CANNON INSTRUMENT COMPANY

TE-1500

Constant Temperature Bath

Instruction & Operation Manual

CONTENTS

CHAPTER 1

TE-1500 OVERVIEW

Introduction

Manual

This manual provides information regarding:

- Functions and operations of the TE-1500 Constant Temperature Bath
- Maintenance and repair of the TE-1500

Applications

The TE-1500 is designed to be used for precise kinematic viscosity measurements between the temperatures of +10°C and -30°C. Because of its temperature stability and ease of use, it is also suitable for use in other applications where temperatures must be maintained within close tolerances.

Cooling capability

The ***CANNON***® TE-1500 Constant Temperature Bath is a thermoelectrically-cooled temperature bath which can maintain temperatures as low as -30°C. The TE-1500 uses air-cooled dual-stage thermoelectric units to maintain constant low temperatures.

Precision

The precision of kinematic viscosity measurements possible with the TE-1500 system meets the sensitivity requirements of ASTM D 445.

*Figure 1: The **CANNON**® TE-1500 Thermoelectric Low Temperature Bath*

Equipment

The TE-1500 is a complete system, consisting of:

- TE-1500 Constant Temperature Bath (Control Chassis & Bath Vessel Housing)
- Assorted hoses, tubes, and connecting cables

Temperature selection

A selector dial on the front panel of the TE-1500 Control Chassis permits convenient temperature selection at 10, 0, -5, -10, -15, -20, -25, and -30°C for kinematic viscosity measurement. After the dial has been set, the bath will equilibrate at or near the desired temperature. The operator can fine-tune the temperature control to within 0.01°C of the desired temperature using either the FIXED control knob (which permits precision control at the common temperatures listed on the Temperature Select dial) or the VARIABLE control knob (which allows for a wider range of temperature adjustment to any setting between +10°C and -30°C).

Bath components

Control Chassis

The Control Chassis for the TE-1500 contains electrical and pneumatic components necessary for control of bath operations. The Control Chassis front panel provides control options, including the bath power and heater switches, temperature selection dial, and related fine-tuning controls for regulating bath temperature.

Bath Vessel Housing

The Bath Vessel Housing for the TE-1500 rests on top of the lower Control Chassis. It contains a rectangular aluminum bath vessel with a four pane, custom-designed glass window.

The Bath Vessel Housing also contains the thermoelectric modules, finned heat sinks, fans, and fluorescent lamps with ballasts. The rear panel has two power connectors from the lower Control Chassis, two air pump connectors from the Control Chassis, and the bath fluid Overflow Jar along with integral pump and tubing connections for the TE-1500 bath fluid circulation system.

Power cables

Two large diameter power cables (AC and DC) with circular connectors on their ends are provided to take power from the lower Control Chassis up to the upper Bath Vessel Housing. Connectors have been designed to attach only in the proper configuration.

Air hoses

Two small diameter silicone air hoses (tube assemblies) with twist/lock pneumatic connectors on their ends are provided to supply and return recirculated bath vapors between the upper Bath Vessel and the Control Chassis. Connectors have been designed to attach only in the proper configuration.

Overflow jar

One glass jar with lid is provided to catch the bath overflow liquid. This jar is to be placed on the rear jar support and joined to the bath fluid control system with the provided segments of small diameter silicone tubing. Fluid from the jar may be recirculated to the TE-1500 bath vessel by depressing the button marked PUSH TO FILL on the rear panel of the instrument.

Temperature probe

One thermistor sensor assembly is provided. The cable from the temperature probe is to be plugged into the back of the lower Control Chassis.

Miscellaneous accessories

Two hole covers, one 1/4-20 cap nut, and one mercury thermometer holder are provided.

Bath apertures

The top cover of the Bath Unit contains two round holes 51 mm (two inches) in diameter for insertion of viscometer holders. One additional hole is provided for a thermometer.

Solid-state control circuitry

A solid-state control circuit provides proportional control of temperature. The sensing element for the control circuit is a stainless steel-encased thermistor.

Safety features

The following safety features are incorporated into the TE-1500 design:

Overtemp thermostat

If the temperature of the bath exceeds the operating limit (+38°C), an internal thermostat senses the over-temperature fault condition. If such a condition occurs, the green lamp above the on/off power will extinguish. All power will be removed from the heater and cooling system until the internal temperature decreases sufficiently. To reset the thermostat, verify that the bath liquid temperature is below +38°C, turn off power to the bath for 20 seconds and then restore power.

Probe disconnect detection

If the temperature probe is disconnected, all power to the bath heater and bath coolers will be cut off.

Overflow drain

If the liquid level in the bath is too high, excess bath liquid will flow into a glass jar located on the bath's overflow platform.

Operator safety

All technicians who use the TE-1500 should follow these basic safety procedures:

- Do not place the TE-1500 system on an unstable cart or stand. The TE-1500 should be placed on a stable laboratory table or bench.
- Keep the TE-1500 away from tubs, sinks, or other water vessels. If any liquids are spilled into the electronic components of the TE-1500, remove power from the unit and contact ***CANNON***® Instrument Company before resuming TE-1500 operations.
- Make sure that the TE-1500 is plugged into a grounded outlet.
- Do not position power cords so that they are likely to be walked on or pinched by items placed on or against them. Keep all connections as neat as possible.
- If the TE-1500 will not be used for an extended period of time, unplug the power cord from the wall outlet. To disconnect the power cord, pull it out by the plug. Never pull the cord itself.

- Do not attempt to service to TE-1500 system by removing panels and trying to effect repairs. Contact ***CANNON***® Instrument Company for all service and repair needs.
- Use a bath fluid appropriate for the desired test temperature and operational environment. Use all proper safety precautions when handling the bath fluid in use (refer to the Material Safety Data Sheet included with the bath fluid for more detail).

General Caution

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.

Protective Conductor

The Protective Conductor Terminal symbol is used to indicate required ground connections for your instrument electrical supply.

WARNING

When supplying power to this instrument, connect the protective ground (earth) terminals of the instrument to the protective conductor of the (supplied) line (MAINS) power cord. The main plug for the power cord should only be inserted in a socket outlet (receptacle) provided with a protective ground (earth) contact. Do not use an extension cord (power cable) without a protective conductor (grounding).

~ MAINS

AC Power Input Symbol

The ~MAINS symbol indicates instructions or connections for the AC power supply. The AC Power input must match the electrical specifications listed on the label on the rear panel of the instrument. The supplied AC Mains power cord must be attached to the connector labelled ~MAINS. This connection serves as a means of disconnect and should be readily accessible.

(O)

Supply OFF Symbol

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

Do not use this equipment in a manner not specified by the manufacturer. If you do, the protection provided by the equipment may be impaired, and you may void the manufacturer warranty.

TE-1500 specifications

TE-1500 Specifications	
Bath Size:	375 mm wide × 420 mm deep × 620 mm high (14.8 × 16.5 × 24.4 inches)
Bath Capacity:	2.5 liters (0.66 gal)
Internal Bath Dimensions:	121 mm wide × 83 mm deep × 305 mm high (4.75 × 3.25 × 12 inches)
Viewing Area:	265 mm high × 95 mm wide (10.45 × 3.75 inches)
Temperature Range:	+10°C to -30°C
Precision:	± 0.01°C
Operating Conditions:	+15°C to 30°C, 10% to 90% RH non-condensing, Installation category II; Pollution degree 2
Bath Weight:	43.1 kg (95 lbs)
Bath Shipping Weight:	59 kg (130 lbs)
Compliance	EMC directive (89/336/EEC); Low voltage directive (73/23/EEC); HI-POT (1900 VDC, 60 sec.)
Electrical:	[match line voltage to unit specifications before supplying unit power]
catalogue # 9726-A62	TE-1500, 115 volts AC ± 10%, 50/60 Hz, 1400 watts
catalogue # 9726-A66	TE-1500F, 230 volts AC ± 10%, 50/60 Hz, 1400 watts
Fuses:	TE-1500, M 250V 12A, 1-1/4" x 1/4"
	TE-1500F, M 250V 6A, 1-1/4" x 1/4"

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CHAPTER 2

UNPACKING & ASSEMBLY

The TE-1500 system is ordinarily shipped in 2 boxes. Please check the packing list to make sure that all items have been received. The bath unit housing is shipped completely assembled with the exception of the Overflow Jar, tubing, and connecting cables.

NOTE

Retain all packing materials until the TE-1500 is connected and functioning properly. If any component must be returned to ***CANNON***® *Instrument Company, it should be packed in its original shipping container.*

Unpacking

CAUTION

Some TE-1500 components are quite heavy. To avoid injury, obtain necessary assistance when lifting and moving shipping cartons and heavier unpacked components.

- Remove all components from their shipping cartons.
- Remove any and all packing materials included to prevent shipping damage (styrofoam, etc.) from the components.
- Inspect all components for damage. Report any damage to the shipper and to ***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***® .

Before beginning assembly, please verify that all components listed on the packing slip are present.

Physical placement

The TE-1500 should be located on a stable, nonflammable laboratory bench or tabletop in a position permitting convenient access to the front and rear of the unit. The bath requires adequate ventilation for the integral cooling fans, so a space of at least eight inches should be provided between the rear and both sides of the TE-1500 and any wall or other obstruction. A clearance area on the right side of the unit is necessary to allow access to the rear pump switch. An electrical service MAINS power outlet matching the electrical specifications on the label on the TE-1500 rear panel must be located within nine feet of the unit.

Assembly

1. Position the Control Chassis in its desired location for operation.

2. Place the Bath Vessel Housing on top of the Control Chassis. The rear mounted alignment bolt on the top rear of the Control Chassis must mate with the hole in the alignment bracket on the bottom rear of the upper Bath Vessel Housing.

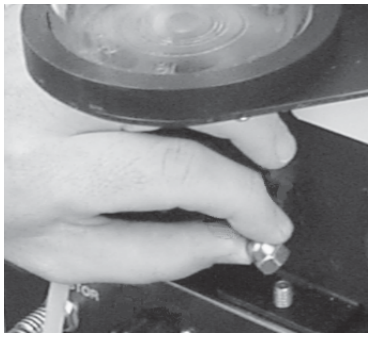


Figure 2: Securing the Bath Vessel Housing to the Control Chassis

3. Secure the connection with the supplied cap nut. The cap nut should only be finger-tightened (see *Figure 2*).

4. Position the Overflow Jar on the rear platform. If the jar platform has not yet been installed, follow the platform installation instructions in the following section of this manual.

5. Slide the tubing from the Control Chassis reciprocating pump onto the connector on the bottom of the Overflow Jar. Ensure that the connection is secure.

6. Place the drain tube from the bath into the Overflow Jar through the circular opening in the cap of the Overflow Jar.

Pneumatic connections

The pneumatic connections on the TE-1500 provide the bath agitation and subsequent stirring by recirculating the bath vapors. To complete pneumatic connections, locate the two silicone tube assemblies. These assemblies have quick-connect bayonet style connectors on their ends.

- Attach one of the tube assemblies to the AIR OUT connection on the Control Chassis. Attach the other end of the assembly to its mating connection on the Bath Vessel Housing (see *Figure 3*, next page). Attach the other assembly to the AIR IN connection on the Control Chassis. Attach the other end of the assembly to its mating connection on the Bath Vessel Housing. To secure the connections, insert the bayonet connector from each hose into its mating connection and turn clockwise 1/8 turn to lock.

Electrical connections

The electrical connections on the TE-1500 provide power to the instrument and transfer bath power (AC and DC) from the Control Chassis to operational components built into the Bath Vessel Housing (see *Figure 3*). Sensor information from the temperature probe is transferred to the Control Chassis via the TEMP PROBE connection.

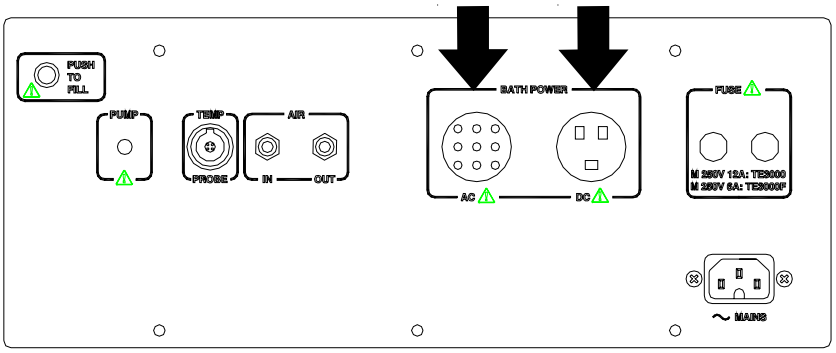


Figure 3: TE-1500 Control Chassis rear panel with Bath Vessel AC and DC power connections highlighted

DC/AC power

Two 12"-long electrical cables deliver DC and AC bath power from the Control Chassis up to the Bath Vessel Housing. Both of these cables have circular plastic connectors on their ends.

- Attach both of these cables to their matching connectors on the Control Chassis and Bath Housing. Ensure a good connection by turning the locking ring on every plug until a slight “click” is felt. The cable with three large rectangular pins carries DC bath power to the Bath Vessel Housing from the Control Chassis. The cable with nine smaller circular pins carries AC bath power from the Control Chassis to the Bath Vessel Housing.

Probe connection

- Connect the small cable with the metal LEMO® connector to the TEMP PROBE connection on the Control Chassis by aligning the red dot on the LEMO® connector with the matching dot on the connection and pushing the connector in until a small "click" is felt. This connection is keyed and operates as a bayonet with a simple push in (*no twisting*). To remove the connector, pull out on the knurled section. This cable carries the temperature probe signal from the upper Bath Vessel Housing to the Control Chassis.

PUMP connection

- Using its attached plastic connector, connect the small wire cable from the liquid pump to the PUMP connection on the lower Control Chassis. This connection is keyed and it operates as a bayonet with a simple push in (*no twisting*). The keyway must be facing upward or insertion will not be permitted. When this connector is properly inserted, a small “click” can be felt. Removal is accomplished with a simple pull. This cable provides power to the Reciprocating Pump.

Mains power connection

- Before connecting the instrument to your mains power source, add bath fluid per manual instructions. See page 13 for more information on the mains connection.

Platform/pump assembly

The platform and pump assembly may be completed with the following items provided by ***CANNON***®

- Overflow Platform
- Assembly screws (2)
- Reciprocating Pump
- Pre-cut tubing (approx. 12", 8" & 4" lengths)

1. If the rear platform is not yet attached to the Bath Vessel Housing, attach it using the two 6-32 screws provided. The tabs which will hold the Overflow Jar in place should be facing upward.

2. After the platform is securely in place, attach the 12" tubing to the bath intake at the top rear of the Bath Vessel Housing by pushing the tubing firmly over the intake nozzle. Then attach the other end of the tube to the hose connection on top of the Reciprocating Pump (next to the electric wire) in the same fashion.

3. Insert the other end of the reciprocating pump into the small hole on the Overflow Platform so that the pump rests on the platform.

4. Attach one end of the 8" tube to the bottom connection on the Reciprocating Pump.

5. Attach the 4" tube to the Bath Vessel Housing overflow outlet located above the Overflow Platform. Place the Overflow Jar on the platform, inserting the other end of the 4" tube through the lid of the jar.

Figure 4: Overflow jar with platform and pump installed

6. Attach the other end of the 8" tube to the connector on the underside of the Overflow Jar. Make sure that all connections are secure.

7. Ensure that the cable from the liquid pump is secured to the PUMP connection on the lower Control Chassis (see instructions, page 7).

Selecting a bath liquid

The "Ideal" Bath Liquid

The "ideal" bath liquid would have a low viscosity, high heat capacity, and low vapor pressure over a wide range of temperatures. This liquid would also have a very high flash point and be relatively inexpensive. If the liquid were to be used in kinematic viscosity measurements where visual observation is important, it would be clear and colorless.

Unfortunately, there is no one "ideal" liquid to use when a wide temperature range is needed. No single liquid meets all of the above requirements.

Temperature Ranges

The kind of liquid used in the TE-1500 Temperature Bath depends upon the desired temperature range of the instrument. The table below lists several different operating ranges and the liquids suitable for use in those ranges:

TE-1500 BATH LIQUIDS

TEMPERATURE RANGE	SUITABLE BATH LIQUIDS
-30°C to +10°C	Methyl Alcohol
-10°C to +10°C	Isopropyl Alcohol Ethyl Alcohol
+5°C to +10°C	Water, Low Viscosity Oils

CAUTION

Methyl alcohol (methanol) is very close to the "ideal" liquid; it can be used at all temperatures in the TE-1500 operating range. However, methanol may not be suitable for some laboratories because of its low flash point and degree of toxicity.

Isopropyl alcohol is less toxic than methyl alcohol and somewhat less volatile. However, it becomes very viscous at low temperatures, making it difficult to maintain good temperature control.

CAUTION

Silicone fluids CANNOT *be used in the TE-1500 Constant Temperature Bath.* NEVER *place a silicone liquid in the TE-1500.*

CAUTION

Do not attempt to use water as a bath fluid for operation at temperatures of 2°C or lower.

Bath Liquid Guidelines

When selecting a liquid for use in the TE-1500, keep the following guidelines in mind:

VISCOSITY	Viscosity should be very low at bath operating temperature 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. Water has about twice the heat capacity of most organic fluids. Most other choices for bath fluids will have about half of the heat capacity of water. (Do NOT attempt to use water as a bath fluid for operation at temperatures of 2°C or lower.)
VOLATILITY	A liquid which is relatively volatile will require frequent replenishment. Furthermore, rapid evaporation at the bath surface produces a cooling effect, making temperature control more difficult.

Filling the bath

Select a bath liquid appropriate for the intended operating temperature(s) for the TE-1500 (see above).

Initially fill the reservoir with the bath liquid until the liquid level reaches the overflow hole (see *Figure 5*) drilled into the wall of the bath.

NOTE

When operating at control temperature, the liquid level in the bath should be about 20 mm (approx. 3/4" below the bath cover). ***Liquid must cover the top edge of the baffle.***

As the bath cools down to the operating temperature, add more bath fluid if necessary to maintain the bath level. If there is bath liquid in the Overflow Jar, depress the circular push button on the upper left corner of the Control Chassis. This button activates the Reciprocating Pump which returns liquid from the Overflow Jar to the bath.

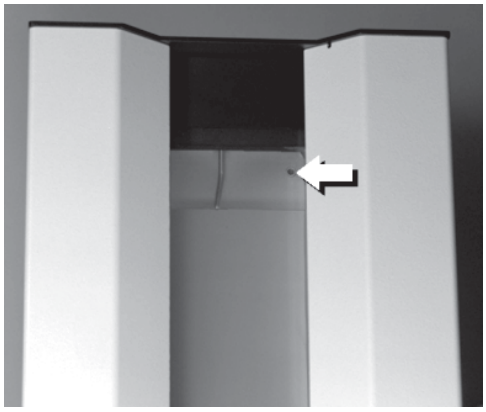


Figure 5:
Bath with overflow hole highlighted

WARNING

Do not purposely overfill the TE-1500 bath, anticipating the contraction of the bath liquid when it cools. The addition of more bath liquid should occur ONLY when test temperature has been reached, and ONLY if the liquid level is too low. Initially overfilling the bath will compromise the overflow system, and could result in bath liquid spilling into the TE-1500, possibly damaging the internal components and creating a hazard.

Overflow

Avoid filling the bath more than necessary after cooling to temperatures below -20°C. The bath liquid will expand as the temperature increases. Excess liquid will drain off into the Overflow Jar in the rear of the bath. Periodically check the amount of liquid in the Overflow Jar. Drain the Overflow Jar when necessary.

Mains power connection

~ MAINS

Attach the MAINS power cord to the connection on the Control Chassis. Make certain that the instrument power switch on the Control Chassis is in the OFF position, then plug the power cord into a wall outlet with electrical specifications matching those on the label on the Control Chassis rear panel. Use only the supplied, approved appliance cord for the TE-1500 power connection.

Draining the bath

CAUTION

Remove power from the TE-1500 before attempting to remove bath fluid. Only remove bath fluid if the bath fluid temperature is within 10°C of ambient.

CAUTION

Use a siphon, inserted through one of the holes for viscometers, to remove fluid from the bath. Never attempt to open the metal bath enclosure.

Figure 6: Removing fluid to a grounded metal waste receiver with a siphon

Bath fluid for the TE-1500 will need to be replaced periodically. Depending on the grade of alcohol being used as a bath liquid, the frequency of replacement may vary greatly. Contaminants contained in solution with the alcohol will remain as sediment in the bath after the alcohol evaporates. All sediment should be removed when replacing bath fluid. If the bath is always maintained at a cold temperature and the holes at the top are always covered, the rate of evaporation of the alcohol will be reduced.

Procedure

The bath liquid in the TE-1500 should be removed by siphoning action. A general purpose siphon (see *Figure 6*) is available wherever kerosene heaters are sold. This simple plastic device has an integral squeeze pump to start the siphoning with a long, straight input hose and a flexible output hose.

An alternate method is a vacuum system with a container trap for containment of the bath fluid. The continuous vacuum in such a system provides an easy means to remove any solid dirt particles and completely empty the bath.

Using a siphon or vacuum hose placed into one of the two instrument holes at the top, transfer all of the bath liquid into another container (Metal waste receivers, if used, should be grounded). Briefly turn on bath power and energize the Reciprocating Pump by depressing the circular

push button on the upper left corner of the Control Chassis rear panel. This will empty any remaining fluid from the Overflow Jar and connection hoses into the bath. Turn off the TE-1500 after the remaining fluid has been returned to the bath vessel.

CAUTION *Do **NOT** leave TE-1500 power on without liquid in the bath!*

Siphon or vacuum the remaining bath liquid from the bath vessel.

Inserting viscometer tubes/thermometers

The top cover of the TE-1500 contains two round holes 51 mm (two inches) in diameter for the insertion of viscometer tube holders. An additional hole is provided for the insertion of a thermometer.

Viscometer tube insertion

Remove the cover(s) from the top of the bath and carefully place the viscometer tube(s) into the plastic holders in the top cover. Insert the tube(s) slowly to permit adequate time for the bath liquid displaced by the tubes to drain through the overflow hole into the Overflow Jar. Monitor the liquid level in the Overflow Jar carefully. If necessary, empty excess fluid from the jar.

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 entire mercury column beneath the surface of the liquid, but with the emergent stem above the surface at ambient temperatures.

Kinematic viscosity thermometers are available from ***CANNON***® Instrument Company. Consult APPENDIX A (Thermometry) for additional details.

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

CHAPTER 3

BATH OPERATION

Setting the temperature

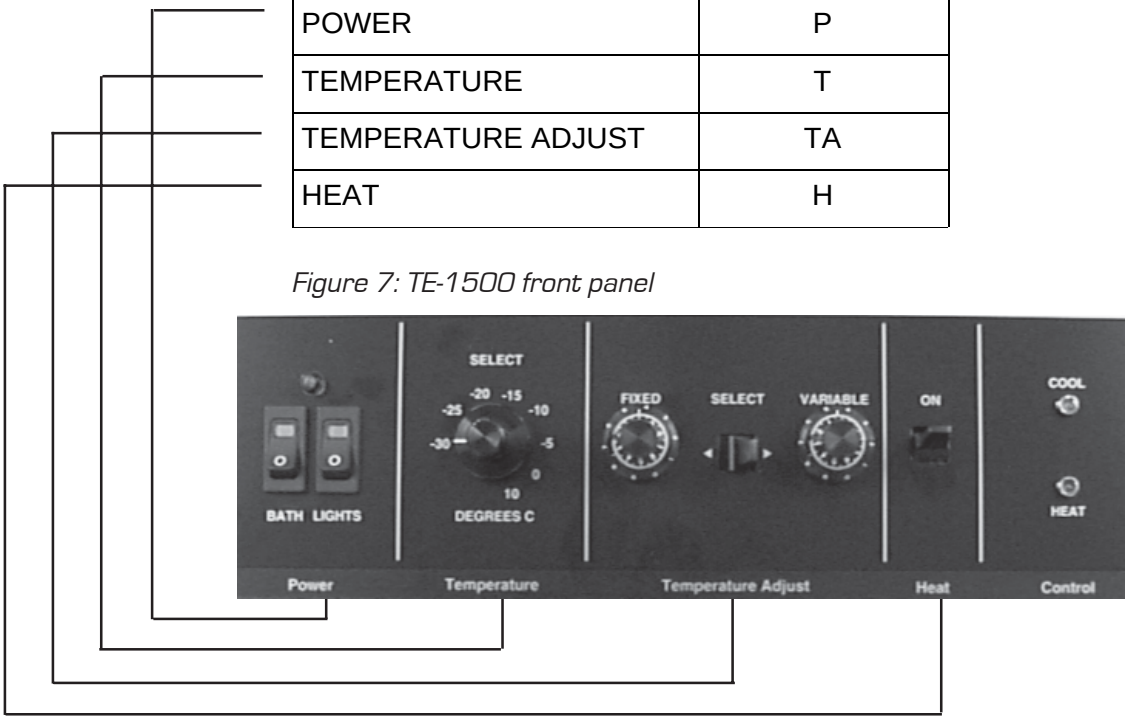
Front Panel Description

The controls for the TE-1500 are divided into 4 different “control areas”, as shown on the front panel (see *Figure 7*). In this manual, the four control areas will be abbreviated as follows:

Front Panel Control Areas

CONTROL AREA	ABBREVIATION
POWER	P
TEMPERATURE	T
TEMPERATURE ADJUST	TA
HEAT	H

Figure 7: TE-1500 front panel



Start-up Procedure

1. Verify that the TE-1500 has been assembled and installed correctly.

2. Turn the bath POWER switch on. The green lamp above the POWER switch should illuminate, indicating the thermostat is functioning. The green lamp in the switch indicates active “mains” power.

CAUTION *Do not operate the TE-1500 with an inadequate volume of liquid in the bath vessel.*

3. Turn on the LIGHTS switch on the front panel and verify that the lamps illuminating the interior of the bath are on.

Temperature control options

There are two ways to set the TE-1500 Bath temperature, *preset* or *custom* temperature selection. Both procedures are described in the following sections. If the desired bath temperature corresponds to a value on the Temperature Select switch, use the Pre-Set Temperature Selection procedure. If the temperature is not one of the Temperature Select switch values, use the Custom Temperature Selection procedure.

Note that dials and switches are identified with their control area abbreviations. For example, TA - FIXED refers to the left-hand dial (marked FIXED) in the TEMPERATURE ADJUST section of the control panel.

NOTE *Both Temperature Adjust dials on the TE-1500 are equipped with dial locks (see Figure 8) to prevent accidental changing of dial settings. Push the lock upward to release the lock and move the dial. When the dial has been set to the proper position, push down on the lock to relock the dial.*

Before beginning the temperature selection procedures, release the dial locks on the TA-FIXED and TA-VARIABLE dials and set the dials to their midpoints (500). Then relock the dials.

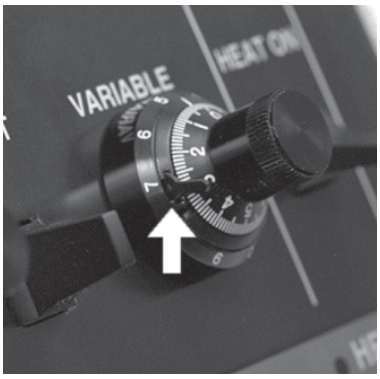


Figure 8:
*Dial lock on **TA-VARIABLE** dial*

Pre-Set Temperature Selection

Selection procedure

1. Turn the T - SELECT dial to the appropriate temperature.

NOTE *The green LED on the right side of the front panel will glow while the cooling units are operating. This light does not mean that the bath is at the proper operating temperature. Do **NOT** use this lamp to gauge the temperature of the bath. Always use the thermometer in the bath to confirm bath temperature.*

2. Move the TA-SELECT switch to the left (FIXED) position.

3. If the desired temperature is warmer than the present bath temperature, turn on the H - HEAT switch . When the switch is turned on, the HEAT LED on the front panel will glow continuously until the desired temperature is reached. To achieve temperature stability more quickly, turn the H - HEAT switch off approximately 2-3°C before your temperature probe indicates the desired temperature.

NOTE *Make sure to turn the* H - HEAT *switch off when the desired temperature has been reached. Otherwise, the temperature stability of the Bath will not be optimum.*

4. If the bath fails to equilibrate within 0.01°C of the desired control temperature, release the lock on the TA - FIXED dial.

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

NOTE *Turn the switch **clockwise** to increase the bath temperature. Turn the switch **counterclockwise** to decrease the bath temperature.*

6. When the desired temperature has been reached, relock the TA - FIXED dial.

NOTES *You may wish to record the dial setting and temperature for future reference in the event that it is necessary to alter the position of the* TA - FIXED *dial for control at a different temperature setting.*

If the desired preset temperature cannot be obtained by adjusting the TA - FIXED *dial, make sure that the* TA - SELECT *switch is set to the left position. If the temperature still cannot be attained using the* TA - FIXED *dial, it may be necessary to adjust the small trimpots below the front panel (see **Adjusting Trimpots**, next page).*

Custom Temperature Selection

Selection procedure

1. Turn the T - SELECT dial to the temperature closest to the desired temperature.

NOTE *The green LED on the right side of the front panel will glow while the cooling units are operating. This light does not mean that the bath is at the proper operating temperature. Do **NOT** use this lamp to gauge the temperature of the bath. Always use the thermometer in the bath to confirm bath temperature.*

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

3. If the desired temperature is warmer than the present bath temperature, turn on the H - HEAT switch . When the switch is turned on, the HEAT LED on the front panel will glow continuously until the desired temperature is reached. To achieve temperature stability more quickly, turn the H - HEAT switch off approximately 2-3°C before your temperature probe indicates the desired temperature.

NOTE *Make sure to turn the* H - HEAT *switch off when the desired temperature has been reached. Otherwise, the temperature stability of the Bath will not be optimum.*

4. After the bath equilibrates, release the lock on the TA - VARIABLE switch.

5. Turn the TA - VARIABLE switch to adjust the temperature. After each adjustment, allow several minutes for the bath temperature to stabilize.

NOTE *Turn the switch **clockwise** to increase the bath temperature. Turn the switch **counterclockwise** to decrease the bath temperature.*

6. When the bath thermometer indicates that the desired temperature has been reached, relock the TA - VARIABLE switch.

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.*

Adjusting trimpots

If you are unable to attain one of the preset bath temperatures using the procedure on pages 14-15 for preset temperature selection, it may be necessary to adjust the trimpots (also called potentiometers), which have been factory-calibrated to maintain the preset temperatures on the T-SELECT dial.

Before adjusting the trimpots, follow this procedure:

1. Turn on the bath power.
2. Set the TA - SELECT switch to the FIXED (left) position.
3. Set the T - SELECT dial to the desired temperature setting.
4. Set the TA - FIXED dial to its midpoint (500).
5. Allow the bath to equilibrate.

Locating trimpots

The trimpots (see *Figure 9*, next page) are located immediately behind the removable panel below the front control panel, and may be accessed by removing the two thumbscrews which hold the removable panel in place.

Trimpots ⁄ TA - FIXED *dial*

Each trimpot is labelled with a number corresponding to one of the temperatures listed on the T -SELECT dial. These trimpots are calibrated so that the TA - FIXED dial will be at the approximate midpoint (5 on the 10-turn dial) of its range when the bath is stabilized at the control temperature (Setting the TA - FIXED dial at the midpoint ensures maximum adjustment potential in either direction to establish the desired temperature).

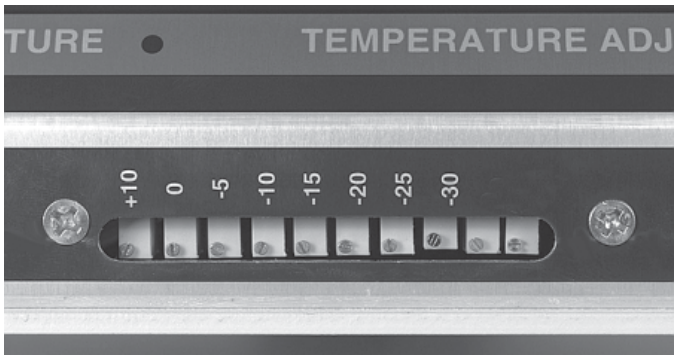


Figure 9: TE-1500 trimpots

Adjusting Trimpots

With the TA - FIXED dial set at its midpoint (500), use the small screwdriver included with the TE-1500 to adjust the trimpot corresponding to the selected temperature. Turning the trimpot clockwise will increase temperature; turning the trimpot counterclockwise will decrease bath temperature. Allow several minutes between adjustments for the temperature in the bath to stabilize. Verify the bath temperature using a calibrated reference thermometer. Continue adjusting the trimpot until the equilibrium temperature matches the value on the T - SELECT dial.

Customizing Temperatures

If one of the temperatures listed on the T - SELECT dial is never used, that setting may be used to set a permanent custom temperature setting. This procedure works only if the custom temperature is relatively close to the preset temperature.

EXAMPLE

If the temperature +10°C is never used, and the temperature +5°C is used frequently, the TE-1500 can be customized to reach a temperature of +5°C automatically.

EXAMPLE procedure

To change the +10°C setting to consistently reach a temperature of +5°C:

1. Turn the T - SELECT dial to +10°C.
2. Turn the TA - FIXED dial to the midpoint (500).
3. Move the TA-SELECT switch to the right (the VARIABLE position).
4. Adjust the +10°C trimpot until the thermometer in the TE-1500 Bath indicates that the Bath is now controlling at +5°C (this may also involve adjusting the TA - FIXED dial).
5. Make sure to note for future reference that this temperature setting has been changed from the preset temperature shown on the T-SELECT dial to the customized temperature.

IMPORTANT

Whenever the customized temperature is the desired temperature for a test, make sure the TA-SELECT *switch is in the* VARIABLE *position.*

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CHAPTER 4

MAINTENANCE

The TE-1500 was designed for minimal care and maximum reliability. By following a few basic rules of preventative maintenance, the TE-1500 should provide years of trouble-free operation.

Preventative (scheduled) maintenance

The TE-1500 requires a minimum amount of maintenance at intervals that are entirely dependent upon the environment and the degree of usage. In the typical situation of an average modern laboratory performing a dozen tests daily, the following tasks should be performed every six months. If the bath is located in a dirty environment and/or is heavily used, the preventative maintenance listed below should be scheduled on a monthly basis.

CAUTION *Remove power from the bath before cleaning or maintenance. Appropriate eye protection (safety goggles) is also required.*

Cleaning the painted surfaces and front panel

The finish of the TE-1500 is a baked-on epoxy enamel in colors of almond and black. This paint is virtually immune to most solvents, however, if acetone is rubbed on the painted surfaces, the paint will be removed. A good quality household cleaner may be used on all painted surfaces and the front panel. Do *not* spray the cleaning fluid directly on any surface, especially the area where the fans and heat sinks are located. The liquid will harden dust particles and cause an accumulation of dust to be imbedded into the heat sinks and make removal very difficult. Instead, a soft cloth should be sprayed with the cleaning solution and the cloth should be used to transfer the solution to the surface of the instrument.

Cleaning the fans and heat sinks

Cleaning fans

Dust and dirt will accumulate with time in the small gaps of the air heat sinks and around the blades of the fans. These deposits will affect the cooling effectiveness of the thermoelectric cells and will ultimately affect the ability of the bath to function at cold temperatures.

Use a compressed air source to blow the dust away. Move the upper Bath Vessel Assembly outside or away from any clean environment. Apply the blasts of clean air through the fans on the sides and the rear, and alternately apply blasts of air directly into the heat sinks. This can

be accomplished without removal of any panels surrounding this upper Bath Vessel Housing.

Cleaning heat sinks

If the bath is operating in a high humidity environment, dirt may become very hard and encrusted on the fins of the heat sinks. If this condition is noticed, it will be necessary to remove the left and right side panels to gain access to the heat sinks.

Removing side panels/ accessing fluorescent lamps

To remove the side panel(s), first verify that the bath power cord has been disconnected from the power supply. Remove the four screws which hold the panel in place. Slide the detached side panel outward for a small distance, then upward to avoid striking the fluorescent lamp.

Using a soft, long bristled brush (available in automotive departments for cleaning wire wheels) loosen the encrusted dust and then blow it away with the compressed air source. Care should be taken to not bend or crush the fins of the heat sinks.

Reassemble the side panels back onto the Bath Vessel Housing by reversing the removal procedure.

Compressed air cleaning

If a central or self-contained air compressor line with a blow gun is not available, compressed air (aerosol) cans may be obtained from most computer supply dealers. These cans may be used with a long nozzle to help direct the air into a small area.

CAUTION *Eye protection should always be worn when using compressed air.*

Cleaning the bath window

The viewing window on the TE-1500 is constructed with four panes of low emissivity glass with all panes tempered for safety. The space between these panes are filled with a gas and sealed to provide a frost-free viewing window. The outside (front) surface of this window may become smudged and dirty and should be cleaned with common household window cleaner. Apply window cleaner to a soft cloth and wipe on the front window of bath.

NOTE *Do not spray cleaner directly on front face of the glass.*

Cleaning the inside of the bath vessel

To clean the inside of the bath vessel, empty the bath using the procedure described on page 11 of this manual.

After all of the bath liquid has been removed and the bath vessel is at room temperature, cleaning can begin. Use a long-handled brush and a good quality liquid household cleaner. Spray the liquid cleaning agent through one of the top holes in the bath vessel and use the brush to scrub off residue on the baffle, side walls, and bath window. Rinse the vessel with water and use a siphon or vacuum system to remove the remaining mixture from the vessel. Ensure that the vessel is clean and dry before refilling with clean alcohol. Use lint-free towels to wipe the vessel dry if a vacuum system is not available.

CHAPTER 5

TROUBLESHOOTING

SYMPTOM	PROBABLE CAUSE	SOLUTION
Bath POWER switch does not illuminate	Power cable not connected.	Connect power cable.
	Power out on mains.	Restore mains power.
Bath illumination not functioning and LED in LIGHTS POWER switch is lit	Fluorescent lamps may be defective.	Replace lamps.
	Lamps may be out of sockets.	Tighten lamps in sockets.
Bath liquid not agitated	AIR IN/OUT tubes on the rear panel of the bath and control unit not connected.	Connect AIR IN/OUT tubes.
Bath control outside of specified limits	Bath liquid viscosity may be too high (inadequate stirring).	Use bath liquid appropriate for bath control temperature.
	Thermistor may be defective.	Remove the probe cable from the rear panel TEMP PROBE connection and check resistance between pin # 1 and pin #2 on the cable connector with an ohmmeter (Call ***CANNON***® for proper resistance at bath temperature). Replace if necessary.
Bath does not cool or heat	Thermistor cable may not be connected. to the TEMP PROBE connection on the rear panel of the Control Chassis	Connect probe cable.
	AC or DC POWER cables may not be connected.	Reconnect AC or DC power cable per manual instructions.
Bath does not cool and the green cooling LED on CONTROL section of front panel is off	Thermistor cable may not be connected.	Connect thermistor cable.
	Bath temperature is below the current bath temperature setting.	Bath coolers will engage only when current bath temperature is above the bath temperature setting.
Bath does not cool and the green cooling LED on CONTROL section of front panel is on	AC or DC power cable at the rear of the unit may not be connected.	Connect power cables per manual instructions.
Visibility in bath is poor.	One or more of the fluorescent lamps are burned out.	Replace the faulty lamp per instructions in maintenance section.
	The bath liquid is dirty or dark colored.	Siphon old bath fluid from vessel and empty overflow jar, clean tank inside glass window and tank sides and bottom. Refill tank and jar with clean alcohol.

SYMPTOM	PROBABLE CAUSE	SOLUTION
The green indicator light on the power switches for "BATH" and "LIGHTS" do not illuminate.	The MAINS outlet on the wall is not energized.	Reset breaker or replace fuse in MAINS panel. Circuit may be overloaded by additional equipment on same breaker/fuse.
	The power cord for the bath is not plugged into the wall outlet and/or the back of the TE-1500.	Plug power cord into wall outlet and the IEC connector on the back of the TE-1500.
	Fuses are blown.	Call ***CANNON***® Customer Service.
Green neon light above power switches is not lit but the other green lights on the power switches are.	Air heat sink temp. is greater than 55°C. Cooling fans have stopped operating due to failure of the +15v power supply and/or some fans are not turning.	Call ***CANNON***® Customer Service.
	Air heat sink temp. is greater than 55°C. Unit has been operating for some time with the cooling fans blocked against a wall or other obstruction.	Move unit away from obstructions at the rear and sides. Turn power off for at least 10 minutes. Allow heat sinks to cool.
	Bath may be in an over-temperature condition.	Turn off power and verify that bath liquid temperature is below 38°C. Wait for 20 seconds, then restore power.
Temperature control/ stability is poor.	Not enough liquid in bath to permit adequate stirring.	Add liquid to bath so that the surface of the liquid is about 1/2 inch above the top edge of the rear (white) baffle.
	Air hoses on rear of bath are faulty or not connected.	Check and/or reconnect hoses. The AIR OUT connection on the Control Chassis must be linked with the AIR IN connection on the Bath Vessel Housing.
	Thermistor is not properly installed into bath vessel.	Reorient sensor. The bottom tip of the temperature sensor should be about 1/2 inch below the top edge of the white baffle and it should be in front of this baffle.
Unit is unable to obtain coldest temperatures.	Ambient air temperature is too warm. The TE-1500 cannot obtain temperatures colder than about 55 degrees Celsius below ambient.	Move unit to an air conditioned room or lower ambient room temperature.
	Some of the cooling air is blocked by an obstruction.	Move unit away from air obstruction(s) on sides/rear of unit.
	Some cooling fans have ceased operation.	Call ***CANNON***® Customer Service.
	Fins on heat sinks are encrusted with dirt	Clean internal components using the maintenance instructions in this manual.
	Not enough liquid in bath to permit adequate cooling.	Add liquid to bath so that the surface of the liquid is about 1/2 inch above the top edge of the baffle.

CHAPTER 6

USER-SERVICEABLE PARTS LIST

Part Number	Description
P01.2060	CAP NUT, 1/4-20
P20.21	HOLE COVERS WITH BLACK KNOBS
P20.22	THERMOMETER HOLDER
P27.1300	FLOURESCENT LAMP (F6T5/CW)
P28.0579	AC POWER CABLE ASSEMBLY
P28.0695	JAR ASSEMBLY, BATH OVERFLOW
P28.0704	TUBE ASSEMBLY, AIR IN
P28.0705	TUBE ASSEMBLY, AIR OUT
P28.0714	PUMP ASSEMBLY, RETURN LIQUID
P28.1450	BALLAST
P28.3255	CHECK VALVE POLYPROPYLENE HSNG
P28.5710	AIRPUMP ASSEMBLY
P28.6100	CABLE DC
P28.6200	CABLE AC
P28.6300	THERMISTOR PROBE 3K
P28.8000	ACCESSORIES KIT 120V
P28.8110	TUBING WATER IN/OUT
P28.8120	8 OZ GLASS JARS
P28.8140	HOLE COVER
P28.8150	RESERVOIR PLUG (HEAT EXCHANGER)
P51.1210	SILICON TUBING, 1/4" OD, 3", 6", 11"
P52.3260.4	AIR FILTER MODIFIED

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CHAPTER 7

WARRANTY/RETURN INFORMATION

Products limited warranty

In addition to other manufacturers' warrantees, ***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. 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.

CHAPTER A

APPENDIX A—THERMOMETRY

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

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

ASTM FAHRENHEIT THERMOMETERS

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

NOTE *International shipments may be subject to special shipping regulations.*

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.

NBS monograph 150: Joining Separated Mercury Columns

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 it 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 by-pass. 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.

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