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viscolite700

Portable Viscometer
User Manual

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This Guarantee shall not apply to any fault resulting from (i) negligence or lack of proper care by the owner or user, (ii) a failure to follow the recommendations set out in this User Manual, or (iii) normal wear and tear on the instrument .

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Viscolite VL7

portable viscometer

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Introduction



The Viscolite® VL7 is an easy-to-use portable instrument for the instant measurement of viscosity anywhere at any time using a simple dip-in probe. No prior setting-up or adjustment is required.

The sensor is a solid probe with no moving parts, seals or bearings. It is connected by a coiled flexible cable to a display unit powered by four AA batteries. The probe also incorporates an integral platinum resistance thermometer (PRT). The whole system is supplied in a compact carrying case for ease of transport.

The Viscolite can be used with any volume of fluid, from a cupful to a tank. Readings are made instantly, enabling rapid assessment of samples or batches *in situ*. The solid sensor can be wiped clean in moments.

This combination of toughness, flexibility and portability make the Viscolite the ideal instrument for the spot measurement of viscosity at a remote site, in the laboratory or in a busy factory.

How it works

The Viscolite is a “resonant” or “vibrational” viscometer. The sensor consists of a steel shaft with an end mass (“bob”) which is made to vibrate at its natural frequency. The actual vibrational movement is very small, but it is enough. As the vibrating sensor shears through a fluid, it loses energy as a result of the viscous drag exerted by the fluid. The viscosity of the fluid can therefore be determined by measuring the amount of energy loss. This technique, combined with high-performance transducer architecture, leads to extremely high repeatability.

Since a Hydramotion viscometer produces no compression or sound waves it can be used in any vessel, regardless of size. The smooth, monolithic design of the sensor eliminates any chance of solid or bubble entrapment. And as the shear rate is high, the effect of external factors such as vibration or changes in fluid velocity will be negligible.

For more details of how the energy loss is converted into a measurement of viscosity, see Appendix 1 (p. 29).

1 Getting started



1.1 Packaging

- First, inspect the contents of the carrying case. Immediately report any apparent shipping damage to Hydramotion Ltd or its representatives as well as to the carrier.
- Please do not discard the packaging. Use it if you need to forward the instrument to another recipient or return it to the factory.
- Keep the Viscolite in its carrying case whenever it is not in use.
- The metal probe can move slightly relative to the black acetal enclosure: this is quite normal.

- For correct operation it is essential that the sensor shaft is perfectly straight. *Do not leave the transducer resting on the sensor shaft.*

1.2 Specification

Viscosity range

model type VL7-100B-d15	0 – 5,000 centipoise (cP)
model type VL7-100B-d20	0 – 1,000 cP
model type VL7-100B-d21	0 – 10,000 cP

Temperature range

–20 to +120 °C

Materials

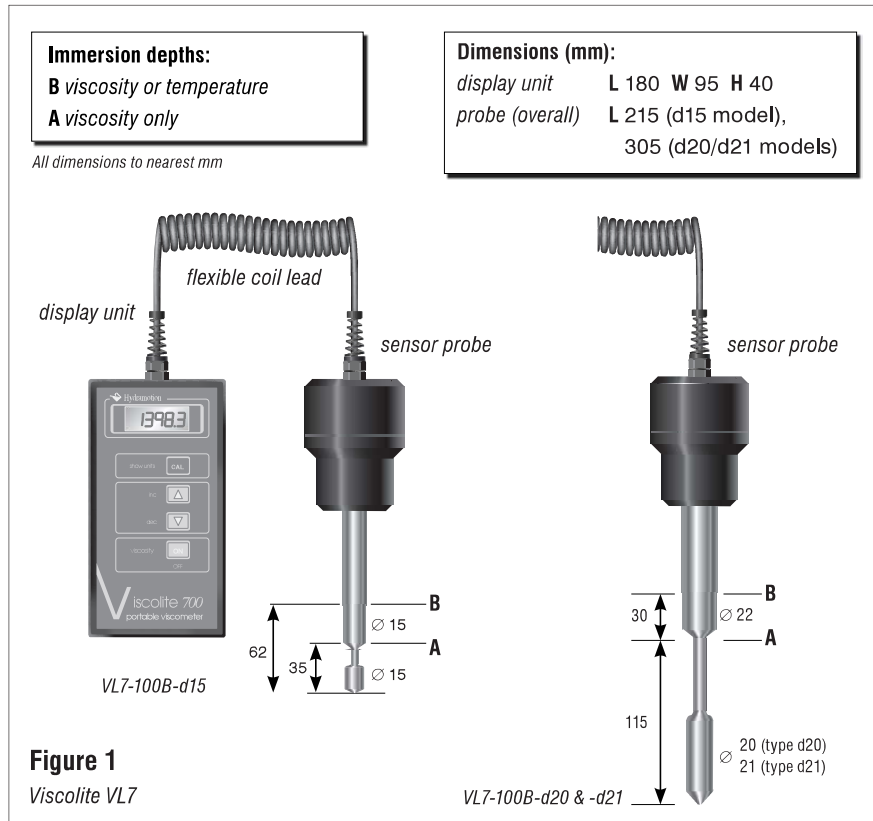
sensor	316L stainless steel (unless otherwise specified)
enclosure	acetal polymer

Power source

4 × 1.5V alkaline batteries size AA

Options

POL	high polished sensor surface 0.4 micron AA
-----	--



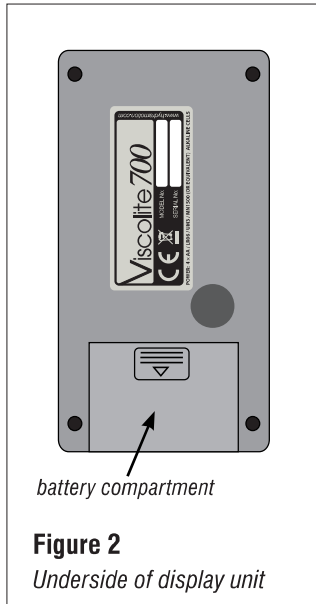
- The full designation of an instrument includes the model type and any applicable Option. Thus “VL7-100B-d15-POL” indicates the d15 model with a high-polish finish.
- A Certificate of Calibration and Conformity is included with each Viscolite. It should be carefully checked against the shipping documents and the serial number stamped on the instrument, then stored in a safe place.

Record the details of your instrument

Model type:

Serial number:

Certificate of Calibration and Conformity number:



1.3 Fitting the batteries

- The Viscolite uses four 1.5V batteries, type AA or equivalent (LR6, AM 3, MN 1500).
- Locate the battery compartment on the underside of the display unit (see Figure 3).
- Remove the lid by pressing the part marked ≡ and sliding sharply backwards.
- Place the batteries in the battery cradle, taking care that they are inserted the right way round.
- Clip the cradle firmly to the connector.
- Place the battery cradle in the compartment and replace the lid.

Note:

- Alkaline batteries (“Duracell” or equivalent) should give up to 50 hours’ use under normal operating conditions.
- Rechargeable batteries are not suitable.







2 Measuring viscosity

Figure 4
Display unit

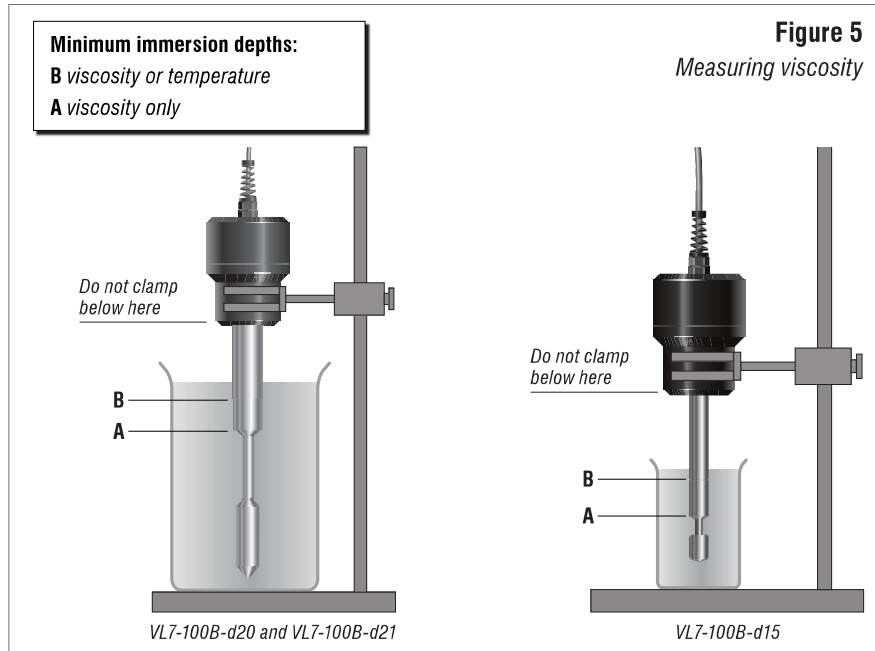


2.1 Turning on

- Press the  key on the display unit and hold it down for a second or two.
- The display shows a succession of digits while the microprocessor goes through a start-up routine. It will then show “UL” briefly before settling on the “live viscosity” reading. This is the dynamic viscosity in centipoise (cP) of whatever fluid is surrounding the sensor.
- The reading is updated every 1.5 seconds approximately.
- Pressing the  or  keys will bring up two other measurements, “t” (temperature) and “UC” (temperature-corrected viscosity). For more details, see pages 12 and 13.
- A beeper sounds each time a key is pressed.
- To switch off, press the  key again.

2.2 Operation check

- The display unit should read 0.0 (zero) so long as the sensor is
 - (i) perfectly clean, dry and
 - (ii) wholly in air and not touching anything.
- The display should show 1.0 (exactly one) if the sensor is immersed in water at 20 °C. For details of the checking procedure, see Section 5.2.
- If the air reading is not exactly zero:
 - (1) check that the sensor is perfectly clean, dry and not in contact with anything.
 - (2) if necessary, perform a “minor null adjustment” as described in Section 4.4 (p. 22).





2.3 Measuring viscosity

- Switch on the Viscolite.
- Immerse the sensor into the fluid to be measured *to the depth shown in Figure 5*.
- If the fluid is likely to be at a different temperature to that of the sensor, be sure to allow sufficient time for complete temperature equalisation before taking a reading.
- The display unit shows the dynamic viscosity of the fluid in **centipoise (cP)**, equivalent to **millipascal-second (mPa·s)**.
- **Instability in the reading** may be caused by
 - (1) temperature differences between the fluid and the sensor,
 - (2) the presence of suspended solids in the fluid, or
 - (3) a notable yield stress in a fluid exhibiting plastic behaviour (Bingham effect).



If the instability is caused by (2) or (3) (suspended solids or plastic behaviour), use the probe to stir the fluid gently.

- The viscosity reading may be noticeably **higher or lower than expected** if:
 - (1) the temperature of the fluid is significantly different from that at which the reference measurement was made, or
 - (2) the sensor is not immersed to the depths shown in Figures 1 and 5, or
 - (3) the fluid is non-Newtonian and the reference measurement was made using a significantly different shear rate*, or
 - (4) the fluid density is significantly higher or lower than the nominal factory setting of 1.0 g/cm³. In this case, enter the correct density value using the procedure described in Section 4.8 (p. 24).



2.4 Measuring temperature

- Switch on the Viscolite.
- Ensure that the sensor is immersed to the depth shown in Figure 5.
- Press the  key. The display will show “t” (temperature) briefly, then the temperature of the fluid surrounding the sensor.
- Allow time for the sensor to reach the fluid temperature before noting the reading.
- To return to viscosity measurement, press the  key. The display will show “uL” briefly before showing the current live viscosity again.

2.5 Temperature-corrected viscosity

- If the display unit is showing live viscosity, press the  key twice or the  key once. The display will show “uL” briefly and then temperature-corrected viscosity.
- For details of how to set the reference temperature, see Section 3.4 (p. 16).
- The displayed reading is calculated using the measured viscosity and temperature and applying two correction factors specific to the fluid under test. See section 3 (p. 14) for details of how to enter these correction factors.

*The Viscolite operates at a very high shear rate, which helps to give it high repeatability. Many laboratory viscometers operate at low shear rates. If the fluid is shear-thinning (pseudoplastic or thixotropic), the Viscolite reading will be lower than that obtained with a low shear-rate viscometer. If the fluid is shear-thickening (dilatant or rheopectic), the Viscolite will give a higher reading. See also Section 4.9 (p. 25).

- To return to viscosity measurement, press the  key twice or the  key once. The display will show “LL” briefly before showing the current live viscosity again.

2.6 General maintenance

- Check periodically that the instrument gives a zero reading in air.
- Clean the sensor after each measurement. It is not usually necessary to switch the Viscolite off while cleaning. The sensor can withstand vigorous cleaning *so long as the shaft is not bent or distorted in any way.*
- It may be necessary to carry out a calibration check if:
 - (1) signs of appreciable wear or abrasion are observed, or
 - (2) the instrument is dropped or knocked sharply.
- Carry out a calibration check immediately if the shaft does not look perfectly straight.
- Further calibration checks are not necessary if the instrument is still giving a zero reading in air and a reading of 1 in water at 20 °C.
- If required, certain minor adjustments are possible, as outlined in Section 4 below (p. 20). For any other calibration problem, please contact Hydramotion Ltd or its representative for details of the Instrument Verification Service.

2.7 Guidelines for optimum performance

- Do not operate the instrument outside its specification. In particular, do not subject the sensor to extremes of heat or cold.
- Remove the batteries if the Viscolite is to remain out of use for a prolonged period.
- Whenever possible, keep the transducer in its carrying case.
- **Never leave the transducer resting on the sensor shaft.**
- **Never use the sensor as a lever or for any other non-measurement purpose.**

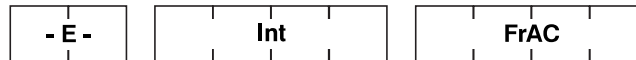
3 Temperature-corrected viscosity

3.1 Introduction

- The Viscolite uses an internal algorithm to calculate temperature-corrected viscosity from the measured live viscosity and the measured temperature. (For more details see Appendix 1, p. 29.)
- To enable temperature-corrected viscosity readings to be calculated, it is necessary for the user to enter
 - (1) the desired reference temperature, and
 - (2) correction factors specific to the fluid under test.
- To determine the correction factors, see Section 3.6 (p. 18).
- The correction factors (and some other parameters) are entered, stored and displayed in “E-format”. Details of how to enter these parameters are given in Section 3.3 (p. 15).

3.2 E-format numbers

- The structure of an E-format number is:



- **- E -** is the exponent (always displayed as two digits).
- **Int** is the integer component of the number (always four digits).
- **FrAC** is the fraction component (decimal part) of the number (also four digits).
- To get the complete number, the sum of the integer and fraction components is multiplied by 10 raised to the power given by the exponent. *I.e.*,

$$\text{number} = (\text{Int} + 0.\text{FrAC}) \times 10^{\text{E}}$$

- For example:

$$0.61280473 = \begin{array}{|c|c|c|} \hline \text{Int} & \text{FrAC} & \text{-E-} \\ \hline \end{array} 6128.0473 \times 10^{-4}$$

Thus the exponent **- E -** indicates how many places the decimal point should move to the *left* (if negative) or *right* (if positive) of the number when expressed as “**Int.FrAC**”.

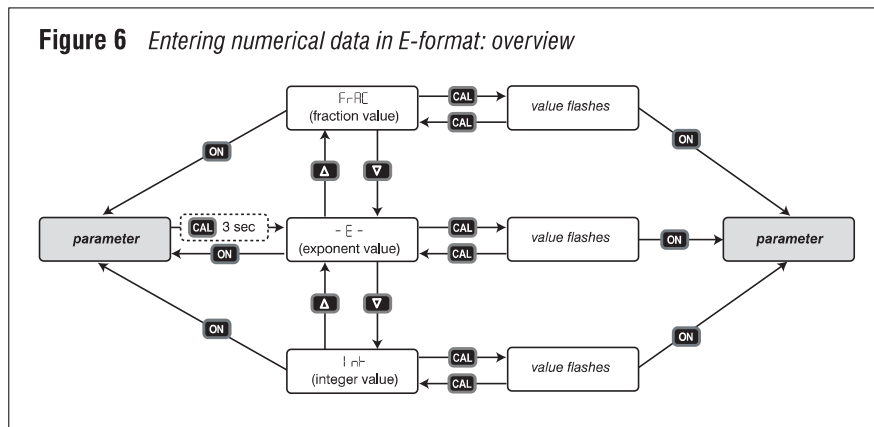
- Other examples:

<i>Number</i>	- E -	Int	FrAC *
0.6059132781	- 04	6059	1328
-58.8009340804	- 02	- 5880	0934
43629.5787797	01	4362	9579

*Note rounding of last digit.

3.3 How to enter an E-format parameter

- Check that the Viscolite is switched on and displaying live viscosity (uL), temperature (F), or temperature-corrected viscosity (uE).
- Press and hold down the **CAL** and **▽** keys simultaneously for a second or two. The display will show “uE”. The instrument is now in “Setup Mode”.
- Navigate through the menus to the desired parameter using the **▽** or **CAL** keys as indicated in Figure 7 (p. 16) or (for calibration and adjustment) Figure 11 (p. 21).
- With the desired parameter displayed (e.g. P91), press **CAL** for 3 seconds (Figure 6 below).
- The display will show “- E -” briefly followed by the value of the exponent.
- To go to the integer component **Int** from the exponent, press **▽**. To go to the fraction component **FrAC** from the exponent, press **△**. To return to the parameter, press **ON**.
- To change a displayed value:
 - (1) press **CAL**. The value will flash.
 - (2) Use the **△** or **▽** keys to increase or decrease the value.
 - (3) When the desired value has been reached, press **CAL** again.



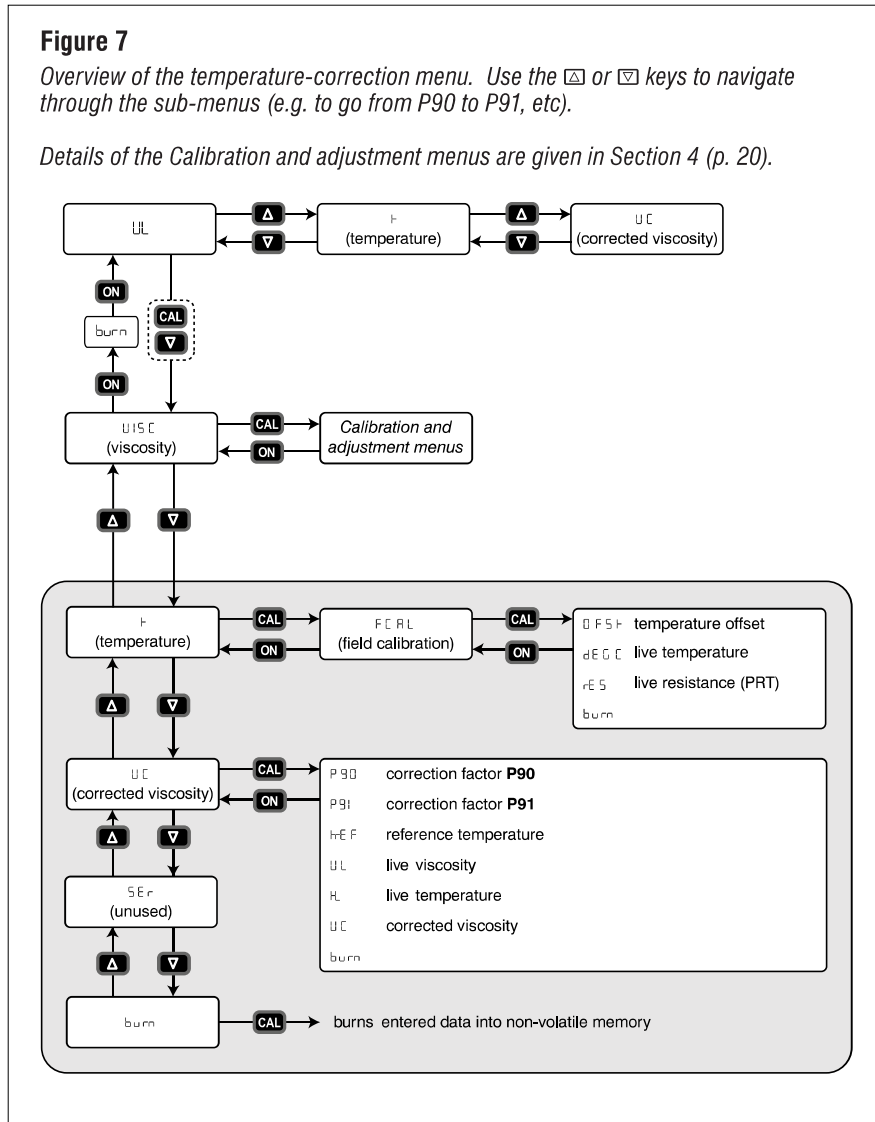
3.4 Setting the reference temperature

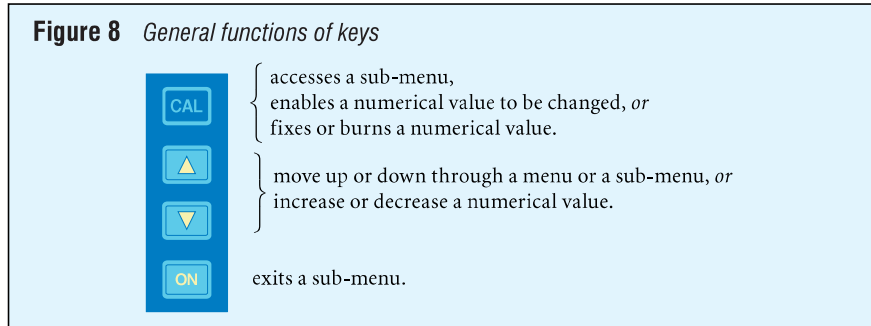
- Put the instrument into Setup Mode as described in Section 3.3 (p. 15), so that “UISC” is showing on the display.

Figure 7

Overview of the temperature-correction menu. Use the Δ or ∇ keys to navigate through the sub-menus (e.g. to go from P90 to P91, etc).

Details of the Calibration and adjustment menus are given in Section 4 (p. 20).





- Press **▽** twice. The display will show “**UC**” (see temperature-correction menu, p. 16).
- Press **CAL**. The display will show “**PG0**” briefly, then its value.
- Press **▽** twice. The display will show “**REF**” (reference temperature) briefly, then its value in °C. The factory default setting is 15.0.
- Press **CAL**. The display will begin to flash.
- Use the **▽** or **▲** keys to change the value as required.
- Press **CAL**. The value will cease flashing.
- Press **ON**. The display will revert to “**UC**”.
- Return to normal operating mode (“**UL**”) using the **▲** and **ON** keys as indicated on the menu on p. 16.
- If required, save the change as described in Section 3.5 below before switching off the Viscolite.

3.5 Saving changes

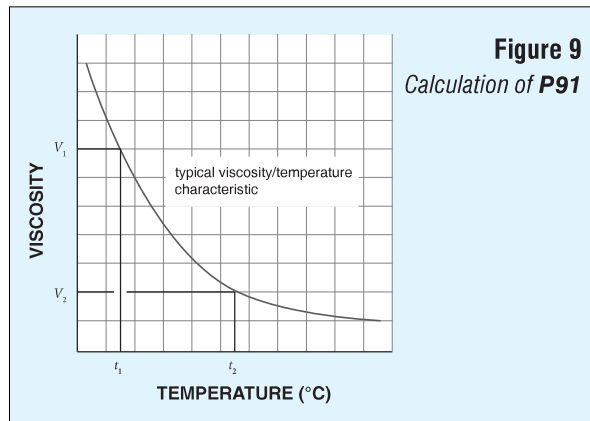
- Any newly-entered value will be lost on power-down unless it is “burned” into permanent (non-volatile) memory. To do this:
 - (1) Navigate through the relevant menu(s) to **BURN**.
 - (2) Press **CAL** for 3 seconds. The display will show “**BURN**” briefly as the data is saved.
- The “burn” can be done at any time before powering-down the Viscolite. It is not necessary to save the data after each entry.

3.6 Determination of temperature correction factors

- The correction factors are called **P90** and **P91** (see p. 30). The first of these (**P90**) is simply an offset and can be left at zero. The factory default setting for **P91** is also zero.
- There are two ways of determining **P91**: (i) calculation and (ii) trial-and-error.

(i) Calculation of **P91**

- To calculate **P91**, it is necessary to know the viscosity of the fluid at two temperatures.



The calculation is:

$$\mathbf{P91} = \frac{\log_e V_1 - \log_e V_2}{[1/(t_1 + 273)] - [1/(t_2 + 273)]}$$

where

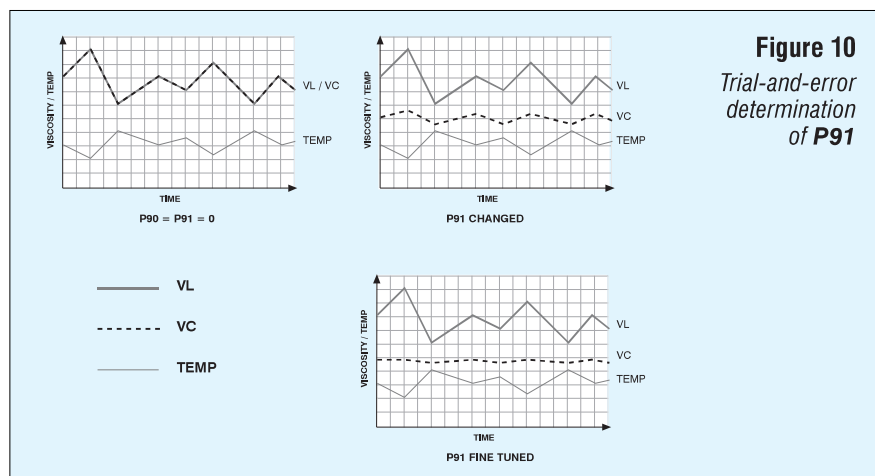
V_1 = viscosity at temperature t_1 °C

V_2 = viscosity at temperature t_2 °C

- If possible, use values of t_1 and t_2 that are close to the fluid temperature and the reference temperature.
- Enter the calculated value of **P91** as described in Section 3.3 (p. 15).
- If required, save the value as described in Section 3.5 (p. 17) before switching off the Viscolite.

(ii) Trial-and-error determination of **P91**

- This method can only be used if
 - (a) variation in fluid temperature is causing the live viscosity reading (VL) to fluctuate, and
 - (b) it is known that the temperature-corrected viscosity would be stable, *i.e.* truly constant, despite the fluctuations in VL.
- Using the \square or \square keys as indicated in Figure 7 (p. 16), navigate through the temperature-correction menu to **P91**.
- Enter a value of 5000 (**- E - = 00, Int = 5000, FrAC = 0000**) as described in Section 3.3.
- Navigate to VL. Note the degree of fluctuation in the reading.
- Go back to **P91** and enter a higher value, say 5250 (**- E - = 00, Int = 5250, FrAC = 0000**).
- Go back to VL and see if there is more or less fluctuation in the reading.
- If the reading is fluctuating less, go back to **P91** and increase the value again. Check the amount of fluctuation in the VL reading. Continue in this way until VL stabilises.
- If the reading is fluctuating more, go back to **P91** and reduce the value. Check the amount of fluctuation in the VL reading. Continue in this way until VL stabilises.
- If required, save the value as described in Section 3.5 (p. 17) before switching off the Viscolite.



4 Operational adjustment

4.1 Introduction

- Minor operational adjustments are carried out using the Calibration and adjustment menus shown in Figure 11 (p. 21).
- The following adjustments can be made:

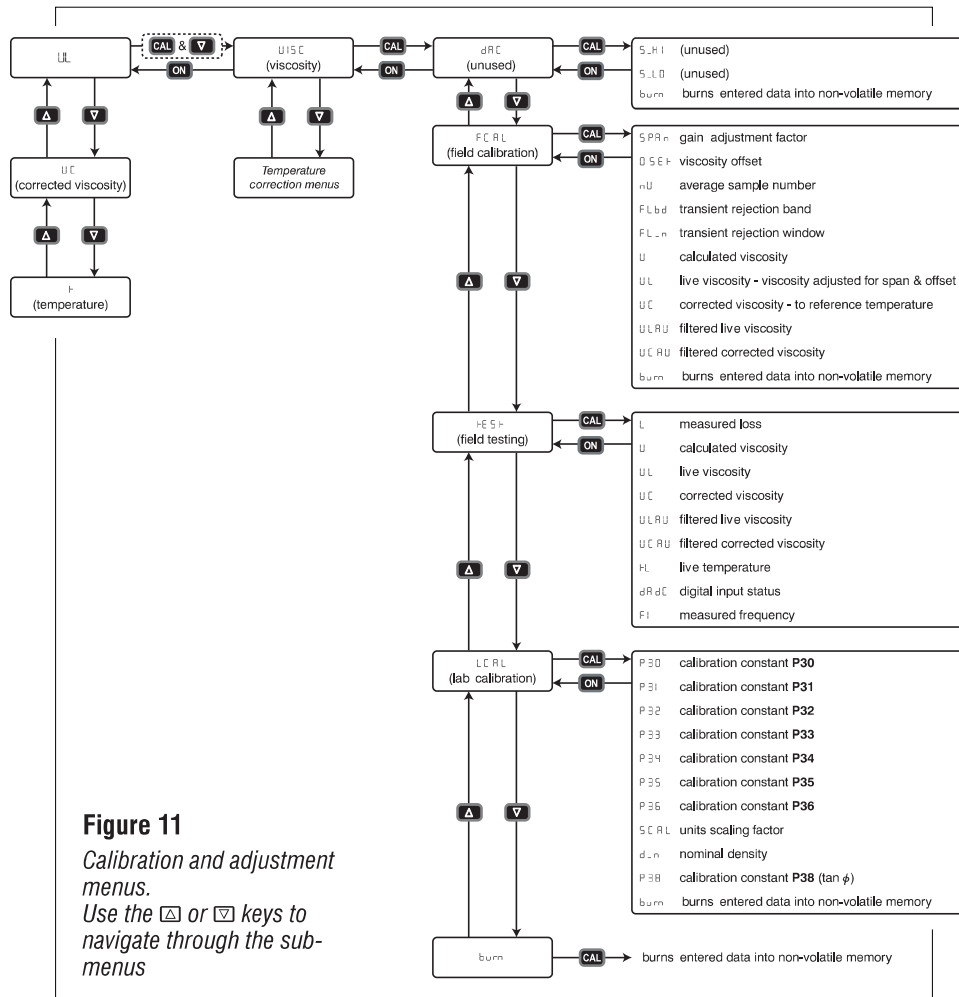
	<i>Reference</i>	<i>Page</i>
correct small non-zero reading of viscosity in air	Section 4.4	22
stabilise reading (especially in high-noise conditions)	Section 4.5	22
scale reading by any desired factor	Section 4.6	23
take account of fluid density	Section 4.7	24
express reading in centistokes (cSt)	Section 4.8	24
match Viscolite to reference viscometer	Section 4.9	25

4.2 How to modify a numerical value

- Parameters stored in “E-format” must be changed as described in Section 3.3 (p. 15).
- Other items are changed as follows:
 - (1) Navigate through the appropriate menu(s) until the desired item is reached.
 - (2) The name of the item will appear briefly, followed by its value.
 - (3) Press **CAL**. The value will flash.
 - (4) Use the **▽** or **△** keys to decrease or increase the value as desired.
 - (5) Press **CAL** again. The value will cease flashing.
 - (6) To go to the next item in the same submenu, press **▽**.
 - (7) To go to the previous item in the same submenu, press **△**.
 - (8) To exit the submenu, press **ON**.

4.3 Accessing calibration and adjustment menus

- To access these menus from normal operating mode (“UL”, etc):
 - Bring the instrument into Setup Mode by pressing **CAL** and **▽** simultaneously. The display will show “USE”.
 - Press **CAL**. The display will show “dRC”.
- Use the keypad to navigate through the menus as indicated below:



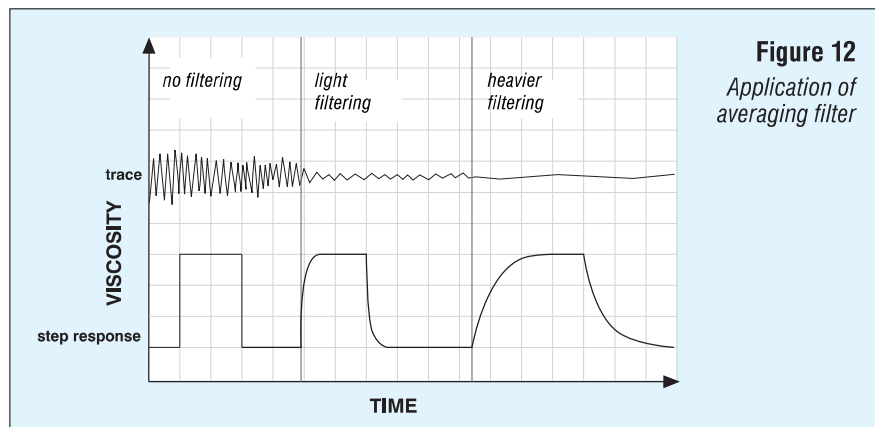
4.4 Minor null adjustment (offset)

- If the μL reading is not zero when the sensor is perfectly clean and dry and completely surrounded by air:
 - (1) Navigate to FCAL . (To do so from dPAC , simply press \square .)
 - (2) Press ENT . The display will show “SPAN” briefly, followed by its value.
 - (3) Press \square . The display will show “OFFSET” (offset) briefly, then its value.
 - (4) Modify the value of OFFSET using the procedure described in Section 4.2 (p. 20).
Example: If the μL reading in air is 0.3 and the value of OFFSET is 0.1, reduce the value of OFFSET to -0.2 .
 - (5) Navigate down the submenu to μL and check that its adjusted value is zero. (It is not necessary to navigate back to the main operating mode to reach μL — see Figure 11.)
 - (6) If desired, compare the adjusted value (μL) with the unadjusted value (μ) in the same submenu.
 - (7) Save the change as described in Section 3.5 (p. 17) before switching off the Viscolite.
- Once back in normal operating mode, the main μL display will show the adjusted reading.

4.5 Stabilise reading (averaging filter)

- The Viscolite has a very high natural rejection of exterior noise and vibration. Under normal circumstances the reading should be stable.
- If there is noticeable instability in the reading, or if very high sensitivity readings are required over a long period of time, an averaging filter can be used.
- The filter is set by changing $n\mu$ in the FCAL submenu. The value of $n\mu$ is the number of readings included in the averaging calculation.
- In fact, the displayed μL reading is the average of $n\mu$ measurements. The average is recalculated each time the Viscolite display is updated (every 1.5 seconds, approx.).
- If $n\mu$ is set to 1, there is no averaging.

- To set the averaging filter:
 - (1) Navigate to nU in the $FCRL$ submenu (see Figure 11, p. 21).
 - (2) Adjust the value as desired.
 - (3) Navigate down the submenu to “ $ULRU$ ” (filtered live viscosity).
 - (4) The filtered reading can be compared with the unfiltered reading (U) in the same submenu.
 - (5) If necessary, go back and increase $ULRU$ by a further amount.
 - (6) If desired, the change can be saved as described in Section 3.5 (p. 17).
- Once back in normal operating mode, the main UL display will show the averaged reading.



4.6 Scale reading by any desired factor

- The factory default setting is for the display to show dynamic (absolute) viscosity in **centipoise (cP)**, equivalent to **millipascal-seconds (mPa·s)**.
- To scale the reading by any desired factor:
 - (1) Navigate to $SCRL$ in the $LCRL$ submenu (see Figure 11, p. 21). The default factory setting is 1.000.

- (2) Enter the appropriate conversion factor (see below).
- (3) If desired, save the change as described in Section 3.5 (p. 17) before switching off.

Scaling from centipoise (cP)			
<i>unit</i>	<i>symbol</i>	<i>cP equivalent</i>	<i>conversion factor</i>
poise	P	100	0.01
poiseuille	Pl ($\equiv \text{Pa}\cdot\text{s}, \text{N}\cdot\text{s}/\text{m}^2$)	1000	0.001

- A Viscolite display can show only one decimal place. The `SCALE` parameter may therefore be used to bring more significant figures into the display. For example:

	<code>SCALE = 1</code>	<code>SCALE = 10</code>	<code>SCALE = 100</code>
<i>Reading on display</i>	1.2	12.3	123.4
<i>Viscosity in cP</i>	1.2	1.23	1.234

4.7 Take account of fluid density

- The factory default setting for fluid density is 1.000 g/cm^3 . To change this:
 - (1) Navigate to `d_n` (nominal density) in the `LCAL` submenu (see Figure 11, p. 21).
 - (2) Enter the appropriate value for the fluid density in g/cm^3 .
 - (3) If desired, save the change as described in Section 3.5 (p. 17) before switching off.

4.8 How to display viscosity in centistokes (cSt) (kinematic viscosity)

- (1) If the fluid density is \mathbf{d} , calculate the value of \mathbf{d}^2 , *i.e.* the square of the density.
 - (1) Navigate to `d_n` in the `LCAL` submenu (see Figure 11, p. 21).
 - (2) Enter the calculated value of \mathbf{d}^2 . Once back in normal operating mode, the main `VL` display will show viscosity in centistokes (*i.e.* kinematic viscosity).
 - (3) If desired, save the change as described in Section 3.5 (p. 17) before switching off.
- Note that this procedure is **fluid-specific**.

4.9 Matching to reference instrument

- The Viscolite is rigorously calibrated at the factory to traceable standards using certified test fluids.
- The instrument has very high repeatability. A Viscolite reading should therefore compare very well with that obtained using any other viscometer that has been properly calibrated and well maintained.
- If the Viscolite is being used correctly, its reading may not match that obtained with a reference viscometer because:
 - (1) measurements are not being made at the same temperature;
 - (2) the fluid is non-Newtonian and the reference viscometer is operating at a significantly different shear rate;
 - (3) the reference viscometer has not been calibrated or maintained properly;
 - (4) the operating parameters of the Viscolite do not match those of the reference viscometer (for example, readings in centipoise are inadvertently being compared with readings in other units); or
 - (5) the Viscolite transducer is worn, bent or damaged.
- If none of the above apply and the discrepancy remains unacceptable:
 - (1) note the reading obtained with the Viscolite. Call this reading **VL**.
 - (2) Note the reading obtained with the reference viscometer under the same measurement conditions. Call this reading **VR**.
 - (3) Calculate the ratio **VR/VL**.
 - (4) Navigate to **SPRN** in the **FERR** submenu and enter the calculated ratio.
 - (5) The adjusted reading (**UL**) can be compared with the unadjusted reading (**U**) in the same submenu.

5 Calibration and Maintenance

5.1 Introduction

- All instruments are factory-calibrated using a range of certified silicone oils.
- Alternative calibration fluids can be used by special request.
- Minor adjustments can be made as described above (Section 4).
- Factory calibration can easily be checked by taking readings in air and water (see Sections 2.2 above and 5.2 below).

5.2 Calibration check

- To check calibration:

(i) Check that the sensor is clean and dry.

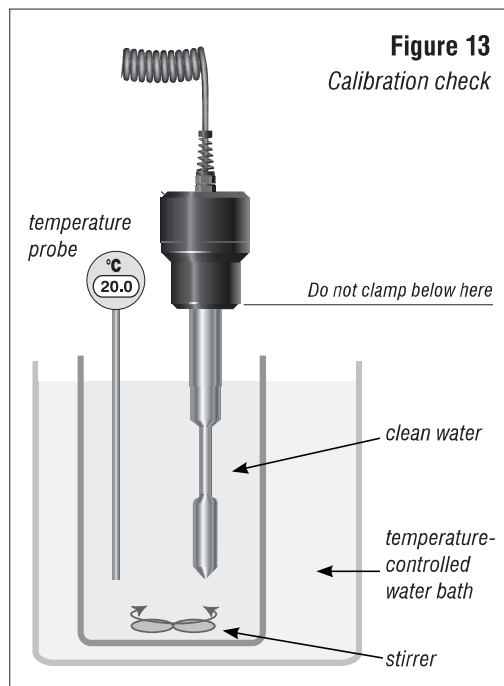
(ii) Set up the instrument as shown in Figure 13.

(iii) Ensure the transducer is stably supported. Apply clamps to the black plastic enclosure, *not* the metal shaft.

(iv) Switch the Viscolite on and note the reading with the sensor in air (*i.e.* not in contact with any fluid or surface). Switch off.

(v) Immerse the sensor in clean water at least to the minimum immersion depth as shown in Figures 1 and 5.

(vi) Switch on the Viscolite.



- (vii) Stir the water to ensure that it is all at a uniform temperature.
- (viii) Allow plenty of time for the sensor and water to reach the same temperature. This may take some minutes.
- (ix) Note the viscosity and temperature readings (see Section 2.2).

Note: Do not hurry this test. Errors can result if sufficient time is not allowed for temperature equalisation.

- Please contact Hydramotion Ltd or its representative if the readings are unacceptable and the problem cannot be resolved using the procedures described in Section 4.

5.3 Instrument Verification Service

- Please contact Hydramotion Ltd or its representative if you wish to arrange a calibration check or require a full recalibration.
- A Viscolite may be fully recalibrated:
 - (1) to comply with quality assurance requirements, or
 - (2) (by request) to adapt the instrument for use with a specific non-Newtonian fluid.
- Otherwise, full recalibration should only be necessary:
 - (1) after a damaged transducer has been repaired,
 - (2) if the sensor has become corroded or eroded, or
 - (3) if the Viscolite has been operated outside specification (*e.g.* subjected to extreme heat).

5.4 Service and repair

- Please do not hesitate to contact Hydramotion at any time for advice or assistance.
- **There are no user-serviceable parts in the Viscolite.** If a fault is suspected, please contact Hydramotion or its representative. Do not attempt to repair the unit.
- If reporting an apparent fault, please provide the following information:
 - (a) Serial number of the unit
 - (b) How long the Viscolite has been in service
 - (c) The type/composition of the fluid(s) being measured

- (d) Measurement conditions (especially temperature)
- (e) Observed and expected viscosity values
- (f) Stability of the measurement(s)
- (g) When the fault was first noticed
- (h) Whether the fault is continuous or intermittent.

- Prior to shipping:

- (1) Clarify any such matters as costs, liability, insurance, import/export documentation, customs declarations etc.

- (2) Fax or mail a Returned Goods COSHH Declaration, duly completed, to:

- Hydramotion Ltd
 - 1 York Road Business Park
 - Seven Street
 - Malton
 - York YO17 6YA
 - England

- When shipping:

- (1) Use the original packaging.
 - (2) Ensure the Viscolite is securely packed.
 - (3) Include documentation clearly stating the serial number and the reason(s) for return.

Appendix 1: Operating principles

How the Viscolite determines viscosity

The signal generated by the transducer is called the “loss factor” L . It is converted to the “raw” calculated viscosity V using the following polynomial equation:

$$V = (1/d)(P30 + P31L + P32L^2 + P33L^3 + P34L^4 + \dots)$$

Here d is the density of the fluid and $P30$, $P31$, $P32$, etc. are “calibration constants” which are unique to each instrument and must be empirically determined. The number of terms used varies between transducer models. All the Calibration Constants are set out on the Certificate of Calibration and Conformity and can be accessed from the `LCAL` submenu.

In fact, the response of a resonant viscometer like the Viscolite is not purely with viscosity but with the product of viscosity and density, *i.e.* viscosity \times density. In practice, however, repeatability is generally far more important than absolute accuracy. Since viscosity changes on a far greater scale than density, changes in density can in most cases safely be ignored.

For maximum accuracy, the density d of the fluid can be entered in the `d_n` parameter. See Section 4.8 above.

Scaling

If the scaling factor `SCAL` (Section 4.6) is applied, the equation becomes:

$$VL = \left(\frac{SCAL}{d} \right) (P30 + P31L + P32L^2 + P33L^3 + P34L^4 + \dots)$$

The “live” viscosity reading displayed in normal operational mode (`VL`) is therefore the product of the “raw” viscosity V and `SCAL`, *i.e.*

$$VL = V \times SCAL$$

Viscometer matching

When matching the Viscolite response to that of a reference instrument, the SPR_n factor is applied (Section 4.9). The viscosity reading displayed in normal operational mode (UL) is then the product of the calculated viscosity VL and SPR_n , *i.e.*

$$UL = VL \times SPR_n$$

Null adjustment

To correct a small non-zero reading in air, an offset $OSEF$ is added (Section 4.4). The viscosity reading displayed in normal operational mode (UL) then becomes $OSEF$ plus the product of the calculated viscosity VL and SPR_n , *i.e.*

$$UL = (VL \times SPR_n) + OSEF$$

Temperature correction (Section 3)

To correct the measured viscosity to viscosity at a given reference temperature, the Viscolite uses an algorithm based on the commonly-accepted Arrhenius relationship

$$\text{viscosity} = Ae^{B/T}$$

where T is the absolute temperature and A and B are constants depending on the particular fluid. The following equation is used to calculate the temperature-corrected viscosity VC from a viscosity reading VL :

$$VC = \{VL \cdot e^{P91[1/(trEF + 273) - 1/(tL + 273)]}\} - P90$$

where

- VC** = viscosity corrected to reference temperature
 - VL** = calculated viscosity
 - trEF** = reference temperature (°C) (Section 3.4)
 - tL** = measured temperature (°C)
 - P90** = correction factor (offset)
 - P91** = correction factor
- } (Section 3.6)

These parameters can all be accessed from UL in the temperature-correction menus.

Appendix 2: Menu overview

Item index

<i>(sub)menu</i>	<i>item</i>	<i>description</i>	<i>section(s)</i>	<i>page(s)</i>
	burn	save settings in non-volatile memory	3.5	17
LCAL	d-n	fluid density	4.8	24
t - FCAL	dEGC	measured temperature		
P30 (etc)	- E -	exponent of E-format number	3.3	14
P30 (etc)	FrAC	fraction of E-format number	3.3	14
P30 (etc)	Int	integer component of E-format number	3.3	14
tEst	L	measured loss		
FCAL	nV	averaging sample number	4.5	22
t - FCAL	OFSt	temperature null offset		
FCAL	OSEt	viscosity null offset	4.4	22
LCAL	P30 – 38	calibration constants	Appx 1	29
t - VC	P90, P91	temperature correction factors	3.6	18
t - FCAL	rES	PRT resistance		
LCAL	SCAL	scaling factor	4.6, 4.7	23, 24
FCAL	SPAn	gain factor	4.9	25
	t	live temperature	2.4	12
VISC	t	temperature menu	3.4	16
tEst	tL	live temperature		
t - VC	tL	live temperature	Appx 1	29
t - VC	trEF	reference temperature	3.4	16
FCAL	V	unadjusted viscosity	4.4	22
tEst	V	unadjusted viscosity		
	VC	temperature-corrected viscosity	2.5	12
tEst	VC	temperature-corrected viscosity		
t - VC	VC	temperature-corrected viscosity		
FCAL	VCAV	filtered temperature-corrected live viscosity		
tEst	VCAV	filtered temperature-corrected live viscosity		
	VISC	viscosity main menu	3.3	15
	VL	live viscosity	2.1	10
tEst	VL	live viscosity		
t-VC	VL	live viscosity		
FCAL	VLAV	filtered live viscosity	4.5	22
tEst	VLAV	filtered live viscosity		

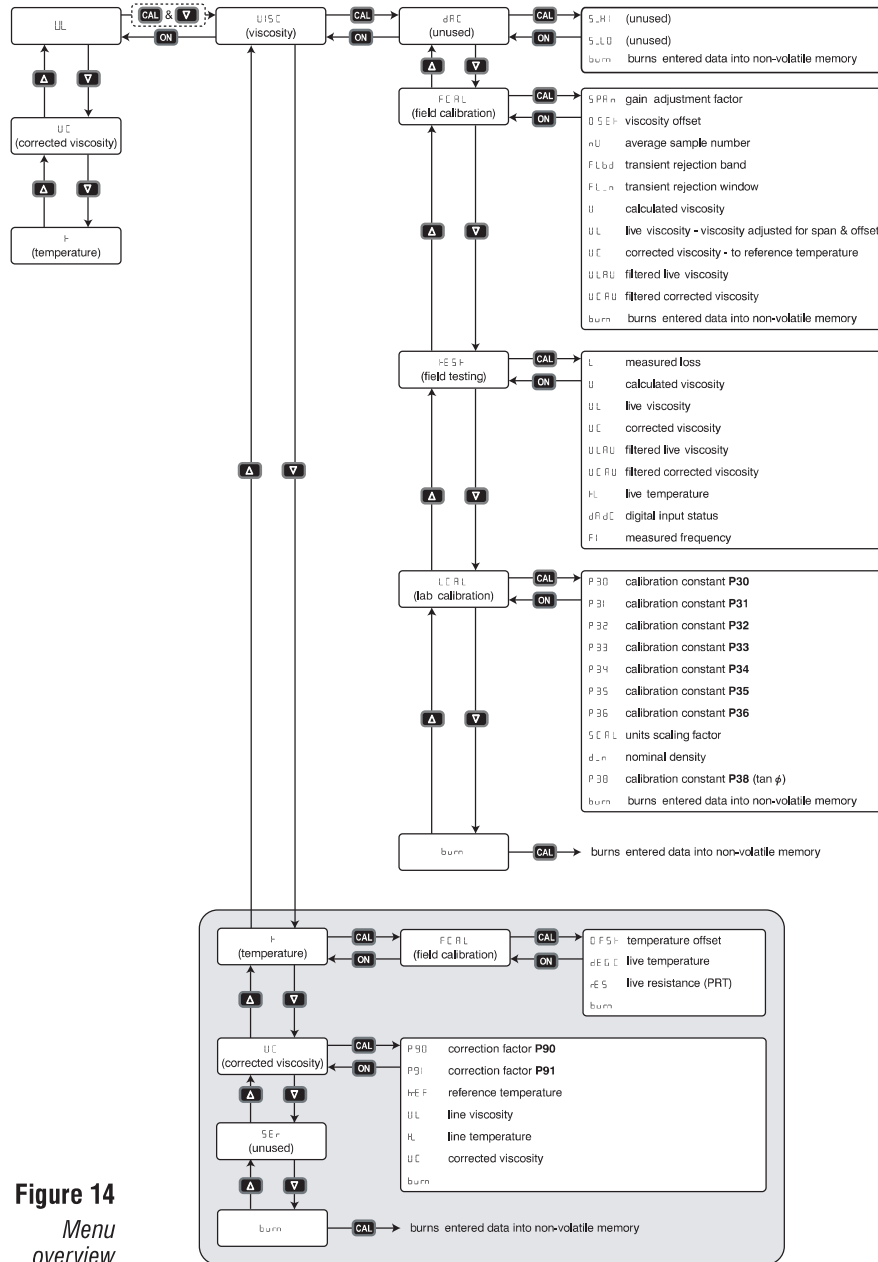


Figure 14
Menu
overview

Troubleshooting

<i>Problem</i>	<i>Possible cause</i>	<i>Remedy</i>	<i>Section</i>
No display	Not switched on	Switch on	2.1
	Batteries flat	Replace batteries	1.3
Reading high	Shear-thickening fluid	—	2.3, 4.9
	Fluid temperature low	Use temperature correction	2.3
	Fluid density high	Enter density value	4.8
Reading low	Shear-thinning fluid	—	2.3, 4.9
	Fluid temperature high	Use temperature correction	2.3
	Fluid density very low	Enter density value	4.8
	Insufficient immersion	Increase immersion depth	2.3
Unstable/jittery reading	Sensor warmer or colder than fluid	Allow equalisation	2.3
	Suspended solids in fluid	Stir gently; filter fluid if possible	2.3
	Plastic fluid (Bingham effect)	Stir gently	2.3
	High-frequency external noise	Set averaging filter	4.5
Reading not precise enough	Fluid has very low viscosity	Change scaling factor	4.6

Alarm displays

bat	batteries low — save any changes without delay to avoid loss of entered data
dead	batteries exhausted — temporary memory no longer operational
SIG	no signal from transducer*

**Please contact Hydramotion Ltd or its representative if you see this display.*

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Hydramotion

EC Declaration of Conformity

Products:

"Viscolite Portable Viscometer"
VL7-x Series VL7- Portable Viscosity Sensor and Signal Processor / Display Unit

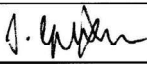
are in accordance with the following Directives:

2004/108/EC Electromagnetic Compatibility Directive

have been designed and manufactured to the following specifications:

EN61326-1:2006 Electrical equipment for measurement, control and laboratory use EMC requirements —
General requirements
EN61326-2-3:2006 Electrical equipment for measurement, control and laboratory use EMC requirements —
Particular requirements

I hereby declare that the equipment named above complies with the relevant sections of the above referenced specifications. The unit complies with all essential requirements of the Directives.

Signed	:		For and on behalf of Hydramotion Limited
Name	:	John Gallagher	Position : Managing Director
Date	:	24 September 2012	

This declaration is issued by:

Hydramotion Ltd, 1 York Road Industrial Park, Malton, North Yorkshire, YO17 6YA, United Kingdom