

Manual Kinematic Viscosity Bath

Tamson TV2000 & TV4000

ASTM D445, IP71, ISO 3104



Rev 1.04

Viscosity Business Today

- ✓ Testing kerosene
- ✓ Testing diesel
- ✓ Testing lubricants
- ✓ Testing fuel oils
- ✓ Testing residues
- ✓ Testing bituminous or asphalt samples
- ✓ Testing used oils
- ✓ Testing bio fuel



Content of Presentation

- ✓ The Method
- ✓ Standards
- ✓ Manual Kinematic Viscosity baths
- ✓ TV2000 & TV4000 (Main Characteristics)
- ✓ Unit Installation and Preparing
- ✓ Accessories for TV2000 & TV4000

The Method

- A manual bath is used for the measurement of transparent liquids and opaque liquids.
- The time is measured for a fixed volume of liquid to flow under gravity through the capillary of a calibrated viscometer at a closely controlled and known temperature.
- The kinematic viscosity (determined value) is the product of the measured flow time and the calibration constant of the viscometer. Two such determinations are needed from which to calculate a kinematic viscosity result that is the average of two acceptable determined
- Depending on sample type and individual preferences a viscometer type has to be selected.

Standards

- Standards: ASTM D445, ASTM D446, ASTM D1655, ASTM D2170, IP71, EN ISO 3104, ISO 3105, and DIN 51562.
- The standard describes the manual measuring of determination of kinematic viscosity.
- Measure the time for a volume of liquid, transparent or opaque, to flow under gravity through a calibrated glass capillary viscometer (please see ASTM D445 & D446).

Manual Baths

Bath Temperature

- Use a bath with a constant temperature.
- Temperature tolerance max. $\pm 0.02^{\circ}\text{C}$ between $+15^{\circ}\text{C}$ to $+100^{\circ}\text{C}$. Outside this range $\pm 0.05^{\circ}\text{C}$.
- The temperature measuring device is a calibrated glass thermometer, accuracy $\pm 0.02^{\circ}\text{C}$ or better. Or a Digital Contact Thermometer (DCT) is allowed. We recommend our E20 DCT thermometer with temp. range from 20°C to $+120^{\circ}\text{C}$ (P/N 19T4043). Other rangers are available.
- In October 2017, mercury in LIG thermometers will be forbidden and the market has to change to DCTs.

Manual Baths

Bath Temperature



Tamson E20 Thermometers

- Complies to IEC 751
- ✓ Accuracy of $\pm 0.01^{\circ}\text{C}$
- ✓ Calibrated of 0.015°C
- ✓ Resolution of $\pm 0.001^{\circ}\text{C}$.
- ✓ Substitute for the commonly known mercury thermometers
- ✓ Free Tamcom software
- ✓ Range from $-40 \dots +140^{\circ}\text{C}$
- ✓ Protective blue suitcase
- ✓ Conforms to new requirements of ASTM D445

- Sensor element PT100
- Display resolution 0.001°C
- Accuracy better than $\pm 0.015^{\circ}\text{C}$
- Linearity $\pm 0.01^{\circ}\text{C}$
- Fast response time 3 sec
- Annual drift $< \pm 0.001^{\circ}\text{C}$

(Thermistor or PT100)
(0.01°C)
($\pm 0.015^{\circ}\text{C}$)
($\pm 0.01^{\circ}\text{C}$)
(< 6 sec)
($< \pm 0.01^{\circ}\text{C}$)

Requirements
ASTM D445

Manual Baths

Capillaries

- The viscometer is a calibrated capillary, the size depends on the sample be tested.
- Flow times between 200 and 900 seconds are recommended.
- The viscometer has to be in a suspended vertical position. This is possible with the special design of the covers used in the Tamson viscosity baths and the Tamson stainless steel viscometer holders. They are available for most of the ASTM D446 viscometers, see WWW.TAMSON.COM for more information.

Manual Baths

Timing Device

- The manual timing device must allow readings with a tolerance of 0.1 second or better. Accuracy $\pm 0.07\%$.
- Electrical timing devices can be used if an accuracy of $\pm 0.05\%$ or better is reached.

Manual Baths

Tamson Timing Device



- Tamson timer (reference number 10T6090) uses a crystal which has a maximum deviation of 20 ppm (parts per million).
- On one second that is $(1 / 1000.000) * 20 = 0.00002$ sec.
- One hour has $60*60*0.00002 = 0.072$ seconds.
- Human reaction time is 0.2 second (200 mS).
- So, fault of Tamson timer when measuring one hour is three times less than human error (viscosity flow time is between 200 and 900 seconds).

TV2000 & TV4000

Main unique features:

- ✓ Standard Worldwide
- ✓ Temperature Range
- ✓ Ultra High Stability
- ✓ Three or Seven Places
- ✓ LED Lights Background
- ✓ Detachable Front Window
- ✓ Bath Drain & Bath Overflow
- ✓ PID Digital Controller



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TV2000 & TV4000

Worldwide standard

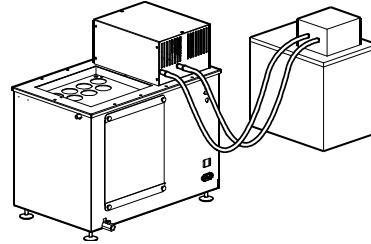
- ✓ TV2000 & TV4000 introduced in late 1980s. New design and electronics since 2010.
- ✓ Since introduction, thousands installed.
- ✓ In every continent and most of the countries worldwide you can find a TV2000/TV4000.
- ✓ Dominant standard in petrochemical labs.



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TV2000 & TV4000 Temperature Range

- Standard range from ambient to +230°C.
- TV2000 & TV4000 is standard equipped with a cooling coil.
- When connecting to tap water or an external cooler, sub ambient temperatures can be reached.



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TV2000 & TV4000 Temperature Range

- When connecting with an external cooling circulator TLC15, +5°C can be reached.

	TV2000	TV2000 + TLC15-5	TV4000	TV4000 + TLC15-5
Range	ambient.. +230°C	+5°C.. +230°C	ambient.. +230°C	+5°C.. +230°C
230V/50Hz	00T0782	00T0782 + 00T0565	00T0772	00T0772 + 00T0565
115V/60Hz	00T0782	00T0784 + 00T0570	00T0774	00T0774 + 00T0570
230V/60Hz	00T0782	00T0782 + 00T0567	00T0772	00T0772 + 00T0567

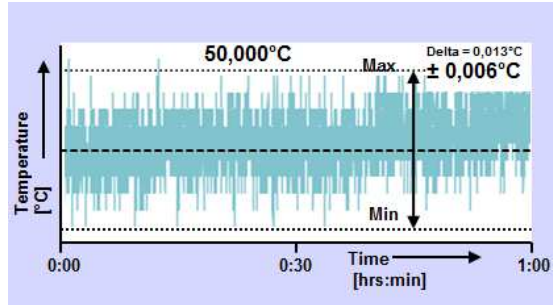


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TV2000 & TV4000

High Temperature Stability

ASTM D445 requirement: Temperature tolerance max. $\pm 0.02^{\circ}\text{C}$ between 15°C to 100°C . Outside this range $\pm 0.05^{\circ}\text{C}$. Stability @ 50°C .

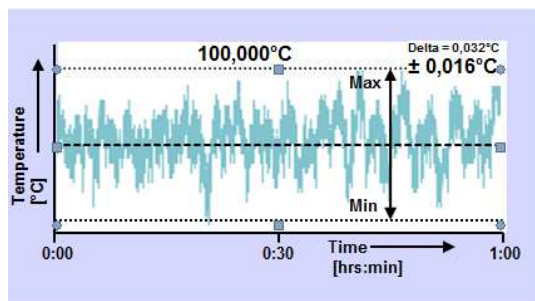


This is the real difference between the minimum and maximum temperature for 60 minutes. Some competitors just state the standard deviation of the mean or mention the stability for a few minutes. 15

TV2000 & TV4000

High Temperature Stability

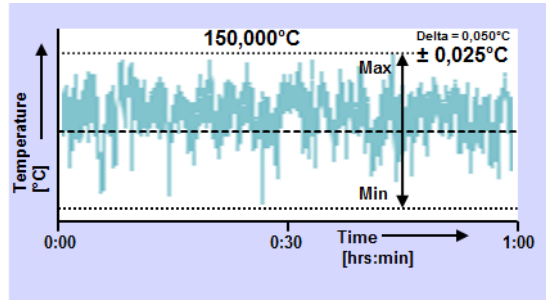
ASTM D445 requirement: Temperature tolerance max. $\pm 0.02^{\circ}\text{C}$ between 15°C to 100°C . Outside this range $\pm 0.05^{\circ}\text{C}$. Stability @ 100°C .



TV2000 & TV4000

High Temperature Stability

ASTM D445 requirement: Temperature tolerance max. $\pm 0.02^{\circ}\text{C}$ between 15°C to 100°C . Outside this range $\pm 0.05^{\circ}\text{C}$. Stability @ 150°C .



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TV2000 & TV4000

High Temperature Stability

As you can read in the paragraph 6.3.1 of ASTM D445, the ASTM committee allows quite a temperature instability.

But what is the consequence for the viscosity result if the bath temperature is varying by 0.02°C ($\pm 0.01^{\circ}\text{C}$)?

Sample	1	2	3	4	5	6
2	132.4	132.69	131.81	131.76	132.79	132.14
3	49.16	49.177	49.172	49.173	49.177	49.162
4	49.19	49.204	49.200	49.202	49.201	49.198
5	0.027	-0.027	-0.028	-0.029	-0.024	-0.036
6	49.17	49.185	49.190	49.184	49.192	49.171

We have tested 6 samples using a Ubbelohde viscometer with a constant of 0.009021. The results of the six tests are mentioned in the table.

Row 2 gives the duration of a measurement in seconds, where the time is measured via two optical infra red sensors.

Row 3 and 4 show the minimum and maximum temperature during a test.

Row 5 demonstrates the difference between the maximum and minimum temperature.

Row 6 gives the average temperature of the bath during a test.

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TV2000 & TV4000 Ultra High Stability

cSt	Deviation	Temp °C	Deviation
1.188607	99.538%	49.184	100.002%
1.194651	100.044%	49.178	99.990%
1.196996	100.240%	49.185	100.003%
1.189058	99.575%	49.190	100.014%
1.197899	100.316%	49.192	100.017%
1.192035	99.825%	49.171	99.976%
Average 1.194128		49.183	

The table shows the kinematic viscosity. For sample 1 it is calculated as follows:

$$v = C \times t$$

$$v = 0.009021 \times 132.43$$

$$v = 1.194651$$

You are allowed to delete one test result, so we have deleted the result of sample 4.

The average in table 2 is taken from the five other samples.

The deviation is calculated by dividing the v by the average of the five samples. This result has been multiplied by 100%.

TV2000 & TV4000 Ultra High Stability

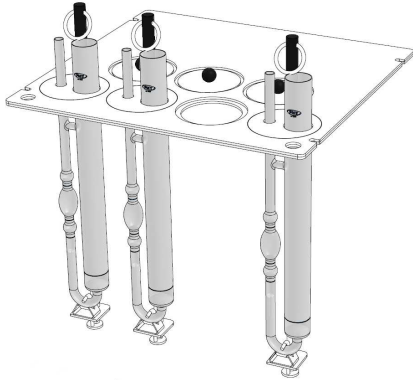
cSt	Deviation	Temp °C	Deviation
1.192035	100.316%	49.171	100.017%
1.197899	99.825%	49.192	99.976%

Table 3 is a part of previous table. The delta in temperature is $49.192^{\circ}\text{C} - 49.171^{\circ}\text{C} = 0.021^{\circ}\text{C}$. And the deviation in the measuring result is $100.316\% - 99.825\% = 0.491\%$!

Based on this experiment, we can conclude that a slight temperature variation by only 0.02°C - thus conform ASTM D445 - can cause a 0.5% deviation in the viscosity result.

Conclusion: It is not only important that the TV2000 & TV4000 is conform the ASTM D445 method. It is also very important that the bath is stable as possible for the best results.

TV2000 & TV4000 Cover with 3 & 7 Positions



The cover of the bath has round 51 mm holes with lids, for suspending glass capillary viscometers in holders.

Additional two round holes are in the lid to accommodate ASTM thermometers.

Cover of TV2000 offers three holes (four holes is optional)

Cover of TV4000 offers seven holes (eight holes is optional)

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TV2000 & TV4000 External LED light



- Tamson has introduced a new design using LED Technology which can be mounted on the TV2000 & TV4000 as a back panel resulting in excellent visibility in the bath.
- It is highly energy efficient (6 Watts)
- It has a wide range inputs from 85V up to 250V/ 50~60Hz
- The LED panel has a much longer expected lifetime than a TL lamp.

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TV2000 & TV4000 Detachable Front Window

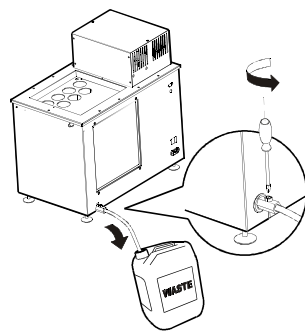
The bath is fitted with a double window of which the front pane is detachable for cleaning purposes (after some years of usage a vapour on the inner windows can reduce the visibility, cleaning of the inner windows is very easy).

Outside window pane can be removed by unscrewing the four black screws which is very easy.



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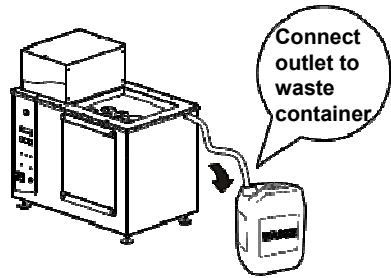
TV2000 & TV4000 Bath Drain & Overflow Outlet



- The TV2000 & TV4000 can be emptied via the drain tap located at the backside of the apparatus.
- For safety reasons the tap can only be opened by using a screwdriver.
- The thread inside the tap is 3/8".

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TV2000 & TV4000 Bath Drain & Overflow Outlet



- If the fluid level is too high, it will leave the bath via the overflow outlet
- Prevent fluid from the overflow outlet entering the side of the bath.
- For this reason the overflow outlet must be connected to a waste container.

TV2000 & TV4000 Digital Controller

One of the reasons for the unique bath stability is that we use our own Tamson Microprocessor controller (TMC70) board. This circuit board offers several nice features:

- ✓ Two decimal readout
- ✓ Offset
- ✓ Percentage heating is shown in display, maximum percentage can be programmed
- ✓ PID settings (automatic and manually)
- ✓ RS232 communication

TV2000 & TV4000

Digital Controller

Two decimal readout



Temperature stability is very important for ASTM D445. Therefore, we show a two decimal readout in the display. Optional is a three decimal readout.

It is doubtful to use a viscosity bath with an analog controller or a digital controller offering 1 decimal readout for ASTM D445 tests.

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TV2000 & TV4000

Digital Controller

Offset

The temperature displayed can be increased or decreased with an offset ranging from +5.00°C down to -5.00°C in steps of 0.01°C. This way the temperature reading on the display can be synchronised with an independent separate thermometer.

N.B. an offset is essential for your viscosity bath.

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TV2000 & TV4000

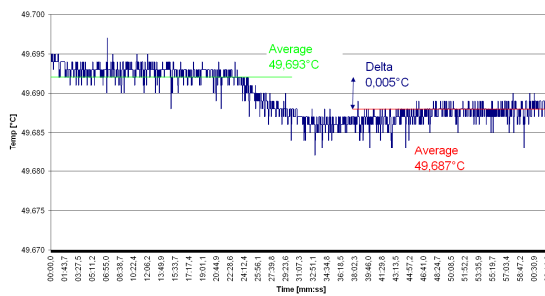
Digital Controller

Offset

Also, we offer standard an additional 0.005°C offset.

This is very important when temp is e.g 39.995°C. With a 0.01°C offset you can only reach 40.005°C.

With the additional 0.005°C offset option you can reach exactly 40.000°C in the bath.

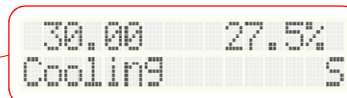


TV2000 & TV4000

Digital Controller

Percentage Heating

Display



- Maximum percentage of heating can be selected in the menu. This maximum power can be selected to prevent overshoot or burning of bath media. Four stages are available: 25%, 50%, 75%, and 100%
- The controller continually calculates the amount of power which should be applied for stable control. The value is displayed with a resolution of 0.1% and ranges from 0% to 99.9%.
- If this percentage is lower than 10%, additional cooling is needed to get good stability. This is a good explanation as to why the bath temperature is not stable. Other brands don't give you this information.

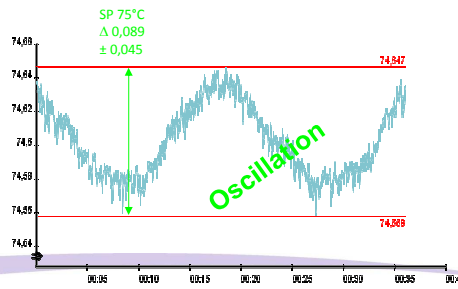
TV2000 & TV4000

Digital Controller

PID Settings

Controller is equipped with PID settings
 If necessary, the PID settings can be manually adjusted to get the best optimum.
 For example, below a graph off an unstable bath.

Temperature: 75°C
 Proportional band (Pb): 100
 Integrator: 16
 Differentiator: 0
 Min/max: ± 0.045



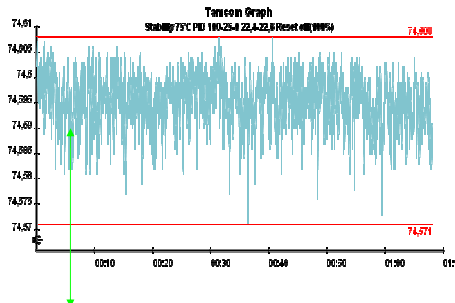
TV2000 & TV4000

Digital Controller

PID Settings

By changing the P from '100' to '50', stability is becoming better. All other variables are the same.

Temperature: 75°C
 Proportional band (Pb): 50
 Integrator: 16
 Differentiator: 0
 Min/max: ± 0.018



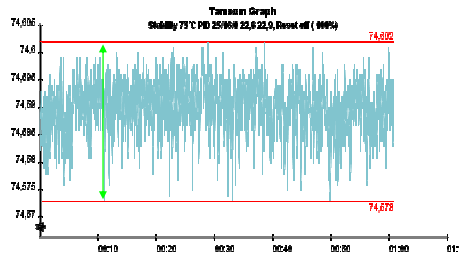
TV2000 & TV4000

Digital Controller

PID Settings

By changing the P from '50' to '25' the temperature stability even improves further.

Temperature: 75°C
Proportional band (Pb): 25
Integrator: 16
Differentiator: 0
Min/max: ± 0.015

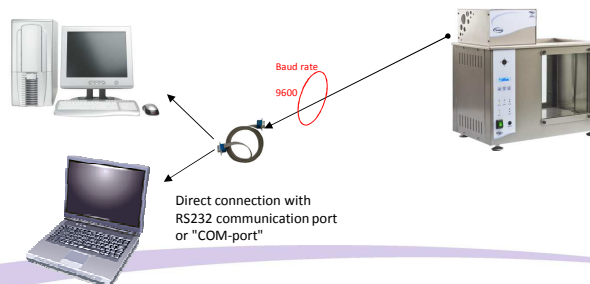


TV2000 & TV4000

Digital Controller

RS232 Communication

- ✓ Equipment is standard equipped with RS232 communication.
- ✓ Using RS232 the controller can be controlled remotely using the Tamson software, or a serial terminal, or your own software.



TV2000 & TV4000

Digital Controller

RS232 Communication

The Tamcom software can do following:

- ✓ Logging data into a file, (CSV)
- ✓ Programming a Set Point curve via simple data in a file
- ✓ Display process value and set point temperature in a graph
- ✓ Actual values
- ✓ Change set point temperature
- ✓ Show Process value
- ✓ Set Offset
- ✓ Set PID values

TV2000 & TV4000

Digital Controller

RS232 Communication

The screenshot shows the Tamcom 2.4.1 software interface. It features a central display area with several panels:

- Process Value:** 31.221 °C
- Setpoint:** 30.00 °C
- Parameters:** low: 27.500, High: 33.223, AS: 1.027, PR: 25, TI: 16, TD: 0, Offset: 0.00, Schedule: none, Firmware: V1.30
- Graph:** A line graph titled 'Tamcom Graph' showing process value and setpoint over time. The y-axis ranges from 27.5 to 31.5, and the x-axis shows time from 00:00:05 to 00:00:40.

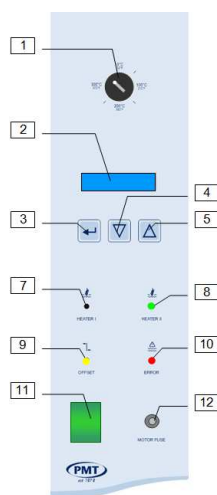
 Surrounding the screenshot are callout boxes with green arrows pointing to specific interface elements:

- Easy setting of important parameters, click and alter:** Points to the parameter fields.
- Actual process value (PV) and set point (SP):** Points to the temperature displays.
- Curve displays PV and SP. Time stamp is hh:mm:ss:** Points to the graph area.
- Min and max values during run. Toggle red marker lines on or off:** Points to the high/low limit indicators.
- Alter PID values, offset or import setpoint curve file:** Points to the PID and offset fields.
- Print or export graph as PNG(word) or CSV(Excel):** Points to the graph's toolbar.
- Reminder text or project description for header log file:** Points to the graph's title bar.

Easy Installation

- ✓ Bath is completely assembled and tested at factory (some manufacturers ask their dealers to assemble the bath).
- ✓ Remove bath from packaging material.
- ✓ Clean inner bath thoroughly of any loose packing materials, etc.
- ✓ Place the bath spirit level. The four supporting feet can be turned in and outwards for exact adjustment.
- ✓ Use a mains supply that is well earthed and clean of interference and can carry the load of the bath. Be sure to check the power requirements (230V/50-60Hz, 115V/60Hz) marked on the tag plate at the back side of the bath.
- ✓ Check operating voltage (230V/50-60Hz, 115V/60Hz) and connect the bath to appropriate mains supply. The bath has to be filled with a liquid suitable for operating temperature.

Preparing - Foil



Item	Description	Function
1	Thermostat	Over-temperature protection
2	Display	Shows bath parameters (see sheet digital controller)
3	Switch	Menu
4	Switch	Down in Menu
5	Switch	Up in Menu
7	LED	Heater I On/Off indicator
8	LED	Heater II On/Off indicator
9	LED	Offset entered
10	LED	System - Error
11	Switch	Mains switch
12	Fuse	Protects stirrer motor

Preparing – Menu options

- ✓ Set point
- ✓ Offset (press: <-5.00 .. +5.00°C resolution 0.01°C)
- ✓ Max Power (press: low 25, med, hi, max)
- ✓ Boost heater (press on / off)
- ✓ Time const (press: fast, medium slow, precise)
- ✓ Stirrer (Inactive for TV2000 & TV4000)
- ✓ Low alarm
- ✓ High alarm
- ✓ PID parameter
- ✓ Backlight (Inactive for TV2000 & TV4000)
- ✓ Temp units
- ✓ Baudrate
- ✓ SP Offset
- ✓ Restart

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Preparing - Display

1 Temperature readout

When the controller starts or is restarted, the displayed value increases to a stable readout appears after a few seconds.

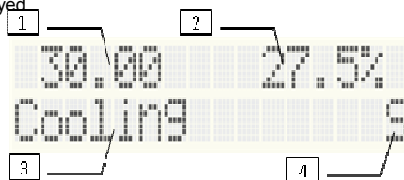
2 Applied percentage of power

The controller calculates every second the amount of power which should be applied for stable control. The value is displayed with a resolution of 0.1% and ranges from 0% to 99.9%.

To have a stable bath heating percentage should be higher than 10% at working temperature.

3 Operating mode

Boost Bath is heating to set point using boost heater
 Heating Bath is heating to set point, boost heater is off
 Cooling Bath is cooling down to set point
 Tuning Ratio Bath is tuning for power needed at set point, first step
 Tuning SA Bath is tuning, second step
 PID SP=25.00 Bath is controlling, set point is 25.00°C



4 Indicator, alarm high, alarm low, control stable

Bath control is stable

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Accessories

- ✓ Bath fluid
- ✓ Viscosity accessories
- ✓ 8-Channel Stopwatch
- ✓ Backlight illumination
- ✓ ASTM Thermometers
- ✓ Digital Contact Thermometer
- ✓ Reference Standards



Bath Fluid



- ✓ **Mineral oil,**
 - ✓ (range +80°C ... +150°C). Part number 00T0220
- ✓ **Silicon oil transparent**
 - ✓ (range +20°C ... +150°C). Part number 08T0001.
 - ✓ (range +80°C ... +250°C). Part number 00T0238.
- ✓ Important viscosity ≤ 10 cSt at working temperature.

Viscosity Accessories

Viscometer capillaries



- ✓ ASTM D446
- ✓ ASTM D2171

See part numbers in catalogue or visit

WWW.TAMSON.COM

Standard Calibration Certificate

Optional ISO 17025 certificate*

Viscosity Accessories

Viscometer Holders (1/2)



- ✓ Cannon Fenske Opaque
- ✓ Cannon Fenske Routine
- ✓ BS U-tube
- ✓ BS/IP/RF U-tube
- ✓ Ubbelohde
- ✓ BS/IP/MSL

- Insulated handle, easy to grab at high working temperatures
- Stainless steel
- Viscometer will not move when applying vacuum
- Ring to hang out

Viscosity Accessories

Viscometer Holders (2/2)



- ✓ Pinkevitz Long
- ✓ Pinkevitz Short
- ✓ U-Tube BS/IP SL
- ✓ BS/IP/SL(S)
- ✓ BS/U/M-Miniture
- ✓ SIL

TV2000 & TV4000

Viscometer Holders



- ✓ TV2000 & TV4000 cover consists of two layers. The bottom layer has the standardized 51 mm openings as prescribed by ASTM D445 and related methods and the upper layer has wider openings to better accommodate our stainless steel holders. Viscometer holders also have a cover consisting of the layers. In the picture, you can see an example of our TV4000 cover.
 - ✓ Tamson stainless steel holders will fit into the openings of the covers used in our viscosity baths perfectly.
 - ✓ Prevent the holders from shifting position when, for example, silicon tubing is connected to the viscometers in order to apply vacuum.
 - ✓ Viscometer tubes will not move due to the bath fluid circulating inside the viscosity bath.
 - ✓ Tamson can guarantee that the viscometer in its stainless steel holder is aligned at a 90 degree angle to the cover as prescribed in ASTM D445 (kinematic viscosity is determined using gravity).
 - ✓ The Tamson stainless steel holders are widely used and popular among users due to a robust design. The insulated handle makes it easy and safer to remove the viscometer even at high working temperatures
 - ✓ Another advantage of the Tamson holder is the clamp at the bottom of the holder, which makes it impossible for the viscometer to fall out of the holder. Breakage of the glass viscometers can easily happen with the rubber and plastic holders available on the market currently.

Viscosity Accessories

Visco Hanger



- ✓ Stainless steel
- ✓ Leakage tray
- ✓ Easy drainage
- ✓ 7 viscometer tubes
- ✓ 51 x 28 x 49 cm
- ✓ part number 10T6065

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Viscosity Accessories

8-Channel Stopwatch



- 8 channels
- Easy to operate
- Long battery life
- Uses simple 9V block
- Keeps value in memory after power off
- 0.01 sec resolution
- Saves bench space
- part number 10T6090

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Viscosity Accessories

Backlight Illumination

Z41 LED LAMP (part number 00T0909)



- ✓ Led panel
- ✓ Better sight than old Z41 with bulb light
- ✓ Adjustable in height
- ✓ Suitable for 85 .. 240 mains voltage
- ✓ Energy efficient
- ✓ part number 00T0909

To be used when measurements have to be followed visually!!

Viscosity Accessories

Backlight Illumination

LED Panel for TV2000 & TV4000

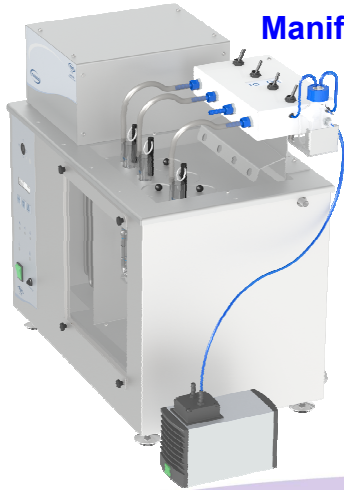


- ✓ Led panel
- ✓ Better light than old Z41 with bulb light
- ✓ Suitable for 85 .. 240 mains voltage
- ✓ Saves important work bench space
- ✓ Clear light
- ✓ Can easily be mounted on TV2000 & TV4000 and TV2000.
- ✓ partnumber 00T0908

To be used when measurements have to be followed visually!!

Viscosity Accessories

Manifold & Vacuum pump



- ✓ Four position manifold is available (part number 00T0941)
- ✓ Can be mounted on TV4000
- ✓ Can be used with vacuum pump (part number 00T0233)
- ✓ Silicon tubing suitable for 6-8 mm capillairs (adapters available on request)
- ✓ Makes the suction of the liquid much easier
- ✓ Applied vacuum can be adjusted by a screw on the manifold.

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ASTM Thermometers



- These thermometers comply with the ASTM E1.
- The glass thermometers are suitable for official calibration.
- To protect the thermometer for mechanical damage a stainless steel holder can be supplied

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E20 DCT Thermometers



Tamson E20 Thermometers

- Complies to IEC 751
- ✓ Accuracy of $\pm 0.01^{\circ}\text{C}$
- ✓ Calibrated of 0.015°C
- ✓ Resolution of $\pm 0.001^{\circ}\text{C}$.
- ✓ Substitute for the commonly known mercury thermometers
- ✓ Free Tamcom software
- ✓ Range from $-40 \dots +140^{\circ}\text{C}$
- ✓ Protective blue suitcase
- ✓ Conforms to new requirements of ASTM D445

- Sensor element PT100
- Display resolution 0.001°C
- Accuracy better than $\pm 0.015^{\circ}\text{C}$
- Linearity $\pm 0.01^{\circ}\text{C}$
- Fast response time 3 sec
- Annual drift $< \pm 0.001^{\circ}\text{C}$

(Thermistor or PT100)
(0.01°C)
($\pm 0.015^{\circ}\text{C}$)
($\pm 0.01^{\circ}\text{C}$)
($< 6 \text{ sec}$)
($< \pm 0.01^{\circ}\text{C}$)

Requirements
ASTM D445

Viscosity Calibration Standards

To be used as a reference standard
for viscosity measurements!



See our extensive database at
www.tamson.com

- ✓ Primary Standard
- ✓ Conforms to ASTM D2162
- ✓ ISO 17025 certified under UKAS
- ✓ Values certified 20, 25, 40, 50 and 100°C
- ✓ Up to 2 Years Shelf life
- ✓ 0.5 liter bottles

✓ Other ASTM references are
supplied (e.g. TAN, TBN,
Flashpoint, CRM)

The end

Thank you for your time and consideration!!