BROOKFIELD R/S-CPS+ RHEOMETER

Operating Instructions

Manual No. **M/01-213-A0706**

BROOKFIELD

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I. General Description

I.1 Use of the Rheometer

The R/S-CPS+ Rheometer is a good choice for use in quality control, product development and research environments, especially where small sample volume and minimum instrument service requirements are important . It allows the rheological characterization of both Newtonian and non-Newtonian fluids. The instrument benefits include a broad measurement range, testing for Yield properties, and the ability to measure flow properties of fluids with delicate structures.

I.2 Measuring Principle

The R/S-CPS+ Rheometer is a rotational controlled stress instrument with geometries (cones and plates) conforming to DIN specification 53-018.

The geometry is directly connected to the motor shaft. A current is applied to the Rheometer motor, and the resulting speed (RPM) is measured with an optical encoder directly connected to the motor shaft. The applied torque is converted to shear stress (Tau), and the RPM is converted to shear rate (D) by the instrument electronics.

This is the controlled shear stress or CSS mode. The user defines the stress value and the instrument maintains that value.

The R/S CPS+ can also operate in controlled shear rate (CSR) mode where a feedback loop is used: A speed or shear rate is entered by the user. The instrument ramps motor current up or down (depending on the starting speed. If the instrument is at 0 rpm, and set point is 500 RPM current is ramped up. If speed is 1000 RPM, current is ramped down). Speed is constantly measured by the optical encoder and once the set point speed is achieved, minor adjustments in the current applied to the motor are made, to maintain that speed.

II. System Configuration

The R/S-CPS+ is available in four versions, the difference being temperature range and temperature control ooptions:

The R/S-CPS+ Rheometer system uses a bath/circulator for temperature range of -20°C to 250°C and consists of:

- The head which contains the drive system, display and electronics
- Instrument base which houses the measurement plate (which is jacketed)
- Constant temperature bath circulator
- AC adapter

The R/S-CPS+ P1 Rheometer system has peltier plate temperature control for temperature range of 0°C to 135°C and consists of:

- The head which contains the drive system, display and electronics
- Instrument base which houses the measurement plate (which is jacketed)
- Peltier controller
- AC adapter

The R/S-CPS+ P2 Rheometer system has peltier plate temperature control for temperature range of 20°C to 180°C and consists of:

- The head which contains the drive system, display and electronics
- Instrument base which houses the measurement plate (which is jacketed)
- Peltier controller
- AC adapter

The R/S-CPS+ E1 Rheometer system is electrically heated for temperature range of 60°C to 250°C and consists of:

- The head which contains the drive system, display and electronics
- Instrument base which houses the measurement plate (which is jacketed)
- Peltier controller
- AC adapter

Available accessories for any of the four systems include:

- Printer
- **Measuring cones and plates (see Appendix A)**
- Computer system
- RHEO 2000 Software

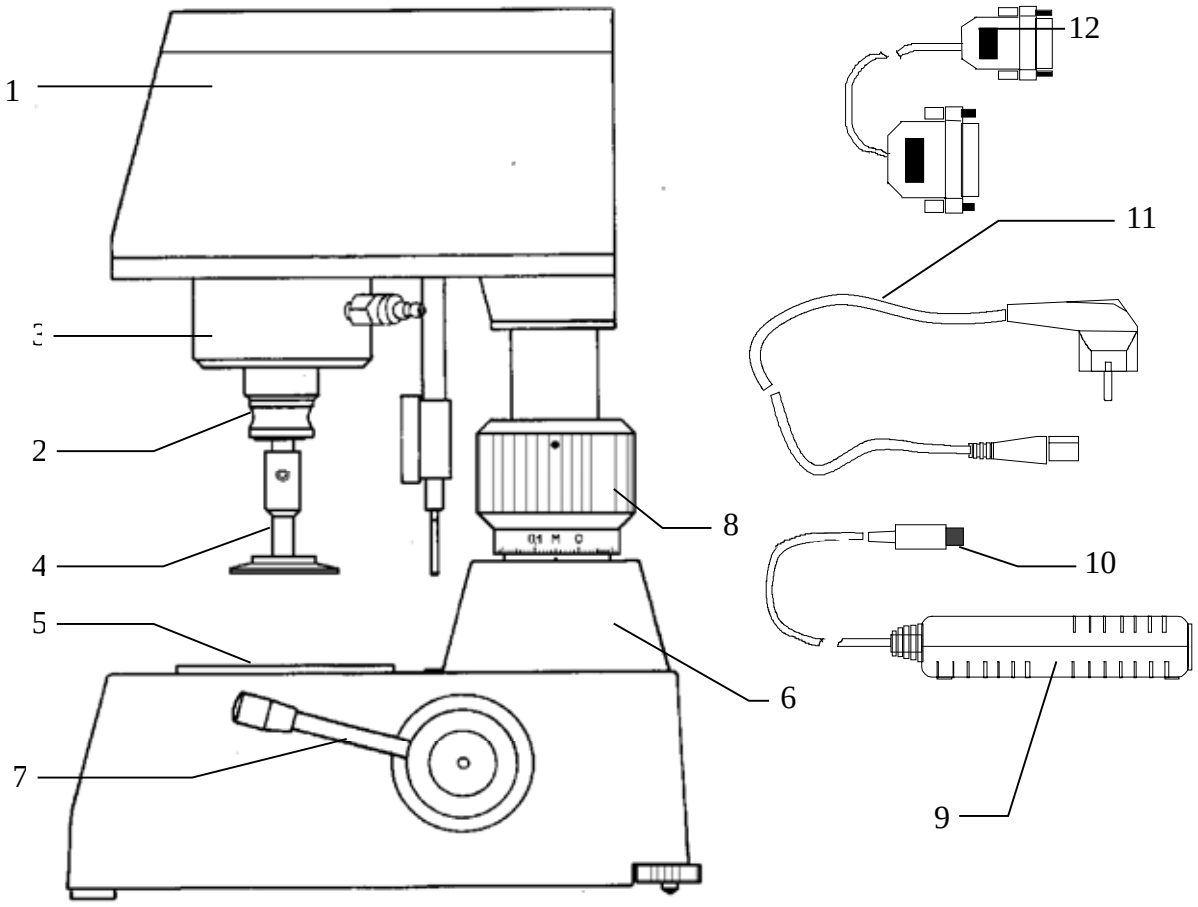
The accessories in bold print are necessary for a minimal configuration.

II.1 R/S-CPS+ Rheometer

The Rheometer head includes:

- Digital control of rotational speed and torque
- Automatic adjustment of control parameters during measurement
- Direct indication of measured and calculated values of speed, torque, shear rate, shear stress, viscosity, temperature, time
- Internal storage of measured values
- Parallel printer port
- RS232C serial port for connection of a computer

The R/S-CPS+ may be operated from the instrument keyboard or with optional Rheo2000 software running under Windows ® 2000 or higher.



1 Measuring Head of R/S-CPS+ Rheometer
2 Measuring Element Coupling
3 Cooling Flange
4 Measuring Cone or Measuring Plate
5 Bottom Measuring Plate
6 Stand
7 Height Adjusting Lever
8 Nonius Micrometer Ring (for fine adjustment)
9 AC Adapter
10 DC Connecting Socket
11 Mains Connection Cable
12 Data Transmission Cable

Fig. 1: Configuration of the R/S-CPS+ Rheometer

II.2 Measuring Devices

The instrument is equipped with a temperature-controlled bottom plate. At least one measuring cone or measuring plate is required for operation. These rotating elements **are not part of the basic equipment** of the R/S-CPS+ Rheometer. They should be ordered based on your application and/or testing requirements.

II.3 Computer System

The computer system is **optional** and provides full control of the Rheometer, data and test program storage, printing of test data and plots etc.

The computer system consists of:

- IBM-compatible PC with the following minimal system requirements:
  - CPU Pentium III or better
  - 512 MB RAM (main memory),
  - 5 GB free hard disk capacity
  - Windows® 2000 or higher
  - Mouse and keyboard
  - 1 RS232c serial port for Rheometer when using R/S-CPS+, two serial ports for R/S-CPS+ P1, P2 and E1.
- Printer
- RHEO2000 Software

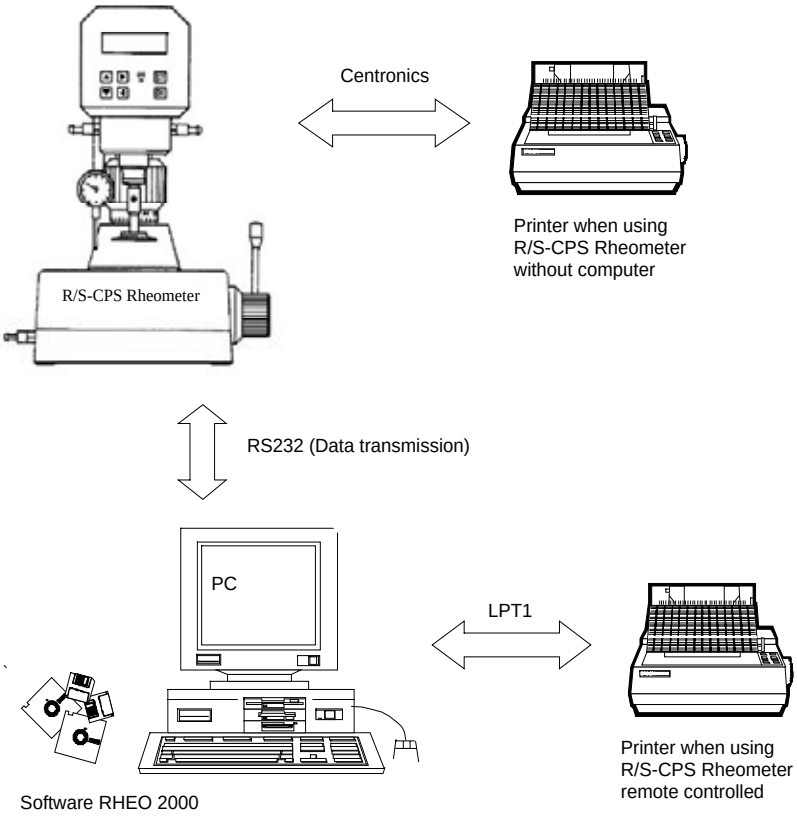


Fig. 2.: Computer System for R/S-CPS+ Rheometer

III. Instrument Installation

This chapter covers installation of the R/S CPS+ Rheometer and includes:

- assembly of the R/S-CPS+ Rheometer
- electrical connections
- installation of accessories such as bath/circulator, measuring systems
- tubing connections.

III.1 Mounting the Instrument

The R/S-CPS+ Rheometer must be positioned on an even surface (laboratory bench) such that there is enough room for easy handling of the instrument. Exposure to direct sunlight and other heat and cooling sources should be avoided to ensure proper temperature control of sample test material.

III.2 Electrical Connections

Connections for the electrical components of the R/S-CPS+ Rheometer are located on the back of the instrument.

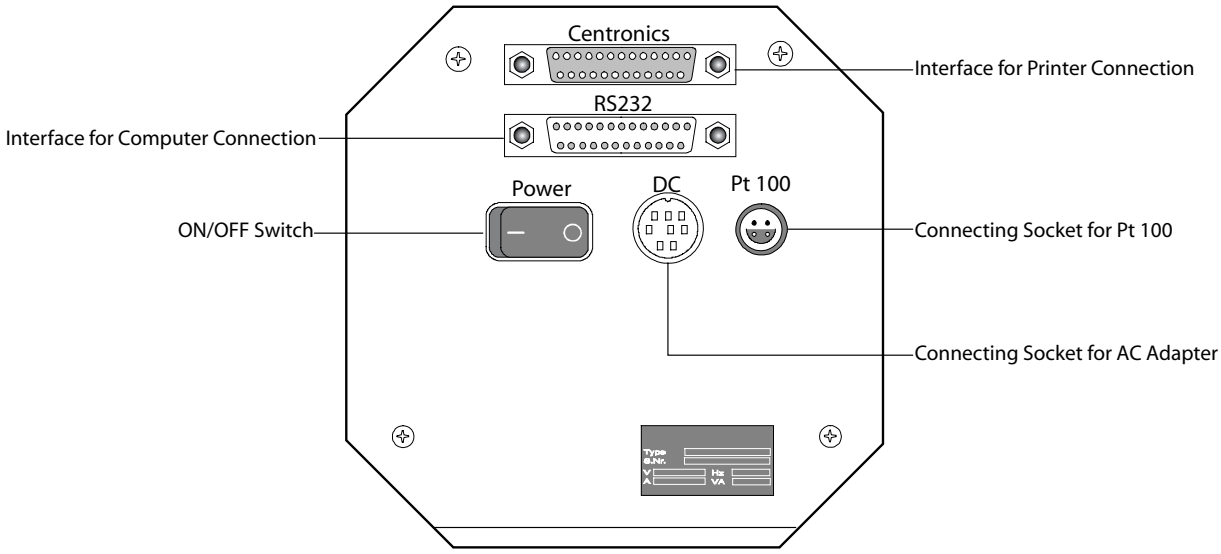


Figure 3: Operating and connecting elements at the back side of the measuring head

All cables from and to the R/S-CPS+ Rheometer must be connected or disconnected only when the instrument is switched off!

III.2.1 Temperature Sensor

The connecting cable of the temperature sensor Pt 100 is inserted into the socket “Pt100” at the back side of the R/S-CPS+ Rheometer. The temperature probe is mounted under the Rheometer plate.

III.2.2 AC Adapter

The AC adapter supplies the R/S-CPS+ Rheometer with power (~16 vdc).

The AC adapter may only be inserted to a socket with proper grounding. Connect the AC adapter using a plug with proper grounding to avoid electric shocks or damage to the system components. Input voltage is 100-240 VAC 50/60 Hz.

Connecting the AC adapter:

- Switch the R/S-CPS+ Rheometer off (“POWER” at the back side of the instrument).
- Insert the AC power cable into the AC adapter.
- Insert the socket of the DC cable into the connector “DC” at the back side of the R/S-CPS+ Rheometer.
- Plug the power cable into the wall socket.
- Turn the R/S-CPS+ Rheometer on.

The AC adapter should not be powered when the it is not connected to the Rheometer.

III.2.3 Printer Connection

Data may be printed without PC by connecting a parallel printer to the parallel port (labeled “centronics” on the Rheometer head. Pre-select “printer” as the output device to print the data during measurement (see Section 6).

- Turn the R/S-CPS+ Rheometer off with the “POWER” switch at the back of the instrument.
- Insert the printer cable into the “CENTRONICS” port at the back side of the instrument.
- Turn the R/S-CPS+ Rheometer on.

III.2.4 Computer Connection

If the R/S-CPS+ Rheometer is to be used in "REMOTE" mode with PC support (RHEO 2000 Software), the serial computer cable (part number RSS-9, supplied with Rheo2000) must be connected to the "RS232 Port" at the back of the instrument.

- Turn the R/S-CPS+ Rheometer off with the "POWER" switch at the back of the instrument.
- Turn your computer off.
- Insert the serial cable into the "RS232 Port" at the back of the R/S-CPS+ Rheometer.
- Connect the other end of the data transmission line to a free RS232 port (e.g. "COM2") on the computer.
- Turn the R/S-CPS+ Rheometer and your computer on.

You must use the computer cable supplied by Brookfield!

Information on the installation of the computer system can be found in the operating manuals of the specific computers.

III.3 Connecting the Temperature Control Device

This chapter discusses how to connect to following temperature control devices:

- A **Bath/circulator** for the temperature range -20°C to +250°C
- The **Peltier temperature control device** for the temperature range 0°C to +135°C
- **The Electrically heated controller for temperature range of 50°C to 250°C**

III.3.1 Connecting a Bath/Circulator

Hose connections are required to connect a bath/circulator to the R/S-CPS+ Rheometer. The hoses of the bath are connected by means of snap couplings. Seen from the front side of the instrument, the supply is the front connection(connected to the bath outlet) and the discharge is the rear connection (to be connected to the bath inlet). The bath fluid enters the instrument in the middle of the bottom plate and spreads evenly towards the plate periphery.

To connect the hoses, push the coupling sleeve slightly back, insert the hose connecting piece and let the coupling go. It will fasten the hose (without screwing and turning) by locking it in place. Check whether the hose connection fits tightly by pulling gently. Check for leaks prior to taking measurements.

The R/S-CPS+ Rheometer can be used at temperatures up to +90°C without additional cooling required. For operation at higher temperatures (+90 to +250°C), tap water must be fed into the cooling flange to keep the bearings cool!

The bath liquids normally used are:

-10°C to +90°C	water (de-ionized) - glycol mixture
-20°C to +250°C	Silicone bath oil

Silicone bath fluids can be ordered from **BROOKFIELD**.

We recommend strongly that the upper temperature limit be set at the liquid circulating thermostat to +90°C if water is used and to +250°C if oil is used.

III.3.2 The Peltier Temperature Control Device

If the R/S-CPS+ Rheometer is equipped with a Peltier temperature control device or electric heater (P1 or P2 or E1) a bath/circulator is not used. The control of a Peltier and Electric control devices are explained in separate manuals.

IV. Environment, Handling, Cleaning and Maintenance

IV.1 Operating Environment

Find a comfortable, convenient working place to install your R/S-CPS+ Rheometer. There should be enough room to place the Rheometer, the measuring systems, the testing material and the peripheral devices (e.g. printer, computer and thermostat). You need a grounded outlet to operate the R/S-CPS+ Rheometer, and you need additional outlets for the connection of each peripheral device. Your operating environment and the place where you store the R/S-CPS+ Rheometer should not be extremely hot, cold or moist. Locations with strong temperature and humidity fluctuation should be avoided. Be sure the R/S-CPS+ Rheometer is not exposed to the following:

- heavy dirt or dust,
- direct sun radiation,
- objects that emit strong heat (e.g. heating radiators),
- objects with a strong electromagnetic field (e.g. loudspeakers, motors etc.),
- liquids or corrosive chemicals.

IV.2 Handling

The R/S-CPS+ Rheometer is designed to work under light bumps or with vibration. You must, however, avoid dropping it or exposing it to heavy shock!

Never lift your R/S-CPS+ Rheometer by the cone or plate coupling, or by an attached cone or plate. Avoid anything that might impair the free and concentric rotation of the measuring element coupling (e.g. shock).

The Rheometer includes electronic torque overload protection and is not damaged if maximum torque load (50 mNm) is exceeded.

IV.3 Cleaning

The paint coating of the R/S-CPS+ Rheometer resists damage by most solvents and weak acids. Use a clean, dry, soft and nap-free cloth to clean the housing. Neutral detergents may be used to clean the housing.

Do not use chemical products such as strong solvents or strong acids to clean the housing, especially the keyboard.

Make sure NO liquid penetrates into the housing (e.g. through the instrument connecting sockets) and into the bearings of the drive. This could destroy the instrument!

IV.4 Maintenance

Work on control electronics, all accessories, the measuring drive, the AC-adaptor and all cables and connections may only be carried out by authorized service personnel trained by Brookfield Engineering.

Measurement accuracy can be checked by the customer at any time. We recommend this measurement be done with mineral oil standards.

V. Measuring Systems

The following types of geometries are available for use with the R/S-CPS+/P1/P2/E1 Rheometer:

a) cone/plate
b) plate/plate

Select a suitable measuring system in the range required for your measurements (see Appendix A1).

When cones are used, the shear rate is the same across the entire measuring area. The available cone angles are α=1° and α=2°. The tip of the measuring cone has been removed to avoid contact and friction with the bottom plate. Each cone is supplied with a data sheet that identifies the cone truncation in millimeters.

Flat (parallel) plates are typically used when there are particles in the sample. It is possible to adjust the gap distance between 0.3 ... 3 mm. The shear rate changes with gap used so the gap must be entered when running a test with P25, P50 or P75 plates.

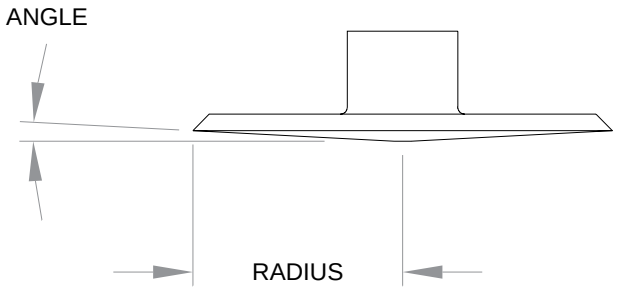


Figure 4.: Measuring cone for R/S-CPS+ Rheometer

V.1 Inserting and Adjusting the Measuring Elements

The cone/plate and plate/plate measuring systems consist of the fixed bottom plate and the upper measuring cone or flat (parallel) plate. The top element will move up and down using the height adjusting lever.

The instrument head is lifted to insert the geometry. To do so, move the height adjusting lever forward to raise the instrument head. Push the coupling sleeve up so the red ring is visible. Insert the measuring element (cone or plate) in the coupling. Push the sleeve down (red ring covered) until the measuring element is held tight by the coupling.

Loosen the hexagon socket screw on the measuring system to allow the cone and cone shaft to move freely.

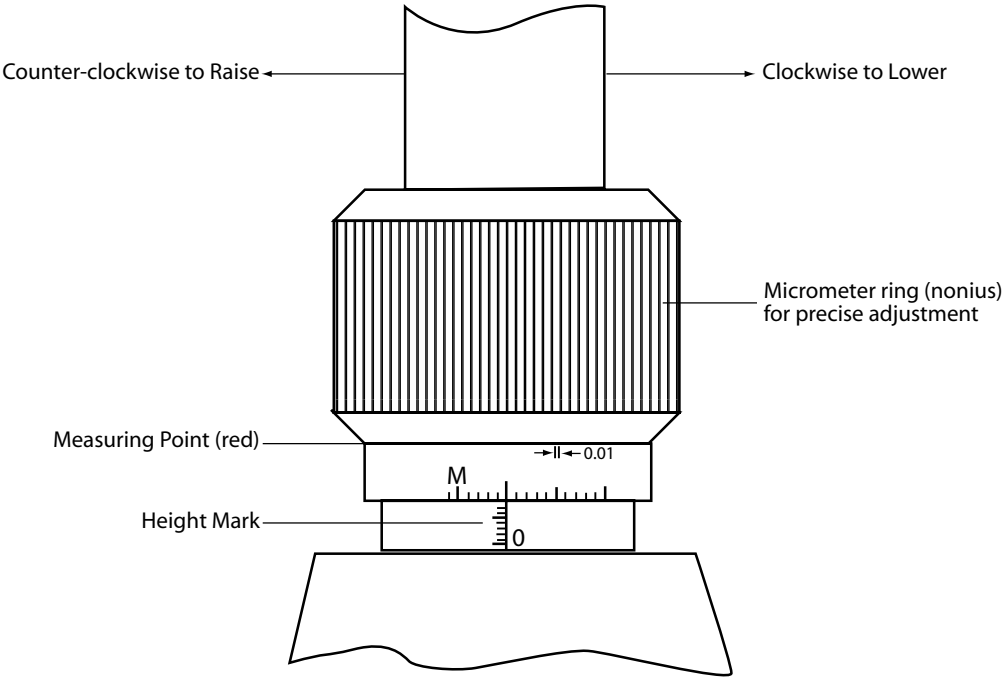


Figure 5: Setting the gap on the R/S-CPS+ Rheometer

Set the micrometer ring to ZERO by first turning it left (clock-wise) to at least 100 μm (one complete revolution) beyond ZERO (scale division 0.01 corresponds to 10 μm), and then counter clock-wise back to 0. This will prevent backlash of threads from influencing the accuracy of the ZERO setting. The height mark "O" must then be set during an upward (counter clockwise) rotation of the micrometer ring.

Lower the instrument head as far as it will go by pushing the height adjusting lever backward. This will compress the element. Now set the reading on the Measuring Dial to "0". Lift the instrument head and lower it again. The reading on the Measuring Dial should read "0" again. If it does, tighten the hexagon socket screw which will lock the measuring element in this position. If it does not, begin again following the same procedure.

Raise the instrument head and set the micrometer ring to the appropriate gap setting (turning the micrometer ring counter clock-wise). The red M on the micrometer ring indicates a 0.05 mm gap setting. ALL cones are supplied with a data sheet that specifies the cone truncation in millimeters. Set the micrometer ring to the cone truncation value listed on the data sheet. This sets the gap to account for the tip of the cone being removed. For ANY plate, the gap setting may be selected freely from 0.3 mm to 3.0 mm. A common gap setting for plate/plate measurements is 1.0 mm, but this is user definable depending on the material being tested and the size of particles within the sample, if any. The micrometer ring can be locked slightly at the back by means of a hexagon socket screw M3.

The measuring cone/plate may only be adjusted, and the hexagon socket screw may only be tightened, when the measuring temperature is set precisely. Otherwise the gap distances may be changed by thermal elongation, resulting in faulty measurement or in damage to the measuring system.

V.2 Filling the Measuring Systems, Measuring

The sample material is placed on the bottom plate with the instrument head in the upper position. Air bubbles in the sample will foul test results and should be avoided. To avoid interfering side effects, remove excess sample from around the cone or plate with a spatula, taking care not to scratch the surface of the bottom plate.

Remove excess sample from cone or plate edge!

Set the bath, peltier or electric heater to the required temperature if measurements are to be taken under controlled temperature. Do not begin the measurement until the temperature in the substance is constant (plate temperature may be displayed by selecting Utilities (Temperature measurement).

Be sure to hold the measuring system with one hand when you remove the cone or plate. Dropping the cone or plate onto the sample plate may damage either piece.

Clean the bottom measuring plate and measuring element carefully without using abrasive objects. (i.e., steel wool). **Avoid scratches! When the cone or plate is not in use it should be stored in the cylindrical container.**

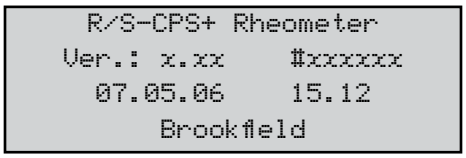
Beginning with firmware Version 4.02, the R/S-CPS+ Rheometer will display in German or English.

The language is selected via the menu level **Configuration→Language** (if English is active) or **Konfiguration→Sprache** (if German is active). For more details on language selection, see Chapter 6.7.6.

After applying power to the R/S-CPS+ Rheometer, the LCD displays the following information for a few seconds:

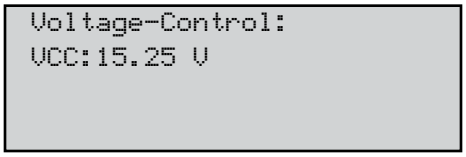
- name of the Rheometer
- software version of the firmware installed in the instrument
- serial number of the instrument
- date and time

Example:



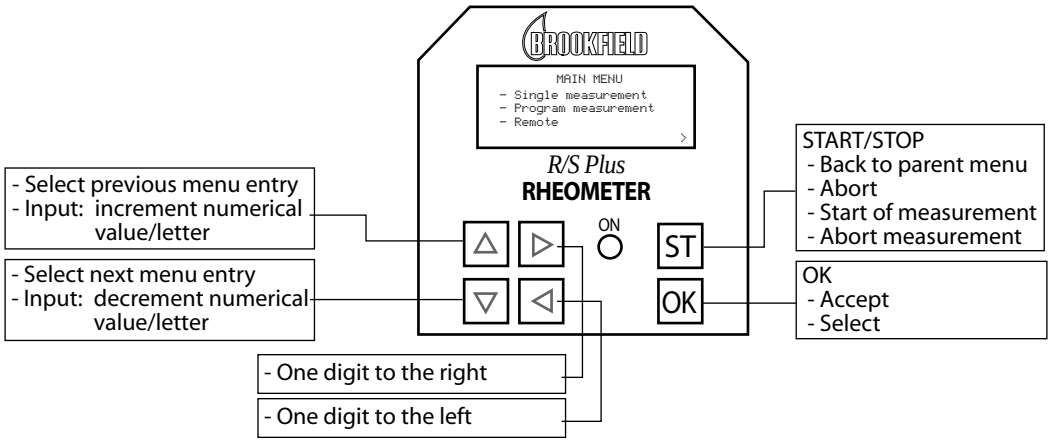
About five seconds later, the instrument checks the voltage of the power supply. The displayed voltage should be in the range of 14.9 to 16V. If the voltage is outside this range, contact Brookfield or your local Brookfield Dealer.

Example:



This message is displayed for about 3 seconds. Then the **MAIN menu** is displayed.

VI.1 Keyboard



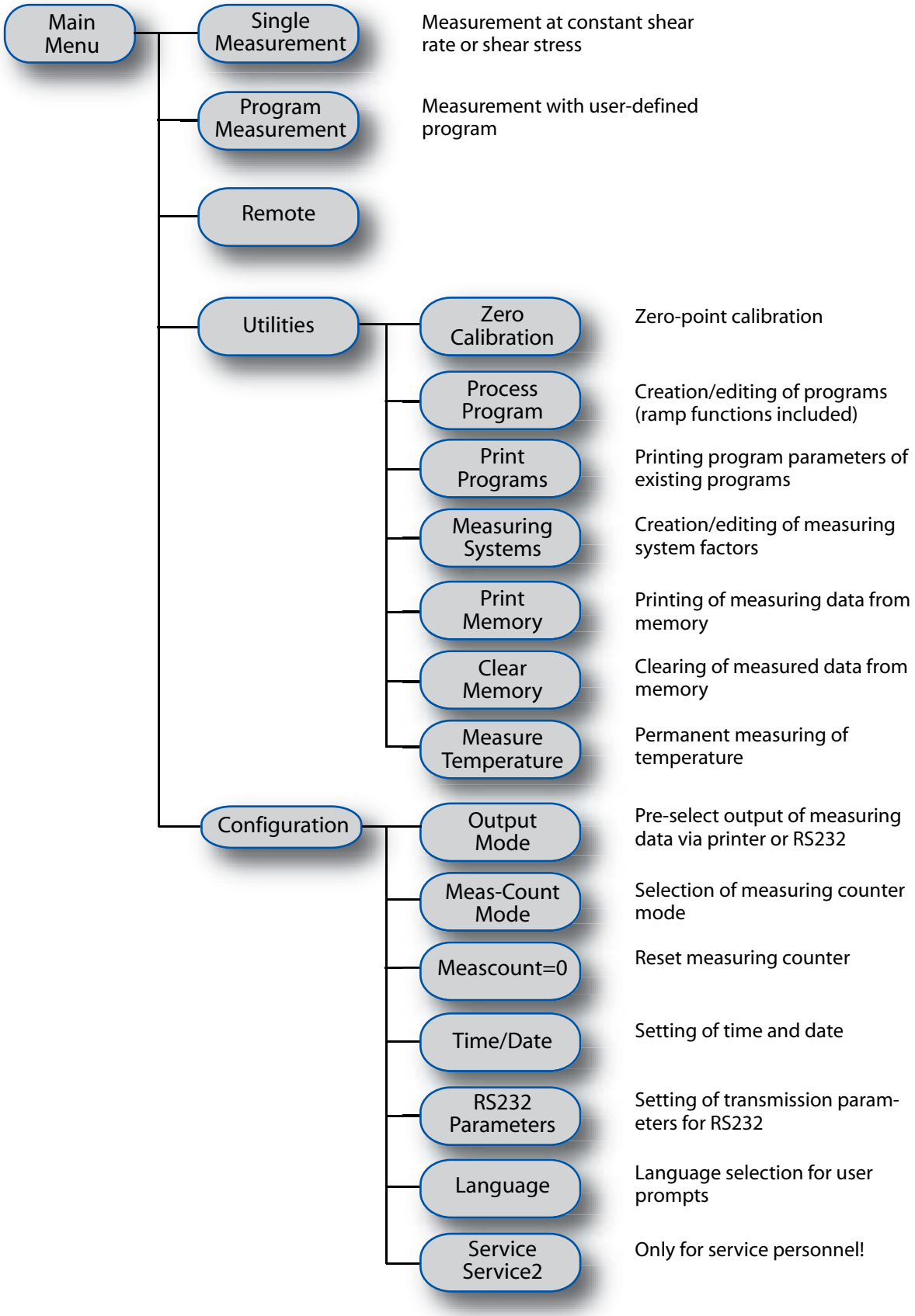
All user inputs are made using the 6 keys located below the LCD. Some of the keys are of multiple use, i.e. their function depends on the current operation. The following table shows the keyboard functions in detail.

Keypad layout of the R/S-CPS+ Rheometer

Key	Operation	Function of Key	Example
▲	1) Menu	1) Select menu entry above active one	1) Utilities → Remote
	2) Input of numerical values	2) Increment	2) 8 → 9 A → B
	3) Selection from list	3) Select list element above active element	3) Select meas. system CP50-2 → CP50-1
▼	1) Menu	1) Enable menu entry below active one	1) Remote Untilities
	2) Input of numerical values	2) Decrement	2) 5 → 4 F → G
	3) Selection from list	3) Select list element below active element	3) Select meas. system CP50-1 → CP50-2
▷	1) Menu	1) Select menu entry above active one	1) Utilities → Remote
	2) Input of numerical values	2) One digit to the right	2) 100.00 → 100.00 Test → Test
	3) Selection from list	3) Select list element above active element	3) Select meas. system

Key	Operation	Function of Key	Example
◁	1) Menu	1) Enable next menu entry below active one	1) Remote → Utilities
	2) Input of numerical values	2) Last digit	2) 100.00 → 100.00 Test → Test
	3) Selection from list	3) Select list element below active element	3) Select meas. system
ST	1) Menu	1) Return to parent menu (turn page downward)	1) Utilities → Main
	2) Input of numerical values	2) Abort input (only if possible)	
	3) Selection from list	3) Abort selection (only if possible)	2) Select meas. system → back to menu
	4) Measurement	4) Start and abort measurement	
	5) Remote operation	5) Abort measurement back to main menu	
OK	1) Menu	1) Select active menu level (open sub-menu)	
	2) Input of numerical values	2) End of input/acceptance	
	3) Selection from list	3) Select active list element	

VI.2 Menu System of R/S-CPS+ Rheometer

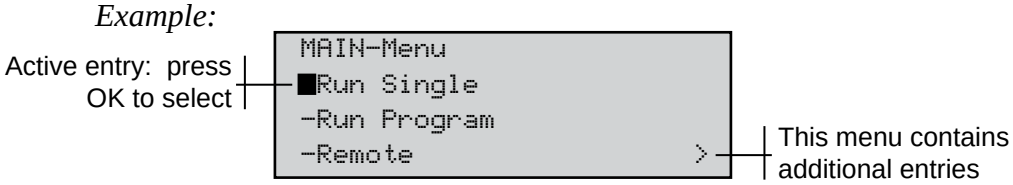


Menu Handling

The first menu displayed after turning on the instrument is the main menu. Only part of the menu (three entries) is displayed at a time because the LCD of the R/S-CPS+ Rheometer cannot show all menu items simultaneously. An arrow ">" on the right side of the display indicates there are more entries in the menu.

The currently active (but not yet selected) entry is marked by a blinking field (cursor) on the left side of the LCD.

Example:



Using the ▲ and ▼ keys, you can move the cursor up and down in the menu until the desired menu entry is reached.

Note: If there are more menu entries in the menu when you have reached the end of the display, the next part of menu will be opened automatically (scrolling).

You can "Start" the menu entry by pressing the OK key, as well as open the related sub-menu.

If you are in a submenu and wish to return to the upper menu, press the ST key.

VI.3 Selecting from Lists

Selection from a Menu List is required for the following:

- Select a measuring system for measurement e.g.in "Single measurement" or "Edit Program"
- Select pre-set values for measurement e.g. in "Single measurement" or "Edit Program"
- Select a program or a measuring system you want to edit in "Edit Program" and "Measuring systems"
- Answer a request "YES" ↔ "NO".
- Select the program to be started in "Program measurement"

The ▲ and ▼ keys move the cursor up and down the list.

The OK key selects the entry, ST aborts the selection from the list (only if possible).

```
Select Meas.system:
1) CP25-2
2) CP50-1
3) CP50-2
```

VI.4 Input of Numerical Values and Alphanumeric Texts

Most user defined entries are numbers. User defined values such as the Start and End values of a ramp, number of measuring points, factors, time, date etc. are entered as numbers with or without decimal digits.

If the display shows the decimal point in a number to be entered, input of a floating-point number is requested. However, the number of digits after the decimal point is limited to the number of displayed decimal digits, i.e. the decimal point cannot be moved during input.

The digit to be changed is indicated by a bar under the digit.

The following example indicates the input of numerical values. We will change the value of shear rate (Val.[1/s]) from 0100.00 to 290.00.

The cursor bar is located under the"1" in the entered shear rate (currently 100.00 s^{-1}).

```
Input Values:
Val.[1/s]: 0100.00
Nr. of MP: 010
time[s]: 0230
```

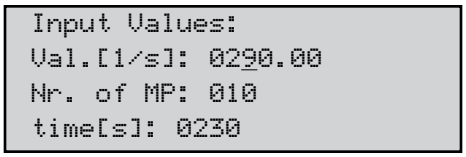
The "1" can be changed (incremented or decremented) by using the ▲ and ▼ keys.
Press the ▲ key once to get:

```
Input Values:
Val.[1/s]: 0200.00
Nr. of MP: 010
time[s]: 0230
```

The cursor can be moved right or left by using the ▷ and ◁ keys. To change the next digit, press the ▷ key:

```
Input Values:
Val.[1/s]: 0200.00
Nr. of MP: 010
time[s]: 0230
```

The next digit can now be changed. In order to insert "9" in place of "0", press the ▼ key once:



Note: If you press and hold one of the keys ▲ or ▼ while entering numbers, the digit will first increment or decrement by +/- 1. However, after a short period of time, the process will continue automatically. This corresponds to the **Repeat Function** of computer keyboards.

In this example, ▲ could be pressed and and held until the "9" is displayed. **The repeat function is only active during numerical and alphanumeric input.**

When the desired number is displayed, accept it by pressing the OK key. In this example, the cursor now moves to the first digit of the next field to be entered.

Alphanumeric inputs

Some fields allow for both numbers and letters. These are entered the same way as previously discussed for numeric fields. The available entries are "0" to "9", "A" to "Z", and the blank symbol " ". If you wish to change the letter "B" to the number "7", press and hold the ▲ or ▼ keys until the "7" appears at the display.

Alphanumeric input is available when assigning a Name to a user defined Program, or an ID to a user defined Test Measurement.

VI.5 Menu Entries (MAIN menu)

Menu entries (see Section VI.2) either lead to submenus (e.g. "Utilities" or "Configuration"), or they start one of the Rheometer's functions directly.

All gray fields in the tree chart in Section VI.2 that have no further right branches start functions. Those with right branches are submenus.

Recall the keyboard layout from Section VI.2. By pressing ▲ and ▼ the cursor (black rectangle) moves up and down. The OK starts a function. If a submenu is assigned to the entry it will open, otherwise the function of the Rheometer is started. The functions of the R/S-CPS+ Rheometer are described in detail in this section.

VI.5.1 MAIN menu → Single Measurement

This function measures shear stress or shear rate (CSS or CSR) at constant user defined values.

The user may select the physical unit from the following:

Shear Rate	D [s^{-1}]
Speed	n [U/min] or [rpm]
Shear Stress	Tau [Pa}
Torque	M[‰] [1000 ‰ correspond to 50 mNm]

The following entries need to be made before measuring:

- selection of the measuring system (see Section VI.3)
- selection of physical unit (see above and Section VI.3) to determine either a controlled rate measurement (shear rate, RPM) or a controlled stress measurement (shear stress, torque).
- input of user defined values (input of numbers, operation, see Section VI.4)
  D [s^{-1}] range of values depends on the measuring system
  n [rpm] 0.7... 1,000 rpm
  Tau [Pa] range of values depends on the measuring system
  M[‰] 0 ... 999 ‰
- input of desired number of measuring points (input of numbers, operation, see Section VI.4)
- Input of the measurement duration in seconds. The minimum allowed interval between two measuring points is different for controlled rate and controlled stress, as follows:
  - shear rate measurement t_{MP} >= 4 s
  - shear stress measurement t_{MP} >= 1 s

Note: The longer the time between 2 measured values, the higher the accuracy of the physical values determined!

- Input of ID for the Test Measurement. (alphanumeric input, operation - see Section VI.4)

The Rheometer will now indicate where the measuring points are:

```
Output of MPs to:
- no output-device
- memory
<▲>menu   <ST>START_
```

Start a measurement by pressing the ST key or return to the main menu with the ▲ key.

This example shows that the measurement data will be written into the instrument memory. Output devices are either a printer or the RS232 serial interface of the Rheometer. Pre-selection of these devices is described in the Section "Configuration → Output mode".

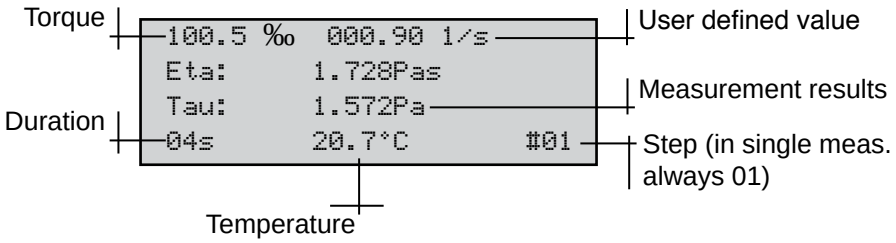
If the memory is full and you want to keep the data, you should abort the "Single measurement" function, print out the data from the memory or send the data to a PC (see "Utilities → Print Memory"). Then you may clear the data from the memory (see chapter

"Utilities → Clear Memory") and run your test.

Tests may run with full memory but the results will not be saved. They will be shown on the LCD as they come from the instrument.

When a measurement is started, the instrument shows:

This message will be displayed until the first measuring point is reached and displayed.



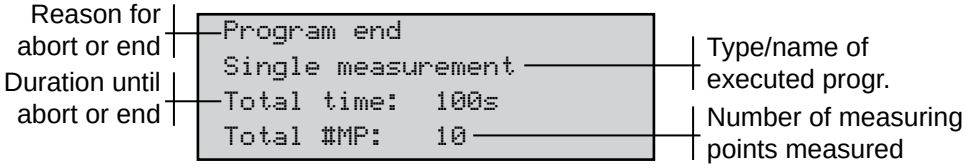
If the torque is below 10 % (scale is 0% to 1,000%), the measurement results are often inaccurate. In this case the user defined parameters should be changed so the torque is higher than 10%.

If the display field for the torque indicates: "M→0!", these values are below the range of resolution of the Rheometer.

If the temperature is not displayed, the measuring sensor is not connected.

The display is updated every new measuring point. The current measurement can be aborted at any time with the ▲ key.

After a measurement or an abort, the display field for Step indicates "END" or "ABORT". The display alternates at intervals of about four seconds between the last displayed measuring point and information about the measurement:



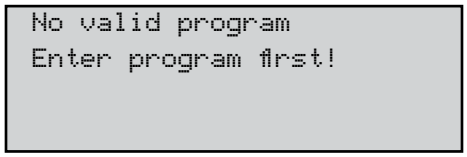
By pressing OK you stop the alternating display and return to the menu.

Note: The last selected program parameters remain in the memory even after switching off the Rheometer.

VI.5.2 MAIN menu → Program Measurement

This function begins a user defined measurement program. With a Program Measurement, the user can also set values as a linear function of time, such as $D[s^{-1}] = f(t)$. It is useful to use a "Program measurement" when doing repeat measurements involving the same preset values and the same measuring system. The user only needs to run the Program rather than select parameters each time they need to run the test. Four standard programs (and more optional ones) may be defined. Section VI.6.2 "Utilities → Edit Program" describes how to prepare or modify such a program.

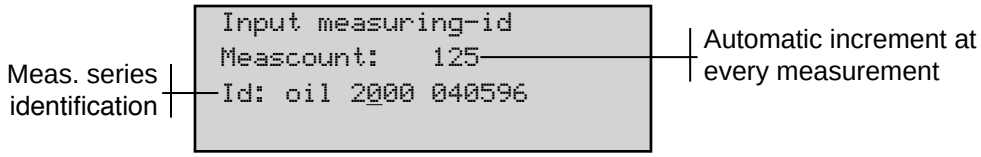
The function "Program measurement" begins one of the available programs. If there is no program available, the following error message is displayed:



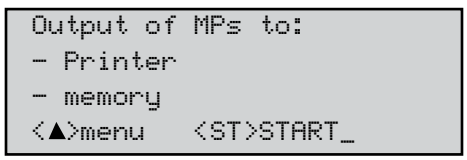
In such a case you have to define a program first ("Utilities → Edit Program"). Use OK to return to the main menu.

If programs are available, a list appears to select from. Select the program to be started (selection from the list, operation, see Section VI.3).

If the OK key is used to select the program (in this example, the program named "Test"), this operation is followed by the option to enter an ID (identification text of the measurement). A name for the measurement may be entered here (maximum 15 characters - for alphanumeric input, see Section VI.4).



When you have entered "Id" the Rheometer will indicate where the measuring points will be outputted to before a measurement begins.



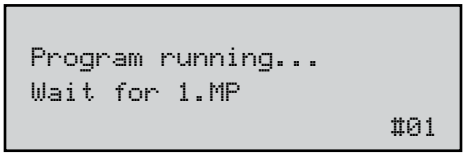
Start a measurement by pressing [ST] or return back to the main menu with [▲].

In the above example, the results will be outputted to memory and printed to the printer connected to the Rheometer. Options for output devices include a printer, the RS232 serial interface or no output device. The section "Configuration → Output mode" describes this in detail.

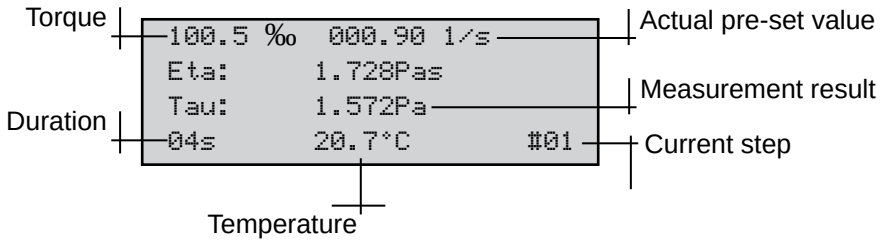
If the memory is full, you should consider aborting the "Program measurement" function, printing the data from the memory or sending it to a PC (see chapter "Utilities → Print memory") and then clearing the data from the memory (see chapter "Utilities → Clear memory").

Measurements can be taken with the memory full but the results will only be shown at the LCD and will be lost after completion of the measurement. If you try to send results to a printer and it is not connected or has no paper in it, an error message will be displayed until the printer is connected and operational or until you abort the activity.

When you start the measurement the instrument shows:



This message will be displayed until the first measuring point is displayed.



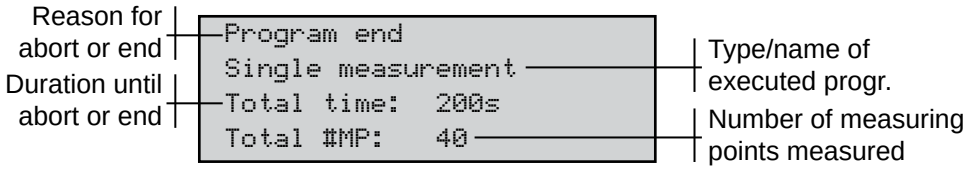
If the torque is less than 10 ‰ the results may be out of instrument range. The user should consider changing the user defined values to get a torque higher than 10 ‰.

If the display field for the torque indicates: "M→0!", these values are below the range of resolution of the Rheometer.

If the temperature is not to displayed, the measuring sensor is not connected and the printout of the temperature will be printed as **1000.0 °C**!

The display is updated at every new measuring point. The current measurement can be aborted at any time with the [ST] key.

After measurement, or after an abort, the display field for step indicates “END” or “ABORT”. The LCD alternates at intervals of about four seconds between the last displayed measuring point and information on the measurement:



Pressing OK ends the alternating display and returns to the main menu.

VI.5.3 MAIN menu → Remote

The “Remote” function initiates measurements to be made under PC control. In this mode all functions of the R/S-CPS+ Rheometer are controlled by a PC. For PC-controlled measurement you need the software package RHEO 2000. This software operates under the Microsoft™ Windows 3.1, Windows for Workgroups 3.11, Windows 95, 98 and NT. More detailed information on RHEO 2000 can be obtained from your supplier.

After selection of the “Remote” option, the Rheometer displays the following:

The Rheometer waits for communication with a PC. Data transfer between the PC and the Rheometer is performed through the RS232 serial interface of the R/S-CPS+ Rheometer.

If RHEO 2000 is installed on the PC, the REMOTE (MEASURE) program can be run and this operation can be ended at any time by the ST key. The current measurement is also aborted by pressing the ST key in REMOTE operation.

On completion of the communication with the PC, the LCD shows: “Remote done ...” Pressing the key ST will return the display to the Main Menu.

During measurement in REMOTE operation, the LCD will display various information which is used to provide troubleshooting information in case errors occur. This information should be disregarded.

VI.5.4 MAIN Menu → Utilities

Entry to open the “Utilities” submenu - see Section VI.6.

VI.5.5 MAIN Menu → Configuration

Entry to open the “Configuration” submenu - see Section VI.6.

VI.6 Menu Entries in the Utilities Menu

The Utilities menu contains several useful functions.

The Options:

Zero Calibration	Initiates the zero calibration procedure of the rheometer
Edit Programs	Input or modification of programs which are started with Program Measurement
Print Programs	Prints all parameters of all the programs in memory to the printer
Measuring Systems	Input of measuring system parameters or generation of new measuring systems
Print Memory	Output of data in memory to the printer or to the serial interface
Delete Memory	Clears all data from memory
Temperature Meas.	Measures temperature without running a measurement

The following sections explain these options in more detail.

VI.6.1 Utilities → Zero calibration

The function “Zero calibration” serves to calibrate the Rheometer zero point. This function continues for approximately 10 minutes and should be done once a week.

Before starting be sure the R/S-CPS+ Rheometer has warmed up for at least 10 minutes, and that NO measuring element is in the measuring element coupling.

Confirm the command that the measuring system is removed by pressing the OK key (start of zero point calibration), or press the ST key to return to the Utilities menu.

Zero point calibration will proceed automatically and comprises several measuring series at different speeds. The progress of calibration is shown by the number of executed steps of the total steps. If an error message appears during zero calibration, repeat the zero calibration. If the error message is displayed again there may be a technical defect (→ repair).

After successful calibration, the values of the zero point are stored internally. These values are preserved until the next calibration.

Press any key to return to the Utilities menu.

Note: You can abort zero point calibration at any time with the ST key. The zero point values determined up to that point will be ignored.

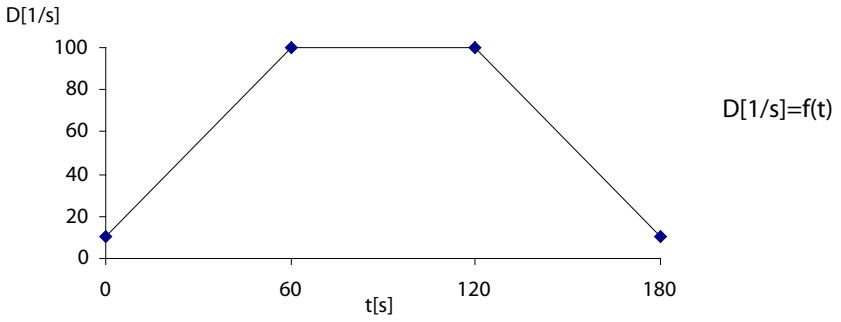
VI.6.2 Utilities → Edit Program

This function allows the input of new, and the modification of existing programs. The programs may be run after successful creation via the menu level "Program measurement" in the main menu.

The following values are user definable in a program:

- measuring system to be used
- preset value for measurement, e.g. shear rate D[s^{-1}]=f(t), as a function of time
- number of measuring points in the program
- duration of measurement

Preset value as a function of time:



A standard measurement shall serve as an example.

1st step: shear rate increases within 60 sec from 10.00 to 100.00 s^{-1}.
2nd step: shear rate remains at 100. 00 s^{-1} for 60 seconds
3rd step: shear rate decreases from 100.00 back to 10.00 s^{-1} within 60 seconds

This measurement consists of three steps, each lasting 60 seconds and containing a number of measuring points.

This example shall serve to explain the input of a program.

Apart from the shear rate D [s^{-1}] = f(t),
speed n [rpm] = f(t)
torque M [‰] = f(t)

shear stress Tau [Pa] = f(t)

can be used as preset values within a defined program. The ramps and straight lines of the preset values are linear (i.e., if the ramp time is 60 seconds and four readings are taken, the readings are taken at 15 second intervals).

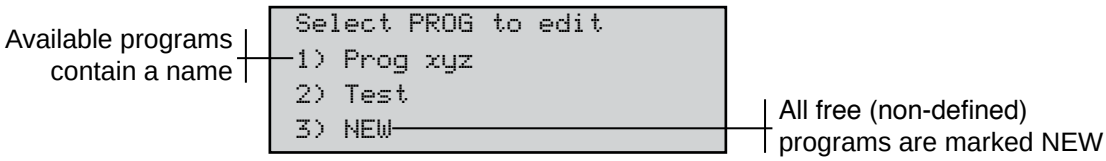
The assignment of user defined values to be processed in each measuring point is calculated with the following formula:

Δ Preset Value = End Value - Start Value/(Number of Measuring points - 1)

The first user defined value (=the first measuring point) is always the start value of the ramp. The last measuring point is determined as the end value of the user defined value range. As in our example, to reach the values D= 10, 20, 30, ... , 100 [s^{-1}] a starting value of 10 [$^{s-1}$] is used with increments of 10, therefore 10 measuring points is required. To check: 100-10/(10-1)=10.

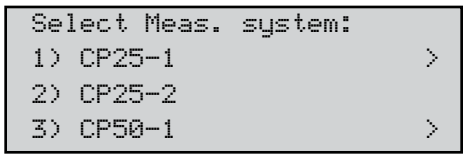
Back to the example.

After selection of the menu level “Edit Program” the user will be prompted to select the program.

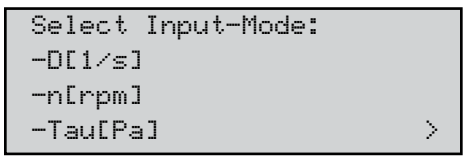


All free programs are initially marked as NEW. To avoid overwriting existing programs, select NEW as a program to be edited and select a measuring system.

Attention: Any defined program MUST ALWAYS be executed with the same measuring system, otherwise improper results will be calculated.



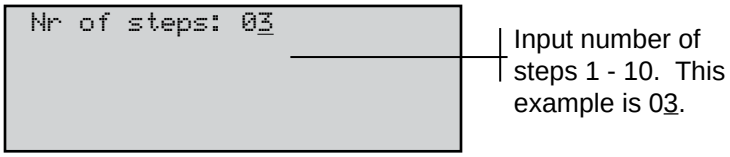
The measurement type is selected:



Available Measurement Types	User Defined Range
Shear Rate D{s^{-1}]	Depends on the measuring system
Speed n[rpm]	0.7 - 800 rpm
Shear Stress Tau [Pa]	Depends on the measuring system
Torque M[‰]	Output of data in memory to the printer or to the serial interface

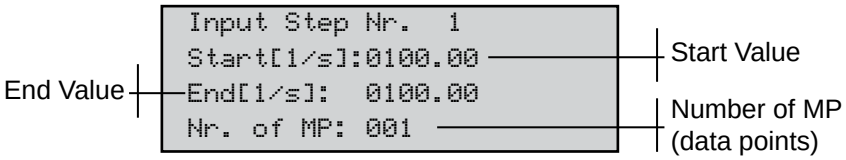
Select the type of measurement and press the OK key (in our example "D[1/s]"). Now enter the user defined values for each step one after the other.

Enter the number of steps (the number of ramp and straight line functions).



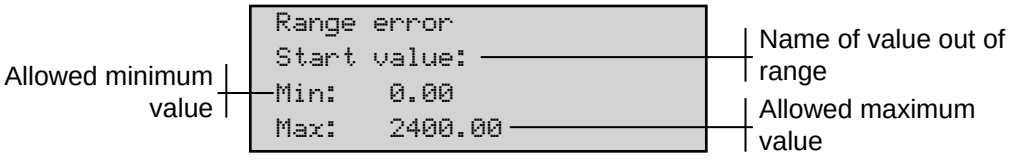
The number of steps can range from **1 to a maximum of 10 steps**. In this example, we need three steps, so the number "01" is changed to "03" - (seeinput of numbers - Section VI.4). The message "Range error" will appear if <1 or >10 is entered.

The following inputs have to be made for each step:



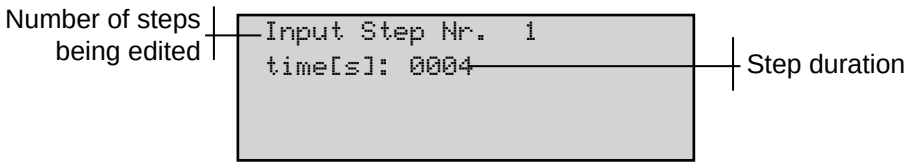
(Input of numbers: see Section VI.4)

Minimum and maximum Start and End values depend on the selected measuring system for shear rate (D[s^{-1}]) and shear stress (Tau [Pa]). At input, the Rheometer checks the Start and End values and indicates the message "Range error" if out of range:



For example, this message would be displayed if a start value for D[s^{-1}] is not within the range of 0 - 2400.00 s^{-1} when using measuring cone CP50-2.

If the Start value, End value and number of Measuring Points are acceptable, the user will be prompted for Step Duration:



Minimum step duration:

Available Measurement Types	User Defined Range
Shear Rate D{s^{-1}]	t_{min} = number of measuring points * 4 s
Speed n[rpm]	t_{min} = number of measuring points * 4 s
Shear Stress Tau [Pa]	t_{min} = number of measuring points * 1 s
Torque M[‰]	t_{min} = number of measuring points * 1 s

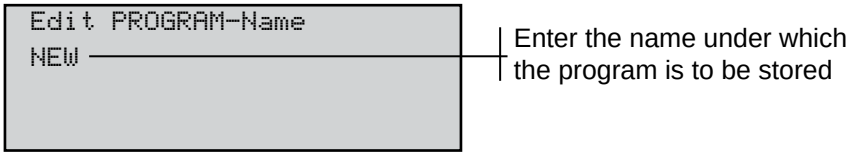
Maximum step duration: **3600 s**

The instrument will automatically check the input. If there is a range error, "Range error" will be displayed together with the allowable range.

The more time between two measuring points, the higher the accuracy of the determined physical parameters!

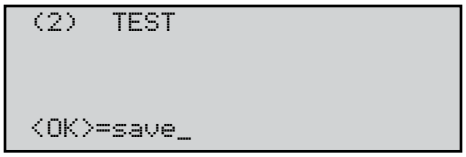
The input procedure for Start and End value, number of Measurement Points and Step Duration is repeated for the next step (step 2). The procedure is repeated until all steps have been entered.

The program will then prompt the user for a program name.



For this example, we will use "TEST". (For the input of alphanumeric texts see Section VI.4)

The instrument will prompt the user to store the Program with the Name:



Press OK to store the program.

If any other key besides OK is pressed, the entries are abandoned and those parameters of the program position existed before editing will be preserved.

VI.6.3 Utilities → Print Programs

This function will print the parameters of the defined programs in memory.

If the printer is not ready for operation when the "Print Programs" function is initiated, the following error message will be displayed:

```
ERROR # 1
Printer not ready!

<OK>cont.  <ST>stop
```

If this error message appears, ensure the printer is ready and contains paper.
Press OK to try printing again or press ST to return to the menu.

VI.6.4 Utilities → Measuring Systems

This function provides a method to create new measuring systems or change existing measuring systems.

The following values can be edited:

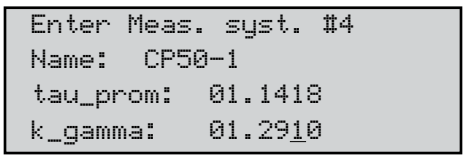
- name of measuring system
- shear rate factor K([min/s] (k_gamma)
- shear stress factor (‰ [Pa] (tau_prom)

Only authorized personnel are permitted to change constants of the measuring system!

After starting the function, you will be prompted to select the measuring system you want to edit. Select the list item "NEW" to generate a new measuring system.

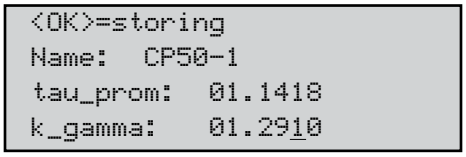
```
Select Meas. system:
1) CP25-1              >
2) CP25-2
3) CP50-1              >
```

After selection of the measuring system entry the user is prompted to enter Name, tau_ prom and k_gamma.



The measuring system Name is entered in alphanumeric form, the factors tau_ prom and k_gamma entered as numerical entries (see Section VI.4).

After entry, the system will prompt the user to store the new parameters.

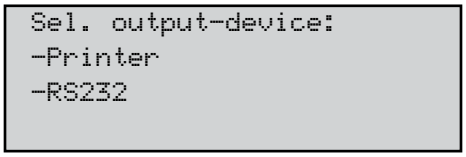


Use OK to store the new information, otherwise press the ST to return to the menu without storing.

VI.6.5 Utilities → Print Memory

This function allows the output of the data stored in the instrument memory to either a printer or to the RS232 serial interface of the Rheometer.

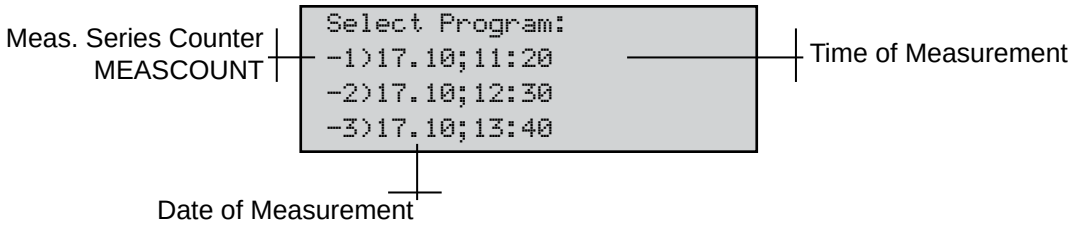
The instrument will prompt you to select the output device, as follows:



a) Output to printer:
The printer must be connected to the Rheometer and ready for operation.

b) Output to the RS232 serial interface:
The data receiving side (typically a PC) must be set to No Handshake. If the receiving side is not set up properly, the data will either not be transmitted or transmitted to Null. (see Section VI.8 “Serial Data Transfer”).

After choosing the output device you are prompted to select the program to be printed or transferred.

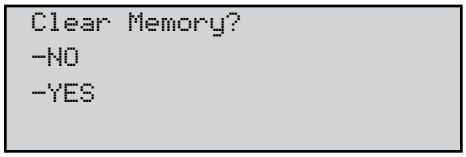


The data of the program will print as a table to a printer or will be transferred via the serial interface. After completion of data transfer, the Rheometer returns to the Utilities Menu.

VI.6.6 Utilities →Clear Memory

This function deletes all measured data stored in the memory of the R/S-CPS+ Rheometer.

Before deleting, ensure that the data has been archived to a printer or PC. Before the memory is cleared, the following prompt is displayed:

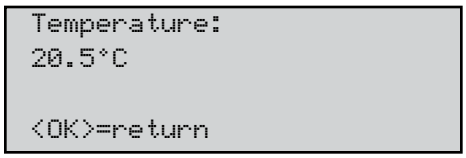


If "YES" is selected, the results will be cleared from the memory; if "NO" is selected, no deletions are made and the user is returned to the menu.

VI.6.7 Utilities →Measure Temperature

This function displays the temperature with the temperature sensor connected to the Rheometer.

After initiating this function the temperature is measured permanently:



Push the OK key to return to the Utilities menu.

VI.7 Menu Entries of the Configuration Menu

The Configuration menu allows the user to set parameters on the Rheometer.

The entries:

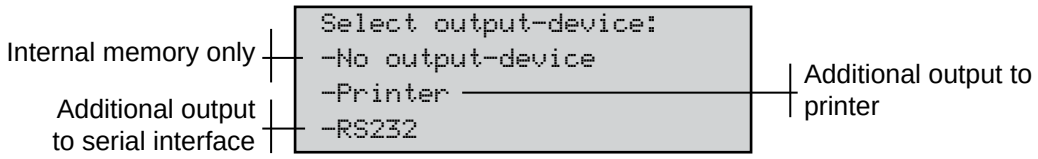
- **Set output-mode:** Defines if data is output to a printer or to the serial interface during measurement.
- **Set meascount mode:** Defines whether the measurement counter MEASCOUNT is reset daily or not.
- **Reset meascount:** Resets the MEASCOUNTcounter to 0.
- **Set time/date:** Input of date and time.
- **Set RS232 param.:** Sets data transfer parameters of the serial interface.
- **Language:** Selects language for user prompts.
- **Service:** For service personnel only
- **Service2:** For service personnel only

These functions are explained in more detail in the following sections.

VI.7.1 Configuration →Output Mode

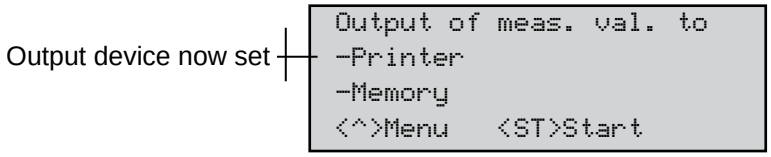
This function defines the output device (printer, serial interface) which will receive the results. This setting is independent of the internal storing of results in memory. When tests are run, the data is automatically stored in memory in addition to the configured output device.

After selecting this function you are prompted for possible output devices:



Choice of an output device is stored in the instrument by pressing the OK key. **This selection remains stored even after switching off the instrument!**

The set output device is prompted before the start of every measurement (see also “Main menu-> Single measurement” and “Main menu-> Program measurement”).



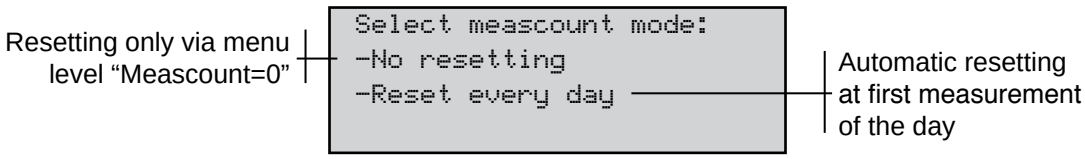
After selecting an output device ensure that before the start of every measurement:

a) PRINTER: the printer is connected to the Rheometer and is ready for operation. If the printer is not ready, you cannnot start the measurement.

b) SERIAL INTERFACE (RS232): the receiving device (normally a PC) is set to the data transfer parameters of the Rheometer (see Section VI.7.5 “RS232 Parameters”) and ready to receive data. If the receiving side is not ready, the data will not be transmitted or will be transmitted to Null (see Section VI.8 “Serial data transfer”).

VI.7.2 Configuration →MeasCount Mode

The measurement series counter MEASCOUNT increases by 1 before each measurement is started. The measurement series counter serves to identify a measurement series. The counter increments until it is reset manually (“MeasCount=0”) or automatically. The user defines whether the measuring counter is reset daily or not.



After choosing one of two reset modes the user will be returned to the Configuration Menu.

VI.7.3 Configuration →MeasCount=0

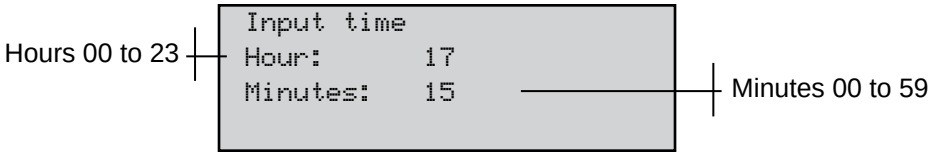
This function resets the measurement series counter to Zero regardless of the set MEASCOUNT mode.

Resetting is initiated by answering YES to the YES/NO prompt.

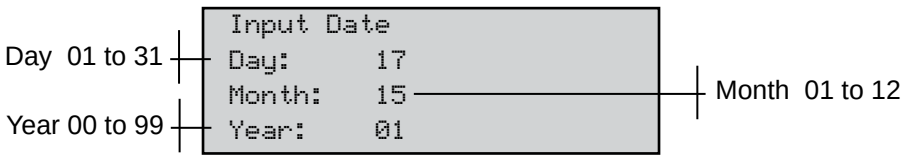
VI.7.4 Configuration →Time/Date

This function allows the user to set the internal clock and internal calendar.

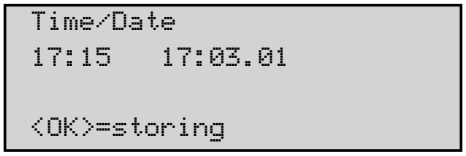
The time is set in 24 hour format.



The date is set as dd.mm.yy format:



After setting time and date you will be prompted to store the clock to the new time.



Set the time using the OK key, or return to the menu without storing by pressing ST.

Note: The new time is entered into the clock only after the OK key is pressed. Note that storing of the time sets the seconds to 00.

VI.7.5 Configuration →RS232 Parameters

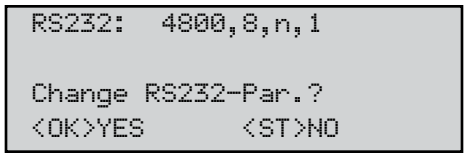
This function allows the preselection of interface parameters.
The serial interface operates **without handshake**.
Data is transferred as **ASCII text**.

Parameters to Set	
Baud rate [Baud]	110, 150, 300, 600, 1200, 2400, 4800, 9600, 19200
Parity	n(= no parity) e(=even) o(=odd)
Stopbits [Bit]	1 or 2
Databits [Bit]	7 or 8

The standard setting is:
Baud rate = 4800
Parity = n
Stopbit = 1
Databits = 8

If you change these settings, you must set the receiving device to the new transfer parameters as well!

After starting the function “RS232 Parameters” the current settings will be shown:

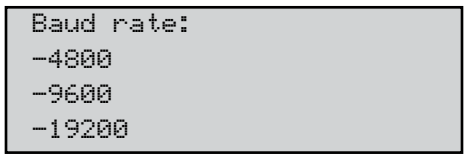


Press the OK to initiate the input of parameters.

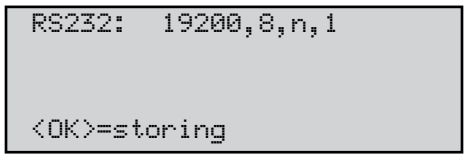
You may enter the following parameters in succession:
- Baud rate [Baud]: 110, 150, 300, 600, 1200, 2400, 4800, 9600, 19200
- Databits [Bit]: 7 or 8
- Parity: n (=none) e(=even) o (=odd)
- Stopbits [Bit]: 1 or 2

Select the required parameter from the list of available parameters and accept by pressing OK.

Example Baud rate:



When all parameters have been selected the new parameters are displayed:



Accept the set parameters by pressing OK.

The new settings are now stored and will remain in the memory even after switching off the instrument.

VI.7.6 Configuration →Language

This function selects the user language of the R/S-CPS+ Rheometer. Available languages are:
- German
- English

Select desired language and press OK. The selected language will be preserved in the instrument even after it is switched off.

VI.7.7 Configuration →Service

These functions are for service personnel only. Password-protected!

VI.8 Serial Data Transfer via the RS232 Interface

Serial data transfer should only be done when the user of the Rheometer has basic knowledge of data processing and is capable of changing data transfer parameters on the sending and receiving sides.

Data can only be transferred successfully when transmitter (=R/S-CPS+ Rheometer) and receiver (e.g. a PC) fulfill the following requirements:

1. The instruments are properly connected by the interface cable which is delivered with the instrument. **Caution: Both instruments must be switched off while the connection is made!** (Pin assignment: see Appendix to this documentation).

2. The transmitter (R/S-CPS+ Rheometer) and the receiver are set to identical data transfer parameters (for R/S-CPS+ Rheometer, see Section VI.7.5. “RS232 Parameters”).

3. **The receiver** has enough computing and memory capacity to receive or store the data.

The following example demonstrates reception by means of the terminal program under Microsoft™ Windows.

1. Switch the Rheometer and the PC off.

2. Connect the Rheometer (connector RS232 at the back side of the instrument) with a free serial interface (e.g. COM2) of the PC. Use the cable supplied by Brookfield.

3. Switch the PC and the Rheometer on.

4. Set the data transfer parameters at the Rheometer (see Section VI.7.5). Here: Standard setting 4800 Baud, Parity n, Stopbit 1, Databit 8.

5. Select the RS232 interface as the output device at the Rheometer (see Section VI.7.1).

6. Open the “Windows Accessories” program group on the PC.

7. Start the “Terminal” program.

8. Select the menu level “Settings” →“Data transfer.”

9. First, a window will appear where you can set the data transfer parameters:
   - Select from “Connection” the COM-port to which the Rheometer is connected.
   - Set “Baud rate” to “4800”.
   - Set “Databits” to “8”.

- Set “Stopbits” to “1”.
- Set “Parity” to “No parity”.
- Set “Protocol” to “No protocol”.
- Deactivate “Parity check” checkbox (if crossed).
- Deactivate “Carrier signal detection” checkbox (if crossed).
- Finish input by pressing OK.

10. Select the menu option “Settings” → “Terminal Settings”
    A window will appear where the user can set the terminal functions:
    - Select “English” option.
    - Activate “IBM in ANSI” (if not crossed yet).

11. Parameters of the terminal program that have been changed up to this time can be stored under the menu option “File” → “Store” by entering the file name, e.g. “R/S-CPS+ Rheometer.TRM”.

    (When the terminal program is started again, this file with can be opened by: “File” → “Open” and load the parameters for data transfer with the R/S-CPS+ Rheometer.

12. Now select the menu level “Transfer” → “Text file reception”.
    - Enter the file name under of the stored data sent from the Rheometer (e.g. “TEST.TXT”).
    - The message “Receiving: TEST.TXT” will then appear in the status line of the terminal program.

13. The terminal program is now ready to receive data (for more detailed instructions or troubleshooting on the terminal program, please read your documentation).

14. Start measurement with the Rheometer. Measuring points should appear as text on the PC display after a short period of time.

15. When the data of one or several measurements have been transferred into the selected text file, terminate the data transfer and end the terminal program.

Should a receiver other than a PC be used for serial data transfer, the pin assignment of this receiver must be checked before the connection is made. You can find the pin assignment of the serial interface plug as well as of the data link cable in the Appendix to this documentation.

VII. Measuring

VII.1 Measuring in Manual Operation

You can measure in manual mode by following these brief instructions:

- Install the R/S-CPS+ Rheometer (see Section III).
- Connect the AC adapter (see Section III).
- Connect the printer, which is optional (see Section III).
- Attach the Measuring System, load the sample (see Section V).
  Make sure no substance or solvent enters the measuring element coupling, the measuring drive or the electronic unit.
- If doing a temperature-controlled measurement, wait until the sample reaches the desired temperature.
- Start a Single Point Test or a Program Measurement (see Section VI).
- After running the test, clean the sample area and Measuring System.

VII.2 Measuring in Remote Operation

- Install the R/S-CPS+ Rheometer (see Section III).
- Connect the AC adaptor (see Section III).
- Connect the proper cable to the Rheometer and PC.
- Switch on the R/S-CPS+ Rheometer and select the menu level **"Remote"**.
- Switch on the computer and all peripheral devices.
- Start the RHEO 2000 software.
- Load a Program within the software
- Attach the Measuring System, load the sample (see Section V).
  Make sure no substance or solvent enters the measuring element coupling, the measuring drive or the electronic unit.
- If doing a temperature-controlled measurement, wait until the sample reaches the desired temperature.
- Start a Single Point Test or a Program Measurement (see Section VI).
- After running the test, clean the sample area and Measuring System.

VIII. Technical Data

R/S-CPS+ Rheometer	
Dimensions	480 mm x 300 mm x 290 mm
Weight	12 kg
Nominal operating voltage Power consumption (average) Power consumption (maximum)	± 15V, 5V 22W 22W
Ambient Conditions Temperature in operation out of operation Relative humidity (not condensable) in operation out of operation	 10° to 40°C 10° to 45°C 20% to 80% 10% to 90%
Accuracy	± 5.0% of stated value
Torque range	0.05 to 50 mNm
Torque resolution	0.01 mNm
Speed range	0.01 to 1,000 min^{-1}
Angle resolution	15.7µrad
Temperature range	-20° to +250°C depending on the thermostatting device used
Range of shear rate	0 to 6,000 s^{-1} depending on the thermostatting device used
Range of shear stress	0 to 16,000 Pa depending on the thermostatting device used
Viscosity range The given range is a standard value (not maximum value)	0 to 10,000 Pa•s depending on the thermostatting device used. Practical low limit is .050 Pa•s for cone/plate measurement.

AC Adapter	
Dimensions	160 mm x 85 mm x 35 mm
Weight	0.5 kg
Power supply Operating voltage Output voltage Output current Output power	 100 to 240 VAC 5V, ± 15V DC 2A, 0.9 / -0.2A 20W
Frequency	50 to 60 Hz
Ambient Conditions Temperature in operation out of operation Relative humidity (not condensable) in operation out of operation	 +10° to +40°C +10° to +45°C 20% to 80% 10% to 90%

Preset, Measured and Evaluated Values

Value	Symbol	Physical Unit
Speed	n	[min^{-1}]
Torque (relative) (1000 ‰ = 50 mNm)	M	[1}
Temperature	T	[°C]
Time	t	[s]
Shear rate	$\dot{\gamma}$	[s^{-1}]
Shear stress	τ	[Pa]
Dynamic viscosity	η	[Pas]

IX. Guarantee

Brookfield Engineering Laboratories guarantees the faultless functioning of this instrument insofar as it is used and maintained appropriately and connected and handled in accordance with this Operating Manual.

The guarantee period shall be 1 year from the date of delivery.
The place of guarantee fulfillment is Brookfield Engineering in Middleboro, MA (USA).

All claims of the customer concerning guarantee and damages shall be forfeited if he has handled the supplied goods improperly, worked on them, or given them to a third party for reworking without our prior approval.

The total liability of Brookfield Engineering Laboratories and your exclusive claim shall be limited, at Brookfield´s choice, to either

(a) the refund of the price paid

or

(b) the repair or replacement of the instrument which does not meet the requirements of the limited guarantee of Brookfield Engineering Laboratories and has been returned with a copy of your receipt to Brookfield Engineering Laboratories. This limited guarantee shall not apply if the instrument's failure is a result of accident, misuse or incorrect application. For a replacement delivery Brookfield Engineering Laboratories guarantees only for the rest of the original guarantee period or for 30 days, whichever is longer.

Brookfield Engineering Laboratories precludes any further guarantee for the instrument and related manuals and written materials.

Neither Brookfield nor the suppliers of Brookfield shall be liable for any damages (lost profit, business interruption, loss of business information or of data or any other financial losses included) that arise due to usage of this Brookfield product or due to the inability to use this Brookfield product, even if Brookfield was informed of the possibility of such damage occuring.

In any case, the liability of Brookfield Engineering Laboratories shall be limited to the amount paid for this product. This exception shall not apply to damages which were caused by intention or gross negligence on the side of Brookfield. Nor shall claims be affected that are based on mandatory laws concerning product liability.

Furthermore the guarantee conditions of "General Delivery Conditions for Products and Services of the Electric Industry" are valid.

Appendix A

A.1 Data Sheets of Standard Measuring Systems

Table A-1: ***Cone/Plate Measuring Systems according to DIN 53018***
(consisting of measuring cone and the bottom measuring plate of the instrument)

Measuring System	C25-1	C25-2	C50-1	C50-2	C75-1	C75-2
Shear rate range [s^{-1}]	0-6,000	0-3,000	0-6,000	0-3,000	0-6,000	0-3,000
Shear stress range [Pa]	0-12,223	0-12,223	0-1,528	0-1,528	0-452	0-452
Viscosity range [Pa•s]	0.25-1,629	0.5-3,259	0.03-203	0.06-407	0.009-60	0.02-120
Filling volume [ml]	0.08	0.3	0.7	1.5	2.0	3.9
Shear rate factor $K\dot{\gamma}$ [min/s]	6.00	3.00	6.00	3.00	6.00	3.00
Shear stress factor $\tau‰$ [Pa]	12.223	12.223	1.528	1.528	0.4527	0.4527
Radius of measuring cone R [mm]	12.5	12.5	25	25	37.5	37.5
Angle of measuring cone α [°]	1	2	1	2	1	2
Cone truncation [µm]	50	50	50	50	50	50

The data in the following table is for plate/plate systems and is valid for a measuring gap of 1 mm. For other plate distances, please calculate $K\dot{\gamma}$ with the formula:

$K_\gamma = (2\pi/60) * (R/H)$ R = radius, H = gap

Table A-2: ***Plate/Plate Measuring Systems according to DIN 53-018***
(consisting of measuring plate and the bottom measuring plate of the instrument)

Measuring System	P25	P50	P75
Shear rate range [s^{-1}]	0-1,308	0-2,600	0-3,925
Shear stress range [Pa]	0-16,298	0-2,037	0-603
Viscosity range [Pa•s]	1.56-9,960	0.097-623	0.02-122
Filling volume [ml]	0.5	2.0	4.5
Shear rate factor $K\dot{\gamma}$ [min/s]	1.309	2.6175	3.927
Shear stress factor $\tau‰$ [Pa]	16.2975	2.037	0.6036
Radius of measuring plate R [mm]	12.5	25	37.5

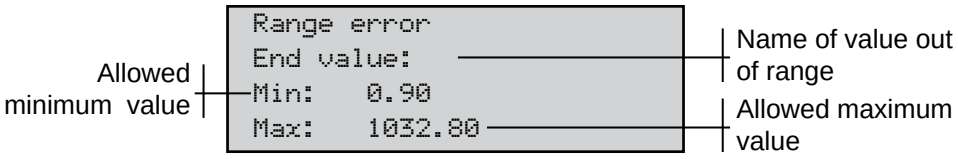
A.2 Error Messages

The R/S-CPS+ Rheometer is user-friendly regarding errors. When errors occur, they are trapped, and the user is informed on the LCD. The most frequent error messages are explained in this chapter.

Range Error

Cause: User's error at input. The user has tried to input a value that is less than the allowed minimum value or is more than the allowed maximum value.

Example of Faulty Input of a Preset Value:



What to Do: Enter the value again. Be sure that the new value is within the allowed value range.

Printer Error

Cause: The printer has been selected as the output device but is not ready for printing.
a] printer cable is not connected to the rheometer
b] paper is out, printer is not on line, other printer errors

Example of Print Error Message

What to Do:
a] make sure printer cable is connected to the rheometer
b] make sure paper try has paper
c] check that the "ready" LED lights of the printer are on
d] remove the error cause at the printer and press OK at the rheometer
e] press ST to abort the process if you cannot find the error cause.

Zero Calibration

Cause: An impermissibly high value was measured during the zero point calibration of the rheometer

Example Message

```
Error #3
Zero cal. error!
Please retry cal.
<OK> cont.     <ST> stop
```

What to Do:
a] press ST
b] ensure the measuring system has been removed from the rheometer
c] retry zero point calibration - if error occurs again, this is an indication of a fault in the measuring instrument

Abort: MOMMAX

Cause: The maximum torque has been exceeded during a measurement
a] utilization of the measuring range is inappropriate for the measured medium
b] rotation element choked in the measuring cup

Example Message

```
ABORT:torque max!
Single measurement
total time:      60 s
total no. of MP: 10
```

What to Do:
a] press OK
b] check whether the measuring system has been fastened properly at the rheometer
c] if fastened properly, select smaller shear rates or speeds for this measurement or use a measuring system with a higher shear stress factor

Abort: Speed Max

Cause: The maximum speed has been exceeded during a measurement
a] the selected shear stress or torque value for this measurement is too high
b] a torque or shear stress measurement has been started without substance in the measuring cup

Example Message

```
ABORT:speed max!
Single measurement
total time:      60 s
total no. of MP: 10
```

What to Do: a] press OK
b] select smaller shear stress or torque for this measurement

A.3 Pin Assignment of the Serial Data Cable

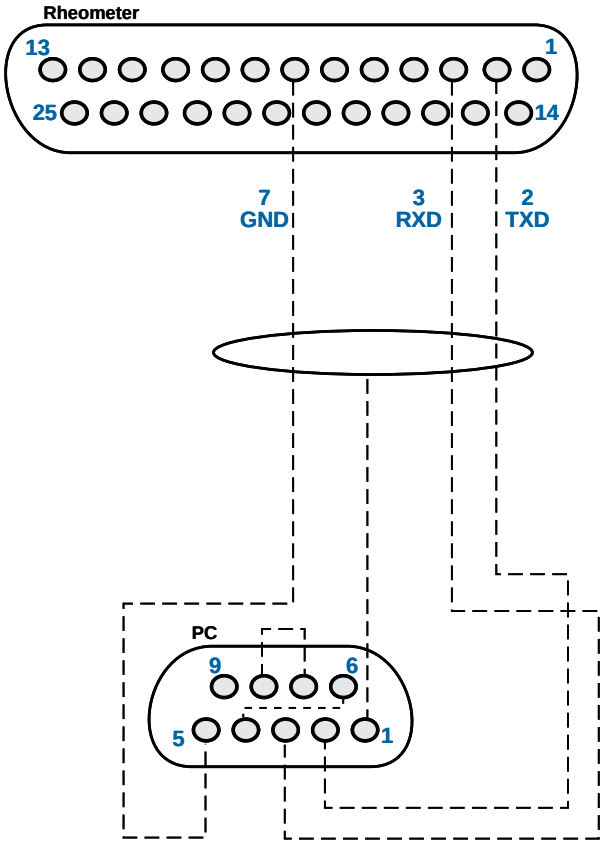
The R/S-CPS+ Rheometer is equipped with a serial interface with a 25-pin sub-D-connector (male) at the back side of the instrument. The serial interface is marked as RS232.

The signal levels are in the range of +12 V and -12 V in accordance with RS232.

Pin assignment of the serial data cable for serial data transfer to a PC:
Unmarked pins must not be connected!

Rheometer side:
25-pin Sub-D-connector (female)
View on soldered connections
All other pins must not be connected!

PC side:
9 pin, sub-D-connector (female)
View on soldered connection



A.4 Requirements to the AC Power Connecting Cables

The AC adapter unit of the R/S-CPS+ Rheometer permits operation of the Rheometer with supply voltages ranging from 100 to 240 VAC with frequencies from 50 to 60 Hz.

The main connecting cable supplied with the R/S-CPS+ Rheometer may not, in some cases, meet the requirements of every country. It is absolutely necessary that you use a main connecting cable that meets the specific requirements and regulations of the relevant country.

The following information explains the requirements that are to be taken into account when choosing the main connecting cable.

General information

- The connecting cable must be permitted (authorized) in the country where it is used.
- The coupler (i.e. the connection with the instrument itself, not the mains plug) must be suitable for the input socket type CEE22/IEC 320 (data sheet C14).
- The mains cable should be at least 2 m and at the most 3 m long.

USA and Canada

- UL-permission and CSA Certificate are required for the mains connecting cable.
- The following minimal requirements are valid for the cable:
  - No. 18 AWG
  - Type SV or similar
  - 3-phase
- The cable must have a nominal rating of at least 10 A.
- The main plug of type NEMA 5-15P (15A, 125V) or NEMA 6-15P (15A, 250V) must have grounding contact.

Japan

The following cable types and connection values are required in Japan:

- All parts of the cables (cable, socket and plug) must have brand name and registration number according to the Dentori law.
- The following minimal requirements apply to the cable:
  - 0.75 mm2, 2-phase
  - Type VCT or VCTF
  - 3-phase
- The cable must have a minimum nominal rating of 7 A.
- The mains plug must be a 2-pin plug with grounding contact according to the Japanese Industrial Standard C8303 (15A, 125V).

Other countries

- The connectors of the mains connecting cable must be approved and certified by the responsible authorities in the respective countries. These authorities are:

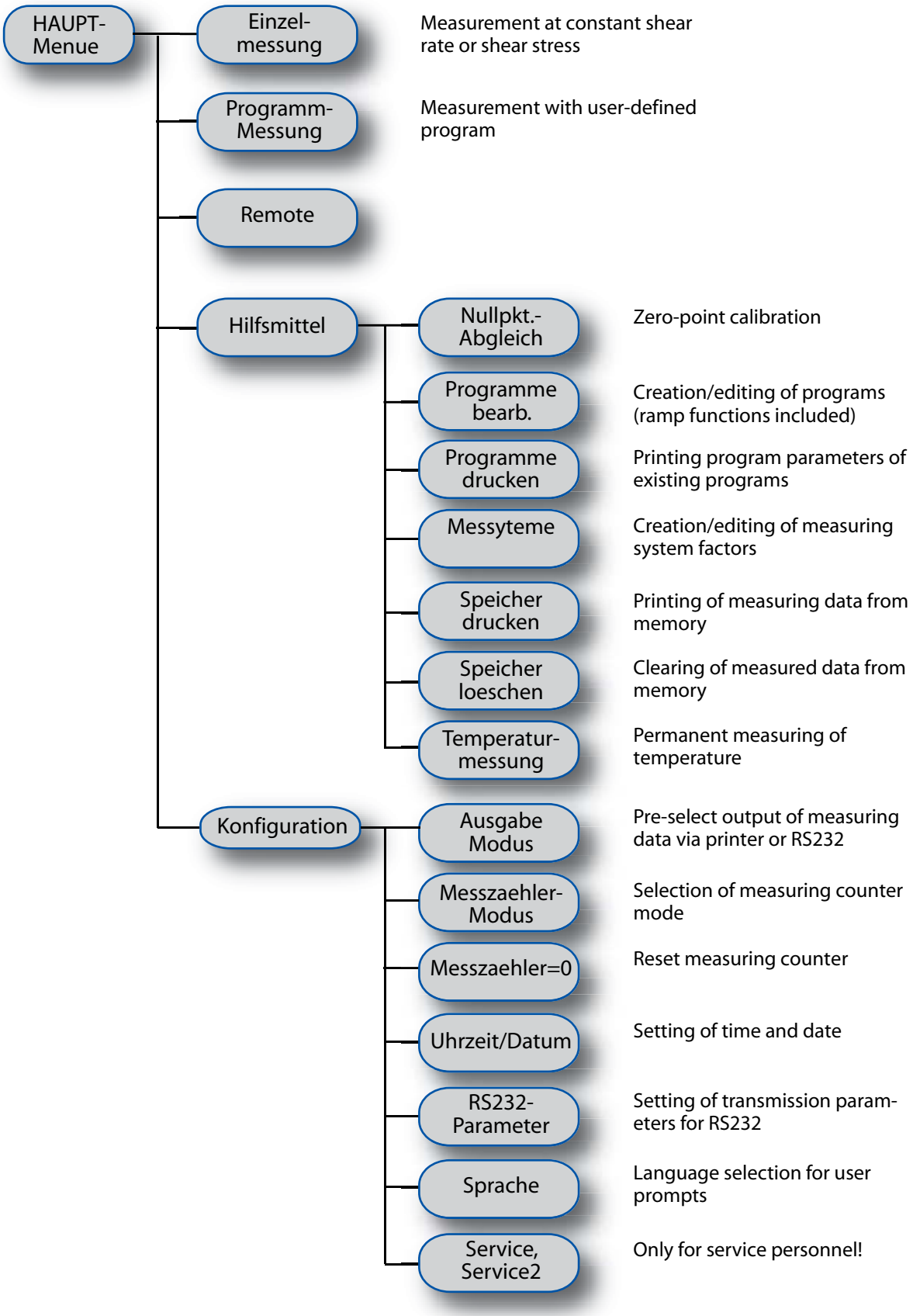
Australia — EANSW	Great Britain — BSI
Austria — OVE	Italy — IMQ
Belgium — CEBEC	Netherlands — KEMA
Denmark — DEMKO	Norway — NEMKO
Finland — SETI	Sweden — SEMKO
France — UTE	Switzerland — SEV
Germany — VDE	

- The cable must be three-phase HAR-cable, type HO5VV-F3, with a minimal phase cross-section of 1.0 mm^2. The main connecting cable must be permitted for a rating of at least 10 A and, depending on country, a nominal voltage of 125 V or 250 V AC.

A.5 Language Cross Reference

English	German	English	German
!M (0!	!M ->0!	Program end	Programmende
ABORT	ABBR.	Program running...	Programm laeuft...
Abort:speed max!	Abbruch Drehz. max!	Range error	Eingabe-Fehler
Abort:torque max!	Abbruch Mom. max.!	Remove meas. system!	Messystem entfernen!
Change RS232 Param.?	Aendern RS232-Par.?	Reset every day	taeglich ruecks.
Clear memory?	Speicher loeschen?	Reset meascount?	Messzaehler=0?
Continue	weiter	Return	zurueck
Enter Meas.sys.	Eing. Mess-Sys.	rpm	U/min
Enter program first!	Zuerst Eingabe Prog!	RS232	RS232
Enter PROGRAM name	Eing. Programmname	Run without mem.	Start o.Speicher
End value:	Endwert:	Store	Speichen
ERROR	FEHLER	Sel. output device:	Wahl Ausgabe-Geraet:
Input measuring id	Eingabe Mess-ID	Select input Mode:	Auswahl Einhe
Input step No.	Eingabe Schritt#	Select meas.system:	Auswahl Messystem:
Input values:	Eingabe Werte:	Select PROG to edit	Welches PROG bearb.?
Meascount	Messzaehler	Select PROG to run	Auswahl Programm
Meascount mode	Messzaehler-Modus	Select program:	Auswahl Programm:
Measuring systems	Messsysteme	Single mode	Einzelmessung
Memory cleared!	Speicher geloescht!	Start value:	Startwert:
Memory	Speicher	Stop	Stop
No free memory!	Kein Speicher frei!	Temperature	Temperatur
No output device	kein Ausgabegeraet	Time	Zeit
No reset	nicht ruecksetzen	Time/Date	Uhrzeit/Datum
No valid data!	keine guelt. Daten!	Todays date	Heutiges Datum:
No valid programm!	Kein guelt. Progr.!	Total #MP:	Gesamt #MP:
NO	NEIN	Total time:	Gesamtzeit:
Not valid	nicht gueltig	User-abort!	Abbruch Benutzer!
Nr. of steps	Anzahl Schritte	User-defined programs	Benutzerdef. Programme
Output of meas.val. to:	Ausgabe Messwerte:	Voltage control	Spannungsversorgung
Please do DAC-CAL!	DAC-Kal. notwendig!	Wait for 1.MP	Warte auf 1.MP
Please do ZERO-CAL!	ZERO-Kal. notwendig!	Wait for RS232...	Warte auf RS232...
Please wait...	bitte warten...	YES	JA
Press any key...	Taste druecken...	Zero cal. done...	Abgleich fertig...
Printer not ready!	Drucker n. bereit!	Zero cal.running...	Abgleich laeuft...
Printer	Drucker	Zero calibration	Nullpkt.abgleich
Printer-Error!	Drucker-Fehler!		

German Menu System of R/S-CPS+ Rheometer



Appendix B Calibration Check Procedure

B.1 Equipment

R/S-CPS+ Cone/Plate Rheometer with appropriate cables
Temperature control apparatus[1]
Flat edged non-metal spatula
Cone Spindle and Certified Mineral Oil Viscosity Standard:
One of the following[2]:

- RC25-1 Cone Spindle with Fluid B41000
- RC50-1 Cone Spindle with Fluid B11000
- RC50-2 Cone Spindle with Fluid B41000
- RC75-1 Cone Spindle with Fluid B4900
- RC75-2 Cone Spindle with Fluid B4900

RHEO2000 Applications Software loaded onto a PC (optional)

Reminders/Comments:

- A calibration check can be performed with or without software.
- The rheometer should always be allowed 10 minutes minimum to warm up.
- Never lift your rheometer by the head, shaft, coupling element, or measuring element coupled to the machine.
- After the spindle has been lowered on to a sample, uncouple the spindle from head before raising the head.
- Total time to perform a calibration check is approximately 50 minutes.

B.2 Setup Procedures

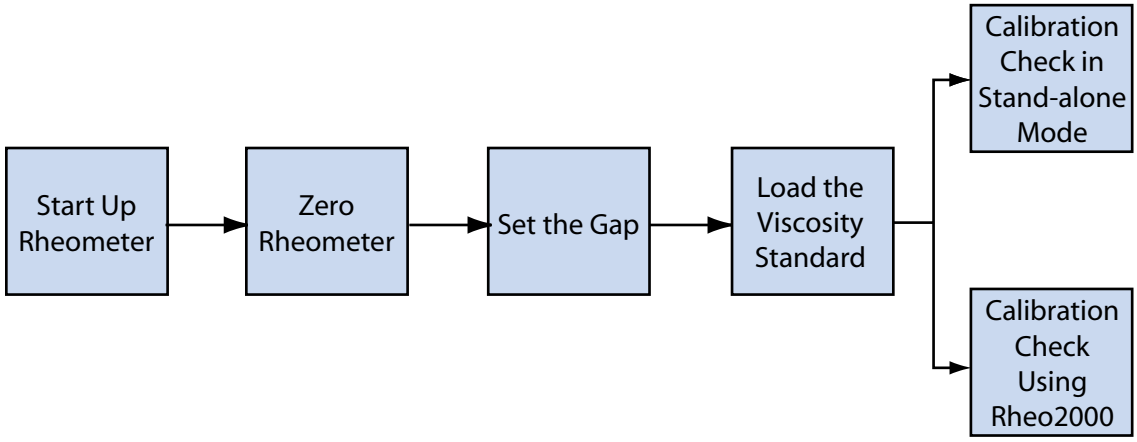


Figure B-1: Flow Chart for Calibration Check Procedure

1. Turn on the R/S-CPS+ Rheometer.

2. Turn on the temperature controller. Set the controller to 25°.

1 Temperature control apparatus consists of one of the following: Peltier System, Water Bath, Oil Bath or Electronic Heat.
2 Calibration Check using either an RC25-1 or RC25-2 is not advised.

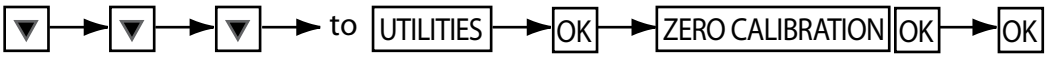
3. Allow the R/S-CPS+ Rheometer to be on for a minimum of 10 minutes prior to taking measurerment data or running a zero calibration.
   - Zero Calibration does not have to be executed prior to every test, but should be run no less than once a week.
   - Zero Calibration takes approximately eight (8) minutes.
   - *Best Practice:* run the R/S-CPS+ Rheometer at 100 rpm for 30 minutes just prior to zero calibration.

4. Ensure the spindle is not installed on the R/S-CPS+ Rheometer.

5. Lower the rheometer head.

6. Lower the spindle coupling collet.

   Select the zero calibration option and push the OK button.



8. Upon successful completion of the zero calibration procedure, the rheometer head will display a message. Press OK to save the information. If an error message appears, check the Troubleshooting section of this document. If the problem cannot be fixed, contact Brookfield or an authorized dealer for troubleshooting advice.

B.3 Setting the Gap

1. Raise the rheometer head (handle forward).

2. Attach the designated spindle on the rheometer.

3. Loosen the set screw so the spindle shaft cone moves freely up and down by hand.

4. Lower the rheometer head so spindle and plate are in contact.

5. Allow the spindle to come to temperature.

   NOTE: The greater the difference between the test temperature and ambient, the greater the time to come to temperature.

6. Raise the rheometer head.

7. With the rheometer head up, turn the micrometer ring to the zero point. Confirm this by observing the horizontal line on the instrument column and the vertical line on the micrometer ring line up as crosshairs. Turning the micormeter ring clockwise lowers the head; turning the micrometer ring counter-clockwise raises the head.

8. Move the micrometer ring clockwise past zero by one half revolution.

9. Move the micrometer ring counter-clockwise to the zero position and stop there.

   ***NOTE*: AFTER THIS STEP, NEVER TURN THE MICROMETER RING CLOCKWISE. A PRECISE GAP SETTING CANNNOT BE ASSURED OTHERWISE.**

   If the micrometer ring IS turned clockwise after this step, the gap setting procedure will need to be repeated starting from Step 7.

10. Lower the rheometer head (by moving the handle away from you) so that the spindle contacts the bottom pllate of the rheometer base and the rheometer head is bottomed out on the micrometer ring.

11. Manually turn the outside ring of the dial indicator so that the needle is on zero.

    Note: Each division on the dial indicator corresponds to 0.01 mm (or 10μm).

12. Move the rheometer head up and down to confirm that the dial indicator needle remains at zero when the rheometer head is in the down (measuring) position.

13. When the following three conditions are met: (1) rheometer head down, (2) micrometer ring set to zero and (3) the dial indicator needle reading zero - tighten the hexagonal nut on the spindle shaft.

14. Raise and lower the rheometer head, to confirm the dial indicator needle reads zero when the rheometer head is in the down (measuring) position.

15. Obtain the spindle truncation from the spindle data sheet that came with the cone spindle.

16. Raise the rheometer head.

17. Turn the micrometer ring counter-clockwise to the truncation point from the spindle data sheet.

18. Lower the rheometer head.

    Note: The dial indicator needle will provide visual confirmation of a proper gap setting. For example, a gap setting of 0.05mm will produce a dial indicator reading of 45. A gap setting of 0.04mm will produce a dial indicator reading of 46. A gap setting of 0.06mm will produce a dial indicator reading of 44.

19. Raise and lower the rheometer head to confirm the dial indicator reading remains consistent.

B.4 Loading the Viscosity Standard

1. With the spindle attached and the gap setting confirmed, raise the rheometer head (handle forward).

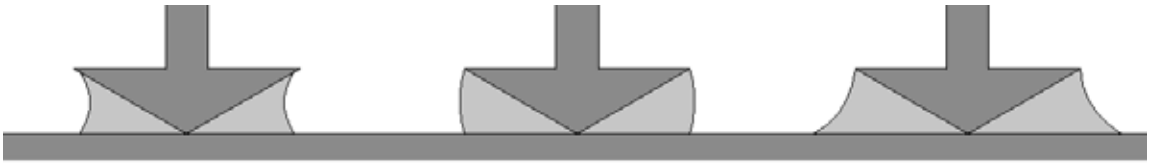
2. Using a non-metal spatula, place the viscosity standard onto the bottom plate of the rheometer directly below the spindle.

Measuring System (Spindle)	C50-1	C50-2	C75-1	C75-2
Approximate Fluid Volume (mL)	1	2	2.5	5

3. Lower the rheometer head onto the viscosity standard so the dial indicator needle reads the proper gap setting for that spindle.

4. There should be viscosity standard visible around the entire edge of the spindle.

5. Trim excess viscosity standard from the edge using a non-metal spatula:



6. Wait fifteen minutes or more to allow the sample to come to temperature.

B.5 Calibration Check Procedure

The R/S-CPS+ calibration check can be performed with or without software. If software is not being used, proceed to *B.5.1 Calibration Check in Stand-alone Mode*. If software is being used, proceed to *B.5.2 Calibration Check with RHEO2000 Software*.

B.5.1 Calibration Check in Stand-alone Mode

1. Input Measuring System's Constants
   a. On the rheometer head, select "Measuring System" within the **Utilities** menu.
   b. Select the appropriate measuring system.
   c. Set Tau-prom and K_gamma to value specified on the spindle's measuring system data sheet.

      Note: Tau-prom (Kt) is the Shear Stress Factor
      K_gamma (Kxxx) is the Shear Rate Factor

   d. Set Distance Dependence to zero.
   e. Save

2. Run Single Program
   a. Select “Run Single” within the Main-Menu
   b. Select the appropriate measuring system (e.g. C50-1)
   c. Select input mode: M[‰.]
   d. Input steps

Input Value:	
Val. [‰]:	250
Nr. Of Mp:	1
Time [s}:	120

   e. Input ID or leave blank. Press OK.
   f. Press ST to start.
   g. Allow the program to complete.

3. Check the temperature from the RS display (refer to the main manual for this procedure). The temperature should read 25.0°C.

4. Check the viscosity reading. The measured viscosity should fall within the stated viscosity value of the viscosity standard at the appropriate temperature.

5. Repeat Steps 2 through 4 with the torque ‰ (Val. [‰]:) set to 500 and 750.

B.5.2 Calibration Check with RHEO2000 Software

1. Launch RHEO2000 Software.

2. Enter Measure/Analysis Menu.

3. Select Remote on the R/S front display.

4. Open communication between the rheometer and the PC.

5. Load your Calibration Program. Refer to the RHEO2000 User’s Manual for the block programming procedure. Calibration program parameters should be set up as follows:

Step Nr 1	
Start [‰] :	250
End [‰] :	250
Nr. Of Mp:	40
time [s] :	120

Step Nr 2	
Start [‰] :	500
End [‰] :	500
Nr. Of Mp:	40
time [s] :	120

Step Nr 3	
Start [‰] :	750
End [‰] :	750
Nr. Of Mp:	40
time [s] :	120

6. Enter the following information in the general block data:
   a. Viscosity Standard Name (e.g. B11000)
   b. Lot Number
   c. Expiration Date
   e. Viscosity Value
   f. Spindle Serial Number

7. Upon test completion, click the Analysis button. The average viscosity of each step will appear in the bottom window.

8. Average viscosity reading should be within ±5% of the standard's stated viscosity value at the appropriate temperature.

B.5.3 Troubleshooting

Check each of the items below if your measured values fall outside the range of uncertainty:

a. Assure that the gap is set properly.
b. Assure that the temperature is set properly.
c. Assure that correct amount of calibration fluid is present and the gap is filled properly.
d. Assure that correct spindle constants are being used.
e. Assure that the rheometer has been zero calibrated.

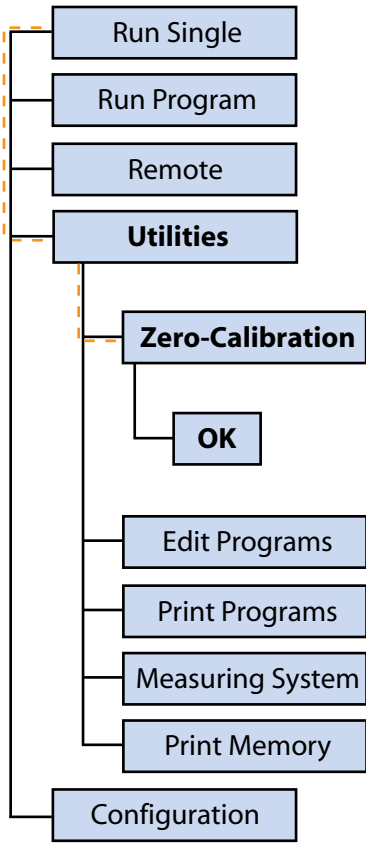
Error Messages

Message	Cause	Solution
Range Error	User input a value less than the allowed minimum value or greater than the allowed maximum value (Speed or Torque)	Check values. The R/S will advise the maximum and minimum values when this error is displayed.
Zero Cal. Error!	An unacceptable value was measured during the zero point calibration.	Ensure the spindle is not mounted to the R/S. Re-try zero calibration. If this fails, call for service.
ABORT: Speed Max!	Fluid is too thin to be run at requested Shear Stress/ Torque level. Alternatively, no fluid is present.	This should not happen following the proceding procedure.

Other Faults

Indication	Possible Cause	Solution
Dial indicator reading is inconsistent.	Set pin has lost hold power.	Pin may need to be replaced. Call for service.
Viscosity reading is low.	Micrometer ring was not lined up with zero on shaft. Head is too high.	Ensure spindle is not mounted to R/ S. Re-try zero calibration. If it fails, call for service.
Viscosity reading is low and spindles does not mvoe freely when hex nut is disengaged.	Contamination has entered the gap between the spindle cone piece and spindle shaft.	Loosen set screw. Extend spindle to maximum length. Clean shaft. Repeat if needed. If the spindle cannot be cleaned sufficiently, call for service of spindle.
Viscosity reading is low.	Rheometer has been placed in a drafty location.	Utilize solvent trap; shield unit from drafts.

B.5.4 Flow Diagram for Zero Calibration



B.5.5 Cone Spindle Data

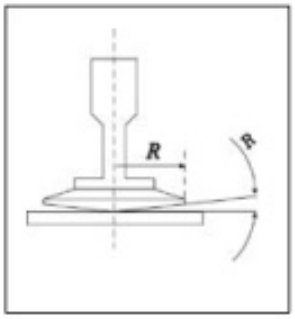
BROOKFIELD

Measuring System Data

Cone/Plate Systems according to DIN 53018

Shear Rate = $K\gamma.n$
Shear Stress = τ_{prom} .M

$K\gamma$ (K_gamma) = Shear Rate factor (s^{-1}/rpm)
n = rotational speed (RPM)
τ_{prom} (Tau_Prom) = Shear Stress factor (Pa/%)
M = torque (%)



Cone Number:			**680**			
Measuring System	C25-1	C25-2	**C50-1**	C50-2	C75-1	C75-2
Shear Rate Factor (K_gamma)			**5.8312**			
Shear Stress Factor (Tau_Prom)	12.223	12.223	**1.528**	1.528	0.4527	0.4527
Sample Volume (mL)	0.08	0.15	**0.6**	1.2	2	3.9
Radius R (mm)	12.5	12.5	**25**	25	37.5	37.5
Cone Angle a (.)			**1.029**			
Cone Truncation (mm)			**0.051**			

Appendix C: Warranty and Repair Service

Warranty

Brookfield Viscometers are guaranteed for one year from date of purchase against defects in materials and workmanship. They are certified against primary viscosity standards traceable to the National Institute of Standards and Technology (NIST). The Viscometer must be returned to **Brookfield Engineering Laboratories, Inc.** or the Brookfield dealer from whom it was purchased for no charge warranty service. Transportation is at the purchaser's expense. The Viscometer should be shipped in its carrying case together with all spindles originally provided with the instrument.

For repair or service in the **United States**, return to:

Brookfield Engineering Laboratories, Inc.
11 Commerce Boulevard
Middleboro, MA 02346 U.S.A.

Telephone: (508) 946-6200 FAX: (508) 946-6262
http://www.brookfieldengineering.com

For repair or service **outside the United States**, consult **Brookfield Engineering Laboratories, Inc.** or the dealer from whom you purchased the instrument.

For repair or service in the **United Kingdom**, return to:

Brookfield Viscometers Limited
1 Whitehall Estate
Flex Meadow
Pinnacles West
Harlow, Essex CM19 5TJ, United Kingdom

Telephone: (44) 27/945 1774 FAX: (44) 27/945 1775
sales@brookfield.co.uk

For repair or service in **Germany**, return to:

Brookfield Engineering Laboratories Vertriebs GmbH
Hauptstrasse 18
D-73547 Lorch, Germany

Telephone: (49) 7172/927100 FAX: (49) 7172/927105
info@brookfield-gmbh.de