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Viscosity of Bitumen

ASTM D2170, EN 12595, ASTM D2171, IP 222, EN 12596, AASHTOT 202

Rev 1.03

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Content of Presentation

- ✓ What is Bitumen
- ✓ Viscosity of Bitumen Today
- ✓ Standards
- ✓ The Method
- ✓ Manual Viscosity baths
- ✓ TV2000 & TV4000 (Main Characteristics)
- ✓ Set-up for ASTM D2170
- ✓ Set-up for ASTM D2171
- ✓ Unit Installation and Preparing

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Viscosity of Bitumen Today

What is bitumen?

- ✓ Bitumen is an oil based substance.
- ✓ Hydrocarbon product, originating from crude oil, refrained from lighter fractions.
- ✓ Refined it is a stable, semi-solid substance, at ambient temperatures.
- ✓ In Europe it is named bitumen, while in North America it is named asphalt cement or asphalt.
- ✓ Usually, “asphalt” is the term used for a mixture of small stones, sand, filler and bitumen, which is used as a road paving material. This asphalt mixture contains approximately 5% bitumen.

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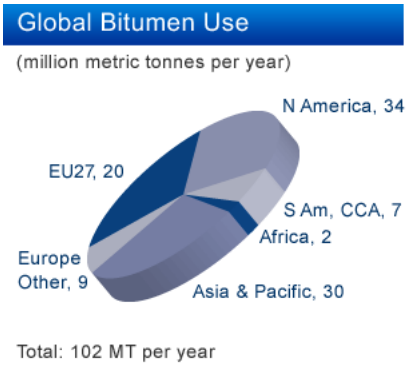
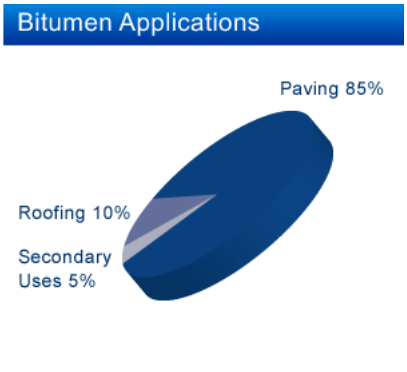
Viscosity of Bitumen Today

Importance today?





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Viscosity of Bitumen Today

Importance today?

Bitumen is a quality product with distinct properties:

- Viscosity grade of bitumen have a thermoplastic property which causes the material to become liquid at high temperatures and to harden at ambient temperatures.
- This unique temperature / viscosity relationship is important when determining the performance parameters such as the adhesion, rheology, durability and application temperatures of bitumen.

Therefore, accurate viscosity analysis of bitumen at different temperatures has become an important test.

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Standards

Kinematic Viscosity of Bitumen

- Standard: ASTM D2170 and EN 12595.
- The standard describes the manual measuring of determination of kinematic viscosity.
- A manual viscosity bath is used for the measurement of bitumen.
- The time is measured for a fixed volume of liquid to flow under gravity through the capillary of a calibrated reverse flow 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.

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Standards

Viscosity of Bitumen by Vacuum Capillary Viscometer

- Standards: ASTM D2171, IP 222, EN 12596, AASHTOT 202.
- The standard describes the manual measuring of determination of dynamic viscosity.
- A manual viscosity bath is used for the measurement of bitumen.
- The time is measured for a fixed volume of liquid to flow under precise vacuum (300 mm HG ± 0.5 mm HG) through the capillary of a calibrated vacuum viscometer at a closely controlled and known temperature.
- The viscosity in Pascal-seconds is calculated by multiplying the flow time in seconds by the viscometer calibration factor.

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Manual Baths

Bath Temperature

- Use a bath with a constant temperature.
- Temperature tolerance max. ± 0.01°C for both ASTM D2170 @ 60°C, ± 0.03°C for both ASTM D2170 @ 135°C and D2171.
- The temperature measuring device is a calibrated liquid in glass thermometer, accuracy ± 0.02°C or better. Or a Digital Contact Thermometer (DCT) is allowed. We recommend our TT3 (P/N 10T6095) with temperature range from 0°C to +150°C (P/N 25T2310 & P/N 10T6096).
- In October 2017, mercury in LIG thermometers will be forbidden and the market has to change to DCTs.

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Manual Baths

Bath Temperature

Tamson E20 Thermometers
Complies to IEC 751
✓Accuracy of ± 0.01°C
✓Calibrated of 0.015°C
✓Resolution of ± 0.001°C.
✓Substitute for the commonly known mercury thermometers
✓Free Tamcom software
✓Range from -40 .. +140°C
✓Protective blue suitcase
✓Conforms to new requirements of ASTM D445

- Sensor element PT100
- Display resolution 0.001°C
- Accuracy better than ±0.015°C
- Linearity ±0.01°C
- Fast response time 3 sec
- Annual drift <± 0.001°C

(Thermistor or PT100)
(0.01°C)
(±0.015°C)
(±0.01°C)
(<6 sec)
(<± 0.01°C)

Requirements ASTM D445

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Manual Baths

Capillaries

- The viscometer is a calibrated capillary, the size depends on the sample being tested.
- Flow times between 200 and 900 seconds are recommended.
- ASTM D2170 prescribes reverse flow viscometers.
- ASTM D2171 prescribes vacuum viscometers.
- The viscometer has to be suspended in a 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. These are available for most viscometers, please see WWW.TAMSON.COM for further information.

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Manual Baths

Timing Device

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

Manual Baths

Timing Device

- Tamson timer (P/N 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

TV2000 & TV4000

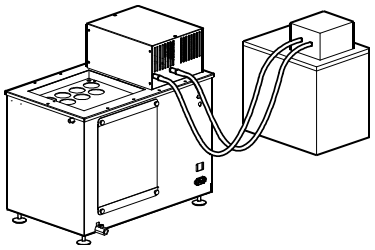
Worldwide standard

- ✓ 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 or TV4000.
- ✓ Dominant standard in petrochemical labs.

TV2000 & TV4000

Temperature Range

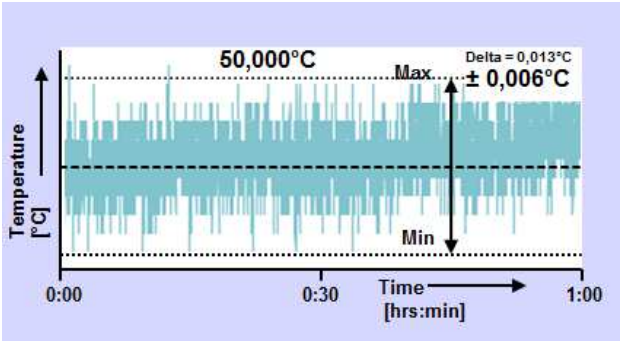
- Standard range from ambient to +230ºC.
- TV2000 & TV4000 is standard equipped with a cooling coil.
- When connecting to tap water or an external cooler, sub ambient temperatures can be reached.



TV2000 & TV4000

High Temperature Stability

ASTM D2171 requirement: temperature tolerance max. ± 0.03°C. ASTM D2170 max. ± 0.01°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.

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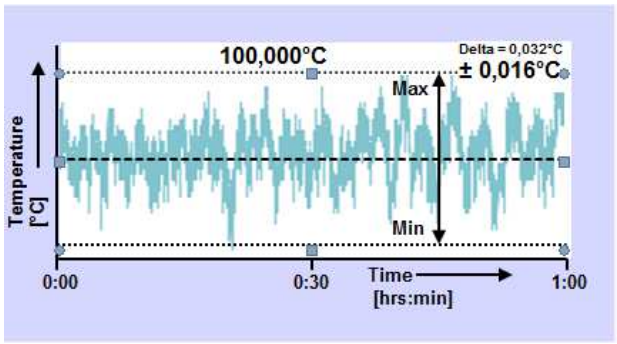
TV2000 & TV4000

High Temperature Stability

ASTM D2171 requirement: temperature tolerance max. ± 0.03°C.



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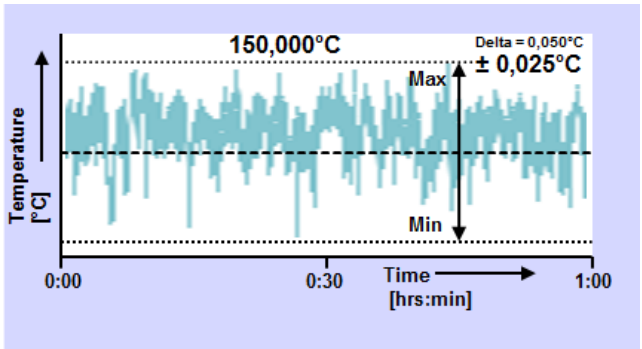
High Temperature Stability

ASTM D2170 / ASTM D2171 requirement: temperature tolerance max. ± 0.03°C.



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TV2000 & TV4000

High Temperature Stability

As you can read in the ASTM D2170 & ASTM D2171, 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 (± 0.01°C)?

	Sample	1	2	3	4	5	6
2	Time [sec.]	132.43	132.69	131.81	131.76	132.79	132.14
3	Min. Temp. °C	49.166	49.177	49.172	49.173	49.177	49.162
4	Max. Temp. °C	49.193	49.204	49.200	49.202	49.201	49.198
5	Delta (±)	-0.027	-0.027	-0.028	-0.029	-0.024	-0.036
6	Average temp. °C	49.178	49.185	49.190	49.184	49.192	49.171

We have tested six 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.

Rows 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

	mm²/s	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 x t
v = 0.009021 x 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

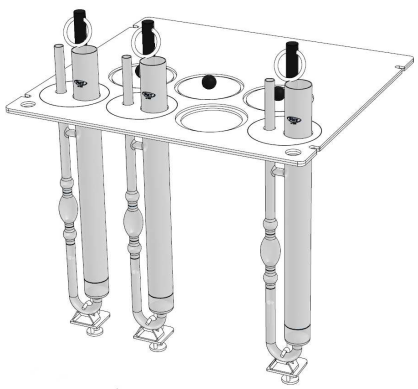
mm²/s	Deviation	Temp °C	Deviation
1.192035	100.316%	49.171	100.017%
1.197899	99.825%	49.192	99.976%

Table 3 is a part of previous table. The delta in temperature is 49.192°C – 49.171°C = 0.021°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 -can cause a 0.5% deviation in the viscosity result.

Conclusion: it is not just important that the TV2000 & TV4000 are conforming to the ASTM D2170 and D2171 methods. It is also very important that the bath temperature is as stable as possible in order to get the most accurate results.

TV2000 & TV4000

Cover with 3 & 7 Positions



- The cover of the bath has round 51 Ø mm holes with lids, for suspending glass capillary viscometers in holders.
- Cover had standard two openings 12,5 mm ø for ASTM thermometers.
- Cover of TV2000 offers three holes (four optional).
- Cover of TV4000 offers seven holes (eight optional).

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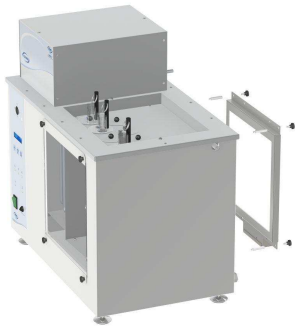
TV2000 & TV4000

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 bulb.

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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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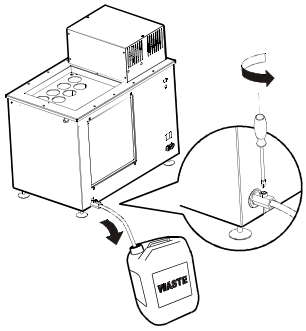
TV2000 & TV4000

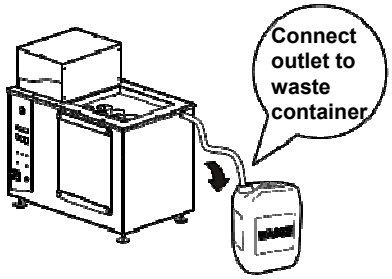
Bath Drain & Overflow Outlet



- 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“ BSP.

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.

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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

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TV2000 & TV4000

Digital Controller

Two decimal readout

Temperature stability is very important for ASTM D2170 & D2171. 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 one decimal readout for ASTM D2170 or ASTM D2171 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

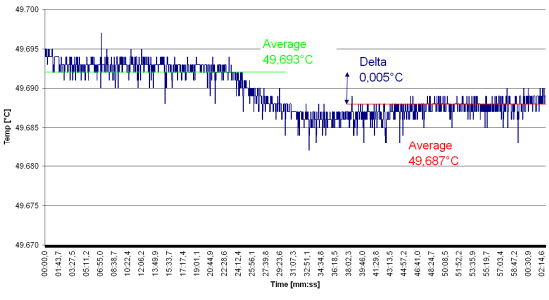
Digital Controller

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.

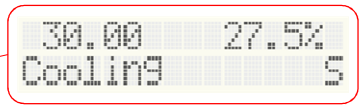
With the additional 0.005°C offset option you can reach exactly 40.000°C in the bath.



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 precise temperature stability. This is a good explanation as to why the bath temperature is not stable. Other brands don't give you this information.

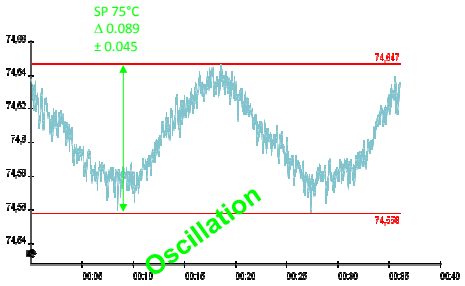
TV2000 & TV4000

Digital Controller

PID Settings

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

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



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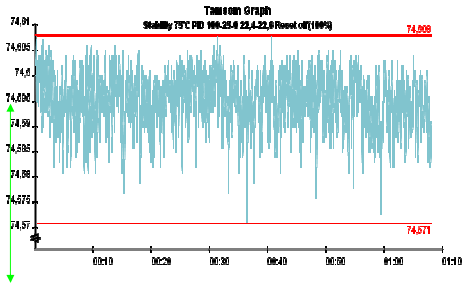
TV2000 & TV4000

Digital Controller

PID Settings

By changing the ‘P’ from ‘100’ to ‘50’, stability is becoming better. All other variables stay the same.

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



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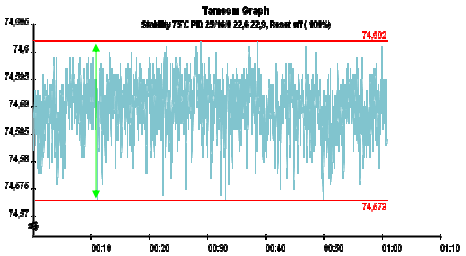
TV2000 & TV4000

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



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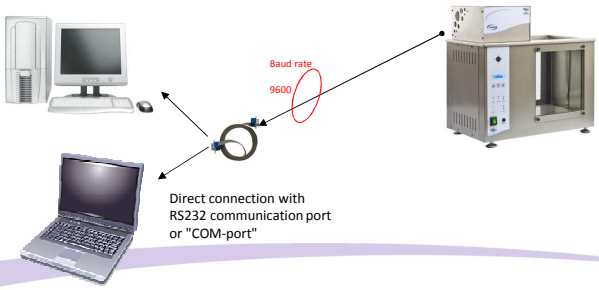
TV2000 & TV4000

Digital Controller

RS232 Communication

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



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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.

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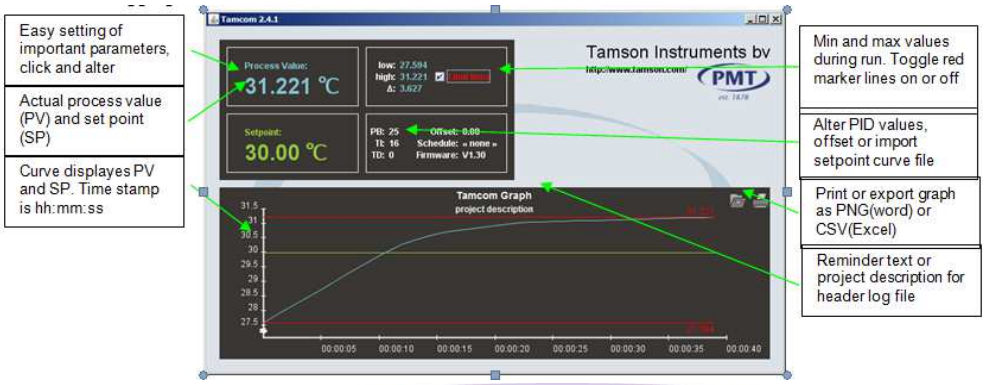
TV2000 & TV4000

Digital Controller

RS232 Communication



Set-up for ASTM D2170

Viscosity bath

- ✓ Three position TV2000 or seven position TV4000
- ✓ Backlight LED Illuminator (P/N 00T0908)
- ✓ Silicon oil (P/N 08T0001)

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Set-up for ASTM D2170

Viscometers

- ✓ Reverse flow viscometers, selection can be made between:
  - ✓ Cannon Fenske Opaque
  - ✓ Zeitfuchs Cross-Arm
  - ✓ BS/IP/RF U-tube
  - ✓ (Lantz-Zeitfuchs cannot be used in a TV2000 or TV4000)
- ✓ Rubber stopper for viscometer CFO and ZCA (P/N 06T1724)
- ✓ Filling tube and stopcork for BS/IP/RF U-tube viscometer (P/N 25T1069)

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Set-up for ASTM D2170

Viscometers 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 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.

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Set-up for ASTM D2170

Viscometers holders

- ✓ Stainless steel holders:
  - ✓ Cannon Fenske Opaque (P/N 10T6071)
  - ✓ BS/IP/RF U-tube (P/N 10T6050)
  - ✓ Zeitfuchs Cross-Arm (P/N 10T6327)
- ✓ Insulated handle, easy to grab at high working temperatures
- ✓ Stainless steel
- ✓ Viscometer will not move when applying vacuum
- ✓ Ring to hang out

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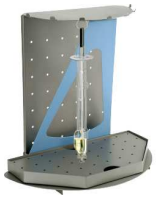
Set-up for ASTM D2170

Other accessories



- ✓ Viscohanger (P/N 10T6065)
- ✓ Timer (P/N 10T6090)
- ✓ ASTM Thermometer
  - ✓ @ 60C (P/N 25T0940)
  - ✓ @ 135C (P/N 25T0981)
  - ✓ Alternative E20 Thermometers P/N 19T4044)
- ✓ General Purpose Standards
- ✓ Leakage tray for TV2000 or TV4000

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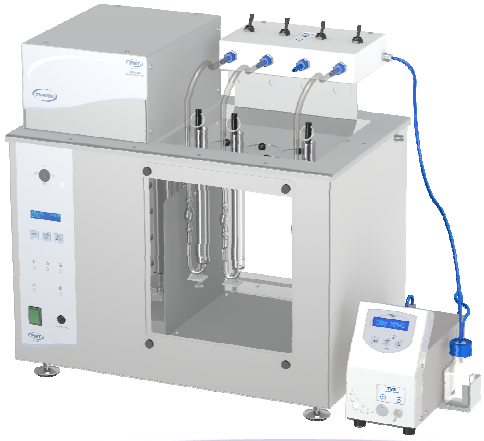
Set-up for ASTM D2171

Complete set-up D2171



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Set-up for ASTM D2171

Viscosity bath

- ✓ Seven position TV4000
- ✓ Backlight LED Illuminator (P/N 00T0908)
- ✓ Silicon oil (P/N 08T0001) if working at temperatures > 80°C

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Set-up for ASTM D2171

Tamson Vacuum System

- ✓ Extremely small footprint
- ✓ Wide input range (85—265 V)
- ✓ 20 to 320 mm HG (negative pressure)
- ✓ Stability ± 0.5 mm Hg
- ✓ Readout selectable in mm HG, PSI or mBAr
- ✓ Very quiet
- ✓ Internal pump can be switched-off between tests to increase life time of pump.
- ✓ Easy calibration
- ✓ Optional additional fluid trap (standard two at backside)

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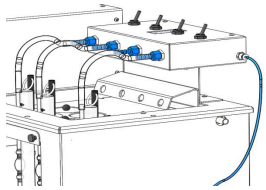
Set-up for ASTM D2171

Tamson Vacuum Manifold (TVM)

- ✓ Four position manifold
- ✓ Can be easily mounted on TV4000 using holes on top plate
- ✓ Delivered with blue silicon tubing to connect TVM with TVS
- ✓ Strong switches



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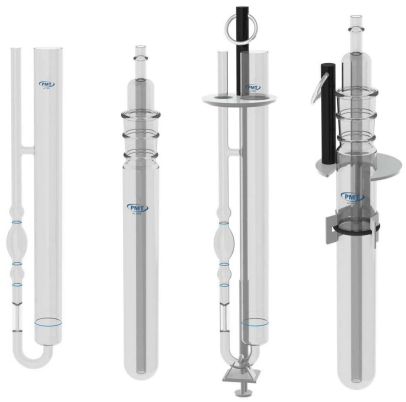
Set-up for ASTM D2171

Viscometers and viscometer Holders



- ✓ Vacuum Viscometers:
  - ✓ Cannon-Manning
  - ✓ Asphalt Institute
  - ✓ Modified Koppers
- ✓ Stainless steel holders vacuum viscometers:
  - ✓ Cannon-Manning and Asphalt Institute (P/N 10T6052)
  - ✓ Modified Koppers (P/N 10T6053)

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PM Tamson Instruments

Set-up for ASTM D2171

Other accessories

- ✓ Viscohanger (P/N 10T6065)
- ✓ Timer (P/N 10T6090)
- ✓ ASTM Thermometer
  - ✓ @ 60C (P/N 25T0940)
  - ✓ @ 135C (P/N 25T0981)
  - ✓ Alternative DCTs
- ✓ General Purpose Standards
- ✓ Leakage tray for TV2000 or TV4000

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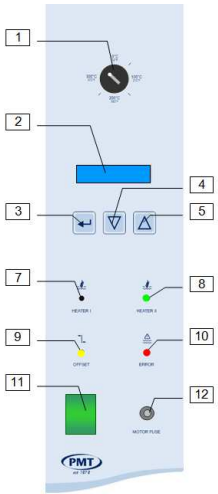
Easy Installation

- ✓ 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

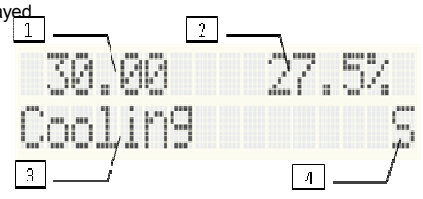
Preparing – Menu options

- ✓ 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

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

The end

Thank you for you time and consideration!