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Overview

This manual is intended to provide information on the installation, characteristics and operation of the CANNON® CT-500/600 series II Constant Temperature Baths. CT-500 references in the manual will apply to all models unless otherwise indicated.

CT-500 function

The CANNON® CT-500 series II Constant Temperature Baths are designed to be used for precise viscosity measurements. Because of its temperature stability and ease of use, the baths are also suitable for many other applications where temperatures must be maintained within ± 0.01 °C.

Effective temperature range

The CANNON® CT-500 will maintain temperatures of 20°C to 100°C ± 0.01°C. The CT-500 includes a built-in cooling coil which, when connected to tap water or a cooling system, permits operation below or slightly above ambient temperature. The cooling coil should be used when controlling temperature within 10°C of ambient.

Precision

The precision of kinematic viscosity measurements possible with the CT-500 system meets the sensitivity requirements of ASTM D 445.

Temperature selection

Ten of the most commonly-used temperatures for kinematic viscosity measurement can be set using the left-hand dial on the bath front panel. The bath will equilibrate within a fraction of one degree of the desired temperature. A fine-tuning control permits further temperature adjustments. By switching to the variable setting on the front panel, the operator can set any temperature within the operating range of the instrument.

Figure 1: The CT-500/518 Series II instruments
Bath description

The bath chamber is a cylindrical clear Pyrex® vessel 300 mm (12 inches) in diameter and 300 mm (12 inches) high. A stainless steel baffle coated with white Teflon® is located in the center of the bath and provides a convenient backdrop for viewing viscometers placed in the bath. The top cover contains seven round holes 51 mm (two inches) in diameter for insertion of viscometer holders. An additional 10 mm (3/8 inch) hole is provided for a thermometer.

A solid-state control circuit provides proportional control of the temperature. The sensing element for the control circuit is a stainless steel-encased thermistor. The entire electrical control system is located in a drawer beneath the bath.

Specifications

<table>
<thead>
<tr>
<th>INSTRUMENT SPECIFICATIONS</th>
<th>CT-500</th>
<th>CT-518</th>
<th>CT-524</th>
<th>CT-600</th>
</tr>
</thead>
<tbody>
<tr>
<td>Instrument Model</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dimensions</td>
<td>407 mm wide 362 mm deep 610 mm high (16 x 14.25 x 24 in)</td>
<td>407 mm wide 362 mm deep 762 mm high (16 x 14.25 x 30 in)</td>
<td>407 mm wide 362 mm deep 914 mm high (16 x 14.25 x 36 in)</td>
<td>407 mm wide 419 mm deep 838 mm high (16 x 16.5 x 33 in)</td>
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<td>Weight</td>
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<td>31.8 kg (70 lbs) incl. bath jar</td>
<td>34.5 kg (76 lbs) incl. bath jar</td>
<td>35.4 kg (78 lbs) incl. bath jar</td>
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<td>Shipping Weight</td>
<td>41.4 kg (91 lbs) incl. bath jar</td>
<td>45 kg (99 lbs) incl. bath jar</td>
<td>48.6 kg (107 lbs) incl. bath jar</td>
<td>49 kg (108 lbs) incl. bath jar</td>
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<tr>
<td>Bath Capacity</td>
<td>22 L (5 gal)</td>
<td>30 L (7 gal)</td>
<td>38 L (9 gal)</td>
<td>22 L (5 gal)</td>
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<tr>
<td>Bath Temp. Range</td>
<td>20°C-100°C</td>
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<td></td>
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<tr>
<td>Bath Temp. Stability</td>
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<tr>
<td>Operating Conditions</td>
<td>15°C-30°C, 10%-90% RH non-condensing; Installation category II Pollution degree 2</td>
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<td>Fuse Replacement</td>
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<td>Compliance</td>
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<td>Catalog Number/</td>
<td>CT-500</td>
<td>CT-518</td>
<td>CT-524</td>
<td>CT-600</td>
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<td>Electrical Requirements</td>
<td></td>
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<td>9726-A10 115V AC ± 10% 50/60 Hz, 1000 watts</td>
<td>9726-A17 115V AC ± 10% 50/60 Hz, 1300 watts</td>
<td>115V AC ± 10% 50/60 Hz, 1300 watts</td>
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<tr>
<td></td>
<td>9726-A15 230V AC ± 10% 50/60 Hz, 1000 watts</td>
<td>9726-A19 230V AC ± 10% 50/60 Hz, 1300 watts</td>
<td>230V AC ± 10% 50/60 Hz, 1300 watts</td>
<td>230V AC ± 10% 50/60 Hz, 1000 watts</td>
</tr>
</tbody>
</table>

*Bath stability may decrease to 0.1°C in the presence of an RF field of 2 V/m or greater
Safety warnings

Please observe the following safety procedures and notices for proper operation of your CT-500 series II Constant Temperature Bath:

• Make sure that your unit is operated only by qualified personnel
• 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.
• Deviation from the installation, operation or maintenance procedures described in this manual may result in a hazardous situation and may void the manufacturer's warranty.
• Transport the unit with care. Sudden jolts or drops may cause damage to components.
• Observe all warning labels.
• Never remove warning labels.
• Never operate damaged or leaking equipment.
• Never operate the unit without appropriate levels of approved bath fluid in the bath.
• Do not add bath fluid to the bath unless the bath temperature is within 10°C of ambient.
• Do not splash liquids on the external surfaces of the CT-500, including the Pyrex® bath jar.
• Do not obstruct the cooling vent on the top of the CT-500.
• 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.
• Always empty the bath before moving the unit.
• Never operate the equipment with damaged mains power cables.
• Refer all service and repairs to qualified personnel.

In addition to the warnings listed above, additional cautions are posted throughout the manual. These warnings may be designated by an appropriate symbol inside an equilateral triangle. General cautions are indicated with an exclamation point (see diagram, left). Read and follow these important instructions. Failure to observe these instructions can result in permanent damage to the unit, significant property damage, personal injury or death.

Hot surface cautions (see diagram, left) may be attached on or near hot surfaces of the CT-500. Avoid touching these surfaces when running the bath at temperatures above 50°C.
**Safety features**

The CT-500 comes equipped with a number of safety features:

*Temperature fault sensor*  
A second thermistor in the temperature bath senses any over-temperature fault condition. If such a condition occurs, all power is removed from the bath until an operator corrects the problem and resets the over-temperature limit circuit.

*Thermistor cutoff detection*  
If the control thermistor is disconnected, all power to the bath heaters is cut off.

*Bath fluid level cutoff*  
The CT-500 will not operate if the liquid level in the bath is too low. If such a condition occurs, all power is removed from the bath until the liquid level in the bath is restored to the minimum safe level.

**NOTE**  
Safety devices may be impaired if equipment is not operated per manual instructions.

**Operator safety**

All technicians who use the CT-500 should follow these basic safety procedures:

- The CT-500 power cord should only be connected to a suitable AC mains power source (with protective earth ground) matching the specifications of the S/N label on the CT-500 rear panel.

- The CT-500 should be placed on a stable laboratory table or bench.

- If any liquids are spilled in or around any electronic components of the CT-500, remove power and contact CANNON® Instrument Company before introducing power to the system again.

- Position power cords so that they are not likely to be walked on or pinched by items placed on or against them. Keep all connections as neat as possible.

- To disconnect the power cord, pull it out by the plug. Never pull the cord itself.

- Do not attempt to service the CT-500 system by removing panels and trying to effect repairs. Contact CANNON® Instrument Company for all service and repair needs.

- Monitor bath fluid level carefully and use caution when operating at temperature set points above ambient temperature. Liquid may expand and overflow the jar.

- Observe appropriate safety precautions when handling bath fluid (refer to the Material Safety Data Sheet included with the bath fluid for more details.)

**CAUTION**  
Never use flammable bath liquids in any CT-500 bath.
Unpacking the CT-500

⚠️ CAUTION

Some CT-500 components, including the glass jar and the primary instrument housing, are quite heavy. It is recommended that two people carry the shipping cartons and the heavier unpacked components.

When lifting the CT-500 bath, do not grasp the handles of the electrical drawer. Drawer handles are not designed to bear the weight of the instrument.

1. Remove all components from the shipping container(s).
2. Remove any and all packing materials (styrofoam, etc.) from the components.
3. Verify reception of shipped materials by comparing equipment items with packing/parts list(s). Report missing items to CANNON® Instrument Company immediately.
4. Inspect each component for signs of damage. Report damages to the shipper and CANNON® Instrument Company immediately.

Damaged items

Retain all packing materials until the instrument is connected and functioning properly. If any component(s) must be returned to CANNON® Instrument Company, the damaged item(s) should be packaged in the original shipping container. Refer to the final chapter of this manual for instructions on returning defective equipment. Customers outside the United States should contact the local CANNON® agent for procedures on returning products to CANNON®.
Assembly

Instrument placement

1. Place the bath control housing in the space that it will occupy when the bath is operable. This should be a sturdy, level tabletop or bench with a non-flammable surface.

⚠️ CAUTION Be careful when lifting the control housing; it is quite heavy.

Minimum clearance

The CT-500 series II bath requires 25 cm (10”) of clearance to the rear and sides of the unit.

Support/insulation

2. Ensure that the 30 cm (12”) diameter stainless steel support plate (CT-600 only), insulating disk and felt pad are installed in that order in the cylindrical section on top of the bath housing.

Felt pad placement

3. Place the felt pad on top of the insulating disk (see Figure 3).

Bath jar placement

4. Place the glass bath jar on top of the felt pad.

⚠️ CAUTION Be careful when lifting the bath jar; it is quite heavy.

5. Position the rear cover containing the motor housing, heaters, cooling coil, and baffle on top of the jar (see Figure 4), feeding all connecting cables from the heaters, float switch and control/overtemp probes through the vertical wiring channel in the rear of the housing. The back of the motor housing should fit over the vertical channel, and the groove on the underside of the half-round cover should fit over the edge of the jar.

6. Place the front bath cover (with holes for the viscometers) on top of the front half of the jar.

6b. CT-600 ONLY: Check for alignment of the tab slots in the rear housing with the screw holes in the vertical channel. If the alignment is not correct, adjust the height of the bath vessel per steps 6c-6g.
6c. Loosen and remove the two Phillips-head screws securing the drawer unit to the brackets inside the drawer housing (see Figure 4b).

6d. Pull out the electrical drawer using the handles provided, disconnecting the two connection cables as you do so.

6e. Pull the drawer completely free of the housing and set it aside.

6f. When the drawer is removed, locate the four 1/4-20 socket head cap screws visible at the top of the drawer opening underneath the bath.

6g. Using the Allen wrench provided, adjust the cap screws until the bath top is level and the tab slots in the rear housing are aligned with the screw holes in the vertical channel (see Figure 4c). Then replace the bath drawer and secure it using the Philips-head screws previously removed.
CT-500 Series motor-stirrer installation

Motor-stirrer installation

To install the motor-stirrer, follow the procedure below.

**NOTE**

If you have the CT-600 Series instrument, skip to the CT-600 Series installation section and complete the installation directions in place of this section.

1. Remove the screws that fasten the top cover to the motor housing and remove the top cover.
2. Remove the motor-stirrer from its box.

**CAUTION**

Use care when handling the motor shaft and impeller to prevent damaging sensitive components. Do NOT hold the motor assembly by the shaft. Doing so could bend the rotor shaft slightly out of alignment.

**NOTE**

Two standoffs, one on each side of the opening for the motor-stirrer, serve as locating pins for the motor support pad. The holes in the pad fit loosely over these standoffs to prevent the motor from vibrating out of position.

3. Carefully slide the motor-stirrer into place on the motor support pad, impeller shaft down, and align the motor line cord so it points toward the rear of the bath (see Figure 5). The motor-stirrer should now lie flat on the top of the bath.
4. Lower the motor-stirrer power cord down through the vertical channel in the rear of the unit.
5. Attach the top cover, making sure that all cords pass through the rear opening and down through the vertical shaft. Secure the front of the cover first. The two longer screws w/toothed washers from the Accessories Kit are used to secure the housing to the sides the vertical shaft.

**CT-600 TE cooler and motor-stirrer installation**

This section of the installation procedure is for the CT-600 bath only.

The CT-600 is shipped with the top housing sections installed, but with the motor-stirrer and TE cooling unit packaged separately. To complete CT-600 installation you will remove the housing sections, install the motor-stirrer and TE cooling unit, and reassemble the housing. Follow the procedure below to install these components.
1. Remove the two screws securing the rear housing to the bath chassis (see Figure 5a). Set the screws aside.

2. Loosen but DO NOT REMOVE the two top screws securing the front housing (see Figure 5b). This will provide play for removal of the rear housing.

3. Remove the rear housing by sliding it backward away from the bath.

4. Remove the screws securing the front housing to the bath chassis.

5. Remove the front housing.

6. Uncoil the cables from the heaters, float switch and control/overtemp probes, then lower the ends of the cables through the vertical channel at the rear of the bath.

7. Install the thermoelectric cooler by sliding it through the circular 2" aperture that will be enclosed by the housing (see Figure 5c).

\[\text{CAUTION}\]

Make certain that the tabs (see Figure 5d, next page) are oriented so that they will clear the edges of the aperture during installation.

8. Tighten the two tab screws (one on each side of the finned tube). During tightening the tabs will orient and seat against the bottom of the bath cover to secure the thermoelectric cooler to the bath cover (see Figure 5e).

9. Attach the two matching white power supply connectors together (see Figure 5f).

10. Attach the two matching black power supply connectors together (see Figure 5g).

11. Carefully slide the motor-stirrer into place on the motor support pad, impeller shaft down (see Figure 5, previous section) with "cut out" portion corresponding to the location of the TE cooler.

12. Make certain to align the motor line cord so it points toward the rear of the bath. The motor-stirrer should now lie flat on the top of the bath.

13. Lower the motor-stirrer power cord down through the vertical channel in the rear of the unit.
14. Loosely install the front housing using the screws previously removed, but do not yet tighten the screws.

15. Install the rear housing by sliding the front flanges forward under the front housing until the two pieces mate. If there is insufficient play, loosen the front housing screws until the flanges can slide into place.

16. Secure the rear housing using the two screws previously removed (see Figure 5h, below).

17. Obtain two additional screws and toothed washers from the Accessories Kit. Install the screws to the tabs at the rear of the front housing to secure the housing to the vertical channel.

18. Tighten all housing screws to complete the housing installation.
**Final assembly**

Connect all remaining plugs and probes to the correspondingly labeled and/or color-coded sockets at the rear of the CT-500 bath unit. (see Figure 6)

![Figure 6: CT-500 rear panel connections. All connections marked with "⚠️" contain potentially hazardous voltages. These sockets are for connection to CT-500 plugs ONLY [see below].](image)

**Rear Panel Connections:**
- **Control Thermistor** — Connects main temperature control thermistor to the Control Unit
- **Float Switch** — Connects the fluid-level sensor to the Control Unit
- **Over-temp. Thermistor** — Connects over-temp. thermistor to the Control Unit
- **Heaters** — Supplies AC Mains power to the bath heaters
- **Stirrer** — Supplies AC Mains power to the motor-stirrer
- **Fuses** — Protects against damage or hazard in the event of an internal fault
- **Mains** — Provides AC mains power entry connection

⚠️ **CAUTION** The CT-500 power cord must be connected to an AC mains source matching the specifications of the S/N label on the instrument rear panel.

**Inserting viscometer tubes/thermometers**

The top cover of the CT-500 contains seven apertures, 51 mm (2") in diameter, for the insertion of viscometer tube holders. Two additional holes are provided for insertion of thermometers.

**Inserting viscometer tubes**

If necessary, remove the viscometer tube hole cover(s) from the top of the bath and carefully place the viscometer tube(s), with the proper holder attached, into the bath through the aperture(s) in the top cover.

**NOTE**

After filling the bath with fluid, adjust the height of the viscometer tube(s) to ensure that the liquid under test and/or any timing marks on the tube are a minimum of 6 mm (¼") below the top level of the liquid.

**Thermometer immersion**

Proper thermometer immersion is critical for viscosity measurements. Even a calibrated thermometer will read incorrectly if is it improperly immersed in the bath. “Total immersion” kinematic viscosity thermometers should be used with the bulb and only the mercury column beneath the surface of the liquid, but with the emergent stem above the surface at ambient temperatures.
NOTE

Different thermometers have different immersion requirements. Refer to the information included with the thermometer in use for specific instructions.

Filling the bath

Make sure that the bath is placed in its intended final position before adding bath fluid. The CT-500 should not be moved with bath fluid in the bath jar. NEVER USE FLAMMABLE BATH LIQUIDS.

1. Make sure that the instrument power is OFF and select a bath liquid appropriate to your operating temperature range (see APPENDIX D).

2. Fill the jar with bath liquid at ambient temperature to a level sufficient to engage the float switch. This float permits bath operation when the minimum amount of fluid has been added to the bath jar.

3. Continue to add fluid until the bath liquid level has risen to approximately 40 mm (1.5") of the top of the jar.

4. Turn the instrument power ON and incrementally heat the bath to desired control temperature while monitoring the bath liquid level carefully. The bath level must be 15-20 mm (approximately ½" to ¾") from the top of the jar at the control temperature. If it becomes apparent that this liquid level will not be achieved, return the bath to within 10°C of ambient, turn the instrument power OFF and add or remove liquid as necessary.

5. Repeat step four until you have attained the proper bath liquid level at the desired control temperature.

**CAUTION**

Different bath fluids expand at different rates. Do not overfill the bath!

**WARNING**

Monitor the level of bath liquid closely when operating the CT-500 at higher temperatures (80-100°C). The bath liquid will expand as the temperature increases. The CT-500 bath jar is not designed to contain liquid under pressure. If the bath is overfilled, liquid may overflow.

Draining the bath

If it becomes necessary to drain the liquid from the bath, obtain a suitable container to hold all of the liquid drained from the bath (approximately 22 liters—4.5 - 5 gallons for the CT-500; approximately 30 liters—7 gallons for the CT-518, approximately 38 liters—9 gallons for the CT-524).

Make sure that the bath liquid is within 10°C of ambient temperature. Then insert a tube into the bath chamber from the top opening and siphon the liquid from the bath into a container positioned lower than the bath.

**WARNING**

Always use a rubber bulb or similar device to apply suction to a tube containing bath liquids.
Front panel

The controls for the CT-500 are divided into 5 different “control areas” on the front panel. Each corresponds with a major function of the bath.

<table>
<thead>
<tr>
<th>CT-500 CONTROL AREAS (front panel)</th>
</tr>
</thead>
<tbody>
<tr>
<td>POWER</td>
</tr>
<tr>
<td>This switch provides power to the bath.</td>
</tr>
</tbody>
</table>

Figure 7: CT-500 front panel

In this manual, the control areas will be abbreviated as follows:

Power = P  Temperature = T  Temperature Adjust = TA  Preheat = PH  Limit Control = LC

The commands in those areas will be printed in bold uppercase type, with the abbreviation preceding. For example, TA - FIXED refers to the left-hand dial (marked FIXED) in the TEMPERATURE ADJUST (TA) section of the control panel.
Turning on the CT-500

**NOTE**  
Temperature Adjust (TA) dials on the CT-500 are equipped with locks to prevent accidental changing of dial settings. Push the lock up to release the dial. When the dial has been set to the proper position, push the lock down to re-lock the dial.

1. Verify that the CT-500 has been assembled and installed correctly (Chapter 2, Unpacking and Assembly).

2. Turn the bath Power switch on. Remember that the bath heaters will not be activated if there is insufficient liquid in the bath.

**NOTE**  
Initially the Limit Control (LC - TEMPERATURE ADJUST) dial must be turned completely clockwise to enable the bath to heat properly. After the bath reaches operating temperature, this dial should be reset to prevent the bath from overheating (see page 11).

3. Move the TA - SELECT switch to the left (fixed) position.

4. Release the dial lock on the TA - FIXED dial and reset it to 5.

5. Re-lock the dial.

Setting the temperature

Do not touch hot surfaces of the CT-500 bath when operating the equipment at high temperatures or burns may result.

There are two ways to set the CT-500 bath temperature. The procedure depends upon whether or not the desired temperature is on the T - SELECT dial.

**Pre-set temperature selection**

To set the CT-500 to a preset temperature:

1. Turn the T - SELECT dial to the appropriate temperature. If the temperature is above the current bath temperature, the CT-500 will begin heating and the HEAT LED (Light-Emitting Diode) will light.

2. Make sure the TA - SELECT switch is set to the left (FIXED) position.

**NOTE**  
To heat the bath more rapidly, turn on the PREHEAT (PH) switch. If the target temperature is below 80°C, turn the PH switch off when the desired temperature is reached. For temperatures above 80°C, keep the PH switch ON to maintain temperature control. When the PH switch has been turned on, the PH - HEAT LED will light.

3. As the bath temperature approaches the selected T -SELECT setting, the LED above the TA controls will start to blink as the heater duty cycle is automatically adjusted to stabilize temperature.
NOTE If the auxiliary heater was engaged, the PREHEAT light will also blink. Make sure to turn off the PREHEAT switch if operating at temperatures below 80°C.

4. Insert the appropriate thermometer for the test temperature (see APPENDIX C for thermometry information).

5. To adjust the bath temperature to the exact temperature desired, first unlock the TA - FIXED dial.

6. Read the thermometer to determine the actual temperature of the bath. Make sure that both the bath temperature and thermometer have stabilized before taking a reading.

7. Turn the TA - FIXED dial to adjust the temperature. After each adjustment, allow several minutes for the bath temperature to stabilize.

8. Turn the dial clockwise to increase the bath temperature or turn the dial counterclockwise to decrease the bath temperature.

9. When the desired temperature has been reached, re-lock the TA - FIXED dial.

10. After the bath has reached the desired temperature, set the HIGH TEMPERATURE LIMIT CONTROL (LC). This will prevent the bath from overheating if a malfunction occurs.

Adjusting the High Temperature Limit Control

NOTE During this procedure, the temperature of the bath may change slightly, but will quickly recover.

1. Using a screwdriver, slowly turn the LC - TEMPERATURE ADJUST control counterclockwise until the OVER TEMP message lights up on the LC - PUSH TO RESET button.

2. Turn the control clockwise approximately ¼ to ½ turn.

3. Push the LC - PUSH TO RESET button. If the bath doesn't recover, repeat step 2 and try again.

Custom temperature selection

To set the CT-500 to a temperature not indicated on the T-SELECT dial:

1. Turn the T - SELECT dial to the temperature closest to your desired temperature. If the temperature is above the current bath temperature, the CT-500 will begin heating and the HEAT LED (Light-Emitting Diode) will light.

2. Move the TA - SELECT switch to the right (the VARIABLE position).

NOTE To heat the bath more rapidly, turn on the PREHEAT (PH) switch. If the target temperature is below 80°C, turn the PH switch off when the desired temperature is reached. For temperatures above 80°C, keep the PH
switch ON to maintain temperature control. When the PH switch has been turned on, the PH - HEAT LED will light.

When the bath temperature is approximately that selected with the T-SELECT switch, the LED above the TA controls will start to blink as the heater duty cycle is automatically adjusted to stabilize temperature.

3. Release the lock on the TA-VARIABLE dial.

4. Read the thermometer in the CT-500 bath to determine the actual temperature of the bath. Make sure that both the thermometer and the bath temperature have stabilized before taking a reading.

5. Turn the TA-VARIABLE dial to adjust the temperature. Turn the dial clockwise to increase the bath temperature. Turn the dial counterclockwise to decrease the bath temperature. After each adjustment, allow several minutes for the bath temperature to stabilize.

6. When the desired temperature has been reached, re-lock the TA-VARIABLE dial.

Limit Control

After the bath has reached the desired temperature, set the HIGH TEMPERATURE LIMIT CONTROL (LC). This will prevent the bath from overheating if a malfunction occurs.

Adjusting the High Temperature Limit Control

**NOTE** During this procedure, the temperature of the bath may change slightly, but will quickly recover.

1. Using a screwdriver, slowly turn the LC-TEMPERATURE ADJUST control counterclockwise until the OVER TEMP message lights up on the LC-PUSH TO RESET button.

2. Turn the control clockwise approximately ¼ to ½ turn.

3. Push the LC-PUSH TO RESET button. If the bath doesn't recover, repeat step 2 and try again.

**NOTE** If the desired temperature is within 2 or 3°C of a temperature listed on the T-SELECT dial, it may be possible to attain the temperature using the TA-FIXED dial. Because this dial has a finer adjustment than the TA-VARIABLE dial, the final temperature can be more easily obtained. To try this alternative method, follow the previous instructions, using the TA-FIXED dial instead of the TA-VARIABLE dial.
Verifying Limit Control operation

The Limit Control should be checked periodically to ensure its functionality. To check the Limit Control, follow the procedure below:

1. Power up the CT-500 and set the instrument to a desired bath temperature. Wait for the temperature to stabilize at the desired temperature.
2. Using a screwdriver, slowly turn the Limit Control counterclockwise until the Limit Control OVER TEMP warning lights up.

⚠️ WARNING If the Limit Control warning fails to light up and the Limit Control has been adjusted counterclockwise to its furthest setting, the unit may need to be repaired. Call CANNON® for assistance.

3. When the Limit Control OVER TEMP warning lights up, turn the Limit Control clockwise for ¼ turn and press the OVER TEMP button to reset the Limit Control for normal operation.

Functionality of the Limit Control has been verified for the current operational temperature. If it is necessary to reset the bath temperature, follow the manual instructions (Setting the temperature, pages 10-13) to reset the Limit Control for the new temperature.

Cleaning

⚠️ CAUTION Before cleaning the CT-500, turn off the instrument and unplug the power cord. Do not clean the instrument unless the bath temperature is within 10°C of ambient.

Periodically clean the outside of the unit with a damp cloth moistened with water and/or a mild detergent solution.

Using the thermoelectric cooling system [CT-600 only]

The CT-600 thermoelectric cooling system is activated via the front panel On/Off switch. Thermoelectric cooling is generally recommended when maintaining a bath temperature within 20 degrees of ambient.

The thermoelectric system should be turned off whenever the bath temperature exceeds 50°C.
**Products limited warranty**

In addition to other manufacturers’ warrentees, 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 election, 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 sold by the Company except as set forth in and limited by the foregoing warranties. 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 option, 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®

Procedure

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 following:

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
Stringent government regulations restrict the shipment of mercury. Please contact CANNON® before returning a product that could possibly contain mercury.

Shipping notification
Products returned without prior notification (by either telephone or fax), or without Cannon’s 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 A — PROBLEM ANALYSIS

<table>
<thead>
<tr>
<th>Problem</th>
<th>Probable Cause</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bath does not appear to have power.</td>
<td>• Power cable not connected to outlet or rear of electrical drawer.</td>
</tr>
<tr>
<td></td>
<td>• Over-temperature control set too low.</td>
</tr>
<tr>
<td></td>
<td>• Electric power out.</td>
</tr>
<tr>
<td></td>
<td>• Fuse may need to be replaced</td>
</tr>
<tr>
<td>Bath liquid not agitated.</td>
<td>• Check connection of stirring motor on rear panel.</td>
</tr>
<tr>
<td></td>
<td>• Check impeller attachment to rotor.</td>
</tr>
<tr>
<td>Bath has power but does not heat.</td>
<td>• Check connections for sensors on rear panel.</td>
</tr>
<tr>
<td></td>
<td>• Check temperature setting — it must be above existing bath temperature for heat to be applied.</td>
</tr>
<tr>
<td></td>
<td>• Bath fluid level may be too low.</td>
</tr>
<tr>
<td></td>
<td>• Limit Control Temperature Adjust dial may be set too low (turn completely clockwise, then press PUSH TO RESET button).</td>
</tr>
<tr>
<td>Bath control outside of specific limits.</td>
<td>• Bath fluid viscosity may be too high (if the fluid is too viscous at the desired temperature the stirring will be inadequate, resulting in poor control).</td>
</tr>
<tr>
<td></td>
<td>• Check stirring motor and motor impeller for normal function.</td>
</tr>
<tr>
<td></td>
<td>• Possible thermistor problem. Remove thermistor probe plug and check resistance with an ohmmeter (call CANNON® for information on correct values for resistance at bath temperature).</td>
</tr>
<tr>
<td>Air bubbles in bath fluid.</td>
<td>• Level of fluid may be too low.</td>
</tr>
<tr>
<td></td>
<td>• Stirring impeller may be on shaft with the wrong orientation.</td>
</tr>
<tr>
<td></td>
<td>• Bath fluid may be too viscous for operation at this temperature.</td>
</tr>
</tbody>
</table>
### APPENDIX B — REPLACEMENT PARTS LIST

Following is a list of parts for the CT-500/600 series instruments. Parts may be reordered from CANNON\textsuperscript{®} Instrument Company. Only use CANNON\textsuperscript{®}-authorized replacement parts for service.

<table>
<thead>
<tr>
<th>ALL INSTRUMENTS</th>
<th>PART #</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>P20.22</td>
<td></td>
<td>THERMOMETER HOLDER</td>
</tr>
<tr>
<td>P20.40</td>
<td></td>
<td>IMPELLER STIRRER LOWER CT500 &amp; CT518 &amp; CT524</td>
</tr>
<tr>
<td>P22.39</td>
<td></td>
<td>HOLE COVERS &amp; THERM HOLDER SET</td>
</tr>
<tr>
<td>P25.2455</td>
<td></td>
<td>FUSE 12A 250V MEDIUM BLOW QTY (2)</td>
</tr>
<tr>
<td>P25.3111</td>
<td></td>
<td>FRONT BATH COVER</td>
</tr>
<tr>
<td>P25.3180</td>
<td></td>
<td>PROBE ASSY CONTROL</td>
</tr>
<tr>
<td>P25.3190</td>
<td></td>
<td>PROBE ASSY OVER-TEMP</td>
</tr>
<tr>
<td>P27.2230.1</td>
<td></td>
<td>LAMP RESET SWITCH 12V</td>
</tr>
<tr>
<td>P27.3700</td>
<td></td>
<td>SCREWDRIVER TRIMPOT (OVER-TEMP ADJUST)</td>
</tr>
<tr>
<td>P27.6121</td>
<td></td>
<td>SUPPORT PAD SPONGE</td>
</tr>
<tr>
<td>P50.82</td>
<td></td>
<td>10-TURN DIAL</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CT-500 ONLY</th>
<th>PART #</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>P20.1</td>
<td></td>
<td>PYREX JAR 12 X 12 CT500</td>
</tr>
<tr>
<td>P25.4005</td>
<td></td>
<td>MOTOR STIRRER ASSY 115V CT500</td>
</tr>
<tr>
<td>P25.4006</td>
<td></td>
<td>MOTOR STIRRER ASSY 230V CT500</td>
</tr>
<tr>
<td>P27.5250</td>
<td></td>
<td>TEFLOM COATED BAFFLE WHITE CT500</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CT-518/524</th>
<th>PART #</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>P20.1A</td>
<td></td>
<td>PYREX JAR 12 X 18 (CT-518 ONLY)</td>
</tr>
<tr>
<td>P20.1B</td>
<td></td>
<td>PYREX JAR 12 X 24 (CT-524 ONLY)</td>
</tr>
<tr>
<td>P25.6010</td>
<td></td>
<td>IMPELLER STIRRER UPPER</td>
</tr>
<tr>
<td>P25.6027</td>
<td></td>
<td>MOTOR STIRRER ASSY</td>
</tr>
<tr>
<td>P25.6028</td>
<td></td>
<td>MOTOR STIRRER ASSY</td>
</tr>
<tr>
<td>P25.6066</td>
<td></td>
<td>TEFLOM COATED BAFFLE WHITE</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CT-600 ONLY</th>
<th>PART #</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>P30.1048</td>
<td></td>
<td>MOTOR STIRRER ASSY 115V</td>
</tr>
<tr>
<td>P30.1051</td>
<td></td>
<td>MOTOR STIRRER ASSY 230V</td>
</tr>
</tbody>
</table>
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Kinematic viscosity and temperature

Kinematic viscosity is an extremely temperature-sensitive measurement - a change of 1°C can sometimes lead to a viscosity change of 10 percent or more. Therefore, it is not surprising that temperature measurement and control are the most common problems encountered by laboratories performing accurate kinematic viscosity measurements. Although capillary viscometers typically measure kinematic viscosity with a precision of several tenths of one percent, measurements accurate to within one tenth of one percent (0.1%) are possible. To achieve this, temperatures must be measured with an accuracy of 0.01°C, and be maintained within a range of ± 0.01°C.

Thermometers

All measurements should be made with the viscometer properly immersed in a liquid constant temperature bath. Ideally, a high-quality standard platinum resistance thermometer with a precision bridge should be used to determine the temperature of the bath. Because many laboratories cannot justify the cost of such a thermometer, CANNON® Instrument Company recommends the use of a calibrated ASTM kinematic viscosity thermometer.

ASTM Thermometers

Each ASTM kinematic viscosity thermometer measures only 3 degrees on a scale subdivided into 0.05°C units (equivalent thermometers are available with Fahrenheit scales). These thermometers contain an ice-point scale which allows recalibration by determining the ice-point temperature.

Thermometer Calibration

Calibration of the thermometer is very important. Often the true temperature of a liquid differs markedly from that shown on the thermometer scale. It is not uncommon for kinematic viscosity thermometers to give readings varying as much as 0.1°C from the actual temperature. The true liquid temperature is obtained by applying the proper correction (as noted on the original calibration certificate) to the reading showing on the thermometer scale and including any difference obtained in a recent ice-point measurement of your thermometer.

Thermometer Immersion

Proper thermometer immersion is critical for viscosity measurements. Even a calibrated thermometer will read incorrectly if it is improperly immersed in the bath. “Total immersion” kinematic viscosity thermometers should be used with the bulb and entire mercury column beneath the surface of the liquid, but with the emergent stem above the surface at ambient temperatures.
NOTE

Different thermometers have different installation requirements. Refer to the information included with the thermometer in use for specific installation instructions.

**ASTM thermometer tables**

The following tables show the ASTM thermometers available from CANNON® Instrument Company:

### ASTM CENTIGRADE THERMOMETERS

<table>
<thead>
<tr>
<th>TYPE</th>
<th>CATALOGUE #</th>
<th>RANGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>74C</td>
<td>9311-K47</td>
<td>-55.4 to -52.6°C</td>
</tr>
<tr>
<td>73C</td>
<td>9311-K45</td>
<td>-41.4 to -38.6°C</td>
</tr>
<tr>
<td>126C</td>
<td>9311-K77</td>
<td>-27.4 to -24.6°C</td>
</tr>
<tr>
<td>127C</td>
<td>9311-K81</td>
<td>-21.4 to -18.6°C</td>
</tr>
<tr>
<td>72C</td>
<td>9311-K42</td>
<td>-19.4 to -16.6°C</td>
</tr>
<tr>
<td>128C</td>
<td>9311-K84</td>
<td>-1.4 to +1.4°C</td>
</tr>
<tr>
<td>44C</td>
<td>9311-K10</td>
<td>18.6 to 21.4°C</td>
</tr>
<tr>
<td>45C</td>
<td>9311-K20</td>
<td>23.6 to 26.4°C</td>
</tr>
<tr>
<td>118C</td>
<td>9311-K60</td>
<td>28.6 to 31.4°C</td>
</tr>
<tr>
<td>28C</td>
<td>9311-K05</td>
<td>36.6 to 39.4°C</td>
</tr>
<tr>
<td>120C</td>
<td>9311-K65</td>
<td>38.6 to 41.4°C</td>
</tr>
<tr>
<td>46C</td>
<td>9311-K30</td>
<td>48.6 to 51.4°C</td>
</tr>
<tr>
<td>29C</td>
<td>9311-K07</td>
<td>52.6 to 55.4°C</td>
</tr>
<tr>
<td>47C</td>
<td>9311-K40</td>
<td>58.6 to 61.4°C</td>
</tr>
<tr>
<td>129C</td>
<td>9311-K88</td>
<td>91.6 to 94.4°C</td>
</tr>
<tr>
<td>121C</td>
<td>9311-K70</td>
<td>98.6 to 101.4°C</td>
</tr>
<tr>
<td>110C</td>
<td>9311-K50</td>
<td>133.6 to 136.4°C</td>
</tr>
</tbody>
</table>
## ASTM FAHRENHEIT THERMOMETERS

<table>
<thead>
<tr>
<th>Type</th>
<th>Catalogue #</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>74F</td>
<td>9311-L80</td>
<td>-67.5 to -62.5°F</td>
</tr>
<tr>
<td>73F</td>
<td>9311-L73</td>
<td>-42.5 to -37.5°F</td>
</tr>
<tr>
<td>126F</td>
<td>9311-L98</td>
<td>-17.5 to -12.5°F</td>
</tr>
<tr>
<td>72F</td>
<td>9311-L66</td>
<td>-2.5 to +2.5°F</td>
</tr>
<tr>
<td>128F</td>
<td>9311-L97</td>
<td>29.5 to 34.5°F</td>
</tr>
<tr>
<td>44F</td>
<td>9311-L31</td>
<td>66.5 to 71.5°F</td>
</tr>
<tr>
<td>45F</td>
<td>9311-L38</td>
<td>74.5 to 79.5°F</td>
</tr>
<tr>
<td>118F</td>
<td>9311-L94</td>
<td>83.5 to 88.5°F</td>
</tr>
<tr>
<td>28F</td>
<td>9311-L10</td>
<td>97.5 to 102.5°F</td>
</tr>
<tr>
<td>46F</td>
<td>9311-L45</td>
<td>119.5 to 124.5°F</td>
</tr>
<tr>
<td>29F</td>
<td>9311-L17</td>
<td>127.5 to 132.5°F</td>
</tr>
<tr>
<td>47F</td>
<td>9311-L52</td>
<td>137.5 to 142.5°F</td>
</tr>
<tr>
<td>48F</td>
<td>9311-L59</td>
<td>177.5 to 182.5°F</td>
</tr>
<tr>
<td>129F</td>
<td>9311-L99</td>
<td>197.5 to 202.5°F</td>
</tr>
<tr>
<td>30F</td>
<td>9311-L24</td>
<td>207.5 to 212.5°F</td>
</tr>
<tr>
<td>110F</td>
<td>9311-L87</td>
<td>272.5 to 277.5°F</td>
</tr>
</tbody>
</table>
**ASTM D 445 — Checking the ice point**

**Frequency**

To achieve an accuracy of ± 0.02°C for calibrated kinematic viscosity thermometers, a check at the ice point must be made. New thermometers should be checked monthly for the first six months, then once every six months.

**Method**

The following text outlines procedures for checking the ice point of a thermometer. The text is adapted from:

1994 Annual Book of ASTM Standards, Volume 05.01, Method E77

ASTM Method E77 contains a detailed procedure for the measurement of ice points. The instructions listed here are specifically designed for the mercury-in-glass “kinematic viscosity” thermometers described in Table 2, and may not apply to other thermometers.

The ice point reading of kinematic viscosity thermometers should be taken eight minutes after it has reached the test temperature. The measurement should be expressed to the nearest 0.01°C or 0.02°F.

Use clear pieces of ice, preferably made from distilled water. Do not use any cloudy portions. Rinse the ice with distilled water and crush or shave it into small pieces. Do not touch the ice with bare skin, or any chemical contaminants.

Fill the Dewar vessel with the crushed ice and add enough distilled (and preferably precooled) water to form a slush. Do not float the ice.

Place the thermometer into the slush, packing the ice gently around the stem. Make sure the thermometer is deep enough such that the slush covers the 0°C (32°F) graduation. As the ice melts drain some of the water and add more crushed ice. Avoid thermometer contact with the sides of the Dewar vessel.

After the thermometer has been in the slush mixture for 3 minutes, raise the thermometer a few millimeters and tap the stem gently. Observe any changes in the temperature reading. Repeat this procedure at 1 minute intervals until temperature readings agree within one tenth of division. Alternatively, some of the ice may clump around the stem above the ice point, forming a deep narrow channel which enables the observation of the temperature reading while kept below the level of the ice. If this is the case, observations can be made as described above, without raising the thermometer.

Record and compare successive readings. If they are higher or lower than the readings from a previous calibration, readings at all other temperatures should be correspondingly increased or decreased.
The following text outlines procedures for joining separated mercury columns in thermometers. The text is adapted from:

**NBS MONOGRAPH 150**
*Liquid-In-Glass Thermometry*

**Wise, Jacquelyn A.**

**NOTE**

Many inquiries are received concerning separated mercury column which occur especially during shipment. Since no means of avoiding such occurrences has yet been found, some directions for joining mercury may be helpful and are described below.

(A) The bulb of the thermometer may be cooled in a solution of common salt, ice, and water (or other cooling agent) to bring the mercury down slowly into the bulb. If the salt solution does not provide sufficient cooling, carbon dioxide snow (dry ice) may be used. Since the temperature of dry ice is approximately -78°C (-108°F), and mercury freezes at approximately -40°C (-40°F), the mercury will solidify. Cool only the bulb and never the stem or mercury column. Moderate tapping of the bulb on a rubber stopper or similar soft spongy object, or the application of centrifugal force, by swinging the thermometer in a short arc (i.e. use of centrifugal force), usually serves to unite the mercury in the bulb. Care must be taken to warm the top of the bulb first, so pressures in the bulb due to expanding mercury may be relieved.

(B) If there is a contraction chamber above the bulb or an expansion chamber at the top of the thermometer, the mercury can sometimes be united by warming the bulb until the column reaches the separated portions in either enlargement. Great care is necessary to avoid filling the expansion chamber completely with mercury, which might produce pressures large enough to burst the bulb. (The expansion chamber should never be more than 2/3 full). Joining the mercury is more readily accomplished if the quantity in either cavity has been shattered into droplets by tapping the thermometer laterally against the hand.

This procedure should not be used if requires the thermometer to be heated above 260°C (500°F) and the bulb should never be heated in an open flame.

(C) As a last resort, especially for thermometers having no expansion chambers, small separated portions of the column can sometimes be dispersed if mercury is warmed into droplets tiny enough to leave space for the gas to bypass. The thermometer is heated, and the droplets are collected by the rising mercury column.

Organic liquid procedures
The procedure for thermometers containing organic liquids is similar. Separated liquid in the stem can be vaporized and permitted to drain down the capillary. Another method consists of gently tapping the stem above the separation against the palm of the hand, forcing the organic fluid to break away from the wall of the capillary and flow down the bore to join the main column.

**Uniting gas bubbles**

Minute gas bubbles, which are sometimes found along the surface of the mercury in the thermometer bulb, may be collected by “washing” the bulb with a large gas bubble. Bring all of the mercury into the bulb as outlined in section (A). Hold the thermometer in a horizontal position and gently tap it against the hand to form a large gas bubble. Force the bubble to travel around the walls of the bulb by rotating the thermometer and tapping it against the palm of the hand. When the entire surface has been “washed” rotate the bubble to the top of the bulb and reunite the mercury as described above.

All of these manipulations require patience, and experience is helpful, but they will yield results if care is used. Results can be verified by checking the ice point or some other reference point on the scale.

**Viscosity standards**

*CANNON*® Instrument Company recommends that laboratories check their kinematic viscosity measurements with viscosity standards. If the laboratory is using *CANNON*® calibrated viscometers and has developed a good measuring technique, kinematic viscosity determination using a standard will often point to temperature errors.

Viscosity standards should *not* be used to establish the correct temperature of the bath, however. Bath temperature should be checked and corrected by applying the reliable thermometric techniques outlined above.
APPENDIX D — CHOOSING A BATH LIQUID

The ideal bath liquid would possess low viscosity, high heat capacity, and low vapor pressure over a wide range of temperatures. In addition, the liquid should have a very high flash point and be relatively low in cost. If the fluid is to be used in a kinematic viscosity bath where it is necessary to view the instruments through the bath liquid, then it is important for the liquid to be clear and without color. Unfortunately, no single fluid meets all these requirements. When selecting a fluid, keep the following guidelines in mind.

**Viscosity:**
Viscosity should be very low so that moderate stirring can effectively eliminate temperature gradients in the bath.

**Heat Capacity:**
Temperature changes in the bath are less rapid with a high heat capacity. With the exception of water, most choices for bath fluids will have about the same heat capacity.

**Volutility:**
A liquid which is relatively volatile will require more frequent replenishment. Furthermore, rapid evaporation at the bath surface produces a cooling effect, making control more difficult.

Because no single fluid can be used at all possible bath temperatures, the choice of a suitable fluid must begin by establishing the temperature range over which the bath will be operated. The following is a list of temperature ranges and bath liquids suitable for use in these ranges:

<table>
<thead>
<tr>
<th>Temperature Range (°C)</th>
<th>Suitable Bath Liquids</th>
</tr>
</thead>
<tbody>
<tr>
<td>+5 to +60</td>
<td>Water, Low Viscosity Oils</td>
</tr>
<tr>
<td></td>
<td>Silicones (Dow 200 fluid, 1 cSt)</td>
</tr>
<tr>
<td>+60 to +135</td>
<td>White Oils with oxidation inhibitor</td>
</tr>
<tr>
<td></td>
<td>Silicones (Dow 200 fluid, 20 cSt)</td>
</tr>
</tbody>
</table>

**CAUTION** NEVER USE FLAMMABLE BATH LIQUIDS.

**Silicone fluids**
Silicone fluids are available in a wide range of viscosities and can be used over a wide range of temperatures if the proper selection of viscosity is made for the temperature range of interest. However, silicones are relatively expensive, and a bath containing silicones requires extra care when used for capillary viscometry. If silicones are inadvertently introduced into a viscometer capillary, its calibration factor will be altered by a significant amount.

---

CANNON® CT-500/600 Series II CONSTANT TEMPERATURE BATH
Version 3.2—March, 2007. CANNON® Instrument Company
2139 High Tech Road • State College, PA • 16803 • USA
**Water**

Water is almost the ideal fluid in the temperature range in which it can be used. Due to the possibility of algae formation, some type of water treatment may be necessary. Water can be used at temperatures close to the boiling point, but water replenishment to offset evaporation becomes a nuisance and the hot vapor can make working above the bath uncomfortable. It may be difficult to establish optimum temperature stability at elevated temperatures because of the rapid cooling resulting from surface evaporation.

**Refined white oils**

Refined white oils (paraffin oils) of relatively low viscosity can be used at temperatures above the level at which water becomes unsatisfactory. Because these oils will turn faintly yellow and continue to darken with prolonged exposure to heat, we recommend adding an oxidation inhibitor to retard discoloration. The addition of an inhibitor will prolong the oil's useful life, but the oil will eventually become as dark as untreated oil.

The search for more suitable bath oils is unending. Hydrogenated vegetable oils, coconut oil, synthetic oils, and certain chemical compounds have been used with some success at various temperatures.