Rotational Viscometer

Instruction Manual

MASTER SERIES

SMART

Fungilab

Leading Viscosity Technology

MASTER SERIES
SMART
Rotational Viscometer

Software Version: 5.2
Manual Version 1.0

Instruction Manual

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Table of Contents

1. Introduction

Thank you for acquiring the Master SMART rotational viscometer model from Fungilab.

The SMART is a rotational viscometer, based on the measurement of the torque of a rotating spindle in a sample at a specified velocity. Three different models, as well as various accessories, allow it to cover a wide range of viscosity measurement.

1.1 Machinery identification

Product designation:	Digital Viscometer
Model:	MASTER SMART
Manufacturer:	FUNGILAB S.A.

Viscolead Series			Master Series				V-series	
One	Advance	PRO	Alpha	Smart	Expert	EVO Expert	V-pad	V-Compact

Table 1 Information table of the Fungilab viscometer models

2. Safety Instructions

- It is not the purpose of this manual to outline all of the safety instructions recommended for the use of the rotational viscometer, its accessories and samples. It is the responsibility of the user to establish health and safety practices and to determine the application's limits before use.
- Fungilab guarantees the satisfactory operation of the viscometers and its accessories if there have not been any unauthorized adjustments to the mechanical pieces, the electronic components and the software.
- The operator should follow all of the instructions and warnings and of this manual to ensure the safe and proper operation of the equipment.
- Do not use the equipment for any other purpose than those described in this manual.
- Do not use any accessory that is not supplied or approved by Fungilab.
- Do not use the viscometer or its accessories if there is any suspicion of malfunction. Do not use the equipment in situations or conditions that can cause personal injuries or material damage.

The rotational viscometer is **not flameproof or intrinsically safe (ATEX)** instrument and therefore should not be used in areas where there is an explosion risk.

Before using the viscometer, carefully read and observe the following precautions:

Not following the instructions may cause serious harm or personal injuries.

To avoid an electric shock:

- The socket by which the viscometer will be connected should have a ground. Verify that the voltage and the frequency match with the specifications for the power supply. Before turning on the machine, let it sit for some time so that it acclimates to the surrounding temperature in order to avoid a short-circuit caused by condensation. The fluctuations of the power source should not surpass ±10 % of the nominal voltage

3. Safety Symbols and Precautions

Safety Symbols: The following symbols are used in this instruction manual:

This symbol warns us of an operational, practical, or similar procedure that, if it is not carried out properly, may damage the equipment

This symbol indicates hazardous voltages may be present

This symbol indicates additional information that it has to be considered

Precautions

If this instrument is used in a manner not specified by the manufacturer, the protection provided by the instrument may be impaired

This instrument is not intended for use in a potentially hazardous environment

In case of emergency, turn off the instrument and then disconnect the electrical cord from the wall outlet

The user should ensure that the substances placed under test do not release poisonous, toxic or flammable gases at the temperatures which they are subjected to during testing

4. Utilities

Input Voltage:	Universal Power Supply (100-240V)
Input Frequency:	50 / 60 Hz
Power Consumption (Apparent):	15 VA
Power Consumption (Real):	25W

Main supply voltage fluctuations are not to exceed ±10% of the nominal supply voltage

5. Specifications

Speeds: 0.01 – 200 RPM
Temperature Sensing Range: -40 °C to 300 °C (-40 °F to 572 °F)
USB A Port for use with temperature probe
Viscosity Accuracy: ±1.0 % of full scale range
The use of accessory items will have an effect on the measurement accuracy

Viscosity Repeatability: ±0.2 % of full scale range
Temperature Accuracy: ±0.1 °C | -40 °C to 300 °C (-40 °F to 572 °F)
Operating Environment: +5 °C to 40 °C temperature range (41 °F to 104 °F)
Non condensing humidity

Noise emitted: Set less than 70 dB (A)
Vibrations emitted: Less than 2.5 m/s²

Certifications:

Conforms to CE Standards:

Machinery directive (2006/42/CE)

Low voltage directive (2014/35/UE):

EN 61010-1:2010	Safety requirements for electrical equipment, for measurement, control and laboratory use

EMC directive (2014/30/UE):

EN 61326-1:2013	Electrical equipment for measurement, control and laboratory use

RoHs directive:	2011/65/UE + 2014/IUE a 2014/6/UE +2014/8/UE a 2014/16/UE

WEEE directive (2012/19/UE)

Notice to customers:

The product is made up of various components and various materials that must be recycled or, failing that, deposited in the corresponding debris removal sites when the product's life has been completed or when otherwise it is necessary to dispose of it. To do this, the end user who acquires the product must know the current regulations of each municipality and / or locality based on the waste electrical and electronic equipment. The user who acquires this product must be aware of and responsible for the potential effects of the components on the environment and human health as a result of the presence of hazardous substances. Never place the product in a conventional container of citizen scope if a previous dismantling and knowledge of the components that incorporates. If you do not know the procedure to follow, consult with the city council for more information.

6. Conditions for use

- Indoor use
- Maximum altitude 2000 m.
- Surrounding temperature range: from +5 to 40ºC.
- The equipment temperature must be kept above the dew point so moisture doesn't condense on or in it. The power source fluctuations should not surpass ±10% of the nominal voltage
- Installation category II
- Pollution level II

7. Maintenance

- Always clean all of the parts after each use! Clean and dry the spindles and the spindle guard well. Make sure that there is not any sample remaining, especially in the delicate zones such as the spindle connector.
- Use detergents or solvents to clean the spindles and the protector:
    - For cleaning food samples, use lukewarm water and if necessary, use soft household detergents
    - Other solvents that generally provide good results are acetone, gasoline, or any solvent with a high percentage of alcohol
    - For the use of any other solvent, make sure that it does not corrode the spindles or the protector. The spindles are made in AISI 316.

Warning: Handle the volatile and flammable solvents with proper cautions. It is the user's responsibility to establish safety conditions at work.

- Regularly check the spindle's thread and the viscometer shaft.
- During the viscometer's lifespan, regular maintenance is important. As the manufacturer, we advise annual check-ups by the technical service of your local distributor.
- The viscometer is powered by a MEAN WELL GST25A12-P6J power supply. Do not open, expose, modify or touch internal circuitry of the power supply.

Fungilab S.A. can check up also the viscometer, working as a technical service, to put in contact with us use the next address.

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8. Equipment presentation

- Once the equipment package is received, check and confirm the delivery note. If some discrepancy or problem is found, immediately notify the supplier.
- Verify that the viscometer model corresponds to the one that was ordered.
- Carefully read the instruction manual.
- The manufacturer is not responsible for any damages that may result from modifications or lack of maintenance of any of the machine's mechanisms (directive 89/655/CEE).

Fungilab recommends using the carry-case provided with the equipment for making any kind of delivery. Please, keep the carry-case in a safe location. In case of transporting the equipment or during long storage periods, always use the carry-case by placing each part as shown in the picture. In the attached photograph (Figure 1) the position of each piece inside the equipment's carry-case is presented. In the case of incorrect packing, the pieces of equipment can suffer some damage; this damage will not be covered by Fungilab's guarantee.

Parts included with the equipment standard delivery:

- Viscometer head with serial number
- Foot or base, 3 height adjustable knobs for the base
- Nut
- Fastening rod
- Standard spindles
- Spindle guard
- Spindle support
- Temperature probe
- Calibration Certificate
- Conformity declaration
- Oil certificate document copy
- USB-Memory containing the User Manual (PDF file). The USB-Memory might contain also the company catalogues.
- Power cable
- PT100 probe
- Clip for holding the PT100 probe
- MEAN WELL GS25A12-P6J power supply

Do not open the power supply due to electrical shock risk and there are not serviceable parts inside. In case of suspecting that the power supply malfunctions please contact FUNGILAB for assistance.

It is mandatory to leave enough free space around the equipment ON/OFF switch, needs to be reachable at any time, especially in case of an emergency or malfunction.

It is very important to treat the silkscreen printed logos carefully when cleaning the equipment. Please use a soft cloth, with isopropyl alcohol (70%).

Standard spindles
Model L: L1, L2, L3, L4
Models R and H: R2, R3, R4, R5, R6, R7

Fig 1. Viscometer in its carry-case (two levels)

9. Equipment Description

Fig. 2 Frontal view of the equipment

1. Screen
2. Capacitive Keyboard
3. Nut
4. Spindle guard
5. Fastening rod
6. Temperature probe
7. Spindle
8. Base (viscometer stand)
9. Height adjustable knob

Fig. 3 Back view of the equipment

1. Serial number label
2. Warning Label
3. Level
4. Power switch
5. Power cable slot
6. USB Temperature probe connector
7. USB Connector
8. Thermosphere connector

9.1 Equipment Identification

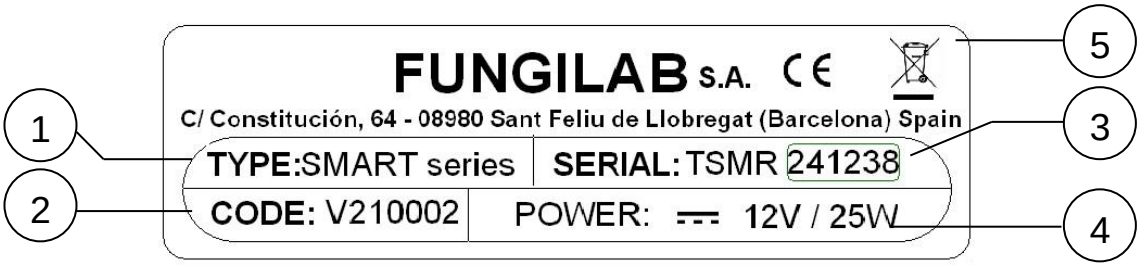


Fig. 4. Equipment identification label

Description of the equipment identification label:

1. Viscometer model
2. Viscometer code
3. Serial number of the equipment
4. Voltage, frequency and power of the equipment
5. Electronic equipment (specifies throw in trash).

9.2 Equipment set-up

- Remove all of the parts from the carry-case. Note the figure below (fig 5).
- Correctly place the three height adjustable knobs (B) on the Y-shaped base (A).
- Mount the fastening rod (C) with the holding screw (D) at the base (A).
- Attach the nut (F) to the fastening rod (C). The viscometer should be connected to the nut (F) by means of its rod (E).

NOTE: *The following process should be done carefully in order to not harm to the shaft of the viscometer. Immediately remove the shaft's plastic protector before beginning to use the viscometer.*

- Insert the horizontal rod of the viscometer (E) into the nut (F).

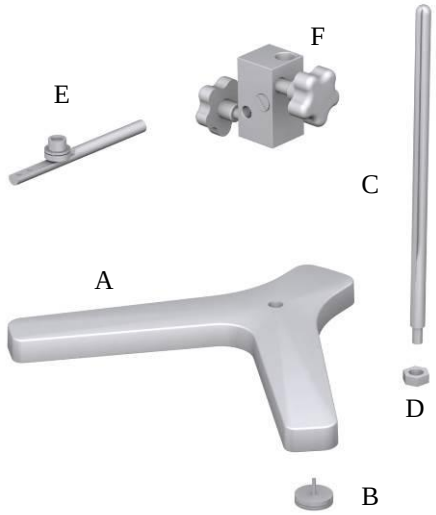


Fig. 5 Set-up for the viscometer base

- The viscometer should be placed on a stable surface free of vibrations (i.e. caused by other machines or equipment). Do not put the viscometer in direct contact with sunlight or in the middle of any air flow (the temperature of the sample can be easily influenced by the surrounding conditions). The viscometer is designed for indoor use.
- Use the height adjustment knobs until the height of the viscometer (located in rod E) is correctly adjusted.
- Plug the power cable into the connector located on the back of the equipment (Fig. 3 position 5) and plug it into the power source.

WARNING:
Verify that the voltage and the frequency coincide with the specifications for the power supply (look at the identification). Before turning on the machine, let it sit for some time so that it acclimates to the surrounding temperature in order to avoid a short-circuit caused by condensation. The fluctuations of the power source should not surpass ±10% of the nominal voltage.

9.3 The keyboard and screen

Before starting up the machine, it is recommended to become familiar with the viscometer controls seen in the previous section. The instrument has a 12 key capacitive keyboard (number 2 Fig. 2) and a colour TFT screen (number 1 Fig. 2) on the frontal to allow the user to interact with the viscometer. The keyboard gives the user the mobility throughout all of the menus and the selection of different options and configurations. The screen presents informative menus in which the user operates. These menus are detailed later in this manual. The measurements collected by the instrument will also be explained later on.

The keyboard has the following configuration:

Fig. 6 The keyboard for the SMART viscometer

The twelve keys available have many assigned functions depending on the operations that need to be carried out. Some of these functions or operations can be carried out from any screen.

The different numbered keys will always allow you to type in the proper numerical value (if a modifiable field has been selected).

Key	Function
'Δ'	Go to the previous option; increase a value when a field has been selected.
'∇'	Go to the next option; decrease a value when a field has been selected.
'▶'	Change the selected field on some menus.
'◀'	Return to the previous screen.
'ENTER'	Accept an option or value in a field. It also allows editing to fields that can be modified. Access to special functions.
'MEM/CLEAR'	Stop the motor during measurements and returns to the main menu screen. Erase the information present in a field when it is highlighted. Shortcut to a test profile from the main menu screen.
'0'/ON	Start the motor and pause it during measurements. It also allows running the measurement from its configuration screen.

Keys 1M1 to 9M9 are used for recordings and their functions are detailed in section 8.4 of this manual.

In the following sections, the function of each key in the corresponding menus will be explained in full detail, including the exceptions to the general operation.

10. Menu system

Fungilab viscometers work with a system of menus that allow the user to go through the instrument in a quick and simple way. The basic actions in the menus are: moving through the options ('Δ' and '∇' keys), selecting an option ('ENTER' key) or returning to the previous menu ('QUIT" key).

10.1 Start-up

Turn on the switch on the back of the machine (number 4, Fig. 3). If after doing this, the machine does not turn on:

- Verify that the power cable is connected to both the power and the Power Supply and that the Power Supply is also connected to the equipment (back part, number 5, Fig. 3).

The machine will beep, indicating that it has started and it will show the autotest screen:

The equipment initially comes configured with:

- English
- Temperature units in Celsius (ºC)
- Viscosity units in centipoises (cP).

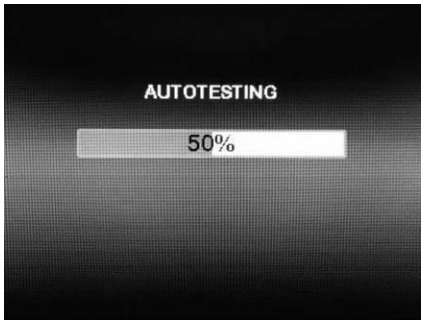
If these are not the desired basic configurations, the equipment can be configured and changed to meet the user's needs. The method of configuring the apparatus by varying these and other parameters is explained in detail in a later section of this manual called 'Instrument setup menu' (section 10.4). Any changes made to the machine will stay configured to the last modification made at the configuration menu and will not return to the factory settings after a restart.
Once the configuration information is given will submit the system to a Autotest.

10.2 Autotest

The Autotest process allows you to verify the proper operation of the viscometer, in a way that allows detection of motor malfunctions in a simple and practical way.

VERY IMPORTANT: The Autotest should be carried out without a spindle.

Once the Autotest screen is shown on the screen, we should confirm that the spindle is not connected. Afterwards, press 'ENTER' and the auto-check process will begin. While this test is running, the screen will show this message:

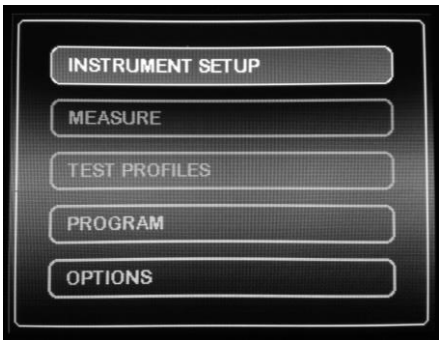


The progress bar that appears below the word ¨AUTOTESTING¨ displays the status of this process accompanied by a textual representation of the progress in a percent format.
Once the Autotest process finishes, two possible messages will appear, depending on the result of the diagnostic.

If the viscometer detects an anomaly, it will show the following message on the screen while it emits an acoustic warning:

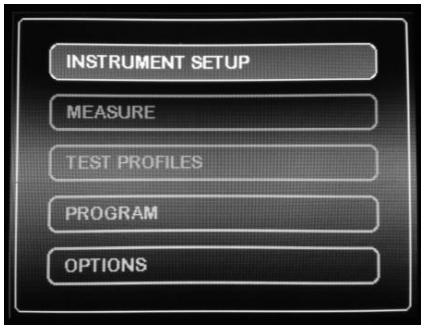
If this message appears, the machine will let off a whistle and a technical service from the supplier or manufacturer should be contacted. To get the manufacturer's contact information, press the <ENTER> key and it will appear in the following format.

If there is a system error, the equipment will stay blocked, meaning the motor is not working properly. If the machine is turned off and restarted, the same screen will reappear.
In the case of a successful check, the main menu will be displayed.



10.3 Main Menu

The main menu is the one that appears after the Autotest screen. It is accessed by turning on the machine normally and after a satisfactory result from the test run. The main menu screen will show:

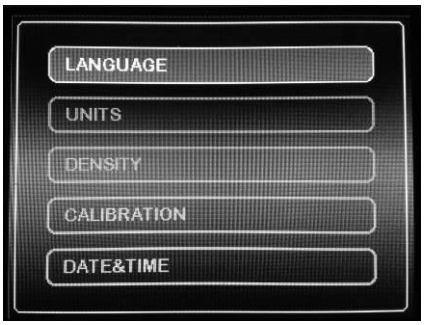


The first time the machine is used, it is advisable to access the 'INSTRUMENT SETUP' option as the first step in order to establish the values for certain parameters of the viscometer such as language and measurement units.
The menu can be navigated with the 'Δ' and '∇' keys. The current selection will be highlighted and by pressing 'ENTER' you will access to the selected submenu (for more information about each function in particular see the corresponding sections).

In the following sections, each of the 5 submenus of the main menu can be seen beginning with the configuration submenu.

10.4 Instrument Setup menu

The configuration menu contains those functions that are not standardized and that modify the state and/or operations of the instrument. Once the 'INSTRUMENT SETUP' option is selected by pressing the 'ENTER' key, the following screen will appear:



Move through the options using the 'Δ' and '∇' keys and select a submenu with the 'ENTER' key. By pressing the 'MEM/CLEAR' key, the user can return to the main menu and by pressing the '◄' key, the user can return the previous screen.
The main menu provides the possibility of:

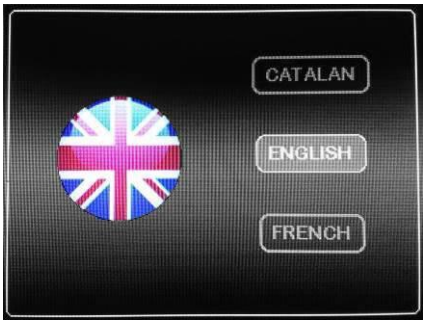
- Changing the working language
- Selecting the measurement units (viscosity and temperature)
- Changing the value of the sample density (by default 1 g/cm^3)
- Carrying out calibrations (the machine comes calibrated from factory, therefore it is not necessary to do any calibrations when the machine is received)
- Adjusting the date and time.

The language, time and units should be selected by the user before beginning to work with the equipment so that it functions properly.

10.4.1 Language

Once the configuration menu has been accessed, the first option that the cursor '>' points to is 'LANGUAGE'. To change the language, this option must be selected by pressing the 'ENTER' key.

When we enter in this submenu, the viscometer will show a screen like the next one:



By using '∆' and '∇' the different working languages for this equipment can be seen, which are:

English
French
German
Italian
Spanish
Catalan
Chinese

Once the language has been selected, press 'ENTER' and it will automatically change the language of the menus and return to the configuration main menu screen.

If you want to leave without changing the language, the 'MEM/CLEAR' keys will take him to the main menu or the '◄' key will take you to the configuration menu.

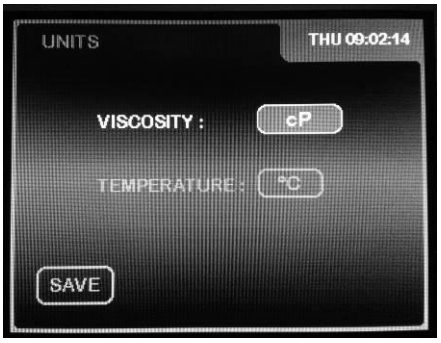
10.4.2 Units

The SMART viscometer allows the user to select the units that are used for measuring viscosity and temperature.

The possible choices for dynamic viscosity are:
- International system of units (Pa·s or mPa·s)
- Centimetre-gram-second system of units (Poise or centipoises)

And those of temperature units are:
- Celsius (ºC)
- Fahrenheit (ºF)

When the 'UNITS' submenu is highlighted, it can be accessed by pressing the 'ENTER' key and the viscometer will show the following screen:



By default, the unit for the viscosity is cP and the unit for the temperature is ºC. Moreover, the 'VISCOSITY' field appears with light blue background, which means that its value can be changed by using the '∆' and '∇' keys. Press 'ENTER' to save the selected viscosity unit and the field 'TEMPERATURE' will appear highlighted with light blue background. The light blue background indicates that the value of the field can be modified by using the '∆' and '∇' keys. Press 'ENTER' to save the selected temperature units.

After the desired units have been selected, hit the 'ENTER' key with the 'SAVE' option highlighted in light blue background. The viscometer will save the selected units and it will return to the 'Instrument setup' menu.

If the 'MEM/CLEAR' key is pressed, it will cancel the new selections made for viscosity and temperature, returning back to the previously used settings.

10.4.3 Density

The value assigned to the density of the fluid being measured can be changed by means of this submenu. By default, we consider the density of water as a reference point, but you can select any other value. The default units will be g/cm^3 of the Centimetre-gram-second system of units (CGS). The field of the whole numbers appears highlighted in light blue background, which means that it can be edited. Use the numerical keyboard to introduce the value desired for the density whole numbers.

Once the digits of the whole numbers are introduced, press 'ENTER' to skip to the next field. Then, the field of the decimal numbers will appear highlighted indicating that this field can be modified. Use the numerical keyboard to introduce the decimal numbers of the density and press 'ENTER' to save these numbers. In order to save the value of the density press 'ENTER' with the 'SAVE' option highlighted in light blue background. The viscometer will return to the 'Instrument setup' menu.

NOTE: *If you modify the density, the viscometer will give its measurements in cSt (centiStokes), whereas if you conserve the initial density (considered the density by default), the measurements will be in cP (centipoises), P (Poise) or mPa·s, Pa·s.*

10.4.4 Calibration

This submenu contains the viscosity and temperature calibration options that the user can exploit to recalibrate the viscometer. Moreover, it also contains the 'RESET' option to restore the factory-stage calibration and erase the memory and the programming.

IMPORTANT:
The viscometer contains a default calibration element, which is installed during the manufacturing process. It is for this reason that it is unnecessary to calibrate the equipment when using it for the first time. Nevertheless, certain norms of quality recommend that the equipment be recalibrated once a year, which is why we offer the user the possibility of realizing this calibration without needing to send the viscometer back to the usual provider, or to FUNGILAB.

FUNGILAB cannot be held responsible for the measurements taken by an independently recalibrated viscometer and it is essential to follow the instructions given by Fungilab carefully when recalibrating.

Calibration Norms:

- To execute a viscosity calibration, it is necessary to have on hand at least a little standard calibration oil and a thermo-statization system to maintain the sample at a constant temperature. If you do not have this equipment, then you will not be able to guarantee good post-calibration measurements.

  Fungilab provides upon request the standard oils necessary for the calibration, as well as the accessories need to thermostatize the oils.

- The calibration of any spindle, will only modify the values of that individual spindle. The rest of the equipment's spindles will not be affected by this calibration. If you want to calibrate more than one spindle you will have to be calibrated one by one. The oils used for each spindle will also be different, so for calibration you should have standard silicon oil for each spindle you're calibrating.

- Tables 6, 7 and 8 (page 63) specify the standard oils necessary for each spindle.

This submenu is accessed through the main configuration menu, by choosing the Calibration menu and pressing 'ENTER'. Once at the submenu, the following screen will appear:

Using the '∆' and '∇' keys, you can select the different options of this submenu, highlighting each option and pressing 'ENTER' for choosing it. Using the '◄' key, you can return to the previous screen and with the 'MEM/CLEAR' key you will return to the main menu. If you hit 'ENTER', you will select the option indicated by the cursor.

10.4.4.1 Reset

This submenu contains the equipment's RESET option.

After resetting, the equipment will recuperate the original viscosity calibration.

Upon entering this submenu, the following screen will appear:

If you want to continue with this process, hit 'ENTER' and you will be brought to the following screen. Otherwise, hit the 'MEM/CLEAR' key, which will bring you back to the main menu. In this submenu, the keys '∆' and '∇' have no function.

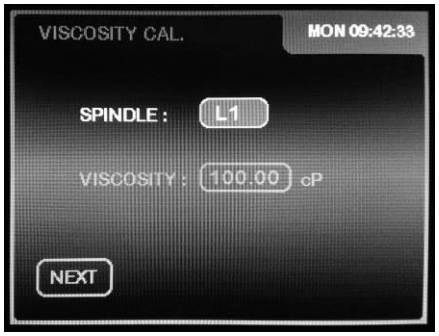
If you press 'ENTER' here, the factory-stage calibration will be restored (calibration, language), the memory will be erased as well as the programming and you will return to the main configuration screen. If you hit 'MEM/Clear', you will return to the main menu and by hitting '◄', no configuration will be restored and you will also return to the main configuration screen. If you press 'ENTER' with the field 'QUIT' highlighted the system will return to the 'CALIBRATION' menu.

10.4.4.2 Viscosity Calibration

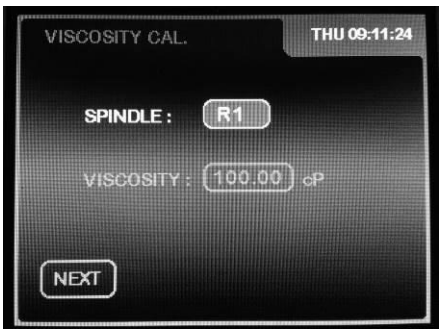
From the ‘CALIBRATION’ menu select the ‘USER CALIBRATION’ option. The following screen will appear:

Select the ‘VISCOSITY’ option and you will access to the following screens, depending on the model of your viscometer:

Model L



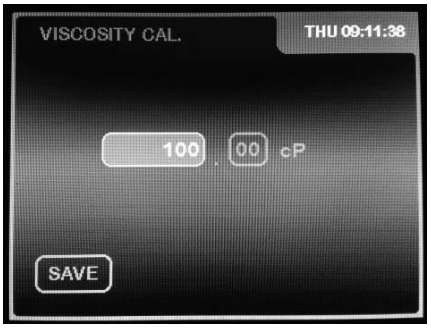
Models R and H



Upon entering this screen, the spindle field is highlighted in light blue background. Using the ‘Δ’ and ‘∇’ keys you can change the Spindle.

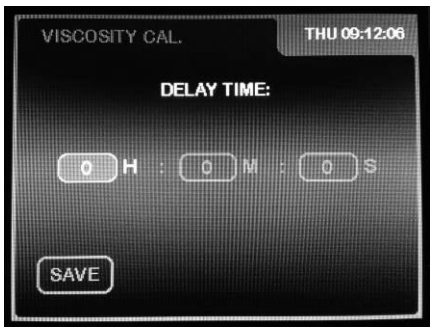
The list of possible spindles to use depends on the model of your viscometer (L, R or H). Thus, in tables 1 through 5 (page 61 and 62) you can see the different spindles available for each model.

Once you’ve selected your spindle press ‘ENTER’ and the ‘VISCOSITY’ field will be highlighted. Press ‘ENTER’ again and the following screen will appear:



Use the numerical keyboard to introduce the value of the viscosity of the standard oil used for calibration (the standard oils provided by Fungilab provide viscosity tables according to different working temperatures). There is a field for entire numbers and other one for the decimal figures. Once introduced the viscosity value, press 'ENTER' with the 'SAVE' option highlighted to confirm the modification. Next, the following screen will appear:

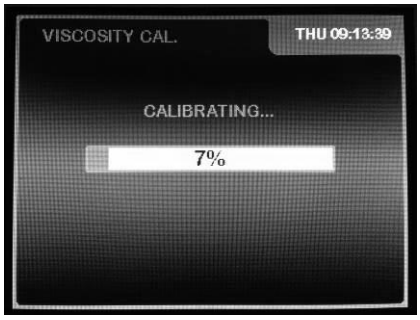
Once the spindle is in position in the device, press 'ENTER' again and the following screen will appear:



In this screen it is necessary to introduce the time required from the moment you give the command to start the calibration to the moment the device begins the calibration process. This time lapse is frequently used to allow the whole of the sample and spindle to arrive at thermal stability before starting the actual calibration.

On this screen, the field for the hours appears highlighted first. Using the 'Δ' and '∇' keys you can change the number of hours. Once the right value is entered, hit 'ENTER' and the field associated with the number of minutes will stay highlighted and ready to be modified using the 'Δ' and '∇' keys. Following this same procedure, the number of seconds can be modified. When pressing the 'ENTER' key with the 'SAVE' option highlighted it will start a countdown back to zero. The following screen can be an example of this countdown:

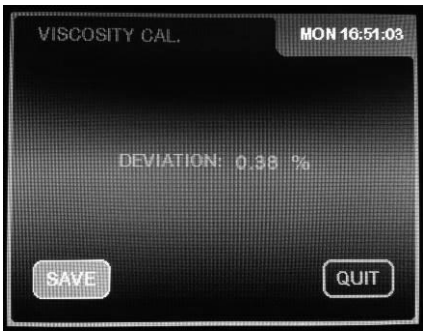
The spindle must already be submerged in the liquid once you confirm the start time.
When the countdown gets to zero, the viscometer will start the calibrating sequence. While the equipment is calibrating, the following screen will appear (example):



On this screen, the progress bar that appears below the word ¨CALIBRATING¨ displays the status of this process accompanied by a textual representation of the progress in a percent format.

The exit key 'MEM/CLEAR' and allow us to exit to the main menu but never while calibrating (never while the screen looks like the example just above).

When the calibration process is over, information on the values of the angles and curvatures of the calibration are displayed, as it is shown in the following screen:

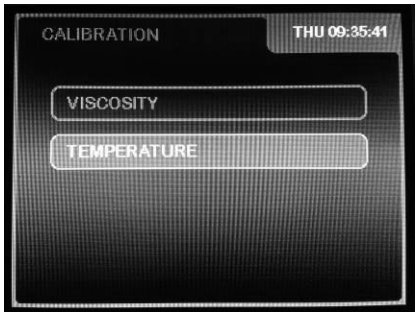


If the curvature is lower to 1.5%, hit 'ENTER' to confirm the calibration and you will be taken to the main menu. The User calibration is now stored in the viscometer's memory.

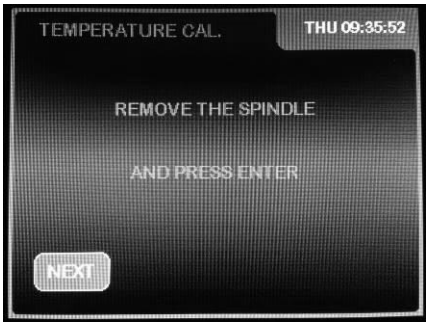
NOTE: *Exiting mid-calibration denies the equipment a proper calibration and therefore it cannot guarantee accurate results.*

10.4.4.3 Temperature calibration

Once selected the Factory Calibration or the User Calibration option from the Calibration submenu, the following screen will appear:

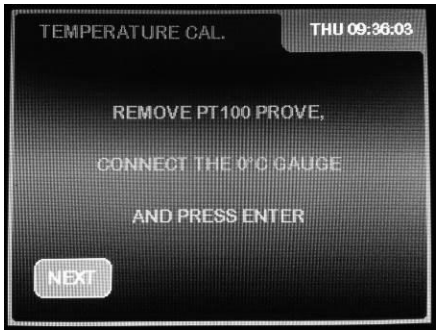


If you select the temperature option (by moving through the menu using the 'Δ' and '∇' keys) and press 'ENTER', you'll be brought to a screen resembling this one:

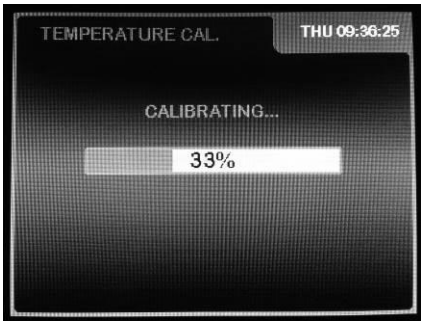


VERY IMPORTANT: The Test-run should be carried out without a spindle.

Once this message is shown on the screen, we should confirm that the spindle is not connected. Afterwards, hit 'ENTER' and you'll be brought to a screen resembling this one:

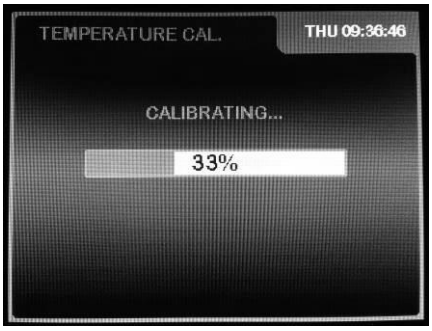


Connect the temperature simulator, using a type A USB connector, to the back of the viscometer simulating the indicated temperature (in this case 0ºC).
The viscometer's screen will show the instructions to follow to achieve the calibration of the probe that measures temperature. You'll have to connect the PT100 simulator generating an impedance equivalent to PT100 at 0 degrees Celsius. Once the gauge is connected hit 'ENTER' and the following screen will appear:

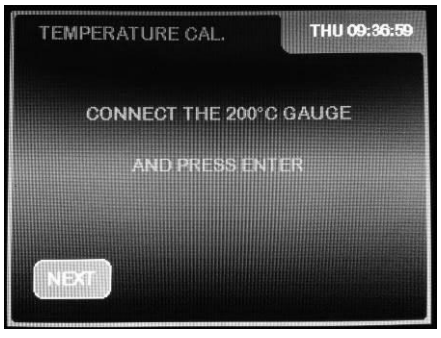


After a few seconds and once the temperature is calibrated to 0 degree Celsius, a second screen of instructions will appear, containing the following information:

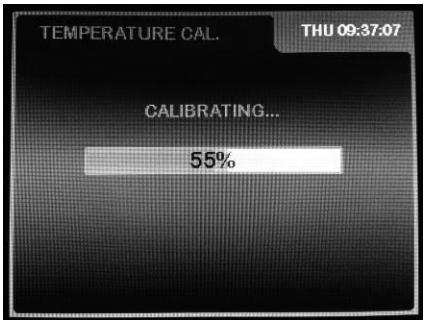
Now, you'll have to connect the PT100 simulator generating impedance equivalent to a 100ºC PT100. With the gauge connected and hitting the 'ENTER' key, this screen will appear:



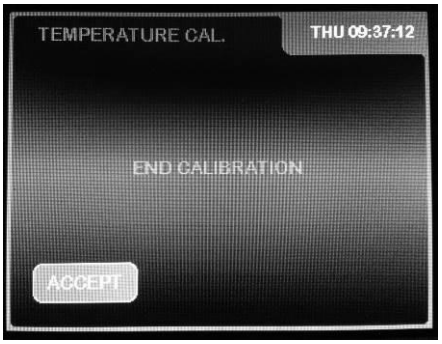
After a few seconds, a second screen of instructions will appear, containing the following information:



Now, you'll have to connect the PT100 simulator generating impedance equivalent to a 200ºC PT100. With the gauge connected and hitting the 'ENTER' key, this screen will appear:



After the calibrating is done, the equipment will show the following screen:

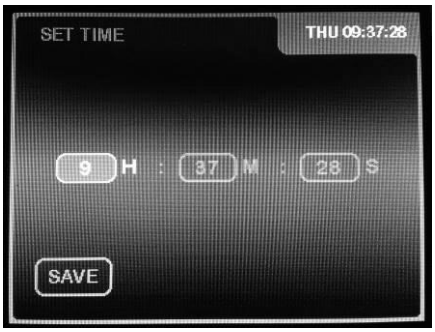


Press 'ENTER' again and the viscometer will show the main menu. The exit keys 'MEM/CLEAR' and '◀' allow us to go back to the main menu or to the previous screen, respectively, though never while calibrating.

Note: *Exiting in mid-calibration denies the equipment a proper calibration and thus cannot guarantee accurate results.*

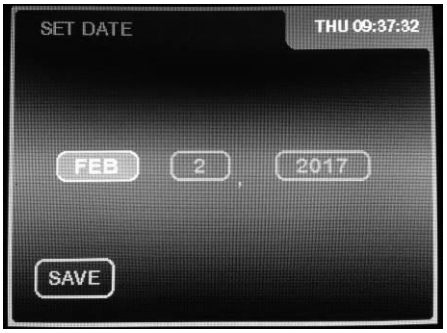
10.4.5 Time Settings

When the 'Date&Time' field is highlighted, press the 'ENTER' key to select this option and the viscometer will display the following page:



At this point, the field associated with the hour will be highlighted, being the background colour of this field light blue. Using the 'Δ' and '∇' keys you can change the hour. Once the right value is entered, hit 'ENTER' and the field associated with the minutes will be highlighted. Following this same procedure, the minutes and seconds can be modified. Press 'ENTER' with the 'SAVE' option highlighted and the time information will be saved. The 'MEM/CLEAR' and '◄' keys fulfil their functions as exit keys, allowing you to return to the main menu without saving the changes or return to the previous screen, respectively.

The date change functions in much the same way as the time change. Once this option is selected, the following screen will appear:



The date can be modified by using the 'Δ' and '∇' keys when the month, day or year field is respectively selected. If you press the 'MEM/CLEAR' key the modification will be cancelled and the previous field value will be restored. By pressing 'MEM/CLEAR' again, you will be brought back to the main menu. The '◄' key allows us to go back to the previous page in which you can switch between modifying the date or the time, but not before pressing 'ENTER' and thus saving the modifications.

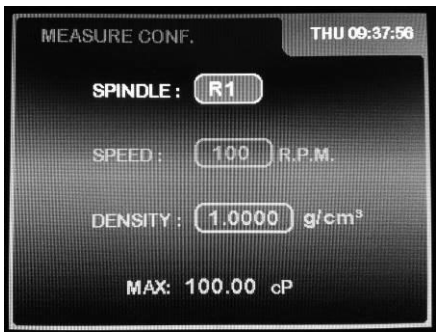
10.5 Measurement Configuration

The measurement configuration menu allows access to the main function of the device: measuring fluid viscosity. From the main menu screen, with the 'MEASURE' field highlighted, press the 'ENTER' key to choose this option.

After choosing this option, you will see one of these screens, depending on the viscometer model you have:

Model L

Model R and H



Let's first look at what each field represents and how to modify it.

- SPINDLE: the field that indicates which spindle we use for the measurement.
- SPEED: the field indicating the working speed.
- DENSITY: indicates the density of the sample
- MAX: Maximum viscosity to be determined with the speed and the spindle selected (guideline value).

The 'SPINDLE' field together with the selected 'SPEED' will determine the maximum and minimum viscosity values (from 9 to 23, from page 72 to 86), as well as the existence of a shear stress measurement (if you're using coaxial spindles).

The 'SPINDLE' field appears highlighted first, in light blue background. The viscometer will only show the spindles that are compatible with your model. Use the 'Δ' and '∇' keys to choose the spindle and press 'ENTER' to skip to the next field.

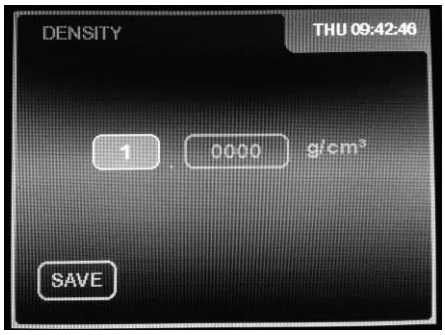
Note: *The Heldal special spindles, from PA to PF, appears in the 'SPINDLE' field when the 'SPEED' field show a speed value equal or lower than 12 rpm. Otherwise, these spindles do not appear in the 'SPINDLE' field and they cannot be selected.*

IMPORTANT: *Selecting a spindle that doesn't correspond to the ones adapted to your model will cause measurement problems.*

The SPEED field appears now highlighted. This field indicates the speed (revolutions per minute) at which the test will be done. The SMART series incorporates 54 pre-determined speeds: 0.01, 0.03, 0.05, 0.07, 0.09, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1, 1.1, 1.2, 1.4, 1.5, 1.8, 2, 2.5, 3, 4, 5, 6, 7.5, 8, 10, 12, 15, 17, 20, 22, 25, 30, 35, 40, 45, 50, 60, 70, 75, 80, 90, 100, 105, 120, 135, 140, 150, 160, 180, 200 RPM.
The viscosity of the liquid and the spindle used determine the speed (refer to tables 9 to 23).
Speed modification: once the corresponding field is selected, showing light blue background, you can move through the pre-established speed using the 'Δ' and '∇' keys. If you want to keep the selected speed, press the 'ENTER' key to skip to the next field.

You have also the option of configuring a stock of personalized speeds to facilitate operations. This option is detailed in section 10.7.2 of the manual.

The field DENSITY is then highlighted. This field indicate the density of the fluid being measured. By default, we consider the density of water as a reference point, but you can select any other value. To modify density, press 'ENTER'. The following screen will appear:



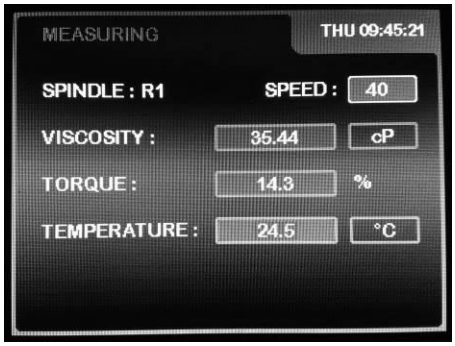
The field for the density whole numbers appears higligthed in light blue background, ready to be modified. The desired number can be introduced using the numerical keyboard. Press 'ENTER' to validate the number. Then, the field for the decimals will change its background colour to light blue, indicating that it is ready to be edited. Use the numerical keyboard to introduce the value desired. Press 'ENTER' to validate this value. Press 'ENTER' again with the 'SAVE' option highlighted in order to save the density value. Then, the viscometer will return to the measurement configuration menu.

NOTE: *If you modify the density, the viscometer will give the measurements in cSt (centiStokes), whereas if you conserve the initial density (considered the density by default), the measurements will be in cP (centipoises), P (Poise) or mPa·s, Pa·s.*

If, once the values of all of the fields are confirmed, you press the '0N' key, you will go on to the measurement screen. If instead you press the 'MEM/CLEAR' key, you'll return to the main menu screen. If you press the '◄' key, you will return to the initial screen.

10.5.1 Measurement Screen

You can access this screen by pressing the 0N key after the introduction of the measurement parameters. The spindle will start rotating, which means that the equipment is ready to start collecting data. In the next picture, an example of the data shown on the screen at this stage can be seen:



As the equipment collects viscosity data (one data value for each rotation of the spindle), the information on the screen will be updated. On the screen you will see:

- SPINDLE: Current spindle. Selected on the previous screen.
- SPEED: Revolutions per minute. Value selected on previous screen.
- VISCOSITY: Viscosity value expressed in cP or mPa·s, or cSt (in the case that a density different from the default one is introduced).
- TORQUE: Certain percentage of the base scale. Percentage value of the curvature of the spring in relation to the base of the same scale.
- TEMP: Temperature of the sample (ºC or ºF).

NOTE: *Depending on the selected speed, it is possible that the speed reading will take a few seconds or minutes to appear. It's important that the viscometer has made at least five rotations (which equals five measurements) before considering the measurements to be valid, as the device needs that time to stabilize. It's also important to only take into account the temperature of a stable sample.*

In addition to visualize the obtained measurements of the sample-on-test, the user can perform other actions in parallel from this screen.

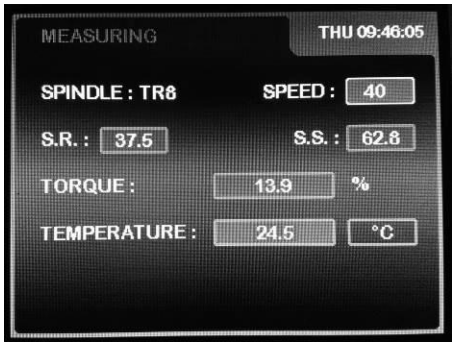
The speed field appears by default selected on this screen, highlighted in light blue background. Using the 'Δ' and '∇' keys, you can increase or reduce the speed of the spindle's rotation (RPM). When you press one of these two keys, the rotation speed increases or decreases, respectively, from the previous speed. This way, we can comfortably modify the turning speed without having to leave the measurement screen.

The units in the temperature field (ºC and ºF) can be modified using the same process but you will have to use the '►' key to select the appropriate field first. The selected field will appear in light blue background.

The instrument allows switching between the viscosity and the Shear Rate and Shear Stress by pressing the 'ENTER' key. This feature is not activated for the spindles that Shear Rate and Shear Stress are not applicable, such as the standard Spindles (L1 to L4 and R1 to R7).

IMPORTANT: *When the certain percentage of the base scale is lower than 15% or is as high as 95%, the measurement cannot be considered valid and the equipment will emit a warning beep with every rotation made under these circumstances.*

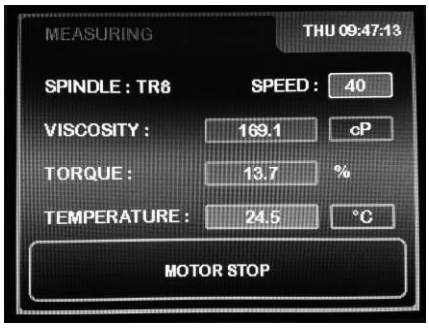
If you are using coaxial spindles (TL or TR) or the low-viscosity spindle (LCP/SP) you can access the other measurement information screen.
By pressing 'ENTER' in the main measurement screen, the following screen will appear:



This screen shows the same values of Spindle, Revolutions per Minute, Percentage and Temperature of the sample that were shown on the previous screen. But in addition this screen shows:

- SR: Share Rate.
- SS: Share Stress.

Pressing the 0N key during an experiment, the user can stop or start the motor, which allows for momentary pauses in an experiment. When you hit this key, the equipment will show the following message:



If you press the 0N key, the equipment will restart the measurements with the same configuration.

10.6 Test Profile

FUNGILAB viscometers incorporate a group of programmable data logs that allow configurations to be saved in order to speed up use of the machine when carrying out measurements of a certain frequency.

From the main menu screen, select the 'TEST PROFILE' option by using the 'Δ' and '∇' arrows and hit the 'ENTER' key to accept. The viscometer will show the following screen:

The first option will start a measurement with some configurations already recorded in the instrument's log and the second is for saving the measurement options of a new configuration. Select one field or the other by using the 'ENTER' key.

By pressing the 'MEM/CLEAR' and '◄' keys the equipment will return to the main menu screen.

10.6.1 Writing Tests Profile (Edit Profile)

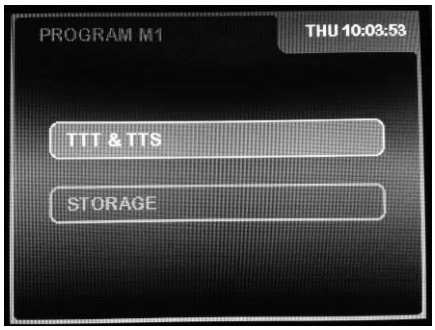
To select this option, the 'ENTER' key should be pressed when the 'EDIT PROFILE' option is highlighted. The viscometer will show the following screen:

To choose one of the tests profile, press the corresponding key for the test profile that is desired. The names correspond to the symbols that there are on each of the keys on the apparatus´ keyboard (for example hitting the key '6 M6' selects log M6). From there, hit the 'ENTER' key to validate the option.

In the test profile recording there are two option blocks that you must to configure once the desired test profile has been chosen. We will now explain viscometer programming and output specific configuration for the measurement.

10.6.1.1 Viscometer programming

Once the log is chosen, the following screen will appear:



For the selection of one of the two options, scroll between the options by using the 'Δ' and '∇' keys and press the 'ENTER' key on the one that is desired. The exit keys, 'MEM/CLEAR' and '◄', continue to fulfil their habitual functions by bringing the user to the main menu screen or the previous screen, respectively. In the case of 'MEM/CLEAR', it will proceed without having saved the changes.

On this screen, these two fields can be configured. Once they are configured, the 0N key accesses to the 'MEASURE CONFIGURATION' screen, which should be filled with the main parameters desired for the measurement, such as the spindle, the motor speed and the density of the sample.

10.6.1.1.1 TTT and TTS

These abbreviations mean:

TTT: Time to Torque. You must set a torque value (%), at which the viscometer will have to stop the measurement. The screen will show the obtained viscosity at this moment in the torque. (see section 10.7.1)

TTS: Time to Stop. You must set a time for the experiment and a time for the viscometer to stop. Once the device has arrived at the determined time, the equipment will stop and display the value of the viscosity (see section 10.7.1)

If you choose the option 'TTT and TTS', the following screen appears:

The two fields to activate in this screen are the TTT and TTS. To select a field, use the 'Δ' or '∇' keys to go through the options cyclically. The field that is selected at each moment will change the colour of the text.

TTT and TTS can only be ON or OFF. To change from one to the other you must have the field selected and use the 'ENTER' key to change modes.

If neither mode is chosen, you cannot access the 'Torque' or 'Time' fields. These fields need to be activated ('ON' in the fields TTT and TTS, respectively) in order to access them.

Once the 'Time to Torque' field is activated, the 'TORQUE' field appears highlighted. Press 'ENTER' again to activate the screen that allows the edition of this parameter. This screen is like the following:

The active field can be changed by pressing the '►' key. Once highlighted the appropriate field, it can be selected by pressing the 'ENTER' key. The selected field changes its background colour to light blue, which means that the field can be edited. Using the numerical keys, you should enter the desired value and press 'ENTER' again with the 'SAVE' option highlighted to save the changes. This value will remain saved even if the option is deactivated ('OFF').

'Time' is modified in a similar way. You should have the 'TTS' option activated (hitting the 'ENTER' key to change the mode to 'ON'). Once it is selected, hit 'ENTER' and the following screen will be shown:

Change the active field with the '►' key and introduce the desired value in each field using the 'Δ' and '∇' arrows. Hit the 'ENTER' key to accept the value. Hitting 'ENTER' again with the 'SAVE' option highlighted saves the changes and these will be saved until the next modification by the same procedure. If we deactivate the 'TTS' option, the value will remain saved in the memory.

The exit keys 'MEM/CLEAR' and the '◄' key continue to fulfil their traditional functions, bring us to the main menu screens or the previous screen, respectively. With the 'MEM/CLEAR' key, the changes will go unsaved. Moreover, the key 'ON' brings us to 'MEASURE CONFIGURATION' screen.

NOTE: *It is impossible to select both the TTT and TTS functions at the same time.*

10.6.1.1.2 Storage

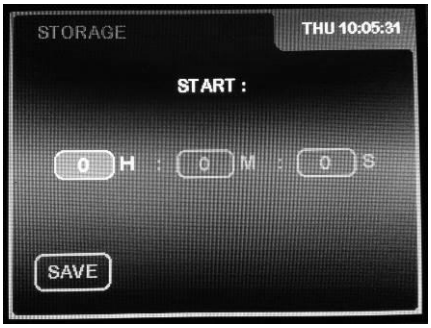
If you choose the Storage option, you will be activating experiment recording or recording measurements in the memory test profile. For this, you will be led to the following screen:

The default mode is 'OFF'. To activate this option, use the 'ENTER' key to turn it 'ON' and vice versa.

While the option is disabled ('OFF'), we cannot select the time fields that regulate this function.

- START: Defines the lapse of time before starting the recording.
- END: Defines the time in which the recording ends.
- INCREMENT: Defines the time interval between recorded samples.

Once the field in active, you can select different fields, jumping for one to another using the 'Δ' and '∇' arrows. To modify each field, press 'ENTER'. A screen such as the following will appear:



The selected field will highlight its background on the screen while it is modified, using the 'Δ' and '∇' arrows and introducing the desired values in the digital places this way. Upon digit entry the viscometer will jump to the next digit place by pressing the 'ENTER' key. To save the changes press 'ENTER' again with the 'SAVE' option highlighted, which will unselect the fields and save the values entered.

The exit keys 'MEM/CLEAR' and the '◄' key continue to fulfil their traditional functions, bringing us to the main menu screens or the previous screen, respectively. With the 'MEM/CLEAR' key, the changes will go unsaved.

10.6.1.2 Measurement Configurations

When the user is in the 'TTT&TTS/SPEED SEETINGS/STORAGE' screen in the 'EDIT PROFILE' option (as it can be seen in the following picture), the configuration of the measurement or experiment can be started. The '0N' key will bring you to a screen resembling this one:

The modification on this screen has already been explained in detail in section 8.3 Measurement configuration menu.

Note: *The profile under edition can be configured with any of the 54 predetermined (standard) speeds. Therefore, all the standard speeds are available when the 'SPEED' field is selected even if the viscometer has activated a preconfigured set of personalized (custom) speeds. More information about the custom speeds will be shown in Section 8.5.2 (Speed Settings).*

Once the measurement parameters are configured, press the '0N' key to save it to the memory test profile. The equipment will move on to the following screen and the recording process will be finalized.

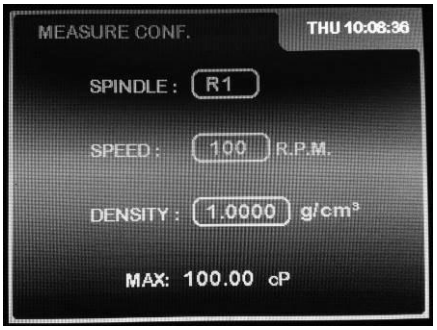
10.6.2 Select Profiles

If the user wants to use some of the machine's logs, the 'ENTER' key should be hit once the field of this option is highlighted and the following screen will appear:

To choose one of the test profile options, hit the log key corresponding to the desired log setting (for example 1 M1, would select log M1). The names correspond to symbols on each key on the viscometer's keyboard. After that, hit the 'ENTER' key to validate the option.

Once the test profile is chosen the following information screen will appear:

The disabled options appear in the 'OFF' status. The activated ones appear with some configuration information ('TTT' and 'TTS' options) or with the 'ON' indication ('STORAGE' option). The information shown will not be able to be modified under any condition; it is only shown to inform the user. Once on this screen, the key '◄' takes the user to the log selection screen and the 'MEM/CLEAR' key would take the user back to the main menu of the machine. Press the 'ON' key to directly start the measurement. Press the 'ENTER' key to hide this screen and the instrument will bring the measurement configuration information on the screen (example):

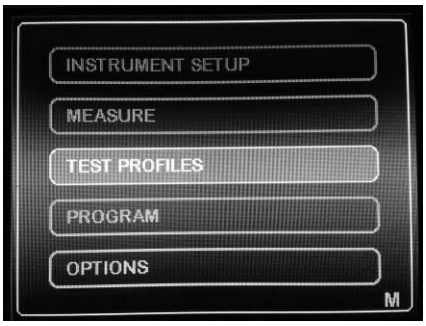


Once on the measurement configuration screen, its details can be seen but not modified. Now if the '0N' key is hit, the measurement can begin. If the '◄' key is pressed, it goes to the log selection screen and the 'MEM/CLEAR' key would take the user back to the main menu of the instrument.

If by error a test profile is selected that has not been recorded on previously (the viscometer comes from the factory with empty tests profile) and if the 'ENTER' key is hit, a 'MEMORY EMPTY' message will appear:

By pressing the 'ENTER' key again, the test profile selection screen will reappear to be able to select another test profile. The 'MEM/CLEAR' and '◄' keys continue fulfilling their habitual functions by carrying the user to the main menu screen o the previous screen, respectively.

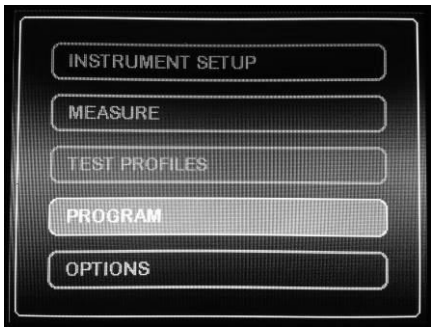
NOTE: *There exists a way to select the log through fast access. When the user is on the main screen of the viscometer, the 'MEM/CLEAR' key can be hit and a letter M will appear on the lower part of the screen giving this view:*



When this M is on the screen the keyboard function has been activated, the user can directly select one of the nine "test profile"*. Press one of the nine keys with a keyboard test profile symbols (for example 3 M3). It takes the user directly to the test profile information screen and the user can proceed as was explained before. In the same way, if an empty test profile is selected (without having been recorded on), it will show the empty slot screen.*

10.7 Programming

The Programming menu contains the functions that allow some optional applications to be programmed for the measurements. The TTT (Time to Torque) and TTS (Time to Stop) are applications that are complementary to the basic measurements.
From the main menu screen, you must highlight the option "Program", as seen in the following diagram:



The exit keys 'MEM/CLEAR' and '◄' will continue to perform their normal functions, bringing you to the viscometer's main menu screen.

10.7.1 TTT (Time to Torque) and TTS (Time to Stop)

Select this function, pressing the 'ENTER' key when the 'TTT and TTS' option is highlighted and the viscometer will show you the following screen:

This screen will allow us to activate and configure the 'TIME TO TORQUE' (TTT) and 'TIME TO STOP' (TTS) options that we will currently explain:

- Time To Torque (TTT): the TTT experiment measures viscosity until torque arrives to the prefixed value. To start the experiment is needed to obtain five consecutive measures with a difference in the torque minor than 2%, after that, the device it will measure viscosity until cross the prefixed value of torque (rising or falling). When the viscometer stops, the last viscosity measurement is displayed on the screen.

- Time to Stop (TTS): the 'Time to Stop' field is where you program the amount of time you want the measurement or experiment to last. Programming this field with a time limit will define the maximum duration of the viscometer's measurement. When the viscometer stops because the program is finished, the last viscosity measurement will be displayed on the screen.

To select the field that we want to activate (TTT or TTS) we use the 'Δ' or '∇' keys to jump from field to field cyclically. Then press the 'ENTER' key to activate the selected option. The options for the two fields TTT and TTS can only either be 'ON' or 'OFF'.

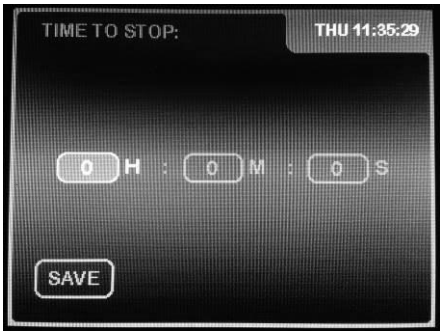
If the 'Time to Torque' or 'Time to Stop' fields are not activated (shows the 'OFF' status) the 'Time' and 'Torque' fields cannot be accessed.

Press 'ENTER' to activate the 'Time to Torque' field ('ON' position) and the 'Torque' field will be highlighted. Press 'ENTER' again to proceed to the modifications. The following screen will appear:

Press enter again to select the entire number field. The background of the selected field will change to light blue, indicating that the field can be edited. By using the numerical keys, we can introduce the desired torque value, between 15.0 and 95.0. By pressing the 'ENTER' key again the decimals can be introduced. Press 'ENTER' again when the 'SAVE' option is highlighted in order to save the torque value. This number will

remain saved, unchanged, even if the 'Time to Torque' option is deactivated (by changing the field option to 'OFF').

The 'Time' field works in a similar way. We need to first activate the 'Time to Stop' option (on 'ON' position) and select it using the 'ENTER' key. The field 'TIME' will appear highlighted. Press 'ENTER' again and the following screen will be on:



The field for the hours appears highlighted in light blue background, so it ready to be edited. Use the '∆' and '∇' arrows to introduce the desired number and press 'ENTER' to activate the next field. The same procedure is followed for the minutes and second fields. Pressing the 'ENTER' key when the 'SAVE' indication is highlighted saves the changes, and these will remain unchanged until a new amount is entered in the same way. If we deactivate the 'Time to Stop' option (in 'OFF' position), the value will be saved.

The 'MEM/CLEAR' and '◄' exit keys will continue serving their normal functions, bring us to the main menu screen or the previous screen, respectively. If you use 'MEM/CLEAR', changes will not be saved. Moreover, the key 'ON' brings us to 'MEASURE CONFIGURATION' screen.

NOTE: *The TTT and TTS are mutually exclusive, so both functions cannot work at the same time.*

10.8 Options

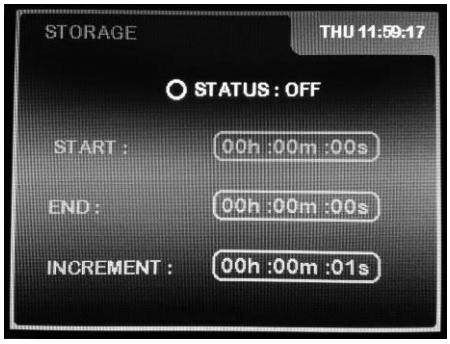
The Options menu contains the information and output options that can be set in the Fungilab Viscometers. When the 'Options' field of the main menu is highlighted, you must select it by pressing 'ENTER'. The viscometer will show the following screen:

Using the '∆' and '∇' keys we can highlight the options in a cyclical way. Press 'ENTER' to choose one of them.

The 'MEM/CLEAR' key and the '◄' key will continue to fulfil their traditional functions, both bringing you to the main menu screen.

10.8.1 Storage

The storage submenu allows you to enable the recording system of the viscometer. This selection is mandatory in order to store such information in a file in a USB memory Stick and/or uploading the file into a FTP server. The Output menu presents the following screen:



By default, the 'Status' field is inactive (in the OFF position). You can press the 'ENTER' key to switch the field between active/inactive states (ON/OFF).

While the 'State' field is deactivated (in the OFF position) you will be unable to select the time fields that regulate this function.

Once the 'Status' field is activated (in the ON position), you will be able to select the different fields using the 'Δ' and '∇' keys. The current selected field will remain highlighted on the screen. To edit each field, you must press 'ENTER' on the selected field and then introduce the values using the 'Δ' and '∇' keys. To save the changes, press 'ENTER', whereupon the field will be unselected and the changes saved.

Screen Information:

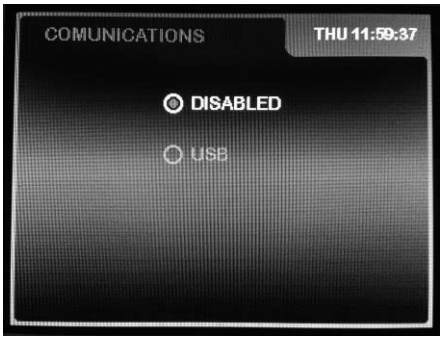
- START: Defines the lapse of time before starting the recording.
- END: Defines the time in which the recording ends.
- INCREMENT: Defines the time interval between recorded samples.

The 'MEM/CLEAR' key and the '◄' key will continue to fulfil their traditional functions, bringing you to the main menu screen and the previous screen, respectively. Without saving the changes in the case of 'MEM/CLEAR'.

It is also possible to perform a non-stop recording leaving both 'INIT' and 'END' time set to zero and changing the 'STATUS' field to active (ON position). The viscometer will save in its memory one recording every second, with a maximum of approximately 36000 samples. The recording will start with the execution of a new experiment and it will end when the data memory becomes full.

10.8.2 Communications

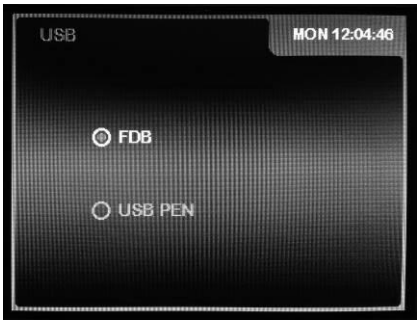
This option allows downloading the data saved in the Viscometer's memory to an external USB-memory. When this option is selected, the following menu appears:



The option by default is 'DISABLED', which disable the downloading channels of the instrument. Press 'ENTER' to activate any external communication made by the viscometer. The activation of the 'USB' can be done selecting the appropriate option with the 'Δ' and 'Δ' keys and then pressing the 'ENTER' key.

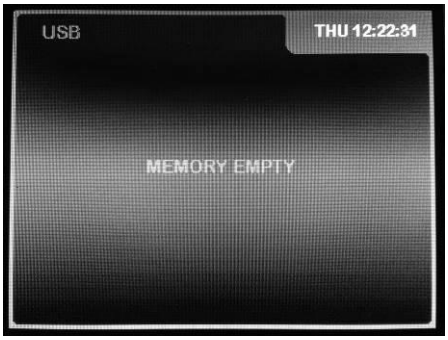
10.8.2.1 Memory Stick

The option 'USB PEN' allows the data download to an external USB memory in the data USB port of the instrument. Be sure that the USB memory is connected to the USB connector intended for communication purposes (the upper right one). This connection is shown in the following picture using a USB memory as storage device:



Use the 'Δ' and '∇' keys to highlight the 'USB' option and press 'ENTER' to start the download. If there is no USB memory the viscometer will not change its screen, waiting for the connection to a USB memory.

If no data is stored it appears the next screen:



If the viscometer detects the USB stick connected to the suitable USB connector the download will start, showing this text on the screen:

NOTE: to download an experiment, a previous process must have been followed: to realize an experiment and activate the output option ('ON' key).

Once completed the download, the viscometer will return to the main menu.

If a USB-memory has been used to download the data, the viscometer will create a folder named 'FUNGILAB' in its root directory. The file or files resulting from the download will be stored in this folder. The first file is named 'FDL0' and the following ones are 'FDL1', 'FDL2' and so on. The files are saved in a CSV (Comma-Separated Values) format, so they can be opened using a plain text editor or a spreadsheet. An example of a file generated by this feature can be seen in the following screenshot:

Fungilab Datalogger						
Viscometer:	EEXR00000					
Date:	10/01/2015					
Measure type:	Normal					
Spindle type:	R1					
Start time:	02:10:11					
Stop time:	02:10:35					
Density:	1.000 g/cm^3					
Visc. Unit:	cP					
Temp. Unit:	ºC					
S.R. Units:	s^-1					
S.S. Units:	g/(cm·s^2)					
Time	Speed	Viscosity	Torque	Shear Rate	Shear Stress	Temperature
2:10:14	40.00	0.00	0.00	0.00	0.00	25.00
2:10:15	40.00	0.00	0.00	0.00	0.00	25.00
2:10:16	40.00	0.00	0.00	0.00	0.00	25.00
2:10:17	40.00	0.00	0.00	0.00	0.00	25.00
2:10:18	40.00	0.00	0.00	0.00	0.00	25.00
2:10:19	40.00	254.44	70.78	0.00	0.00	25.00
2:10:20	40.00	240.78	96.45	0.00	0.00	25.00
2:10:21	40.00	240.78	96.45	0.00	0.00	25.00
2:10:22	40.00	239.95	96.36	0.00	0.00	25.00
2:10:23	40.00	237.39	95.25	0.00	0.00	25.00
2:10:24	40.00	237.39	95.25	0.00	0.00	25.00
2:10:25	40.00	235.44	94.56	0.00	0.00	25.00
2:10:26	40.00	217.68	87.38	0.00	0.00	25.00
2:10:27	40.00	217.68	87.38	0.00	0.00	25.00
2:10:28	40.00	213.23	85.62	0.00	0.00	25.00
2:10:29	40.00	198.20	79.58	0.00	0.00	25.00
2:10:30	40.00	190.94	76.66	0.00	0.00	25.00
2:10:31	40.00	190.94	76.66	0.00	0.00	25.00
2:10:32	40.00	184.40	74.03	0.00	0.00	25.00
2:10:33	40.00	185.12	74.32	0.00	0.00	25.00
2:10:34	40.00	185.12	74.33	0.00	0.00	25.00
2:10:35	40.00	178.07	71.49	0.00	0.00	25.00
22 measurements in total						

10.8.3 Information

If you select the 'INFO' option, you will be brought to the following screen:

The geographic area can be chosen here use the '∆' and '∇' keys. Press the 'ENTER' key and it will be displayed a screen with the contact information of the manufacturer, resembling this:

This option is incorporated as a means of security in the case of loss of the present document or the displacement of any reference to the company in technical support or on paper.

11. Important rheological information

To obtain precise results it is necessary to know the most important rheological properties of the sample.

Newtonian fluids
The viscosity of these fluids does not depend on the shear rate meaning that at any speed the viscosity is the same. Only temperature affects the viscosity; changes of 1ºC can provoke a change in the viscosity of up to 10%.

Non-Newtonian fluids

The viscosity of this type of products changes with the speed variable. Due to this inconsistency, the term *Apparent Viscosity* is habitually used.

Within the classification you can find two different groups:

Time-independent non-Newtonian fluids
Time-dependent Newtonian fluids

Time-independent non-Newtonian fluids

The viscosity of a time-independent non-Newtonian fluid depends on the temperature and the speed gradient.

Pseudo plastic Fluids:
The viscosity diminishes when the speed gradient increases.
Practical examples: paints, shampoos, fruit juice concentrate, adhesives, polymers, grease, starch, etc.

Dilatants-Fluids:
The viscosity increases with the speed gradient.
Practical examples: clay, sweets components, etc.

Plastic Fluids:
These fluids only start to flow after having been submitted to a certain force (shearing force). They behave like solids in static conditions.
Practical example: Ketchup.

Time-dependent non-Newtonian fluids.

The viscosity of time-dependent non-Newtonian fluids is dependent on the temperature, on the speed gradient and on time.

Tixotropical fluids:
In these substances the viscosity diminishes with time when the fluid is subjected to a constant speed gradient. These substances tend to return to their previous viscosity once the speed gradient ceases to be applied.
Practical examples: Many products in industrial food production (yogurt, etc.)

Reopectic fluids:
In these fluids, the viscosity increases with time when the fluid is subjected to a constant speed gradient.
These substances tend to return to their previous viscosity once the speed gradient ceases to be applied.
These fluids are not very common.

NOTE: *The turbulent behaviour of a fluid can produce falsely high results in viscosity tests. Normally, turbulent behaviour is due to an excessively high rotation speed in relation to the viscosity of the sample (see detailed Warning further on).*

FACTORS AFFECTING VISCOSITY

There are many variables that affect the rheological properties of products, so it is very important to take the following factors into account.

Temperature
Temperature is one of the most obvious factors affecting rheological behaviour.
It is essential to consider the effects of temperature on viscosity in the evaluation of materials that are subject to changes in temperature during its use or other processes. Some examples of this are motor oils, greases and adhesives.

Shear Rate
When a fluid is subjected to variations in the speed gradient during its process or use, it is essential to know its viscosity at the projected speed gradients.
Examples of materials, which are subjected to and affected by important variations in speed gradient during its process or use, are: paints, cosmetics, liquid latex, some food products such as ketchup and blood in the human circulatory system.

Measurement conditions
The measurement conditions of a material during its viscosity reading can have a considerable effect on the results of this measurement. Consequently, it is important to be careful and control the environment and conditions of any sample subjected to analysis.
Variables such as the type of viscometer, the speed/spindle combination, the sample's container, the absence or presence of a spindle protector, the temperature of the sample and the sample preparation techniques, etc, can affect not only the precision of the reading but also the real viscosity of the sample.

Time
Ageing under the same speed gradient conditions affects tixotropical and reopectical fluids.
In some fluids the action of time combined with the proportion of the shear is very complex. In these cases, one can observe, with time, a return to the original fluid state.

Previous conditions
The conditions that the sample is subjected to before the viscosity reading can significantly affect the results, especially with heat-sensitive fluids or ageing.
Thus, the storage condition and the sample preparation techniques should be conceived to minimize effects on the viscosity measurements.

Composition and additives
A material's composition is a determining factor in its viscosity. When the composition is altered, whether this is by changing substance proportions that compose it or adding other substances, important changes can be observed in their viscosity.
For example, adding solvent to printing ink reduces the viscosity of the ink and other types of additives are used to control the rheological properties of paints.

VISCOSITY MEASURING PROCEDURES

Data history

We recommend documenting the following information each time you take a viscosity measurement:

- Model or type of viscometer
- Spindle (and accessory)
- Rotation speed
- Sample container
- Sample temperature
- Sample preparation procedure (if existent)
- Spindle protection use

The process is necessary in the event of comparison of results with other organizations, in the interest of being able to guarantee the possibility of reproduction of the results obtained.

The spindle and its protection

Examine each spindle before using it. If it's damaged or eroded in such a way that its dimensions are changed, it will provide false results for your viscosity reading.
The spindle protector (provided with every Fungilab rotational viscometer) protects the spindle and the viscometer axle and it is important for the reading of low viscosities with standard spindles.
The protector should always be used. In the event that it is not used, its absence must be reported in the measurement procedure notes.
The protector isn't used with most of the accessories.

Speed selection and spindle

If there is no described work procedure, the best method for the selection of the spindle for each speed is "trial and error". The objective is a torque reading between 15 and 95%, according to the type of product in question and a percentage higher than 50% is recommendable.
If you know the fluid's approximate viscosity, the quickest spindle/speed selection method is referring to the tables of maximum approximate viscosity.
When you do tests at different speeds, you should select a spindle with which all of the speeds show a torque reading of between 15 and 95%

GENERALLY:

RPM INCREMENT $\Rightarrow$ READING PRECISION INCREMENT

SPINDLE SIZE-REDUCTION $\Rightarrow$ READING PRECISION INCREMENT

(Except for the non-Newtonian fluids that change their viscosity value when the rotational speed is modified. In these cases, we recommended measuring with a determined speed and using a comparison method.)

Size of the sample container

For measurements using the Fungilab viscometer, we recommend working with containers with an interior diameter of 83 mm or more. The usual container is a 600 ml precipitation vase.
If a smaller container is used, the viscosity values could be greater, especially with low-viscosity fluids.

Sample conditions

The sample should be free of air bubbles.
It should be exposed to a constant and uniform temperature. Before doing the viscosity readings, make sure that the spindle and its protection are the same temperature. Usually, thermostatic baths are used to maintain the sample at the desired temperature.

The sample should have the properties of a homogeneous liquid; this means that it cannot have particles capable of being precipitated, deformed by the shear rate or decomposed into smaller particles.
The measured substances shouldn't be subject to chemical or physical changes during the measurement.

Other essential conditions
Experiments in conditions in which turbulent behaviour can be encountered should be avoided.
The condition should be that of stationary fluid. Accelerations or retarding processes are excluded from the parameters of measurement.

Spindle immersion
The standard spindle should be submerged to the halfway mark in the axle. An erroneous immersion can compromise the result of the viscosity measurement.
With the disc spindles you should avoid the creation of air bubbles, which could remain under the disc. To this end you should insert the spindle laterally and smoothly and bring it over to the centre of the sample. Once it is there, attach it to the viscometer's axle.

Precision and Repetition
FUNGILAB viscometers guarantee a precision of ±1% from the bottom of the speed/spindle combination scale and a repetition of ±0.2%.
The precision of temperature measurement is ±0.2 ºC.

Getting a viscosity reading
Before working with the viscometer you should make sure of the following points:
The viscometer is properly fastened to the stick and level.
Both spindle and speed are selected. (read attentively the section about speed and spindle selection).
The spindle is carefully placed and fastened.
The instructions and necessary parameters for obtaining a viscosity reading have been carefully read in the user's manual.
Once the readings have been initiated, allow some time for stabilization, the length of which will be in function of the rotational speed during the measurement.

IMPORTANT WARNING
When you wish to obtain viscosity reading with FUNGILAB rotational viscometers, there are two considerations to take into account:

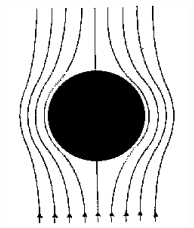
The obtained viscosity results must be between 15% and 100% of the torque range, for whichever spindle/rotational speed combination.
The viscosity reading must be executed under laminar flow condition, not turbulent flow conditions.

The first consideration is linked to the precision of the instruments. All of the FUNGILAB rotational viscometers guarantee a precision of (±) 1% from the bottom of any spindle/rotational speed combination scale.
Working with less than 15% of the bottom of the scale is not recommended due to that the potential (±) 1% error in the viscosity is relatively big compared to the equipment reading.

The second consideration has to do with fluid mechanics. All of the rheological measurements of fluid flow properties must be taken under laminar flow conditions. Laminar flow is when all of the movements of the fluid particles are in sheets, directed by an external applied force.

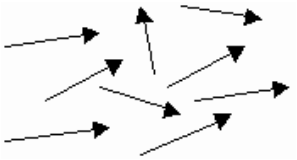
The flow lines represent speed and fluid flow direction.

Laminar flow: "straight" flow lines. Relatively easy to predict. Generally slow.



Turbulent flow: "non-linear" flow lines. Impossible to predict the exact movement of the fluid. Very quick.

For rotational systems, this means that the fluid's movement must be circumferential. When the internal forces of a fluid end up being too great, the fluid can become a turbulent flow, in that the particles that make it up become unpredictable, making it impossible to analyse it with standard mathematical models.
This turbulence creates a false reading which is a lot higher than the real one, without linear growth and totally unpredictable.



For the following geometries, these transition points have been found to be approximate to turbulent flow:

1) Spindle L1:	15 cP to 60 rpm
2) Spindle R1:	100 cP to 50 rpm
3) Adaptor LCP:	0.85 cP to 60 rpm

Turbulent flow conditions will always exist in these conditions as long as the RPM/cP ratio exceeds the values listed above.

12. Accessories

12.1. Low viscosity adapters (LCP and LCP/B)

Low viscosity adapters (LCP and LCP/B) do not come with the standard delivery. Any of these two versions (with or without thermo station jacket) must be ordered as an additional accessory. Both LCP and LCP/B accessories are supplied complete with a spindle.

Low viscosity adapters allow more precise measurements than using the standard spindle. The viscometer can measure very low viscosity levels, from 1 cP (when using the L model).
Thanks to its cylindrical geometry shape, it is possible to get Shear Rate determinations and Shear Stress.
Only a small quantity of a sample is needed (16 ml.)

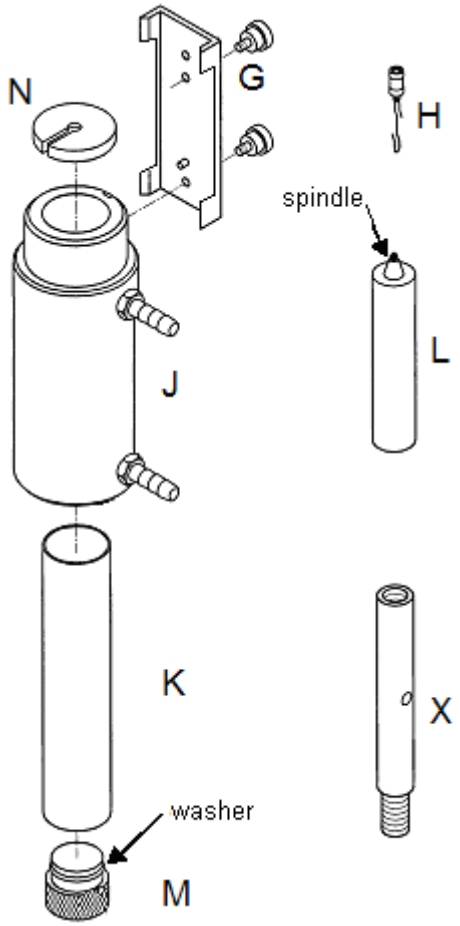


Fig. 7: LCP Spare parts

Fig.8: LCP Adapter assembled in viscometer

12.1.1 Mounting

The mounting process is different according to the types of low viscosity accessories (LCP and LCP/B).
The difference between them only remains that the LCP has a thermo station jacket (J) and a container (K) and the LCP/B only incorporates a container (K). The LCP screw its thermo station jacket (J) to the connector (G), on the other hand, the LCP/B screws the container directly to the connector (G). Now is detailed the LCP assembling:

- Unplug the viscometer.
- Attach the extension (X) between the base Y shaped (A) and the rib (C). Use a 19 mm adjustable spanner in order to fasten the nut (D).
- Assemble the viscometer again starting with the base. The extension (X) is necessary because of the length of the LCP adapter. Without this extension the assembly of this accessory would be difficult, especially the assembly of the spindle.

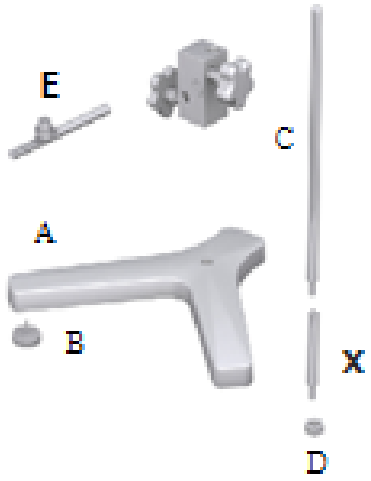


Fig. 9: Mounting the LCP adapter extension.

- Close the sample (K) container with the stopper (M).
- Insert the container (K) to the lower part, in the circulation jacket (J) by turning it gently.
- Fasten the circulation jacket (J) to the connector (G).
- Fill the sample container with a 20 ml syringe, or less and fill the 16 ml sample container.
- Connect the hook (H) and the spindle (L)
- Insert the spindle (L) in the circulation jacket (See the note * below)
- Fasten the connector (G) to the hole in the back of the viscometer's metallic base. **(See the note ** below)**
- Screw it with the viscometer axle by turning it clockwise.
- Check the level of the sample. It should be approximately in the middle of the cone, which is connected to the spindle connector (H). Figure 10 shows more information about this.
- Place the upper stopper (N) over the sample container.

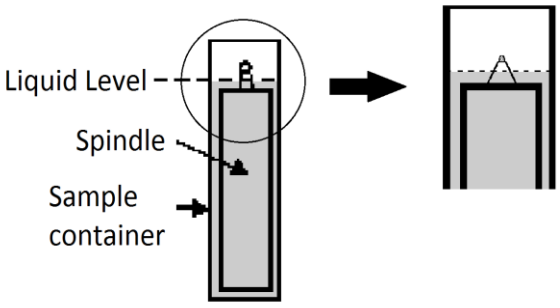


Fig. 10: Full LCP adapter.

***Important:**

Do this slowly since the spindle must be inserted correctly in the sample. When working with a more viscous sample be careful to avoid pulling the spindle upwards. Hold the spindle connector.

****Important:**
The piece named G has two possible holes for the upper screw.

The top hole is a Universal hole to screw our low viscosity adapter to other viscometers.
The bottom hole is to screw Fungilab pieces.

NOTE:

Before starting with the measurements, make sure the viscometer is correctly balanced (check it with the bubble level). The spindle that should be selected is 'LCP/SP'.

12.1.2 Dismounting and cleaning

- Unscrew the spindle of the viscometer axis and lower the spindle slowly in the sample container (K).
- Remove Adapter (G) from metallic glass.
- Place the viscometer upright. Remove the upper stopper (N).
- Remove the spindle carefully (L).
- Unscrew the bottom stopper (M) and remove the container (K) from below the thermo station jacket (J).
- Remove the container, wash it or use compressed air. Wash the circulation jacket too if necessary.
- Remove Adapter (G) from the circulation jacket.

Important:
Do not use any cleaner or tool that can damage the metallic surface. Make sure you only use liquids that agree with the LCP adapter material!

Solvents that can be used: water, ethanol or high concentrations of alcohol. For other solvents, check the chemistry compatibility table.

12.1.3 Technical specification for LCP accessories

Measurements rank:
- Sample L: 0.9*) until 2 000 mPa.s or cP
- Sample R: 3.2**) until 21 333 mPa.s or cP

*) Limited by turbulences
**) For the measurements that represent 10 % of the base scale

Sample volume: 16.0 ml

Shear rate factor for the LCP spindle: 1.2236 x RPM ***)

***) Shear rate is calculated based on the features of Newtonian liquids.

Temperature rank of the circulation jacket & thermo station conditions:
- Temperature rank allowed: -10 a +100°C (14 a 212 °F)
- Use a thermo station wash with demineralised water or special refrigeration liquid. Change thermostat liquid regularly. Recommended flow: 15 l/min.

Materials:
- The metallic parts are made of stainless steel; the leads are made of black delrin plastic. The parts that come into contact with the sample (sample container and spindle) are made of AISI 316 and are suitable for the food industry.
- The lead inferior washer is made with black delrin. It is designed to withstand a maximum temperature of 100ºC (212 ºF)
- The circulation jacket is made of acetyl and Delrin.
- The O-ring on the plastic stopper (M) of the LCP Adapter is made of delrin. The softening point is 110 °C (230 °F).

12. 2. Small sample adapters APM and APM/B

NOTE:

Small sample adapters (APM and APM/B) do not belong to the standard delivery. Any of these two versions (with or without thermo station jacket) must be ordered as an additional accessory. APM and APM/B accessory are not supplied with a spindle. Special spindles (TL or TR) are used according to the viscometer sample (L, R or H).

Small sample adapters allow more precise measurements than the standard spindles. The measurement rank of a viscometer can get lower viscosity levels.

Thanks to its known cylindrical geometry shape, it is possible to get Shear Rate and Shear Stress determinations. Only a small quantity of the sample is needed.

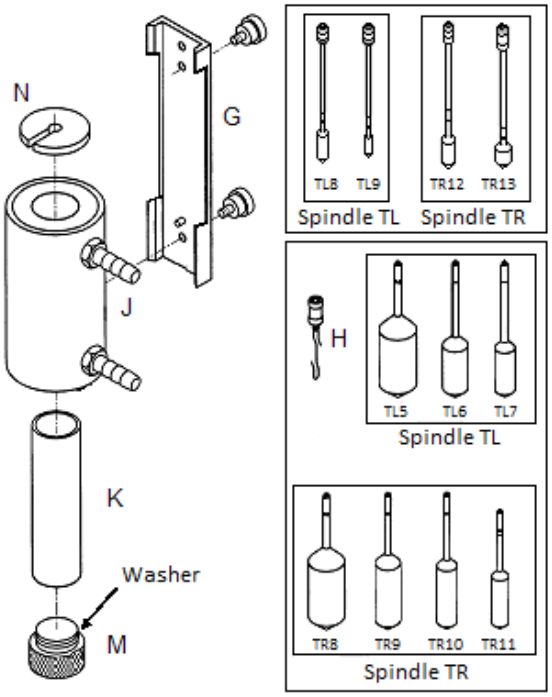


Fig. 11 APM accessory parts

Fig. 12 Set APM

12. 2. 1 Assembly

NOTE:

The mounting process is different according to the types of low viscosity accessories (APM and APM/B).
The difference between them only remains that the APM has a thermo station jacket (J) and a container (K) and the APM/B only incorporates a container (K). The APM screw its thermo station jacket (J) to the connector (G), on the other hand, the APM/B screws the container directly to the connector (G). Now is detailed the APM assembling:

- Unplug the viscometer.
- Close the sample (K) container with the stopper (M).
- Insert the container (K) to the lower part, in the circulation jacket (J) by turning it gently.
- Fasten the circulation jacket (J) to the connector (G)
- Fill the sample container with a 20 ml syringe or less and fill the sample container according to the spindle selected (see section 10.2.3).
- Connect the hook (H) and the spindle (L)
- Insert the spindle (L) in the circulation jacket (See the note * below)
- Fasten the connector (G) to the hole in the back of the viscometer's metallic base **(See the note ** below)**
- Screw it with the viscometer axle by turning it clockwise.

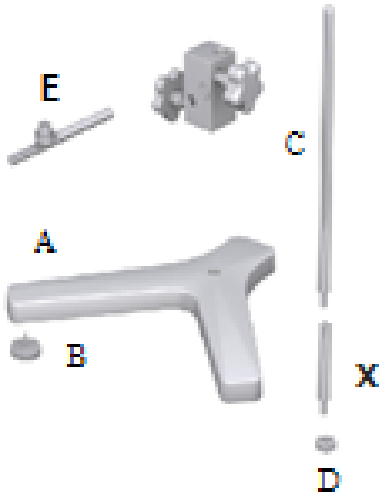


Fig. 13: Dismounting the LCP adapter extension.

- Check the level of the sample. It should be approximately in the middle of the cone, which is connected to the spindle connector (H). Figure 14 shows more information about this.
- Place the upper stopper (N) over the sample container.

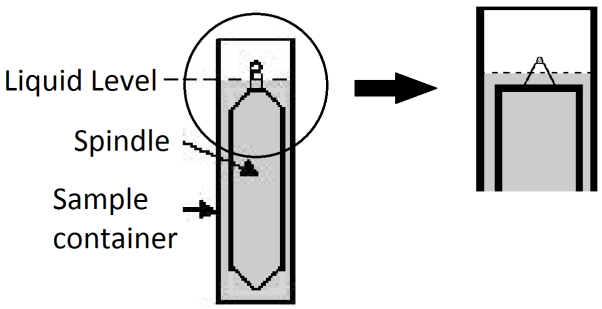


Fig. 14: Full APM adapter.

***Important:**

Do this slowly since the spindle must be inserted correctly in the sample. When working with a more viscous sample be careful to avoid pulling the spindle upwards. Hold the spindle connector.

****Important:**

The piece named G has two possible holes for the upper screw.
The top hole is a Universal hole to screw our small sample adapter to other viscometers.
The bottom hole is to screw Fungilab pieces.

NOTE:
Before starting with the measurements, make sure the viscometer is correctly balanced (check it with the bubble level). The Spindle you have to select is TL or TR in function of the model of viscometer (L. R or H).

12. 2. 2 Dismounting and cleaning

- Unscrew the spindle of the viscometer axis and lower the spindle slowly in the sample container (K).

Caution on removing the spindle, it can be hot due to a previous high temperature experiment.

- Remove Adapter (G) from metallic glass.
- Place the viscometer upright. Remove the upper stopper (N).
- Remove the spindle carefully (L).
- Unscrew the bottom stopper (M) and remove the container (K) from below the thermostatic flow jacket (J).
- Remove the container, wash it or use compressed air. Wash the circulation jacket too if necessary.
- Remove Adapter (G) from the circulation jacket.

Important:
Do not use any cleaner or tool that can damage the metallic surface. Make sure you only use liquids that agree with the APM adapter material!

Solvents that can be used: water, ethanol or high concentrations of alcohol. For other solvents, check the chemistry compatibility table.

12. 2. 3 Technical specifications of APM and APM/B

Measurement range:

- Model L: 1.5* to 200 000 mPa.s
- Model R: 25* to 3 300 000 mPa.s
- Model H: 0.2* to 26 660 Pa.s

* Measurement representing 10 % of the full scale.

Spindles features and APM filling:

- L Model & TL spindles

Spindle	Shear rate [s^{-1}] *)	Sample volume [ml]	Container
TL5	1.32 x RPM	6.7	STC
TL6	0.34 x RPM	9.0	STC
TL7	0.28 x RPM	9.4	STC
TL8	0.29 x RPM	4.2	TL8C
TL9	0.22 x RPM	16.0	STC

- R Model or H & TR spindles

Spindle	Shear rate [s^{-1}] *)	Sample volume [ml]	Container
TR8	0.93 x RPM	7.1	STC
TR9	0.34 x RPM	10.4	STC
TR10	0.28 x RPM	11.0	STC
TR11	0.25 x RPM	13.5	STC
TR12	0.48 x RPM	3.8	TR12C
TR13	0.40 x RPM	2.1	TR13C

*) Shear rate is calculated based on the features of Newtonian liquids.

Container	Stopper	D [mm]	L [mm]
TL8C	T8BC	13.03	27.57
TR13C	T13BC	12.7	42.7
TR12C	T12BC	12.7	22.9
STC	STBC	19.05	7

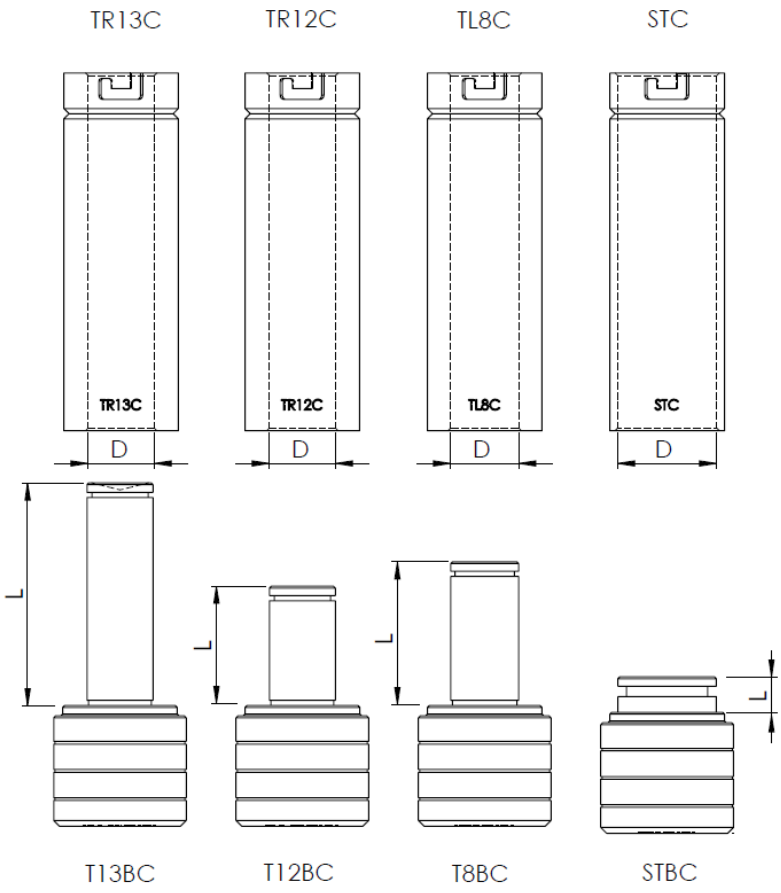


Fig. 15 Container dimensions

Temperature range of circulation jacket and thermostatic flow conditions:

- Permitted temperature range: -10 a +100°C (14 a 212 °F)
- Use a thermostatic bath with demineralised water or refrigeration special liquid. Change the liquid form the thermostatic bath regularly. Recommended flow: 15 l/min.

Materials:

- The metallic parts are made of stainless steel; the lids are made of plastic in Delrin. The parts in contact with the sample (sample container and spindle) are made of AISI 316 suitable for food industry.
- The lid inferior washer is made in black Delrin. It is designed to get a maximum temperature of 100ºC (212 ºF)
- The circulation jacket is made of acetal and Delrin.
- The O-ring on the plastic stopper (M) of the APM Adapter is made of Delrin.
  The softening point is 110 °C (230 °F).

12.3 HELDAL UNIT – Helicoidal Movement Unit

NOTICE:

The Heldal adapter doesn't come with the standard delivery. It can be ordered as an accessory. The unit is supplied complete with T-shaped spindles, in this case.

The Heldal accessory is used with substances that do not flow by themselves (like ice or pastas). Is engine moves the viscometer slowly in a vertical movement and at the same time the spindle makes the rotation movement. This generates a helicoidal movement that makes that the T-shaped spindle is always in contact with the sample.

The measurements obtained with Heldal do not measure absolute viscosity! They are only comparative measurements with the same geometry as T-shaped spindles.

Fig. 16 Heldal Unit in its case

12. 3. 1 Heldal unit Mounting

Fig. 17 Heldal unit set in the viscometer

1. Power cable	9. Base
2. Lower stop ring	10. Levelling knobs
3. Displacement command	11. Heldal engine unit
4. Viscometer fastening bolt	12. Knobbed fastening rib
5. Upper stopper ring	13. Functioning pilot
6. Heldal fastening group	14. Nut bolt
7. ON/OFF switch	15. Viscometer fastening rib
8. Fastener	

6.1 Spindle connector
6.2 Upper spindle receptor
6.3 Lower spindle receptor
6.4 Counterweight, spindle connector
6.5 Spindle

- Place the fastener (8) facing the short end of the Y-shaped base (9).
- Place the safety shell (1) over the fastening rib (8) on the base of the viscometer (9).
- Place the lower ring in the fastener (8) as explained in the sketch and fasten it with the knobbed fastening rib (12).

Important:
Do not fasten the stop rings to the fastening ribs (12) too tightly. They are plastic pieces and they can be damaged. Both stopper rings (upper and lower) look exactly the same and can be changed.

- Place the Heldal engine (11) in the fastener (8) while pressing the displacement command (3).
- Connect the upper stop ring to the fastener (8) and fasten it with the fastening rib (12).
- Insert the viscometer by placing the fastening rib (15) in the Heldal bolt (4) and fasten it with the nut bolt (14).
- Balance the viscometer – Heldal set with the balancing knobs (10).
- Fasten the T-shaped spindle (PA to PF samples) to the viscometer. In order to choose the right one, look at the selection tables (T.3).

    - Screw the counterweight (6.4) in the lower part of the spindle receptor (6.3).
    - Insert the spindle receptor (6.5) between both upper and lower parts of the spindle receptor (6.2 and 6.3). Do not separate these two parts.
    - Fasten the spindle and screw in the lower part of the receptor (6.3) until it is completely fastened.

Important:
Do not fasten the spindle tighter than necessary. There should always be a small hole between both parts of the receptor.

- Fasten the spindle receptor and the spindle to the axis of the viscometer, by connecting the thread.
- Place the sample container under the viscometer and insert the spindle into the sample fluid by pressing the displacement button (3).
- The stopper rings limit the vertical movement of the spindle. Therefore, these two rings must be fastened correctly and in their correct positions.

Important:
Placement of stopper rings as explained here:

- Upper ring: the spindle should be kept in the same fluid
- Lower stopper ring: The spindle must not touch the edge of the container. If so, the viscometer's axle can be damaged and the results can be wrong.
- Once the rings are fastened, connect the viscometer and the Heldal to the power point. Switch the viscometer on and insert the speed and the spindle, as always.
- Set the Heldal unit on with the ON/OFF switch (7). Check if the pilot is on. If not, check the mains connection.

OPERATION:
The Heldal unit (which moves helicoidally) is moved up and down between the two stopper rings. When the engine touches one of them, the unit changes direction.
The Heldal unit will keep moving, until turned with the ON/OFF switch (7).

12.4. Thermosphere

The Thermosphere is a heating chamber that is used to work with different samples at high temperatures, it allows to perform different test with a controlled temperature. The thermosphere works in standalone mode, but it can be connected to the viscometer to send the temperature data to the viscometer screen.

The Thermosphere is not included in the standard delivery. It must be ordered as an additional accessory.

Fig. 18 Viscometer with Thermosphere unit*

*The image shown above may not correspond with the delivered equipment.

12.4.1 Connecting Thermosphere to viscometer

To communicate the Thermosphere with the viscometer it is only needed to connect the USB cable in the USB port dedicated to that function (fig 18.). When you turn on the Thermosphere it will automatically connect with the viscometer. The temperature value it will appear on the measuring screen when the viscometer initiates an experiment.

Fig. 19 Thermosphere connection

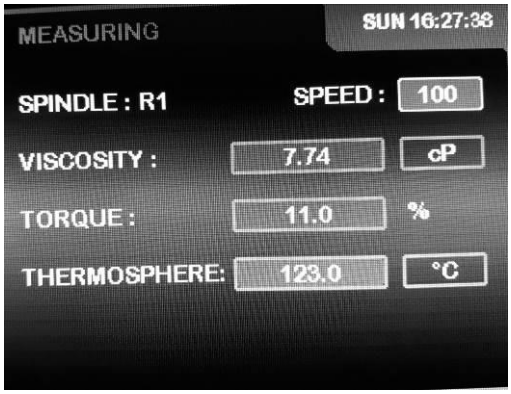


Fig. 20 Thermosphere screen

13. Model/Spindle correspondence tables

Standard Spindles + R1 (Table 1):

Viscometer model	Spindle
SMART L	L1
	L2
	L3
	L4
	L5
	L2C
	L3C
SMART R	R1
	R2
	R3
	R4
	R5
	R6
	R7
SMART H	R1
	R2
	R3
	R4
	R5
	R6
	R7

SPECIAL SPINDLES FOR APM ADAPTER (Table 2):

Viscometer model	Spindle
SMART L	TL5
	TL6
	TL7
	TL8
	TL9
SMART R	TR8
	TR9
	TR10
	TR11
	TR12
	TR13
SMART H	TR8
	TR9
	TR10
	TR11
	TR12
	TR13

SPECIAL HELDAL SPINDLES (Table 3):

Viscometer model	Spindle
SMART L	PA
	PB
	PC
	PD
	PE
	PF
SMART R	PA
	PB
	PC
	PD
	PE
	PF
SMART H	PA
	PB
	PC
	PD
	PE
	PF

SPECIAL SPINDLES FOR LCP ADAPTER (Table 4):

Viscometer model	Spindle
SMART L	LCP/SP
SMART R	LCP/SP

SPECIAL VANE SPINDLES (Table 5):

Viscometer model	Spindle
SMART L	V71
	V72
	V73
	V74
	V75
SMART R	V71
	V72
	V73
	V74
	V75
SMART H	V71
	V72
	V73
	V74
	V75

14. Model/spindle/oil calibration tables

MODEL L (Table 6):

Spindle	Standard oil
L1	RT50
L2	RT500
L2C	RT500
L3	RT1000
L3C	RT1000
L4	RT5000
L5	RT12500
TL5	RT50
TL6	RT500
TL7	RT500
TL8	RT1000
TL9	RT5000
LCP	RT5

MODEL R (Table 7):

Spindle	Standard oil
R1	RT50
R2	RT500
R3	RT500
R4	RT1000
R5	RT5000
R6	RT5000
R7	RT30000
TR8	RT500
TR9	RT5000
TR10	RT5000
TR11	RT5000
TR12	RT5000
TR13	RT12500
LCP	RT50

MODEL H (Table 8):

Spindle	Standard oil
R1	RT1000
R2	RT5000
R3	RT12500
R4	RT12500
R5	RT30000
R6	RT100000
R7	RT100000
TR8	RT5000
TR9	RT12500
TR10	RT30000
TR11	RT60000
TR12	RT60000
TR13	RT60000

15. SMART L standard spindle selection table

Maximum guideline values in cP (mPa·s)

RPM / SP	L1	L2	L3	L4	L5
0.01	600K	3M	12M	60M	120K
0.3	20K	100K	400K	2M	4M
0.5	12K	60K	240K	1.2M	2.5M
0.6	10K	50K	200K	1M	2M
1	6K	30K	120K	600K	1.2M
1.5	4K	20K	80K	400K	800K
2	3K	15K	60K	300K	600K
2.5	2.4K	12K	48K	240K	500K
3	2K	10K	40K	200K	400K
4	1.5K	7.5K	30K	150K	300K
5	1.2K	6K	24K	120K	250K
6	1K	5K	20K	100K	200K
10	600	3K	12K	60K	125K
12	500	2.5K	10K	50K	100K
20	300	1.5K	6K	30K	60K
30	200	1K	4K	20K	40K
50	120	600	2.4K	12K	25K
60	100	500	2K	10K	20K
100	60	300	1.2K	6K	12K
200	30	150	600	3K	6K

Table 9.

ATTENTION:

K Indicates thousands. Example: 7.8K = 7800
M Indicates millions Example: 1.56M = 1560000

NOTE: It is not recommended to work with viscosity values of less than 15% of the lower part of the selected scale.

16. SMART L Special aerial spindle selection table

Maximum guideline values in cP (mPa·s)

RPM / SP	L2C	L3C
0.01	300K	12M
0.3	100K	400K
0.5	60K	250K
0.6	50K	200K
1	30K	125K
1.5	20K	80K
2	15K	60K
2.5	12K	50K
3	10K	40K
4	7.5K	30K
5	6K	25K
6	5K	20K
10	3K	12K
12	2.5K	10K
20	1.5K	6K
30	1K	4K
50	600	2.5K
60	500	2K
100	300	1.2K
200	150	600

Table 10.

ATTENTION:

K Indicates thousands. Example: 7.8K = 7800
M Indicates millions Example: 1.56M = 1560000

NOTE: It is not recommended to work with viscosity values of less than 15% of the lower part of the selected scale.

17. SMART L Special spindle selection table

Maximum guideline values in cP (mPa·s)

RPM / SP	TL5	TL6	TL7	TL8	TL9
0.01	300K	3M	6M	12M	48M
0.3	10K	100K	200K	400K	1.6M
0.5	6K	60K	120K	240K	1M
0.6	5K	50K	100K	200K	800K
1	3K	30K	60K	100K	500K
1.5	2K	20K	40K	80K	330K
2	1.5K	15K	30K	60K	250K
2.5	1.2K	12K	24K	50K	200K
3	1K	10K	20K	40K	160K
4	750	7.5K	15K	30K	125K
5	600	6K	12K	25K	100K
6	500	5K	10K	20K	80K
10	300	3K	6K	12K	50K
12	250	2.5K	5K	10K	40K
20	150	1.5K	3K	6K	25K
30	100	1K	2K	4K	16K
50	60	600	1.2K	2.5K	10K
60	50	500	1K	2K	8K
100	30	300	600	1.2K	5K
200	15	125	300	600	2.5K

Table 11.

ATTENTION:

K Indicates thousands. Example: 7.8K = 7800
M Indicates millions Example: 1.56M = 1560000

NOTE: It is not recommended to work with viscosity values of less than 15% of the lower part of the selected scale.

18. SMART L LCP Adaptor table

Maximum guideline values in cP (mPa·s)

RPM/SP	LCP
0.01	60K
0.3	2K
0.5	1.2K
0.6	1K
1	600
1.5	400
2	300
2.5	240
3	200
4	150
5	120
6	100
10	60
12	50
20	30
30	20
50	12
60	10
100	6.0
200	3.0

Table 12.

ATTENTION:

K Indicates thousands. Example: 7.8K = 7800
M Indicates millions Example: 1.56M = 1560000

NOTE: It is not recommended to work with viscosity values of less than 15% of the lower part of the selected scale.

19. SMART L Special Vane spindle selection table

Maximum guideline values in cP (mPa·s)

RPM / SP	V71	V72	V73	V74	V75
0.01	245K	1.0M	5M	50M	20M
0.3	8.1K	34.6K	167K	1.6M	721K
0.5	4.9K	20.8K	100K	1M	433K
0.6	4K	17.3K	83.5K	848K	360K
1	2.4K	10.4K	50.1K	508K	216K
1.5	1.6K	6.93K	33.4K	339K	144K
2	1.2K	5.2K	25K	254K	108K
2.5	982.2	4.1K	20K	203K	86.6K
3	818.5	3.4K	16.7K	169K	72.1K
4	613.9	2.6K	12.5K	127K	54.1K
5	491.1	2k	10K	101K	43.3K
6	409.2	1.7K	8.3K	84.8K	36K
10	245.5	1K	5K	50.8K	21.6K
12	204.6	867	4.1K	42.4K	18K
20	122.7	520.2	2.5K	25.4K	10.8K
30	81.8	346.8	1.6K	16.9K	7.2K
50	49.1	208	1K	10.1K	4.3K
60	40.9	173.4	835.7	8.4K	3.6K
100	24.5	100	501.4	5K	2.1K
200	12.2	52	250.7	2.5K	1K

Table 13.

ATTENTION:

K Indicates thousands. Example: 7.8K = 7800
M Indicates millions Example: 1.56M = 1560000

NOTE: It is not recommended to work with viscosity values of less than 15% of the lower part of the selected scale.

20. SMART L special Heldal spindle selection table

Maximum guideline values in cP (mPa·s)

RPM/SP	PA	PB	PC	PD	PE	PF
0.01	1.8M	3.7M	9.3M	18.7M	46.8M	93.6M
0.3	62.4K	124.8K	312K	624K	1.5M	3.1M
0.5	37.4K	74.8K	187K	374K	936K	1.8M
0.6	31.2K	62.4K	156K	312K	780K	1M
1	18.7K	37.4K	93.6K	187K	468K	936K
1.5	12.4K	24.9K	62.4K	124K	312K	624K
2	9.3K	18.7K	46.8K	93.6K	234K	468K
2.5	7.4K	14.9K	37.4K	74.8K	187K	374.4K
3	6.2K	12.4K	31.2K	62.4K	156K	312K
4	4.6K	9.3K	23.4K	46.8K	117K	234K
5	3.7K	7.4K	18.7K	37.4K	93.6K	187.2K
6	3.1K	6.2K	15.6K	31.2K	78K	156K
10	1.8K	3.7K	9.3K	18.7K	46.8K	93.6K
12	1.5K	3.1K	7.8K	15.6K	39K	78K

Table 14.

ATTENTION:

K Indicates thousands. Example: 7.8K = 7800
M Indicates millions Example: 1.56M = 1560000

NOTE: It is not recommended to work with viscosity values of less than 15% of the lower part of the selected scale.

21. SMART R standard spindle selection table

Maximum guideline values in cP (mPa·s)

RPM / SP	R1	R2	R3	R4	R5	R6	R7
0.01	1M	4M	10M	20M	40M	100M	400M
0.3	33.3K	133.3K	333.3K	666.6K	1.3M	3.33M	13.3M
0.5	20K	80K	200K	400K	800K	2M	8M
0.6	16.6K	66.6K	166.6K	333.3K	666.6K	1.6M	6.6M
1	10K	40K	100K	200K	400K	1M	4M
1.5	6.6K	26.6K	66.6K	133.3K	266.6K	666.6K	2.6M
2	5K	20K	50K	100K	200K	500K	2M
2.5	4K	16K	40K	80K	160K	400K	1.6M
3	3.3K	13.3K	33.3K	66.6K	133.3K	333.3K	1.3M
4	2.5K	10K	25K	50K	100K	250K	1M
5	2K	8K	20K	40K	80K	200K	800K
6	1.6K	6.6K	16.6K	33.3K	66.6K	166.6K	666.6K
10	1K	4K	10K	20K	40K	100K	400K
12	833	3.3K	8.3K	16.6K	33.3K	83.3K	333.3K
20	500	2K	5K	10K	20K	50K	200K
30	333	1.3K	3.3K	6.6K	13.3K	33.3K	133.3K
50	200	800	2K	4K	8K	20K	80K
60	166	660	1.6K	3.3K	6.6K	16.6K	66.6K
100	100	400	1K	2K	4K	10K	40K
200	50	200	500	1K	2K	5K	20K

Table 15.

ATTENTION:

K Indicates thousands. Example: 7.8K = 7800
M Indicates millions Example: 1.56M = 1560000

NOTE: It is not recommended to work with viscosity values of less than 15% of the lower part of the selected scale.

22. SMART R Special spindle selection table

Maximum guideline values in cP (mPa·s)

RPM / SP	TR8	TR9	TR10	TR11	TR12	TR13
0.01	5M	25M	50M	100M	50M	125M
0.3	166.6K	833.3K	1.6M	3.3M	1.6M	4.1M
0.5	100K	500K	1M	2M	1M	2.5M
0.6	83.3K	416.6K	833.3K	1.6M	833.3K	2M
1	50K	250K	500K	1M	500K	1.2M
1.5	33.3K	166.6K	333.3K	666.6K	333.3K	833.3K
2	25K	125K	250K	500K	250K	625K
2.5	20K	100K	200K	400K	200K	500K
3	16.6K	83.3K	166.6K	333.3K	166.6K	416.6K
4	12.5K	62.5K	125K	250K	125K	312.5K
5	10K	50K	100K	200K	100K	250K
6	8.3K	41.6K	83.3K	166.6K	83.3K	208.3K
10	5K	25K	50K	100K	50K	125K
12	4.16K	20.83K	41.6K	83.3K	41.6K	104.1K
20	2.5K	12.5K	25K	50K	25K	62.5K
30	1.6K	8.3K	16.6K	33.3K	16.6K	41.6K
50	1K	5K	10K	20K	10K	25k
60	833.3	4.16K	8.3K	16.6K	8.3K	20.8k
100	500	2.5K	5K	10K	5K	12.5K
200	250	1.2K	2.5K	5K	2.5K	6.2K

Table 16.

ATTENTION:

K Indicates thousands. Example: 7.8K = 7800
M Indicates millions Example: 1.56M = 1560000

NOTE: It is not recommended to work with viscosity values of less than 15% of the lower part of the selected scale.

23. SMART R LCP Adaptor table

Maximum guideline values in cP (mPa·s)

RPM	LCP
0.01	640K
0.3	21.3K
0.5	12.8K
0.6	10K
1	6.4K
1.5	4.2K
2	3.2K
2.5	2.5K
3	2.1K
4	1.6K
5	1.2K
6	1K
10	640
12	533
20	320
30	213
50	128
60	106
100	64
200	32

Table 17.

ATTENTION:

K Indicates thousands. Example: 7.8K = 7800
M Indicates millions Example: 1.56M = 1560000

NOTE: It is not recommended to work with viscosity values of less than 15% of the lower part of the selected scale.

24. SMART R special Vane spindle selection table

Maximum guideline values in cP (mPa·s)

RPM / SP	V71	V72	V73	V74	V75
0.01	2.6M	11.1M	53.5M	543M	213M
0.3	87.3K	370K	1.7M	18.1M	7.6M
0.5	52.3K	222K	1M	10.8M	4.6M
0.6	43.6K	185K	891K	9M	3.8M
1	26.1K	111K	535K	5.4M	2.1M
1.5	17.4K	74K	356K	3.6M	1.5M
2	13K	55.5K	267K	2.7M	1.1M
2.5	10.4K	44.4K	214K	2.1M	924K
3	8.7K	37K	178K	1.8M	770K
4	6.5K	27.7K	133K	1.3M	577K
5	5.2K	22.2K	107K	1M	462K
6	4.3K	18.5K	89.1K	905K	385K
10	2.6K	11.1K	53.5K	543K	213K
12	2.1K	9.2K	44.5K	452K	192K
20	1.3K	5.5K	26.7K	271K	115K
30	873.3	3.7K	17.8K	181K	77K
50	524	2.2K	10.7K	108K	46.2K
60	436.6	1.8K	8.9K	90.5K	38.5K
100	262	1.1K	5.3K	54.3K	21.3K
200	131	550	2.6K	27.1K	11.5K

Table 18.

ATTENTION:

K Indicates thousands. Example: 7.8K = 7800
M Indicates millions Example: 1.56M = 1560000

NOTE: It is not recommended to work with viscosity values of less than 15% of the lower part of the selected scale.

25. SMART R special Heldal spindle selection table

Maximum guideline values in cP (mPa·s)

RPM/SP	PA	PB	PC	PD	PE	PF
0.01	20M	40M	100M	200M	500M	1000M
0.3	666.6K	1.3M	3.3M	6.6M	16.6M	33.3M
0.5	400K	800K	2M	4M	10M	20M
0.6	333.3K	666.6K	1.6M	3.3M	8.3M	16.6M
1	200K	400K	1M	2M	5M	10M
1.5	133.3K	266.6K	666.6K	1.3M	3.3M	6.6M
2	100K	200K	500K	1M	2.5M	5M
2.5	80K	160K	400K	800K	2M	4M
3	66.6K	133.3K	333.3K	666.6K	1.6M	3.3M
4	50K	100K	250K	500K	1.25M	2.5M
5	40K	80K	200K	400K	1M	2M
6	33.3K	66.6K	166.6K	333.3K	833.3K	1.6M
10	20K	40K	100K	200K	500K	1M
12	16.6K	33.3K	83.3K	166.6K	416.6K	833.2K

Table 19.

ATTENTION:

K Indicates thousands. Example: 7.8K = 7800
M Indicates millions Example: 1.56M = 1560000

NOTE: It is not recommended to work with viscosity values of less than 15% of the lower part of the selected scale.

26. SMART H standard spindle selection table

Maximum guideline values in Poise

RPM/SP	R1	R2	R3	R4	R5	R6	R7
0.01	80K	320K	800K	1.6M	3.2M	8M	32M
0.3	2.6K	10.6K	26.6K	53.3K	106.6K	266.6K	1M
0.5	1.6K	6.4K	16K	32K	64K	160K	640K
0.6	1.3K	5.3K	13.3K	26.6K	53.3K	133.3K	533.3K
1	800	3.2K	8K	16K	32K	80K	320K
1.5	533.3	2133	5.3K	10.6K	21.3K	53.3K	213.3K
2	400	1.6K	4K	8K	16K	40K	160K
2.5	320	1.28K	3.2K	6.4K	12.8K	32K	128K
3	266.6	1066	2.6K	5.3K	10.6K	26.6K	106.6K
4	200	800	2K	4K	8K	20K	80K
5	160	640	1.6K	3.2K	6.4K	16K	64K
6	133.3	533.3	1.3K	2.6K	5.3K	13.3K	53.3K
10	80	320	800	1.6K	3.2K	8K	32K
12	66.6	266.6	666	1.3K	2.6K	6.6K	26.6K
20	40	160	400	800	1.6K	4K	16K
30	26.6	106.6	266	533	1066	2.6K	10.6K
50	16	64	160	320	640	1.6K	6.4K
60	13.3	53.3	133.3	266.6	533	1.3K	5.3K
100	8	32	80	160	320	800	3.2K
200	4	16	40	80	160	400	1.6K

Table 20.

ATTENTION:

K Indicates thousands. Example: 7.8K = 7800
M Indicates millions Example: 1.56M = 1560000

NOTE: It is not recommended to work with viscosity values of less than 15% of the lower part of the selected scale.

27. SMART H Special spindle selection table

Maximum guideline values in Poise

RPM / SP	TR8	TR9	TR10	TR11	TR12	TR13
0.01	400K	2M	4M	8M	4M	10M
0.3	13.6K	66.6K	133.3K	266.6K	133.3K	333.3K
0.5	8K	40K	80K	160k	80K	200K
0.6	6.6K	33.3K	66.6K	133.3K	66.6K	166.6K
1	4K	20K	40K	80K	40K	100K
1.5	2.6K	13.3K	26.6K	53.3K	26.6K	66.6K
2	2K	10K	20K	40K	20K	50K
2.5	1.6K	8K	16K	32K	16K	40K
3	1.3K	6.6K	13.3K	26.6K	13.3K	33.3K
4	1K	5K	10K	20K	10K	25K
5	800	4K	8K	16K	8K	20K
6	666	3.30K	6.6K	13.3K	6.6K	16.6K
10	400	2K	4K	8K	4K	10K
12	333	1.6	3.3K	6.6K	3.3K	8.3K
20	200	1K	2K	4K	2K	5K
30	133	666	1.3K	2.6K	1.3K	3.3K
50	80	400	800	1.6K	800	2K
60	66	333	666	1.3K	666	1.6K
100	40	200	400	800	400	1K
200	20	100	200	400	200	500

Table 21.

ATTENTION:

K Indicates thousands. Example: 7.8K = 7800
M Indicates millions Example: 1.56M = 1560000

NOTE: It is not recommended to work with viscosity values of less than 15% of the lower part of the selected scale.

28. SMART H special Vane spindle selection table

Maximum guideline values in poise

RPM / SP	V71	V72	V73	V74	V75
0.01	200K	880K	4.28M	43.4M	18.4M
0.3	6.9K	29.6K	142K	1.4M	615K
0.5	4.1K	17.7K	85.6K	868K	369K
0.6	3.4K	14.8K	71.3K	724K	307K
1	2K	8.8K	42.8K	434K	184K
1.5	1.3K	5.9K	28.5K	289K	123K
2	1K	4.4K	21.4K	217K	92.4K
2.5	838	3.5K	17.1K	173K	73.9K
3	698	2.9K	14.2K	144K	61.6K
4	523	2.2K	10.7K	108K	46.2K
5	419	1.7K	8.5K	86.8K	36.9K
6	349	1.4K	7.1K	72.4K	30.8K
10	209	888	4.2K	43.4K	18.4K
12	174	740	3.5K	36.2K	15.4K
20	104	444	2.1K	21.7K	9.24K
30	69.8	296	1.4K	14.4K	6.1K
50	41.9	177	856	8.6K	3.6K
60	34.9	148	713	7.2K	3K
100	20.9	88.8	428	4.3K	1.8K
200	10.4	44.4	21.4	2.17K	924

Table 22.

ATTENTION:

K Indicates thousands. Example: 7.8K = 7800
M Indicates millions Example: 1.56M = 1560000

NOTE: It is not recommended to work with viscosity values of less than 15% of the lower part of the selected scale.

29. SMART H special Heldal spindle selection table

Maximum guideline values in Poise

RPM/SP	PA	PB	PC	PD	PE	PF
0.01	1.6M	3.2M	8M	16M	40M	80M
0.3	53.3K	106K	266.6K	533.3K	1.3M	2.6M
0.5	32K	64K	160K	320K	800K	1.6M
0.6	26.6K	53.3K	133.3K	266.6K	666.6K	1.3M
1	16K	32K	80K	160K	400K	800K
1.5	10.6K	21.3K	53.3K	106K	266.6K	533.3K
2	8K	16K	40K	80K	200K	400K
2.5	6.4K	12.8K	32K	64K	160K	380K
3	5.3K	10.6K	26.6K	53.3K	133.3K	266.6K
4	4K	8K	20K	40K	100K	200K
5	3.2K	6.4K	16K	32K	80K	160K
6	2.6K	5.3K	13.3K	26.6K	66.6K	133.3K
10	1.6K	3.2K	8K	16K	40K	80K
12	1.3K	2.6K	6.6K	13.3K	33.3K	66.6K

Table 23

ATTENTION:

K Indicates thousands. Example: 7.8K = 7800
M Indicates millions Example: 1.56M = 1560000

NOTE: It is not recommended to work with viscosity values of less than 15% of the lower part of the selected scale.

WARRANTY CERTIFICATE

FUNGILAB S.A. guarantee the perfect functioning of this instrument against defects in material or workmanship, when used under appropriate conditions and in accordance with the operation instructions for a period of **TWO YEARS** from the invoice date of the product.

The following cases cancel the warranty period:

- Misuse of the instruments
- When the equipment has been made damaged by the user
- When the user has not had in mind the Fungilab recommendations and maintenance.
- When the instrument 'has been repaired or mishandled by anybody not allowed for the Fungilab technical service.
- When the serial number is incorrect or it does not suit with the written in the warranty.

FUNGILAB's sole obligation shall be to repair or to replace any part(s) that prove defective within the warranty period and shall not be liable for consequential damages resulting from the use of its products.

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