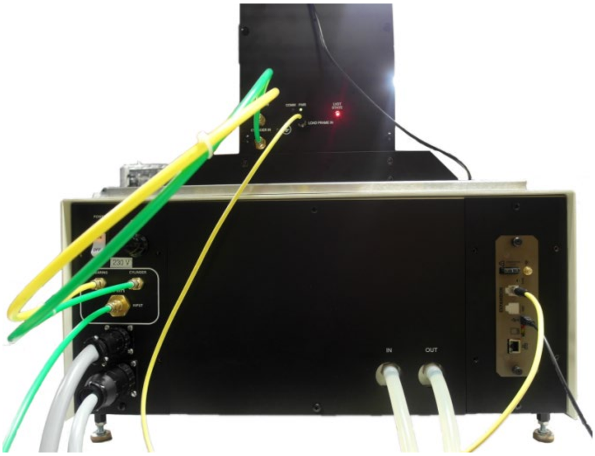


Figure 8: Electrical Connections – Load Frame to Control Unit

Control Unit – Heat Exchanger Connections

Make certain the power switch on the TE-BBR is in the OFF (O) position. Then connect the two large power cables between the air/water heat exchanger and the rear panel of the Control Unit. Refer to Figure 9. The connections are keyed and will only fit one way. Insert the MAINS power cord into the MAINS outlet on the Air/Water Heat Exchanger and plug the other end into a suitable receptacle matching the electrical specifications on the rear of the unit.

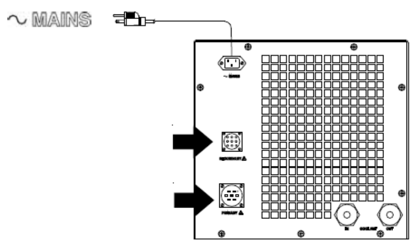


Figure 9: Air/Water Heat Exchanger Power Connections

Serial Connections

Connect the USB cable between the TE-BBR Control Unit rear panel and USB port on the host computer as shown in Figure 10.

Figure 10: TE-BBR Serial Connections Back Panel and to PC (shown without and with cables)

Tubing Connections

Dry Air/Nitrogen Connections

CANNON recommends the use of dry air as the most effective compressed gas supply. An air dryer should be installed on your line as close to the instrument as possible to prevent condensation and corrosion.

To complete compressed gas connections, attach the gas supply to the Air Input on the Control Unit with the longer of the ¼ inch OD plastic tubes. Connect the shorter lengths of ¼ inch OD plastic tubing between the fittings on the rear of the Control Unit (CU) and the connections at the rear of the Load Frame. The Bearing Out connection should be linked to the Bearing In connection on the Load Frame. The Cylinder Out connection (CU) should be linked to the Cylinder In connection on the Load Frame. Refer to Figure 11.

Figure 11: Dry Air/Nitrogen Connections – Control Unit

Air/Water Heat Exchanger Connections

Note: Use tubing clamps to secure all hoses.

Connect one end of each of the two silicone tubes to the Control Unit by sliding them onto each of the (IN/OUT) fittings at the rear of the Control Unit. Then connect the opposite end of each tube to the rear of the air/ water heat exchanger by plugging directly onto the fittings on the exchanger rear panel.

Connect the tube from the IN fitting of the Control Unit to the COOLANT OUT connection on the Air/Water Heat Exchanger. Connect the tube from the OUT fitting on the Control Unit to the COOLANT IN connection on the Air/Water Heat Exchanger.

Software Installation

For peak performance, the recommended computer hardware components are:

- Pentium or better processor
- 32 MB RAM
- 500 MB or larger hard drive
- Video card and monitor capable of 256 color display at 800 x 600 pixels or better

Software requires Windows® 7® or later.

The program is written to display real-time plotting of load and deflection during the test, to perform calculations of stiffness values and the log slope of the creep curve at selected loading times, and to display the results and test parameters at the end of each test.

The installation program will copy the BBRw executable file and other necessary files to the directory specified by the operator.

To verify correct installation of the BBRw software, follow the procedure below and the Windows® process to install and start the BBRw program.

Installation Procedure

1. Turn on your computer and place the installation disk in your CD disc drive.
2. Follow the Windows prompts to complete the installation.

Contact Service at CANNON with any software installation issues.

TE-BBR System Preparation & Maintenance

Note: Complete the TE-BBR assembly before beginning procedures in this section.

Fill the Air/Water Heat Exchanger

Obtain a supply of quality ethylene glycol (automotive antifreeze) and mix it with water in a ratio of 30% ethylene glycol to 70% water. After the Exchanger tubing connections are secured (see section *Tubing Connections*), pour the mixture into the reservoir opening on the top of the Air/Water Heat Exchanger until it is full (approximately 1-2 liters). Refer to Figure 12.

Figure 12: Air/Water Heat Exchanger Reservoir

Caution: Replace water/anitfreeze mixture annually to ensure reliable performance and prevention of corrosion of internal components. Ethylene glycol is a toxic substance. Use proper safety measures when handling. Follow appropriate (M)SDS procedures.

Do not use "environmentally friendly” alternatives to ethylene glycol (such as polyethylene glycol) in the heat exchanger. Such products can coagulate under colder conditions and damage the TE-BBR circulation system.

After the instrument is turned on it is necessary to add additional ethylene glycol/water mixture to the Exchanger when the unit commences operation. You can observe the liquid circulating through the tubing. If air bubbles are consistently visible in the coolant lines, add additional mixture until the Exchanger reservoir is full.

Before turning on the power switch, make sure that the (supplied) cross-shaped magnetic stirring bar is placed in the center of the bath section of the Control Unit. The circulator guard should be placed over the stirring bar, and the speed adjustment knob, located on the right rear panel (front view), should initially be turned counter-clockwise to its lowest setting.

Turn the power switch (located at the rear of the Control Unit) to the ON position, and continue to add additional water/ethylene glycol mixture to the reservoir until it reaches the previous level. You will be able to observe the liquid circulating inside the reservoir from the opening at the top.

Turn the power switch to the OFF position.

Prepare the Temperature Bath

Select a Bath Liquid

The ideal bath liquid has a low viscosity, high heat capacity, and low vapor pressure over a wide range of temperatures. This liquid also has a very high flash point and is relatively inexpensive. Methyl alcohol (methanol) is very close to the ideal liquid; it can be used at all temperatures in the TE-BBR’s operating range. However, methanol may not be suitable for some laboratories because of its low flash point and degree of toxicity.

Ethyl alcohol is less toxic than methyl alcohol and somewhat less volatile. A commercially-available grain alcohol (such as Everclear®) may be used down to -40 °C. Alternative low-temperature liquids are available.

Caution: Methyl alcohol is a flammable and toxic liquid. Use care when handling and keep away from open flame or sparks. Do not add bath liquid while TE-BBR power is ON.

Fill the Bath with Liquid

After selecting a suitable bath liquid, fill the bath to the fill line (approximately 5 liters).

Caution: Do not overfill the Bath as this will result in damage to the Load Cell.

Check Bath Components

Check the function of bath components as follows:

Stirring Bar Speed

1. Make sure that the cross-shaped magnetic stirring bar (supplied) is placed in the center of the bath section of the Control Unit. With the circulator guard in place over the stirrer, turn the speed adjustment knob, located on the right rear panel, fully counter-clockwise to its lowest setting.
2. Turn the Control Unit power switch ON. The TE-BBR power switch is located on the right rear corner of the Control Unit.
3. Slowly turn the motor stirrer speed adjustment knob (next to the power switch) clockwise to increase the speed of the stirring barto the desired level.

Note: Excessive stirring speeds may cause the magnetic stirring bar to lose its attraction and spin out.

LED Checks

There are three LED (Light-Emitting Diode) indicators on the front panel of the Thermoelectric Bending Beam Rheometer. These provide a visual check for the status of the thermoelectric temperature control system.

- The yellow LED, which should be lit whenever the power switch is on, indicates DC POWER. When this LED is lit, MAINS power is available and no elements of the thermoelectric system are over temperature.
- The green LED labelled COOL indicates that coolant is circulating between the Control Unit and the Refrigeration Unit. A steady green LED indicates cooling. A flashing green LED indicates that the system is controlling at the test temperature specified in the SETUP menu.
- The red LED labelled HEAT is illuminated or flashing red when the bath heaters have been energized.

Note: Temperature control must be software-enabled from the SETUP menu before the TE-BBR will begin heating or cooling.

Check the Control Unit

The default settings for front panel indicators are LOCAL and ZERO. Check for these initial settings, which should be maintained or restored prior to activating the air bearing compressed gas supply. When power is turned ON, the red indicator LEDs for the small push-button switches on the left panel should be on.

Note: If either switch has the green LED illuminated when power is initially applied, there may be a problem.

Toggle the upper LOCAL/REMOTE switch on the front panel to the REMOTE (green) mode, and then back to LOCAL (red) mode. Do the same for the ZERO/LOAD switch located directly below the LOCAL/ REMOTE switch. An audible “click” of a solenoid valve should be noticed each time this switch is pressed.
The ZERO/LOAD switch only functions when the LOCAL/REMOTE switch is in the LOCAL mode.

Control Unit Operation Checklist

1. Make sure that there are no beams on the supports and that thefront panel indicators are set to the LOCAL and ZERO modes.
2. Turn on the compressor or the valve on the compressed gas supply.
3. Using the dials on the Control Unit front panel, adjust the LINE pressure to 40 psi, and the BEARING pressure to 25 psi. Turning the dials clockwise increases the pressure; counter-clockwise reduces the pressure. Make certain that the LINE (supply) pressure is always set higher than the bearing pressure to ensure adequate regulation from the bearing pressure regulator.
4. Place the LOAD switch in the ZERO mode. Adjust the ZERO pressure regulator to obtain a free-floating condition for the shaft. Turn the dial counter-clockwise to lower the shaft, clockwise to raise the shaft.
5. Return the ZERO/LOAD switch to LOAD.
6. Turn the LOAD pressure regulator until the shaft is again in free-float condition.

Note: Because each unit may differ in bearing characteristics, there is a sticker attached to the gauge with the pressure settings.

Initial Software Settings

Before running TE-BBR tests, setup information must be entered.

1. Turn on computer and load the BBRw software.
2. Select **Instrument Setup** from the BBRw menu options. Refer to Figure 13.

Figure 13: Instrument Setup

3. Set the COM port:
   a. Click on **Port** from the tab options on the **Instrument Setup** menu.
   b. Click on ▼ (down arrow) from the Serial Port page to display the port selection options.
   c. Click on the Serial Port setting which corresponds with the port for the USB cable connection between the BBR and your PC.
4. Input equipment data, including temperature calibration constants:
   a. Click on **Equipment** from the tab options on the **Instrument Setup** property sheet.
   b. Input an alphanumeric identifier for your BBR instrument (up to 30 characters in length) in the **Apparatus ID** field.
   c. Input the RTD thermometer probe values (constants) for **S/N**, **A0**, **A1** and **A2** from the calibration certificate shipped with the probe. Use the tab key or mouse to select the appropriate fields for data entry. Make sure to include negative signs (-) and decimal points as indicated on the calibration certificate.

Note: Once set, the temperature constants should only be changed if replacing the RTD Probe.

5. Choose a default data path:
    a. Click on **Archive** from the tab options on the **Instrument Setup** property sheet. The current archive directory is displayed.
    b. Click on **Browse** to select an alternate directory.
    c. Click on the desired directory from the Windows directory dialog.
6. Change default settings for gage block depth:
    a. Click on **Gage Block** from the tab options on the **Instrument Setup** menu.
    b. Input the gage block height, as measured from the bottom of the block, at each level (default settings are 16 mm for the top level, 15 mm for the Red level, 13 mm for the White level and 10 mm for the Blue level).
7. Change the default settings for the steel beam dimensions:
    a. Click on **Instrument Setup** from the Setup menu and select **Beam Dimensions**.
    b. Measure the steel beams and input each measured value (up to two decimal places) into the appropriate field. (These measurements are provided with the beams sent with the instrument.)
    c. Click **OK**.
8. Change the default settings for the confidence test tolerance (optional):
    a. Click on **Confidence Test** from the tab options on the **Instrument Setup** menu.
    b. Input the values for minimum and maximum acceptable limits for measurement of the modulus of elasticity. Default values are 183 GPa for the minimum modulus value, and 223 GPa for the maximum modulus value (203 GPa ± 10 percent).
9. Add the rest of the default values for the X (horizontal) and Y (vertical) axis of the line graph created from the BBR test data:
    a. Click on **Graphs** from the tab options on the **Instrument Setup** menu.
    b. Input the values for deflection per graph division (the default is 1 mm) and force per graph division (the default is 1000 mN).
    c. If desired, click on the Autoscaling option. When checked, the BBRw software will automatically select graph scale values for effective display of test data.

Note: To enhance the readability of graph data when the Autoscaling option is not used, set the numbers so that the highest graph value is slightly above the maximum anticipated values for the test.

10. Set Bath Temperature:
    a. Click on **Bath** from the tab options on the **Instrument Setup** menu.
    b. Enter the desired temperature (between +25 °C and -40 ℃).

Enable Temperature Control

The TE-BBR will not control temperature unless the **Enable Temperature Control** option is turned on. When temperature control is enabled, the **Enable** option on the Setup menu will have a check mark in front of it.

To enable temperature control, select **Setup** from the **Main Menu** and click on **Enable Temperature Control.**

Note: Temperature Control is disabled when the instrument is turned off. If the software application is exited but the TE-BBR remains on, the Enable Temperature Control option will retain its previous setting when the instrument is restarted.

Disable Temperature Control

To disable temperature control, repeat the process used to enable temperature control as previously outlined. When you click on **Enable Temperature Control**, the check mark is removed to indicate that temperature control is no longer enabled.

Calibration

To provide accurate readings from the RTD temperature probe, it is necessary to calibrate the probe periodically with a calibrated thermometer.

RTD Temperature Probe Calibration Procedure

1. Load the BBRw software and select **Calibrate > Temperature** from the BBRw Main Menu or use the Thermometer icon.
2. Enter the current temperature of the bath to the nearest 0.01 °C as indicated by a separate calibrated thermometer and click **OK**.

LVDT and Load Cell Calibration

It is necessary to calibrate the LVDT (Linear Variable Differential Transducer) and Load Cell in order to expect accurate readings for the output.

1. Select **Calibrate** from the BBRw Main Menu.
2. Select **Force**, **Deflection** and **Compliance** from the calibration options.
3. Follow the on-screen prompts to complete calibration.

A cylindrical metal gage block is provided for the LVDT calibration. Refer to Figure 14. This block is placed to the left of the load platform on the small pin provided so the block can easily rotate. A 6.35 mm (¼") thick stainless steel beam and four 100 gram weights are supplied for the calibration.

Figure 14: Load Frame Calibration

At the end of the calibration run, remove the weights from the load platform, and the 6.35 mm (¼") steel beam from the bath.

Compliance

During BBR load cell calibration, the data obtained is used to automatically generate a correction factor for the LVDT measurement. This factor is defined as device compliance, and is displayed by the BBR software at the conclusion of the calibration. The correction factor compensates for slight changes in the reading of the LVDT which are not a function of the beam deflection. A slight but significant part of the deflection reading is due to compression of the load cell itself. By making a correction to the deflection reading with each load, a more accurate measurement of the actual deflection of the sample is obtained. The value for this correction has been found to be between two and nine µm/N, depending on the physical characteristics of the load cell, and should be stable within 1.5 µm/N.

Run the Confidence Test

While not a part of the calibration procedure, a measurement of the stiffness modulus of a thin steel beam is made to confirm the calibration.

The confidence test should be performed immediately prior to BBR asphalt binder testing and after the instrument has reached the desired test temperature. A good confidence test result (yielding results in GPa of ±10 percent of the value on the certificate) provides greater assurance of accurate results with subsequent testing.

To run the confidence test, select **Run a Confidence Test** from the **Calibrate** menu. Follow the screen prompts to complete the test. A thin (approximately 1.20 mm) steel beam is needed, as well as two to four 100-gram weights, depending on the laboratory calibration protocol.

If the test fails repeatedly, recalibrate the instrument and rerun the confidence test.

Verify Calibration

To verify that the instrument is providing accurate data for force and deflection complete the procedure outlined in this section.

1. With the instrument in LOCAL and ZERO modes, place the gage block in the Load Frame with the shaft on the top level of the block.
2. Read the deflection from the computer screen and verify that the value agrees with the certificate of calibration for the gage block (ΔRED) ± TOL.
3. Repeat the previous two steps for the red, white and blue levels.
4. Place the shaft on the red level of the gage block and read the force. The value should be 0.00 ± 10 mN.

5. Remove the gage block from the Load Frame.

6. Adjust the Zero regulator until the shaft is floating freely at the approximate midpoint in its vertical travel.

7. Gently add a weight of 2 grams to the load platform and verify that the shaft drops slowly downward under the weight. Refer to Figure 15.

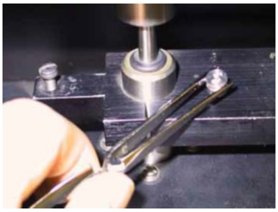


Figure 15: Placing Weight with Forceps

8. Remove the weight and place the quarter inch beam on the beam supports in the bath.

9. Verify that the instrument is in the ZERO mode and adjust the Zero regulator until the shaft is touching the beam with a force of 20 mN ± 10 mN.

10. Add one 2 gram weight (± 0.2 g) to the load platform.

11. Verify that the force increases by 20 mN ± TOL.

12. Add a second 2 gram weight (± 0.2 g) to the load platform.

Note: **TOL**(tolerance) values may vary depending on the reference method for your laboratory. AASHTO T-313 specifies ± 0.005 mm for deflection and ± 5 mN for force.
If the TE-BBR is not performing within the specifications prescribed by your method, repeat the calibration. If verification problems persist, contact your CANNON representative.

Erratic Readings Error Message

The error message **Erratic readings have been received** indicates that new calibration measurements differ significantly from previous results.

1. Verify correct calibration setup: Zero pressure, amount of weight, and position of block. If incorrect, adjust and run calibration again.

2. If setup is correct, click the **Ignore** button and continue. Calibration results must be within .14 mN/bit to .16 mN/bit for force, and .14 µm/bit to .16 µm/bit for the deflection with .15

mN being optimal. If results exceed these ranges, contact CANNON service department for help with further diagnosis.

Calibrate with the Auto-Thickness Option

The BBRw software automatically measures the thickness of the specimen if the **Auto-Thickness** option box in the **Test Setup** dialog is checked. When entering preliminary data for the test, click on the option box to select or deselect this option.

Follow the procedure in this section to calibrate the BBR instrument to use the Auto-Thickness option.

1. Check the **Beam Dimensions** property sheet in the **Instrument Setup** dialog to make certain that the correct value has been entered for Thick Beam Thickness.
2. Select **Calibrate** from the main menu, then **Auto-Thickness Datum** from the **Calibrate** options.
3. Follow the screen prompts to complete the Auto-Thickness calibration procedure. The BBRw software uses the input values and LVDT readings to generate necessary calibration data for determination of specimen thickness during BBR testing.

Note: Is it necessary to calbrate the Auto-Thickness each time an LVDT/Load Cell calibration is performed.

Software Menu Options

Although the use of the software is largely intuitive, the descriptions in this section may provide assistance during training and initial use of the TE-BBR computer interface. Additionally, the BBRw software includes Help files for convenient on-screen reference during operation of the program. To access the Help files, click on **Help** from the BBRw **Main Menu** or click on the **Help** buttons available in most BBRw dialog windows.

Main Menu

Table 4: Test Menu Options

Name	Description
Run a New Test	Initiates a new test by opening a new test file and prompting for user input.
Open a Saved Test	Activates the Open dialog, permitting user selection of the appropriate file(s).
Close a Test Window*	Closes the file associated with the currently active window.
Export Data*	Exports data from the currently active window to a file with the format specified (.csv or .dat file format).
Batch Export Data	Allows the user to select data files for export in ASCII format. The .csv files provide all recorded temperature/deflection/ force values for the selected test(s).
Print*	Opens the Windows print dialog.
Print Preview*	Provides an on-screen preview of the printed output.
Print Setup	Activated the Windows Print Setup controls.
…,2…,3…,4	Lists the most recently opened files. Double-click the file name to open the file.
Exit	Exits the BBR software program.

*option available only when test file is open.

Table 5: View Menu Options

Name	Description
Toolbar	Displays or hides the BBRw toolbar.
Status bar	Displays or hides the status bar, which displays information about the current application status or other contextual information generated by the location of the cursor or mouse icon.
Instrument status	Displays or hides the instrument status window, which displays current force, deflection and temperature information, as well as the target BBR temperature.
Graph*	Opens a graph view of the current BBR data file.
Report*	Opens a columnar report view of the current BBR data file.

*option available only when test file is open

Table 6: Calibrate Menu Options

Name	Description
Force, deflection and compliance	Calibrates the Load Unit for maximum accuracy (see *Calibration* for more information).
RTD Probe Calibration	Calibrates the RTD probe to ensure accurate temperature readings (see *Calibration*).
Auto-Thickness	Calibrates the BBR for precision measurement of specimen thickness using the thick steel beam as a reference standard.
Run a Confidence Test	Initiates the steel beam test sequence to verify normal operation of the BBR instrument. Run a Confidence Test verifies the function of the BBR instrument using a procedure which measures the known stiffness modulus of a steel beam (see *Calibration*).

Setup Menu Options

Instrument Setup: The **Instrument Setup** menu provides access to important software/system configuration settings.

Set Bath Temperature: Bath temperature is also set from the **Instrument Setup** menu. To enter the desired bath temperature:

1. Click **Bath** from the tab options on the **Instrument Setup** property sheet.
2. Enter the desired temperature (between +25 °C and -40 °C).
3. Click **OK** to save the settings, or **Cancel** to discard the changes.

Enable Temperature Control: The TE-BBR will not control temperature unless the **Enable Temperature Control** software option is turned on. When temperature control is enabled, the **Enable Temperature Control** option on the **Setup** menu will have a check mark in front of it.

Note: When the TE-BBR is turned off, Temperature Control is disabled. If the software application is exited but the instrument remains on, the Enable Temperature Control option will retain its previous setting when the TE-BBR software is restarted.

Disabling Temperature Control: To disable temperature control, repeat the process used to enable temperature control (see above). When you click on **Enable Temperature Control**, the check mark is removed to indicate that temperature control is no longer enabled.

Help Menu Options

Help: Displays BBRw Help topics and offers explanations of software inputs.
About: Displays the BBRw current version, copyright information, and current Deflection/Force/Compliance constants.

Toolbar Options

The BBRw software is designed to provide easy access to some of the most critical BBR functions with a single click of your mouse. The BBRw Toolbar includes buttons for initiating a test, opening data files, viewing and printing BBRw textual and graphical data, calibrating and checking the calibration, and aborting the test. Refer to Figure 16 for a brief description of toolbar options.

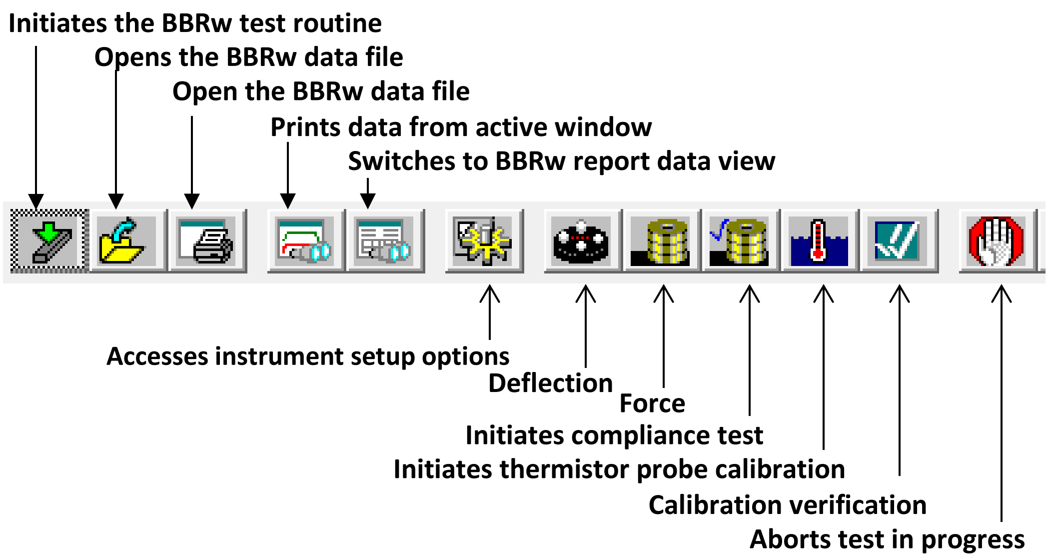


Figure 16: Toolbar Options

Delta Tc Calculation

The latest version of BBRw software provides an option under the test menu to calculate the Delta Tc of two test results. This test option requires two valid test results with different temperatures with:

- S values of two temperatures, one higher than 300 MPa and one lower than 300 MPa
- m value of two temperatures with one higher than 0.300 and one lower than 0.300

Procedure:

1. From the main menu, open the **Test** tab as shown in Figure 17.

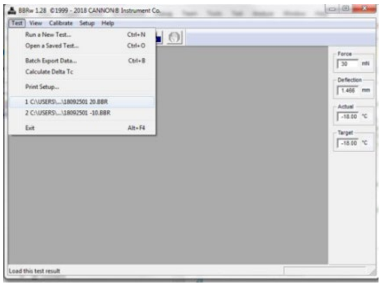


Figure 17: Test Menu Calculate Delta Tc Option

2. Select **Calculate Delta Tc.** A windows dialog box will open.
3. Using the keyboard Ctrl button and the mouse, select two .bbr test result files.
4. If test results do not meet the specified parameters for calculating the Delta Tc, an error message will appear as shown in Figure 18.

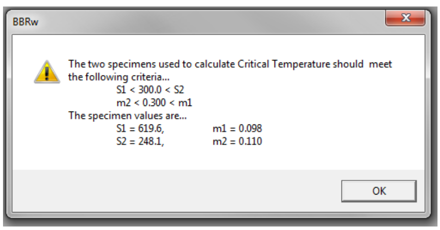


Figure 18: Delta Tc Error Message

5. After two appropriate tests are selected, the software calculates the Delta Tc for those results.

Beam Preparation

The method described in this section is essentially a description of current ASTM/AASHTO-approved test methods for asphalt bending beam preparation. This manual procedure is not intended to supersede the current methodology. Consult the appropriate method for specific test procedures.

Asphalt Beam Dimensions

The desired dimensions for the test beam are 127 mm (5") long, 12.7 mm (½”) wide and 6.35 mm (¼”) thick.

Test Method

The Bending Beam Rheometer is designed to measure the low-temperature stiffness of asphalt binders. Low temperature stiffness is significantly affected by the thermal history of the specimen. Therefore, from the time the specimen is poured until the completion of the test, time intervals and temperatures should be strictly controlled. Appropriate methodology must be followed precisely. Failure to follow these guidelines can result in errors of 30 percent or more in the measured stiffness.

Proper specimen preparation will produce test beams 6.35 ± .05 mm thick by 12.7 ± 0.05 mm wide by 127 ± 0.5 mm long. Specimen preparation involves three major steps:

- Mold preparation
- Specimen pouring
- Specimen demolding

When preparing the specimen, allow time for the TE-BBR bath to reach the test temperature and stabilize. The bath should be equilibrated at the test temperature for at least 30 minutes before running the asphalt beam test.

Mold Preparation

A diagram of a specimen mold often used to prepare the test beam is shown in Figure 19 on the following page. To prepare the mold for filling, execute the following checklist:

1. Cover the inside surfaces of the metal bars with tacking material.

The tacking material should be a commercial, petroleum-based grease that retains its tackiness at the pouring temperature without stiffening excessively at low temperatures. The layer should be uniform and very thin.

The purpose of the grease is to hold the plastic strips in contact with the metal faces of the mold. After spreading the thin film of grease, clean the sides and edges of the bars with a clean tissue moistened with solvent to prevent grease from coming in contact with the poured asphalt.

2. **Cover the greased surfaces of the three metal bars with the plastic strips.**

When applying the strips, avoid entrapping air bubbles between the strips and the bars. First, locate the wider plastic strip and align it with the greased side of the (wider) base plate, pressing it firmly into place.

The narrower plastic strips for the side plates are made longer but should match the width of the side plates exactly. Place these two plastic strips on top of the tacking film, and press the strips onto the bars.

3. **Debond the end pieces.**

The only inner metal surfaces of the assembled mold which will not be covered by plastic are the inner edges of the two short end pieces. To prevent asphalt from sticking to these surfaces, cover them with a thin layer of debonding agent (CANNON recommends using a mixture of talcum powder and glycerol) and a narrow spatula, wire or rod. Avoid spreading the mixture on the plastic surfaces.

4. **Assemble the mold.**

Place the end pieces at the ends of the base plate, on the face covered with the plastic sheet. Position the two side bars on the sides of the end plates with their covered sides facing inward. Use two rubber O-rings to hold the side bars securely to the base bar at each end of the mold.

5. **Inspect the mold.**

After assembling the mold, inspect it for any air bubbles or detachment between the plastic sheets and the bars. Insert a clean metal bar 6.35 mm (0.25") thick into the mold and move it back and forth (using sliding action) between the two end pieces. This will allow you to ensure that the plastic sheets are completely attached to the bars and that the sample volume is accurate.

When the above steps have been completed, the mold is ready for pouring. After it is assembled, keep the mold at room temperature until the asphalt is to be poured. Refer to Figure 19.

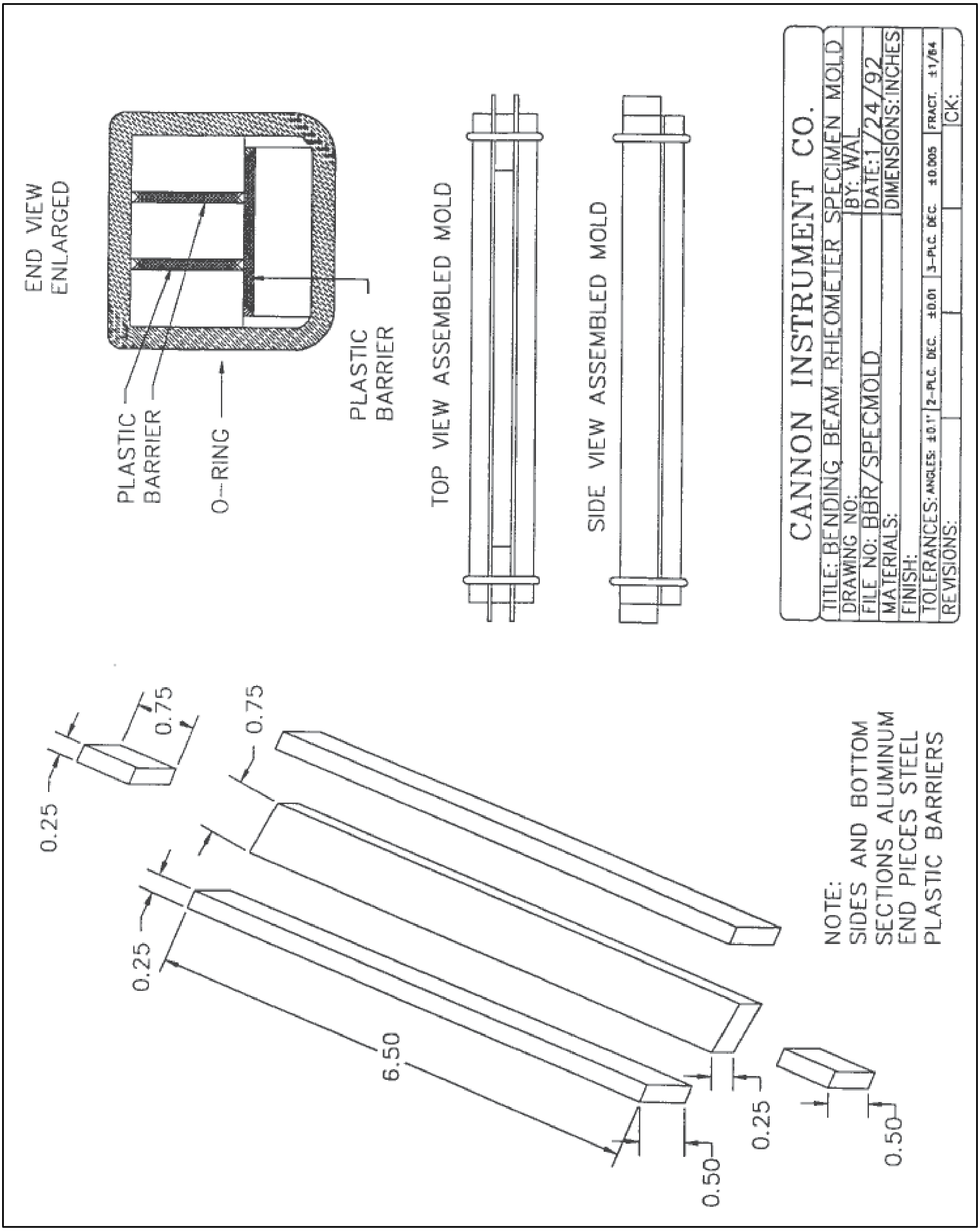


Figure 19: Mold Specimen Diagram

Specimen Pouring

Follow the steps below to pour a specimen for testing in the Bending Beam Rheometer.

1. Heat the asphalt binder sample.

Heat the asphalt sample in an oven to a temperature not exceeding 165 °C to 180 °C (329 °F to 356 °F) until it has become sufficiently fluid to pour. The temperature should be sufficient to produce a coefficient of viscosity from 100 cSt to 200 cSt. The time and temperature required depends on the size of the sample and the hardness of the asphalt. For virgin asphalt, and for a sample of about 50 g, 60 minutes at 135 °C (275 °F) is generally sufficient.

Caution: Take appropriate safety precautions when handling hot asphalt.

The sample should be stirred occasionally to aid heat transfer and to assure uniformity. But avoid excessive stirring to prevent oxidative hardening. After bringing sample to the required temperature, stir the sample until it is homogeneous and free of air bubbles.

2. **Pour the asphalt.**

Pour the asphalt into the mold, starting at one end and moving slowly toward the other. Hold the sample container 25 mm to 40 mm (1” to 1.5") from the mold and pour continuously until the mold is completely filled. Try to fill the mold in one pass, as pouring the beam in several passes may entrap air gaps or bubbles in the specimen.

Overfill the molds slightly with asphalt so that the excess can be trimmed after the asphalt cools. Overfilling is necessary so that the demolded specimen has square edges and uniform width. After pouring the specimen, cool the filled mold at room temperature (approximately 20 °C or greater) for 45 to 60 minutes.

3. **Trim the specimen.**

After the specimen has cooled, use a hot knife or a heated spatula to trim the upper face of the specimen so that it is level with the top of the mold. Any excess asphalt on the side bars should be carefully cleaned with the hot knife or other appropriate sharp-edged instrument.

Note: It’s very important to trim and clean the top side of the mold. If the width of the specimen is more than 12.7 mm (¼”) it will not fit correctly on the device supports. If the upper side of the mold is not cleaned carefully the specimen will adhere to the side bars, making removal difficult.

4. **Cure the specimen.**

After trimming the filled mold, allow the mold to remain at room temperature for one hour (± 15 minutes) before demolding. This period of time is necessary for the specimen to reach thermal equilibrium.

Specimen Demolding

Before demolding, prepare the bending beam instrument for operation. Make sure to allow time for the bath to reach the test temperature and stabilize. The bath should be equilibrated at the test temperature for at least 30 minutes before running the test.
Load the BBRw software.

1. **Cool the specimen.**

Caution: Use caution when cooling the specimen as asphalt may be brittle at lower temperatures. Do not use the TE-BBR test bath to cool the sample. Immersing the warm mold in the bath could disturb the temperature equilibration and force a delay in testing. If cooling is too rapid, the difference in contraction rate between the mold and the asphalt may result in internal stresses and cracking.

2. **Demold the specimen per the following instructions:**

   a. Remove the specimen from its cooling place and, if needed, wipe it dry. Start demolding immediately.

   b. Remove the O-rings. Then shear the base plate to the side.

   c. Carefully peel off the base plate plastic sheet adhered to the asphalt specimen.

   d. Shear off the side bars by applying opposite rotations at the ends of the bars. Then peel off the side plastic strips and remove the end pieces.

   e. Inspect the asphalt specimen to make sure that the sides are uniform and free of any irregularities.

3. **Store the asphalt beams in the test bath. A small beaker or wire frame in a corner of the bath can be used for this purpose.**

4. **Record the time the beam is placed in the bath.**

Note: The demolding process should be completed as quickly as possible to prevent deformation of the specimen.

Initial Startup

Remove any beams from the beam supports.

Turn the computer and the TE-BBR instrument ON and check the push button switches on the BBR left panel to make sure that the red indicator LEDs are lit. These default settings for BBR front panel switches are LOCAL and ZERO. Maintain or restore these default settings prior to activating the air bearing compressed gas supply.

Enable Temperature Control

The TE-BBR will not control temperature unless the **Enable Temperature Control** software option is turned on. When temperature control is enabled, the **Enable Temperature Control** option on the **Setup** menu will have a check mark in front of it.

To enable temperature control, select **Setup** from the Main Menu and click on **Enable Temperature Control.**

Note: When the TE-BBR is turned off, Temperature Control is disabled. If the software application is exited but the instrument remains on, the Enable Temperature Control option retains its previous setting when the BBR is restarted.

Adjust Gas Pressure

1. Before turning on the compressor or compressed gas valve, make sure that there are no beams on the supports.
2. Turn on your compressor or compressed gas supply and make sure it is functioning normally.
3. Adjust the LINE pressure to 40 psi and the BEARING pressure to 25 psi. Ensure that the supply pressure is always set to a minimum of 60 psi to guarantee adequate regulation from the bearing pressure regulator.

Adjust Load Settings

1. Place the 6.35 mm (¼") thick stainless steel beam on the supports.
2. Set the switches on the front of the Control Unit to LOCAL, and ZERO.

3. Watch the Force value on the **Instrument Status Bar** and adjust the Control Unit ZERO pressure dial until the load reading displayed is 35 mN ± 10 mN.
4. Switch to the LOAD mode (Control Unit front panel, left side) and adjust the LOAD regulator until the computer display reading for the load is 980 ± 50 mN.
5. Switch back to the ZERO mode and check to see if the shaft has drifted up off the beam. If so, repeat the load procedure.
6. Manually raise the shaft enough to remove the stainless steel beam.

Test Asphalt Binder Samples

After preparing the TE-BBR instrument for testing and completing the confidence test, follow the procedure below to test asphalt binder samples:

1. Check the bath temperature to ensure it is at the desired test temperature. If not, follow the procedure in section *Prepare the Temperature Bath*. Input the desired temperature using the **Bath** option from the **Instrument Setup** menu, making sure that temperature control is enabled.

Wait until the temperature has stabilized at the desired level before proceeding with the next step. Set the switch on the Control Unit to LOCAL.

2. Use tongs to place the thick 6.35 mm (¼") steel beam carefully on the supports and slowly lower the shaft until it touches the beam.

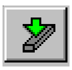
3. Adjust the Control Unit ZERO pressure dial until the load reading shows the desired contact load of 35 mN ± 10 mN.

4. Switch to the LOAD mode (on the Control Unit front panel) and adjust the LOAD regulator until the computer display reading for the load is 981mN ± 50 mN.

5. Switch back to ZERO and check to see if the shaft has drifted up off the beam. If it has, repeat steps 3-4. If not, proceed to step 6.

Testing the Specimen

6. Use tongs to remove the thick steel beam from the bath.

7. To initiate the software-driven test procedure, click on **Run a New Test** from the **Test** menu options. Or click  on the BBRw software toolbar.

8. Enter preliminary test information from the **Test Setup** dialog and click on **OK**.

9. Set the LOCAL/REMOTE switch to the REMOTE setting.

10. Follow the software prompts to complete the test.

During the test, the deflection/force values are plotted on a graph on the computer screen. At the conclusion of the test, the screen display changes to the Report view. At the end of the loading period, there is an automatic return to zero load condition.

To make additional tests, simply repeat this procedure and make changes as desired using the menu options.

Test Description

The full load will initially be applied to the sample for a one-second period, and then removed for twenty seconds before it is again applied for the full 240 second test period. The short pre-loading ensures that the beam is well seated on the supports before the actual test begins. Since some slight deformation will occur, the twenty-second unloading period allows the beam to recover to the original state.

The progress of the test can be observed by following the graph plot of load and deflection appearing on the computer monitor. At the end of the loading period, there is an automatic return to zero load condition and the graph plot is redrawn with revised vertical axis scale values if the BBR Autoscaling feature is enabled. Refer to Figure 20 for an example of a test graph.

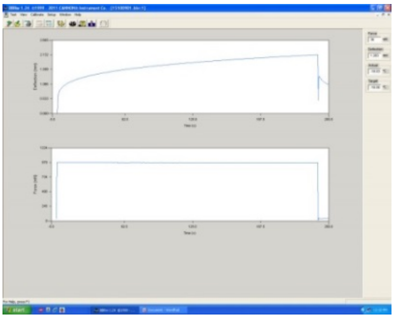
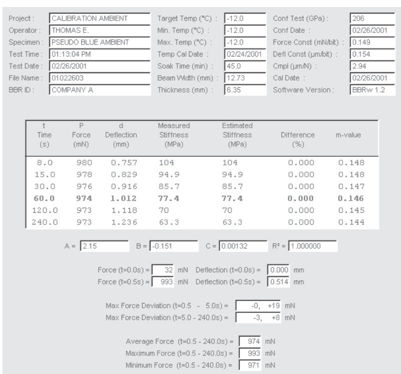


Figure 20: Graph of Test Results

Results also appear in Report form. Figure 21 is an example of test results in Report view. See *Appendix 1 – Test Reports* for more information about test results.



Project :	CALIBRATION AMBIENT	Target Temp (°C) :	-12.0	Conf Test (GPa) :	206
Operator :	THOMAS E.	Min. Temp (°C) :	-12.0	Conf Date :	02/26/2001
Specimen :	PSEUDO BLUE AMBIENT	Max. Temp (°C) :	-12.0	Force Const (mN/bit) :	0.149
Test Time :	01:13:04 PM	Temp Cal Date :	02/24/2001	Defl Const (µm/bit) :	0.154
Test Date :	02/26/2001	Soak Time (min) :	45.0	Cmpl (µm/N) :	2.94
File Name :	01022603	Beam Width (mm) :	12.73	Cal Date :	02/26/2001
BBR ID :	COMPANY A	Thickness (mm) :	6.35	Software Version :	BBRw 1.2

t Time (s)	P Force (mN)	d Deflection (mm)	Measured Stiffness (MPa)	Estimated Stiffness (MPa)	Difference (%)	m-value
8.0	980	0.757	104	104	0.000	0.148
15.0	978	0.829	94.9	94.9	0.000	0.148
30.0	976	0.916	85.7	85.7	0.000	0.147
60.0	**974**	**1.012**	**77.4**	**77.4**	**0.000**	**0.146**
120.0	973	1.118	70	70	0.000	0.145
240.0	973	1.236	63.3	63.3	0.000	0.144

A = 2.15 B = -0.151 C = 0.00132 R^2 = 1.000000

Force (t=0.0s) = 32 mN Deflection (t=0.0s) = 0.000 mm
Force (t=0.5s) = 993 mN Deflection (t=0.5s) = 0.514 mm

Max Force Deviation (t=0.5 - 5.0s) = -0, +19 mN
Max Force Deviation (t=5.0 - 240.0s) = -3, +8 mN

Average Force (t=0.5 - 240.0s) = 974 mN
Maximum Force (t=0.5 - 240.0s) = 993 mN
Minimum Force (t=0.5 - 240.0s) = 971 mN

Figure 21: Report View of Test Results

Shut Down the Instrument

At the conclusion of testing, follow the proper shutdown procedure outlined in this section to prevent damage to TE-BBR components.

1. Remove any beams from the supports and heat the bath to +5 °C.
2. Raise the Load Frame shaft and place the gage block on the left side of the load platform. Lower the shaft so that the adjustment screw rests on the top surface of the gage block.
3. Turn off, by rotating counter-clockwise, the LINE regulator on the front panel to remove pressure from the system.

   Caution: The LINE regulator must be turned off before any external supply valve is turned off to prevent the shaft from shooting upward.

4. Seal the bath with the bath cover to minimize evaporation of bath liquid.
5. Turn off the Control Unit power switch and air compressor or other gas supply.

Troubleshooting

Stability of the compliance value is the most critical aspect. Compliance should be monitored to ensure that values are within the parameters described above. If values differ significantly, recalibrate and check for "play" in the Delrin load shaft or asphalt residue on the shaft nose, beam or beam supports. If the problem is still unresolved, call CANNON for technical assistance.

Troubleshoot Confidence Test

If a satisfactory Confidence Test result is not obtained, select **Instrument Setup** from the BBR software Setup menu. Then click on **Beam Dimensions** and make sure that the proper beam dimension values are entered. The thin beam is approximately 1.19 mm (0.047") thick and 12.7 mm wide. Use a calibrated caliper/micrometer to measure the dimensions of the beam at the point where force will be applied. Enter the values for **Thin Beam Thickness** and **Width** in the appropriate fields.

FHP Motors

For routine maintenance and improved bearing life expectancy, add a few drops of non-detergent 'twenty weight' oil every 12 months.
Fans should be cleared of dust/other material on a regular basis.

Common Issues and Solutions

Problem: Shaft does not move freely up and down.
Solution(s): Check the LINE and AIR BEARING pressure on the dials the front panel of the instrument. Ensure that the recommended pressure settings are being used. (45 psi to 60 psi for LINE; 25 psi to 35 psi for the AIR BEARING)
Confirm that the magnet on the Load Frame is not making contact with the guide frame. If it is, follow this procedure to restore the magnet to its correct position:

1. Loosen the set screw holding the magnet in place.
2. Move the magnet about 2 mm (1/16") away from the Load Frame guide frame.
3. Tighten the magnet set screw securely.

If the shaft movement is still inhibited, check for water in the air lines:

1. Turn off air to the instrument.
2. Remove the air line from the air bearing.
3. Apply air pressure to the open line.

If water is expelled from the line, supply dry gas (such as nitrogen) to the bearing to remove moisture from the bearing and from the line. Then, attach a trap to the air line to remove water. Reconnect the air line and turn on air to the instrument.

Recheck shaft movement. If it is not improved, check the Load Cell wires to confirm they are not contacting the frame:

1. Loosen the four screws at the corners of the front panel of the Load Frame.
2. Remove the front panel from the Load Frame. Make sure that the load cell wires are not contacting the stationary part of the frame. Reassemble the front panel.

If the load cell wires are not contacting the stationary part of the frame and the problem continues, contact your CANNON representative for assistance.

Flush and Drain the Air/Water Heat Exchanger

The water/antifreeze mixture should be replaced annually for reliable performance and to prevent corrosion of internal components. To flush fluid from the Exchanger and BBR, you'll need to obtain replacement antifreeze, a funnel, a drain bucket and a supply of warm water. Then follow the procedures outlined below.

Flush Procedure

1. Turn off the TE-BBR power switch to remove power from the instrument and Exchanger.
2. Detach the quick-connect fitting securing the tubing from the BBR to the IN connection on the Exchanger by pushing down on the release button while pulling the hose connection out. Refer to Figure 22. Place the tube end in the drain bucket and pull the hose off of the ribbed section of the fitting. Fluid will begin draining from the BBR and Exchanger.

Figure 22: Remove Exchanger Tubing Connection

3. Open the lid of the Exchanger reservoir and place the funnel in the opening.

4. Turn on the BBR instrument to engage the Exchanger circulating pump. Fluid from the Exchanger and BBR will flow into the drain bucket.

5. Immediately begin adding warm water to the Exchanger reservoir through the funnel and continue as it is pumped out into the drain bucket until the water exiting the drain hose into the drain bucket flows clear.

6. Stop adding water to the reservoir and immediately turn off the TE- BBR power switch.

7. Replace the connector on the Exchanger hose, and reattach the connector to the fitting on the Exchanger as shown in Figure 22 on previous page.

Caution: Do not permit the Exchanger pump to operate without fluid in the system. This damages the pump.

Drain Fluid Procedure

After the antifreeze mixture has been flushed from the Air/Water Heat Exchanger per the preceding procedure, drain the system as follows:

1. Ensure that the TE-BBR power is OFF. Remove the external housing from the Air/Water Heat Exchanger by removing the six screws securing the housing to the sides of the frame (three screws on each side of the unit) and the six screws on the top and sides of the rear panel.

Locate the twin stopcocks at the top and bottom of the radiator. Attach a drain hose to the bottom stopcock and place the opposite end of the hose in a drain bucket. Refer to Figure 23.

Figure 23: Exchanger with Housing Removed

2. Open the top and bottom stopcocks by turning them parallel to the nozzle and permit water to drain from the radiator. Then close the stopcocks and remove the drain hose from the bottom stopcock.

   Note: A small amount of water/antifreeze mixture may remain in the tubing leading from the external connector to the reservoir. This can be drained by pulling the hose off of the ribbed section of the quick-connect fitting previously installed. Reattach the tubing before completing the remainder of this procedure.

3. Replace the external housing on the Air/Water Heat Exchanger and secure it with the six screws previously removed. If necessary, reseat the gasket around the reservoir opening with a small screwdriver.
4. Add water/antifreeze mixture to the Exchanger per the instructions in the section *Fill the Air/Water Heat Exchanger* to complete the water/antifreeze flush and drain procedure.

Confidence Test Failures

Problem: The confidence test fails repeatedly.
Solution(s): Check software settings for the thin beam thickness as follows:

1. Choose **Setup** from the BBRw Main Menu and click **Instrument Setup**.
2. Select the **Beam Dimensions** tab from the property sheet.
3. Measure the thickness and width of the thin steel beam used for the test and compare the measurements with the recorded value for **Thin Beam Thickness and Width**.
4. If the setting is incorrect, enter the correct value in the appropriate field and click **OK** to save the new value. If the setting is correct, recalibrate for Force, Deflection and Compliance (see *Calibration* section for instructions).
5. Rerun the confidence test.

Level the BBR

If the TE-BBR is not level, the weight platform may rub against the steel bar used to prevent rotation of the platform. The resulting friction produces an erroneous measure of the steel beam modulus.
To level the TE-BBR, place the bubble level (supplied with the instrument) on the Load Platform of the Load Frame and adjust the leveling legs under the Control Unit to level the instrument. The supplied bubble level is pictured in Figure 24.

Figure 24: Bubble Level

Other possible causes for confidence test failure may be that the LVDT/load cell is not properly adjusted.

Fluctuation in Deflection/Load during a Test

Problem: The test graph shows considerable fluctuations in the deflection and/or load values during the progress of the test.
Solution(s): Fluctuation may be caused by inconsistent line air pressure. Check the source for problems with flow. Eliminate all sources of vibration around the instrument. Move any machinery with vibrating components such as motors and/or pumps away from the instrument. Run the test again and check for abnormal Deflection/Load values.
Several tests can be performed to isolate an electrical problem.

Clean the Instrument Housing

Caution: Turn off all power and unplug the power cord before cleaning the BBR.

Periodically clean the outside of the TE-BBR units with a damp cloth moistened with water and/or a mild detergent solution. Do not wipe or otherwise apply pressure to the base of the load shaft in order to avoid damaging the load cell.

Check Function of TE-BBR Cooling Modules

This section provides a preliminary procedure for checking function of the thermoelectric cooling modules mounted internally to the TE-BBR bath. The procedure will check the integrity of the electrical circuit defined by input and output leads from the modules.

Tools Required: Phillips screwdriver, multimeter

Procedure

1. Remove power from the TE-BBR unit and unplug the MAINS power source.
2. Using a Phillips screwdriver, remove the four screws securing the left rear side panel of the TE-BBR. Remove the panel to reveal and access the internal electronics. Refer to Figure 25.

Caution: The TE-BBR is designed with a capacitor capable of holding a strong charge. Do not touch the capacitor or other internal components unless specifically instructed to do so in this procedure.

Figure 25: TE-BBR Capacitor

3. Locate the internal barrier block. The block includes six pairs of terminal connections. Refer to Figure 26.

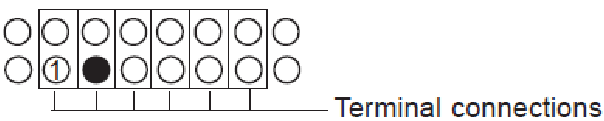


Figure 26: Terminal Connections

4. Remove the bottom screw from the second pair of terminal connections from the left (the dark circle in the diagram in Figure 26).

5. Attach the black wire from the multimeter to the ring terminal of the lead just disconnected from the barrier block (previous step).
6. Touch the red wire from the multimeter to the bottom screw on the first pair of terminal connections from the left (numbered in the diagram in Figure 26).
7. Set the multimeter to indicate resistance (ohms).
8. Check the multimeter reading. It should indicate a completed circuit (zero to very low ohm value). If it does not, then the function of the modules has been compromised, and the TE-BBR unit needs to be repaired.
9. After completing the multimeter test, replace the black wire in its original position on the terminal strip and secure it with the previously removed screw.

Check the Thermostat

Perform the following procedure to check the function of the thermostat.

1. Remove the brown wire from terminal #4 and attach the black lead of the multimeter to the wire.
2. Touch the red lead of the multimeter to terminal #6 (set to measure resistance). The meter should show continuity (zero to very low ohm value).
3. If the appropriate reading is obtained, reattach the brown wire to terminal #4. If an inappropriate reading is obtained, the thermostat needs to be replaced. Call CANNON for assistance.

Conclude the Evaluation

1. Replace the rear panel and secure it with the previously removed screws.
2. If desired, restore MAINS power to the TE-BBR instrument.

Clean Air Bearing Shaft and Load Cylinder in TE-BBR

If vertical movement of the Load Frame air bearing shaft is impeded, it may be due to asphalt contamination at the top of the shaft, or other contaminants possibly introduced through the air lines to the load cylinder. Do not attempt to lubricate the air bearing shaft as lubricants can inhibit the function of the air bearing. Use the following procedures to remove contaminants and debris.

Required Tools: Medium size Phillips screwdriver, asphalt solvent, 3/8” or adjustable wrench, petroleum based (Stoddard® type) solvent

Remove Asphalt from the Shaft

Prepare the instrument for normal operation per manual instructions, including the section on adjustment of gas pressure.

1. It is not necessary to prepare a beam or achieve a bath test temperature.
2. Carefully remove the Load Frame from the bath and place it on top of the Control Unit.
3. Adjust the ZERO regulator until the air bearing is lifted to the top of its travel.
4. Apply a small amount of asphalt solvent to an absorbent paper towel. Then gently wipe the air bearing shaft beneath the load platform to remove asphalt from the shaft.

   Caution: Do not apply lateral pressure to the air bearing as this may damage the instrument.

5. Repeat step 4 until the air bearing moves freely. If movement of the shaft remains inhibited after several repetitions, perform the load cylinder cleaning procedure in the next section of this technical note.

Remove Load Cylinder Contaminants

Follow the procedure outlined in this section to remove any contaminants introduced through the twin air lines to the load cylinder.

1. Turn off instrument power at the rear of the TE-BBR Control Unit. Remove the Load Frame from the bath and place it on top of the Control Unit.
2. Use the Phillips screwdriver to remove the four screws securing the front panel to the Load Frame.
3. Remove the front panel from the Load Frame.
4. Locate the upper and lower air line connections to the load cylinder as shown in Figure 27.

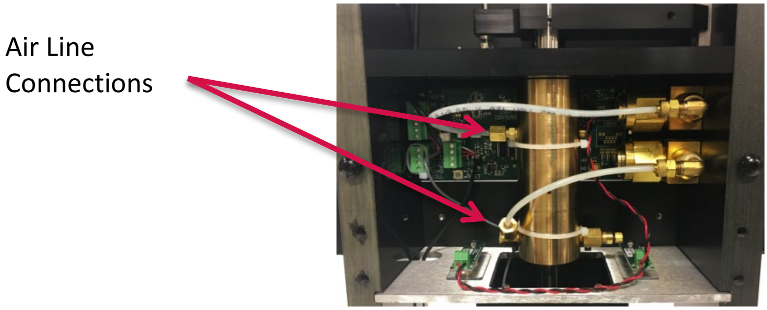


Figure 27: Load Cylinder Air Line Connections

5. Using the wrench, disconnect the upper and lower air line at the load cylinder.
6. Restore power to the TE-BBR and permit air to blow through the unattached air lines for two or three minutes to clear the lines of any contaminants.
7. Use the ZERO regulator on the Control Unit to adjust the ZERO pressure to 0 psi.
8. Use the LINE regulator on the Control Unit to adjust the LINE pressure to 0 psi.
9. Reconnect the upper air line, tightening the connection finger tight; then tighten an additional quarter-turn with the wrench.
10. Introduce a small amount of petroleum-based solvent to the load cylinder around the air bearing shaft where the shaft passes through the horizontal support frame beneath the load platform.
11. Continue to apply small amounts of solvent while manually raising and lowering the load platform to encourage distribution of solvent between the shaft and the wall of the load cylinder. Allow the solvent to remain in the cylinder for several minutes.
12. Use the LINE regulator on the Control Unit to restore normal line pressure. Solvent is then forced out the top and bottom of the load cylinder.
13. Gently wipe away excess solvent from the shaft and load cylinder with an absorbent paper towel. Continue this air-drying procedure until all solvent has been removed from the air bearing.
14. Reattach the bottom air line to the air cylinder and adjust the pressure regulator for the ZERO load to obtain a free-floating condition for the shaft. Check the travel of the shaft to ensure free movement over the entire travel of the shaft.
15. If travel is restored, replace the previously removed screws to reattach the Load Frame front cover, replace the Load Frame in the bath, and continue with normal TE-BBR operations.

If the cleaning procedures have failed, contact your local Cannon Instrument Company representative for further assistance.

TE-BBR Force Reading Error

This section provides information on correcting the TE-BBR Force Reading 0.0 Error. The reason for the force reading of 0.0 when the deflection and temperature settings are correct is due to a failure of the registry of the computer running the instrument. Therefore, the TE-BBR software program needs to be reloaded on the controlling PC.

Procedure

1. Record all information from the certificates for the temperature probe, gauge block, thick beam and thin beam.
2. Remove the Cannon TE-BBR program from the controlling computer.
3. Go to `RUN`, type in `REGEDIT` and find the registry keys associated with the TE-BBR. The path is `H_KEY LOCAL MACHINE/SOFTWARE/CANNONINSTRUMENT/BBRw/1.3`
4. Delete the **BBRw** key.
5. Reload the Cannon TE-BBR program.
6. Re-enter the data from your certificates.
7. Recalibrate the instrument.

For a 64 bit Windows Computer

`HKEY_LOCAL_MACHINE/SOFTWARE/WOW6432NODE/CANNONINSTRUMENT/BBRW`

For a 32 bit Windows Computer

`HKEY_LOCAL_MACHINE/SOFTWARE/CANNONINSTRUMENT/BBRW`

If the problem is still unresolved, contact your local CANNON representative for technical assistance.

Replacement Parts

Table 7 is a list of TE-BBR replacement parts available from Cannon Instrument Company upon request.

Table 7: TE-BBR Replacement Parts

Description	Part Number	Description	Part Number
Silicone Rubber Mold for BBR	9728-V40	Stirrer Motor Replacement Kit	44.0610
Tubing Polyflo Grn	02.1740	Front Back Alignment Beam	44.0615
Solenoid Valve	41.5	2 gram weight	44.0657
Rubber-Mold Frame	44.0009	Cover Assembly Bath	44.1080
Rubber-Mold Silicone Insert	44.0010	Pressure Gauge (0-100)	44.1520
Cover 6 ¼ x 6 ¼ Glass	44.0011	Pressure Gauge (0-15)	44.1530
Sheet 6” x 6” Square Silicone	44.0012	Pressure Regulator (high)	44.1540
Clip 3” (BBR Beam Mold)	44.0013	Pressure Regulator (precision)	44.1550
Laser Film 1 5/8” W x 6” L	44.0014	Solenoid Valve (240v)	44.1570
Power Switch (18A)	44.0546	Zero Regulator Assembly	44.1582
Spin Star	44.0574	Load Regulator Assembly	44.1583
Stirrer Protection Sheet	44.0589	Beam Mold Kit (makes 1 beam)	44.6200
O-Ring Bottom Cylinder	44.4160	Beam Mold Side Section	44.6210
Window Lamp (Lexan)	44.4550	Beam Mold End Section	44.6230
Beam Mold Kit (makes 6 beams)	44.6205	O-Ring 7/8 OD X 11/16 ID	44.6240
Beam Mold Bottom Section	44.6220	Thin Steel Beam	44.6511
O-Ring Set OF 12	44.6235	Setup Beam	44.6525

Description	Part Number
Plastic Strip Set	44.6250
Thick Steel Beam	44.6521
Gage Block	44.6535
Cable, M8 M-F 1.5M, 4 POS Shielded	44.5795

Description	Part Number
Weight Gram 100	44.6540
PRT Probe Assy x4	44.5720
CCA TEBBR Lamp	44.8011
USB Cable, Type A	44.5794

Warranty

Products Limited Warranty

In addition to other manufacturers' warranties, CANNON Instrument Company ("the Company") warrants all products (other than reagents and chemicals) delivered to and retained by their original purchasers to be free from defect in material and workmanship for one year from the date of the Company's invoice to the purchaser. For a period of one year from the date of such invoice, the Company will correct, either by repair or replacement at the Company's sole discretion, any defect in material or workmanship (not including defects due to misuse, abuse, abnormal conditions or operation, accident or acts of God, or to service or modification of the product without prior authorization of the Company) without charge for parts and labor. The determination of whether any product has been subject to misuse or abuse will be made solely by the Company. The Company shall not be liable for any special, incidental, or consequential damages, or any damage to plant, personnel, equipment or products, directly or indirectly resulting from the use or misuse of any product. Representations and warranties made by any person, including dealers and representatives of the Company, which are inconsistent, in conflict with, or in excess of the terms of this warranty shall not be binding upon the Company unless placed in writing and approved by an officer of the Company.

Reagent and Chemical Warranty

Cannon Instrument Company ("the Company") warrants all reagents and chemicals sold by the Company and delivered to and retained by their original purchasers to conform to the weight, specifications and standards stated on the package. The Company will, at its sole discretion, either replace or refund the price (net of freight, handling charges and taxes), of any reagent or chemical sold by the Company which does not conform to such weight, specifications and standards upon the prompt return of the unused portion. Except for replacement or refund of the net price, the Company shall not be liable for any damages occurring as a consequence of the failure of any reagent or chemical sold by the Company to conform to the weight, specifications and standards stated on the package.

Returning a Product to CANNON

Before returning a CANNON product for repair or service, make every attempt to identify the problem. If, after careful checking, the problem remains unidentified or unsolved, telephone Cannon Instrument Company (or the local service agent) to consult with a product specialist. If the specialist cannot recommend a simple solution or repair, CANNON will authorize the return of the product through the issuance of a Return Authorization number (RA).

CANNON Telephone Number: 814-353-8000
CANNON Fax Number: 814-353-8007

Products returned to CANNON must be carefully packed. Ship prepaid to the following address:

Cannon Instrument Company
ATTN: Return Authorization # __________
2139 High Tech Road
State College, PA 16803 USA

Please include the required information.

Required Information

- The Return Authorization number (RA).
- The name and telephone number of the person at your company to contact regarding the product.
- Shipping and billing instructions for the return of the product to your location.
- A detailed explanation of the reason for the return. If the product is not covered by warranty, the customer will be provided with an estimate of the repair costs and asked for approval before any repairs are made. The customer will be required to issue a purchase order for the cost of the repairs.

Hazardous Materials

Please contact CANNON before returning a product that could possibly contain hazardous material.

Shipping Notification

Products returned without CANNON's prior authorization will not be accepted. The customer may be billed a testing fee if a product is returned to CANNON and found to be working properly.

Appendix 1 – Test Reports

ASCII File Format for TE-BBR Report Files (.csv)

(Quotes indicate constant strings)

- “Project”, Project ID
- “Operator”, Operator ID
- “Specimen”, Specimen ID
- “Timestamp”, Test Date and Time
- “Target Temperature (C)”, Test Temperature
- “Soak Time (minutes)”, Time in Bath
- “Beam Span (mm)”, 101.6
- “Beam Width (mm)”, Width Measurement
- “Beam Thickness (mm)”, Thickness Measurement
- “Time (s)”,”Force (mN)”,”Deflection (mm)”,”Temperature (C)”
- 0.0, Force at 0.0 s, Deflection at 0.0 s, Temperature at 0.0 s
- 0.5, Force at 0.5 s, Deflection at 0.5 s, Temperature at 0.5 s
- 249.5, Force at 249.5 s, Deflection at 249.5 s, Temperature at 249.5 s

ASCII File Format for TE-BBR Data Files (.dat)

Table 8: ASCII File Format

Field	Width	Decimal Places	Format
Version	5	N/A	V X.X
Specimen ID	22	N/A	--
Project ID	22	N/A	--
Operator ID	22	N/A	--
Test Date	8	N/A	MM/DD/YY
Test Time	8	N/A	HH:MM:SS
Calibration Date	8	N/A	MM/DD/YY
Confidence Test Date	8	N/A	MM/DD/YY
Value of r^2	8	6	0.123456
Estimated Slope @ 8 s	6	3	--
Estimated Slope @ 15 s	6	3	--
Estimated Slope @ 30 s	6	3	--
Estimated Slope @ 60 s	6	3	--
Estimated Slope @ 120 s	6	3	--
Estimated Slope @ 240 s	6	3	--
Actual Temperature °C	7	1	--
Target Temperature °C	7	1	--
Beam Thickness (mm)	7	3	--
Beam Width (mm)	7	3	--
Estimated Stiffness (MPa) @ 8 s	8	0	--
Estimated Stiffness (MPa) @ 15 s	8	0	--
Estimated Stiffness (MPa) @ 30 s	8	0	--
Estimated Stiffness (MPa) @ 60 s	8	0	--
Estimated Stiffness (MPa) @ 120 s	8	0	--
Estimated Stiffness (MPa) @ 240 s	8	0	--
Measured Stiffness (MPa) @ 8 s	8	0	--
Measured Stiffness (MPa) @ 15 s	8	0	--
Measured Stiffness (MPa) @ 30 s	8	0	--

Field	Width	Decimal Places	Format
Measured Stiffness (MPa) @ 60 s	8	0	--
Measured Stiffness (MPa) @ 120 s	8	0	--
Measured Stiffness (MPa) @ 240 s	8	0	--
Force (mN) @ 8 s	8	1	--
Force (mN) @ 15 s	8	1	--
Force (mN) @ 30 s	8	1	--
Force (mN) @ 60 s	8	1	--
Force (mN) @ 120 s	8	1	--
Force (mN) @ 240 s	8	1	--
Confidence Test Results (MPa)	10	0	--
Load Constant (g)	10	6	--
Deflection Constant (mm)	10	6	--
Soak Time (minutes)	5	0	--
Deflection (mm) @ 8 s	7	3	--
Deflection (mm) @ 15 s	7	3	--
Deflection (mm) @ 30 s	7	3	--
Deflection (mm) @ 60 s	7	3	
Deflection (mm) @ 120 s	7	3	
Deflection (mm) @ 240 s	7	3	
Regression coefficient A	11	6	
Regression coefficient B	11	6	
Regression coefficient C	11	6	

TE-BBR Sample Data

Select **Report** or **Graph** from **View menu** options. Refer to Figure 28 and Figure 29.

Project :	CALIBRATION AMBIENT	Target Temp (°C) :	-12.0	Conf Test (GPa) :	206
Operator :	THOMAS E.	Min. Temp (°C) :	-12.0	Conf Date :	02/26/2001
Specimen :	PSEUDO BLUE AMBIENT	Max. Temp (°C) :	-12.0	Force Const (mN/bit) :	0.149
Test Time :	01:13:04 PM	Temp Cal Date :	02/24/2001	Defl Const (µm/bit) :	0.154
Test Date :	02/26/2001	Soak Time (min) :	45.0	Cmpl (µm/N) :	2.94
File Name :	01022603	Beam Width (mm) :	12.73	Cal Date :	02/26/2001
BBR ID :	COMPANY A	Thickness (mm) :	6.35	Software Version :	BBRw 1.2

t Time (s)	P Force (mN)	d Deflection (mm)	Measured Stiffness (MPa)	Estimated Stiffness (MPa)	Difference (%)	m-value
8.0	980	0.757	104	104	0.000	0.148
15.0	978	0.829	94.9	94.9	0.000	0.148
30.0	976	0.916	85.7	85.7	0.000	0.147
60.0	**974**	**1.012**	**77.4**	**77.4**	**0.000**	**0.146**
120.0	973	1.118	70	70	0.000	0.145
240.0	973	1.236	63.3	63.3	0.000	0.144

A = 2.15 B = -0.151 C = 0.00132 R² = 1.000000

Force (t=0.0s) = 32 mN Deflection (t=0.0s) = 0.000 mm

Force (t=0.5s) = 993 mN Deflection (t=0.5s) = 0.514 mm

Max Force Deviation (t=0.5 - 5.0s) = -0, +19 mN

Max Force Deviation (t=5.0 - 240.0s) = -3, +8 mN

Average Force (t=0.5 - 240.0s) = 974 mN

Maximum Force (t=0.5 - 240.0s) = 993 mN

Minimum Force (t=0.5 - 240.0s) = 971 mN

Figure 28: Report View

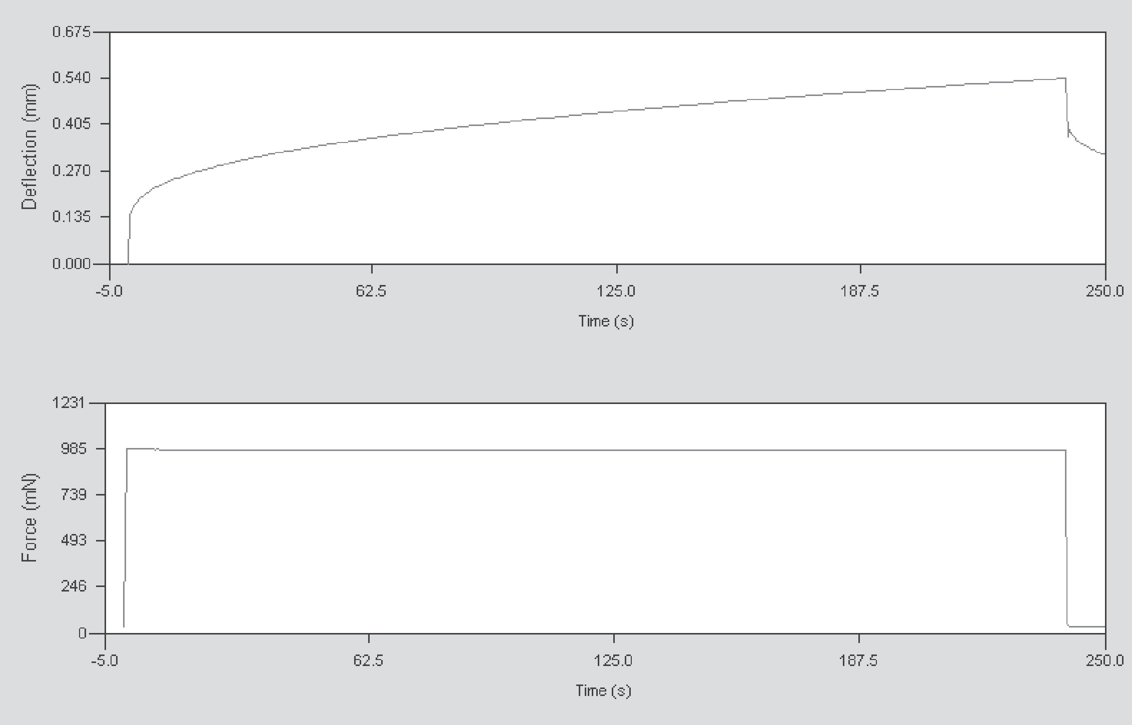


Figure 29: Graph View

Appendix 2 – BBR Motor Stirrer Installation

Technical Note 0306131

This section describes the procedure for installing the replacement motor stirrer (p/n 44.0610) for the Thermoelectric Bending Beam Rheometer. It is also available as a technical note from CANNON.

Caution: This procedure requires access to the instrument's internal components. Follow all instructions carefully. Use appropriate procedures to prevent damage to ESD-sensitive components. Prior to beginning procedure, remove power from the TE-BBR unit heat exchanger supply.

Tools Required: Philips #2 screwdriver, two open-end wrenches (1/2" and 9/16"), stubby #2 Phillips, large common screwdriver, TE-BBR Motor Stirrer (p/n 44.0610)

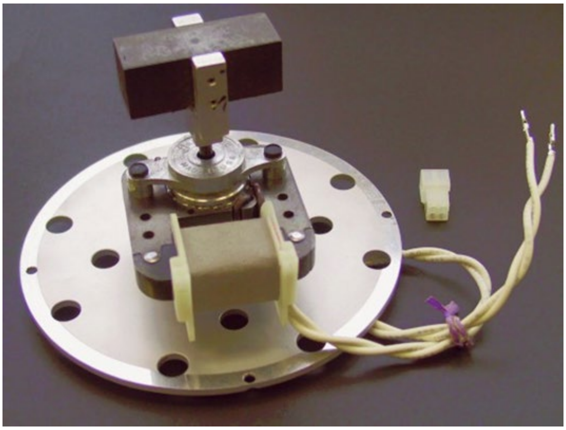


Figure 30: TE-BBR Motor Stirrer/Plate and AC Power Connector

Install Procedure

1. Drain the TE-BBR bath and remove the Load Frame, bath cover, stirrer and stirrer grid from the instrument.
2. Carefully turn the TE-BBR unit upside down to access the bottom panel.

Caution: The TE-BBR is heavy. Obtain assistance for this procedure. Use appropriate safety precautions when lifting.
All panels are connected to the TE-BBR components by wiring. Do not disconnect wiring. Avoid contact with internal electrical components during the procedure.

3. Remove the four Phillips screws securing the bottom motor mounting plate to the TE-BBR frame.
4. Cut the two wires to the motor stirrer and remove the motor and plate. Refer to Figure 30.
5. Slide the wires from the new motor stirrer through the grommet.
6. Ensure that the wires have been inserted through the grommet (step 6). Then attach the wires to #1 and #2 on the new connector. Refer to Figure 31.

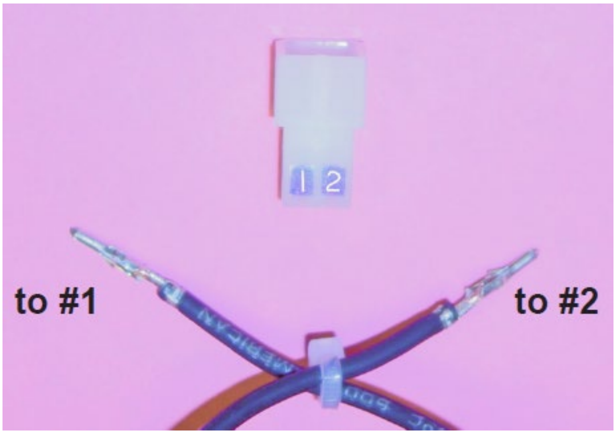


Figure 31: Motor Stirrer Wiring Diagram

7. Orient the bottom plate in its original position on the bath and reattach the new connector to the AC power connection with the flathead screws previously removed. Be careful not to pinch the wires between TE-BBR components as this can damage the wire insulation.
8. Reattach the front and rear panels using the screws previously removed.
9. Return the instrument to its upright position and replace the bath stirrer, stirrer grid, bath liquid, Load Frame and bath cover. The motor stirrer installation is complete.

Please contact CANNON for a return authorization (RA) to return the old motor and plate assembly.

Appendix 3 – BBR Crack Seal Option Installation

Technical Note 0611091

This section describes the procedure for installing the Crack Seal Option (p/n 44.0675) for the Thermoelectric Bending-Beam Rheometer. This is also available as a technical note. Refer to Table 9 for components of the Crack Seal kit.

Table 9: BBR Crack Seal Kit Components (p/n 44.0675)

Description	Part Number	Quantity
Binder with Calibration Certificates	93.2021	1
6-32 ½-inch Phillips flat-head screws	01.0920	2
6-32 3/8-inch Phillips flat-head screws	01.0880	2
Support, Crack Seal	44.0659	2
Adaptor, Support, Crack Seal	44.0660	2
Thin beam assembly for Crack Seal verification	44.0663	1
New ½” thick beam for Crack Seal calibration	44.0664	1
Technical Note 0611091-Crack Seal Installation Instructions	44.0910	1

Tools Required: Stubby #2 Phillips screwdriver, stubby flat blade screwdriver, absorbent paper towels

Replacement Procedure

Caution: Turn off TE-BBR and remove MAINS power from the instrument heat exchanger power supply before beginning procedure. Instrument is heavy, use two or more people for this procedure.

1. Disconnect the Load Frame from the Control Unit. Remove the four bayonet signal connectors and the two air line connections at the rear of the Load Frame.

2. On a lab table or bench, place two 16" high boxes or two 16" high stacks of books approximately 8" apart.
3. Carefully lift the Load Frame out of the TE-BBR bath. While maintaining the Load Frame in its vertical position, transfer it to the table and orient so that the Load Frame is suspended in its vertical position on the 16" supports. Refer to Figure 32. Clean and dry the Frame.

Figure 32: Supported Load Frame

4. Using the stubby flat blade screwdriver, remove the four screws/washers securing the twin beam supports to the base of the Load Frame. The screws are located on the underside of the Load Frame. Refer to Figure 33.

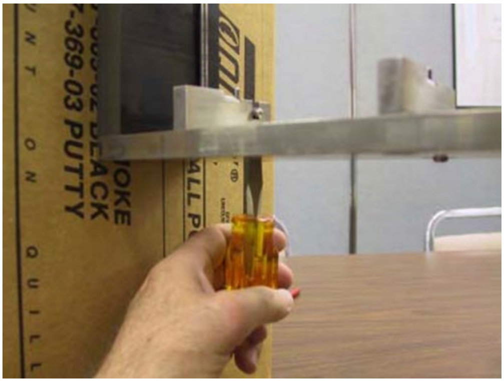


Figure 33: Load Frame Supports

5. Set the screws/washers removed in Step 3 aside. Remove the old beam supports from the Load Frame.

6. Set the two interchangeable replacement beam supports/adapters on the base of the Load Frame in place of the beam supports previously removed.
7. Secure the new beam support/adapters to the Load Frame using the screws/washers previously removed, in the same orientation as the previous supports. The groove for temperature probe should be oriented toward the rear of the Load Frame.
8. Ensure that the thin beam assembly and the thick beam can fit in the cut-out area on the (lower) Crack Seal beam support. Refer to Figure 34. If they cannot be seated properly, loosen the screws securing the beam support to the Load Frame and take advantage of any "play" to readjust the position of the supports until the beam(s) can be correctly positioned.

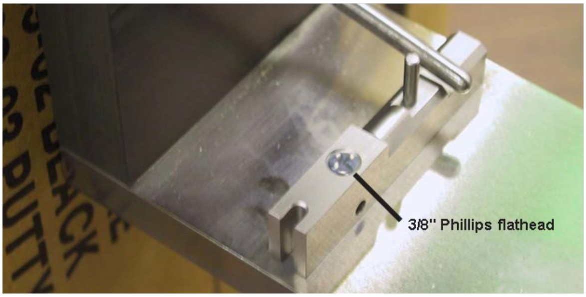


Figure 34: Crack Seal Option Installation (note probe location and cut-out area for beam placement)

9. If necessary/desired, secure the beam support adapter (for asphalt beam testing) to the beam support using the ½” flathead Phillips screws provided. Otherwise, install the shorter 3/8" Phillips screws to the bottom beam support to prevent debris from plugging the hole. Refer to Figure 35.

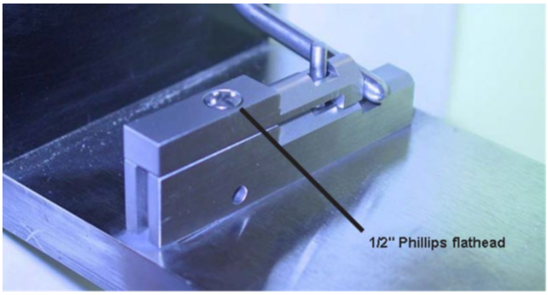


Figure 35: Crack Seal Option Installation with Adaptor for Normal Asphalt Beam BBR Operation

10. Return the Load Frame and bath fluid to the TE-BBR bath per safety-approved procedures. Refer to section Prepare the Temperature Bath for instructions. The Crack Seal Option installation is complete.

Do NOT use the new Crack Seal thick beam and/or the Crack Seal thin beam adapter assembly when the Support Adapter (upper member) is installed. The new components are only used for calibration/verification for the Crack Seal test. These new components are designed to rest on the Crack Seal Support (lower member).
To calibrate the TE-BBR for the normal asphalt test, use the thick and thin beams provided with the instrument.

CANNON INSTRUMENT COMPANY®

2139 High Tech Road | State College, PA 16803 | USA
800-676-6232 | 814-353-8000 | Fax: 814-353-8007
sales@cannoninstrument.com | cannoninstrument.com