Bruker Micro-Imaging

Rheo-NMR Accessory

Service Manual

002

Innovation with Integrity

NMR

This manual was written by

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1 Overview

The Rheo-NMR accessory for Bruker micro-imaging is available for wide bore and super-wide bore magnets.

The main components of the accessory include:

- Various rheometric cells, which are mounted into the Micro 2.5 or MicWB40 probe types.
- A stepper motor and gear box with control electronics to rotate the rheometric cells.
- A drive shaft to connect the motor with the rheometric cell.
- Various mechanical items.

These parts are mounted into a wide bore shim system and adapted to a Micro 2.5 imaging probe with gradient system and a 25 mm ID exchangeable RF-resonator.

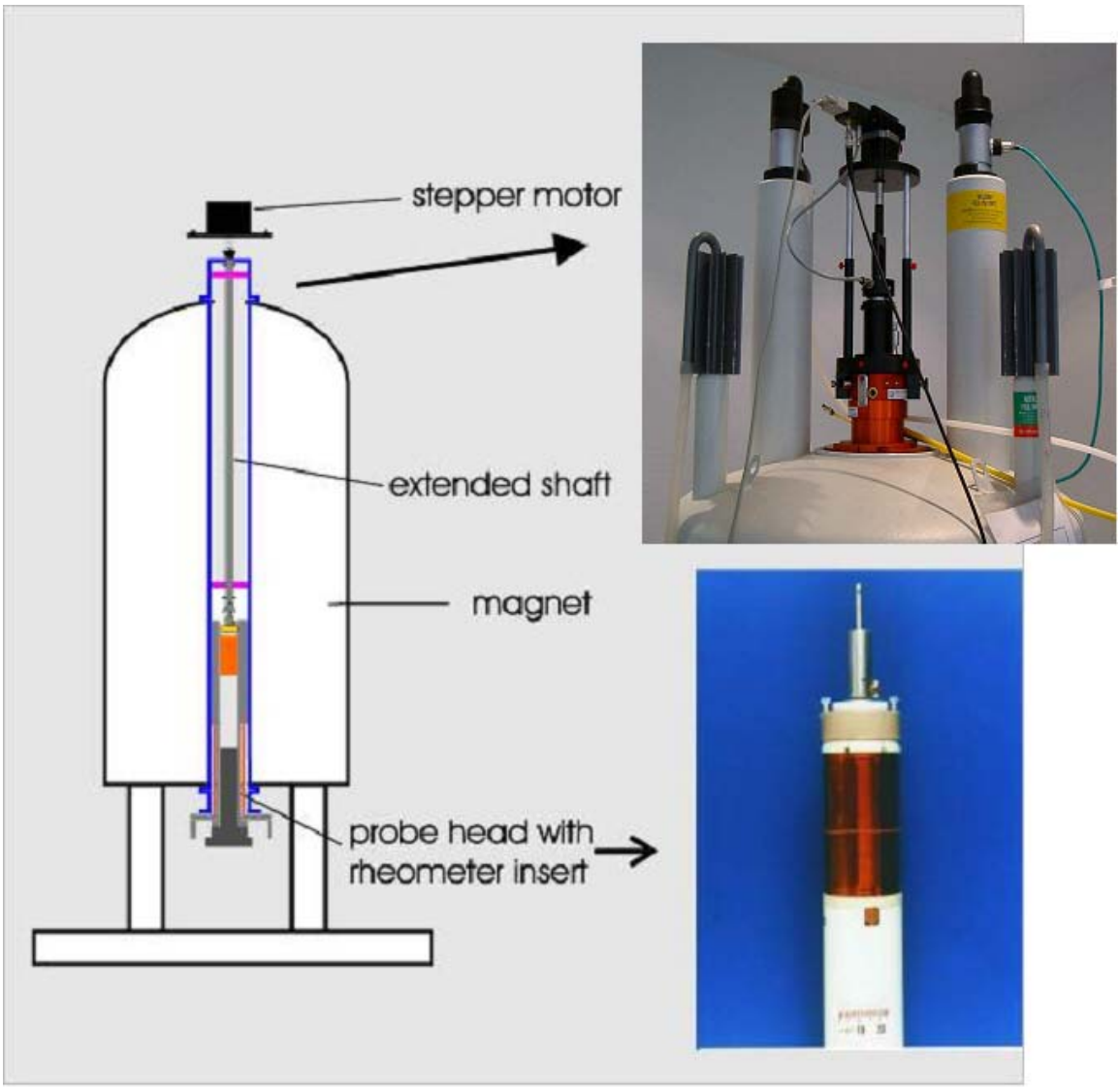


Figure 1.1: Rheo NMR Accessory Overview

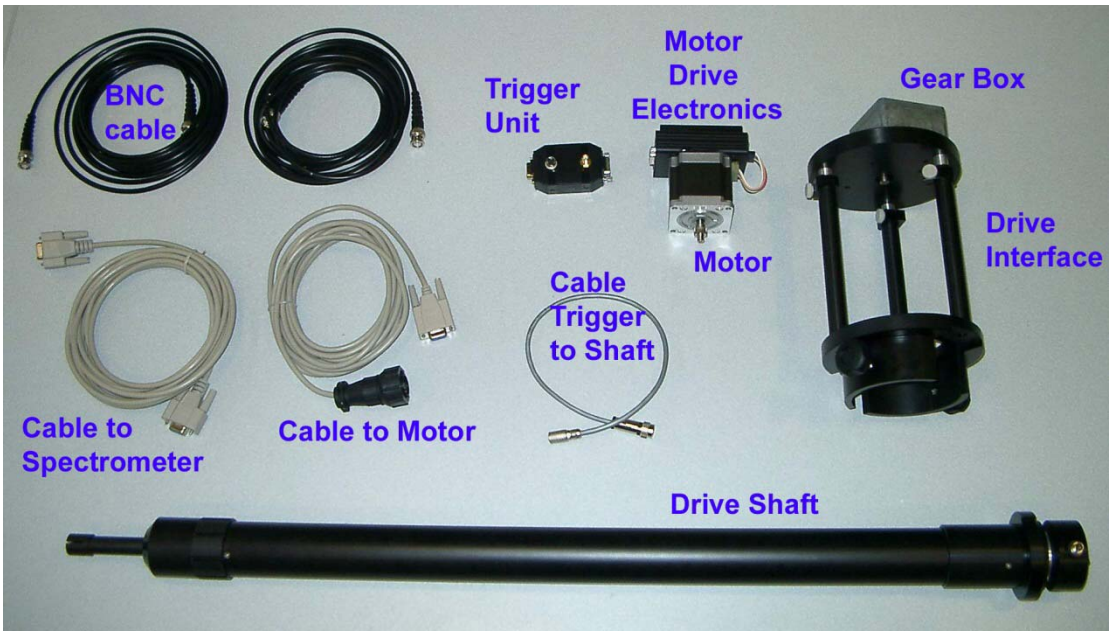


Figure 1.2: Rheo Shaft, Drive Interface with Gear Box, Rheo Motor, Trigger Unit and Cables

Note: The trigger unit is integrated into the motor drive electronics with the version for AVANCE III spectrometers.

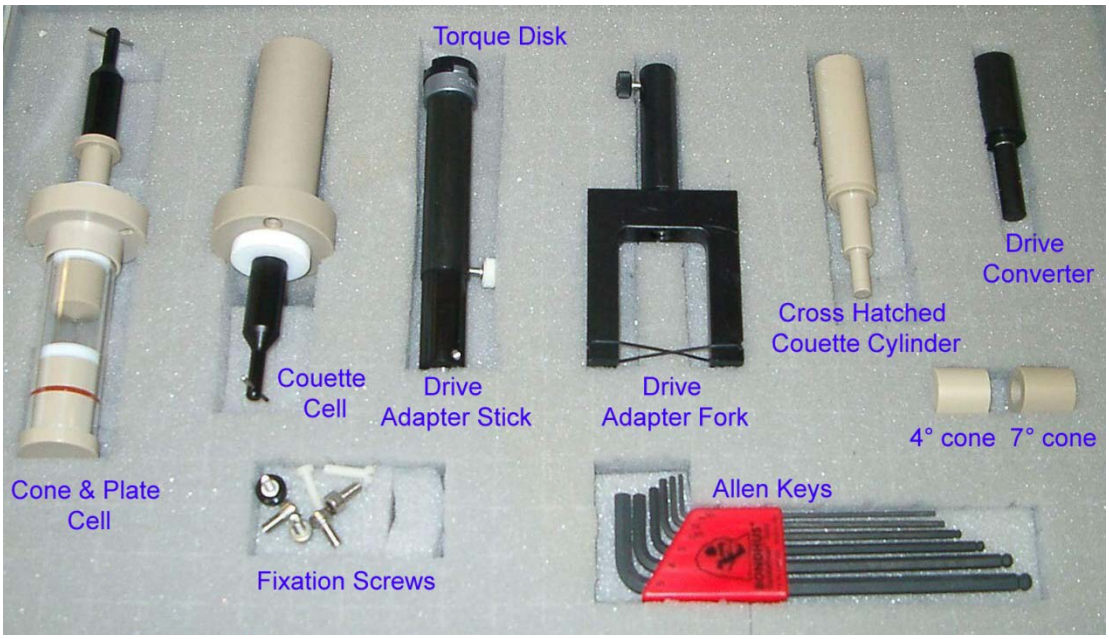


Figure 1.3: Cone & Plate and Couette Rheo Cells, Mechanical Adapters and Tools

Note: The drive fork and the allen keys are not included in the version for the AVANCE III spectrometers.

Figure 1.4: Rheo Controller

The Rheo-NMR system is available in two versions, dependent on the style of the upper shim barrel. The upper shim barrel needs to be considered when the accessory is ordered.

Before installing this accessory it is important that the user:

- Reads and understands the contents of this manual.
- Notes and adheres to all warnings and safety considerations.
- Identifies all the parts of the accessory.

2 Installation

The Rheo accessory is installed in the following order:

1. Mount the Rheo drive shaft.
2. Mount the Rheo motor.
3. Connect the Rheo controller.
4. Mount the Rheo cell into the probe.
5. Mount the probe in the magnet.

The following figure shows the arrangement of the installed Rheo accessory at the top of the magnet.

Figure 2.1: Rheo-NMR Accessory Mounted on a Wide Bore Magnet.

⚠ WARNING

Danger to life from strong magnetic fields!

Strong magnetic fields may cause serious injuries or death and significant damage to property.

1. Persons fitted with heart pacemakers must be kept away from the device. The functionality of the heart pacemaker could be compromised.
2. Persons with metal implants must be kept away from the device. Implants may heat up or be subject to magnetic attraction.
3. Ferromagnetic materials and electromagnets must be kept away from the magnetic source. Such materials could be subject to magnetic attraction and may fly around the room, injuring or killing people. Minimum distance 3 meters.
4. Remove magnetic items (jewelry, watches, pens etc.) before carrying out maintenance work.
5. Keep electronic equipment away from the magnetic source. Such equipment could be damaged.
6. Keep storage media, credit cards etc. away from the magnetic source. Data could be erased.

2.1 Mounting the Rheo Drive Shaft

The Rheo drive shaft enables the Rheo-NMR cell to be driven by a motor external to the magnet. The drive shaft is located inside the magnet, thus all materials are non-magnetic. The motor itself, and the tools used to install the drive shaft are magnetic, therefore caution should be used when working around the magnet.

The shaft is designed to fit inside the magnet bore, with the tapered base resting on the top of the spinner housing. The length of the shaft depends on the internal dimensions of the magnet and the shim system.

There are two versions of the drive shaft:

- One for the older style (gray) wide bore shim system.
- One for the new style (red) wide bore shim systems.

Note: Although the drive shaft has ventilation holes top and bottom, caution should be used when carrying out Rheo-NMR variable temperature experiments to ensure the magnet room temperature bore is not exposed to temperature extremes.

Depending on the upper shim barrel design the shaft is “locked” in place by either a slide and thumb screw or notch that locates to the spin sense connector on the upper shim barrel.

1. Insert the drive shaft gently into the spinner housing bore with the tapered end downward.
2. Ensure that the bottom of the drive shaft couples with the cell drive connector by gently turning the end of the shaft by hand.

For the older style BST type upper shim barrels (gray in color) it is essential that the drive shaft locates with the spin sensor connector on the upper shim barrel. For the newer WB99 shim barrels (red in color) the motor interface locates the drive shaft.

Figure 2.2: Drive Shaft in the Old Gray Style Shim System.

2.2 Mounting the Rheo Motor

The following components are relevant for mounting the Rheo motor:

- Motor drive electronics.
- Motor.
- Gear box (optional).
- Drive interface.
- 1/4“ drive converter (optional)
- Drive adapter.
- Trigger unit.
- Slide pin.

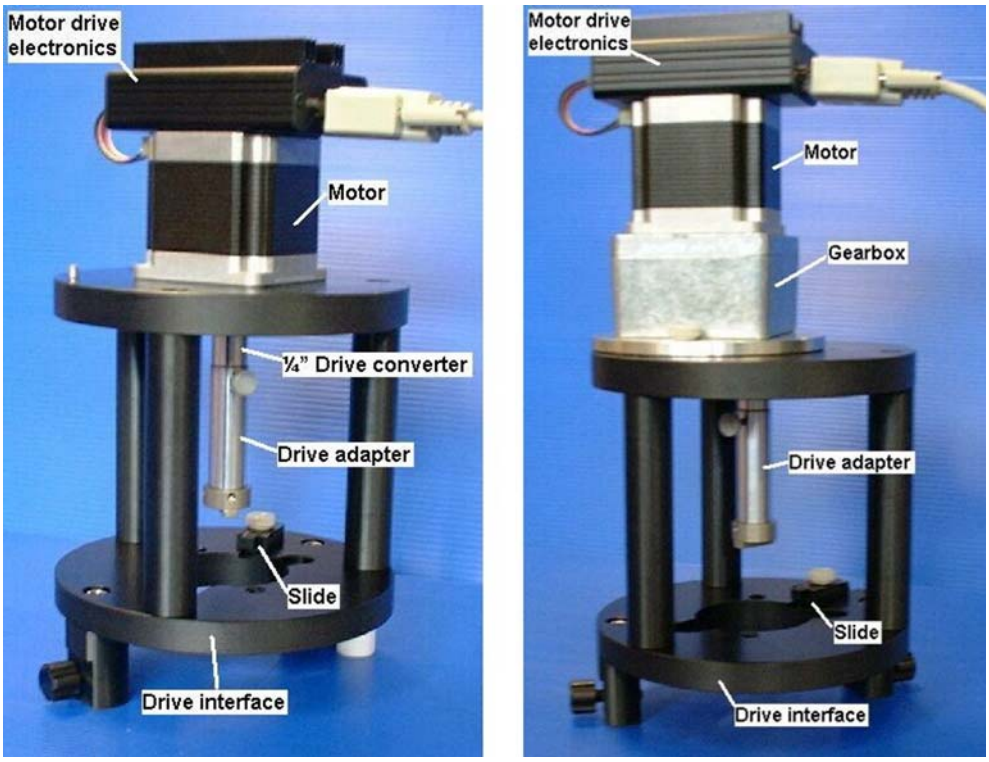


Figure 2.3: Rheo Motor Assembly Components.

Motor Drive Electronics

The motor drive electronics (mounted on the motor) houses a DB9 style connector to link the motor to the Rheo-NMR controller, a push button “manual control” switch and a status LED.

The push button manual control switch, when depressed, drives the motor at a constant 0.1 Hz, which is useful when aligning the motor/gear box on the drive shaft.

The status LED flashes when the drive is in standby mode and is on when the motor is being operated.

Motor

The motor has a speed range of 0.1 to 14 Hz. For speeds less than 0.1 Hz an optional fixed ratio gear box can be fitted on the drive interface between the motor and drive shaft.

The motor is mounted together with the gear box (optional) and mechanical drive adapter onto the drive interface. The drive interface is then mounted on the magnet.

Gear Box

The optional fixed ratio gear box can be fitted on the drive interface between the motor and drive shaft by means of a variable length drive adapter.

Drive Interface

The drive interface connects the drive shaft to the motor/gearbox assembly. There are two versions of the interface available, depending on the model of upper shim barrel:

- A drive interface for the older BST upper shim barrel.
- A drive interface for the new WB99 shim barrel.

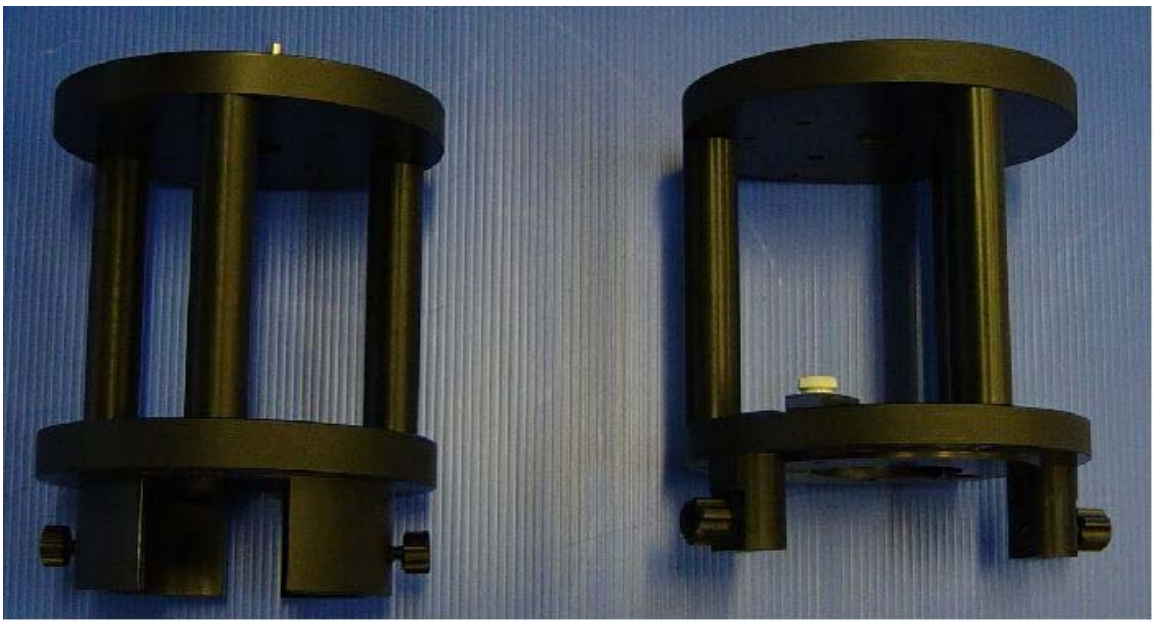


Figure 2.4: The BST Upper Shim Barrel (left) and WB99 Shim Barrel (right) Drive Interfaces

Drive Adapters

The adjustable length drive adapter is used to connect the motor to the drive shaft. For AVANCE III systems a drive adapter stick is used, for older systems a drive adapter fork is used.

When a gear box is not used, a 1/4“ drive converter must be used between the motor and the drive adapter.

Trigger Unit

The trigger unit is used for data acquisition in a triggered mode. For older systems an external unit is required, for AVANCE III spectrometers a version is available with the trigger unit integrated in the motor drive electronics.

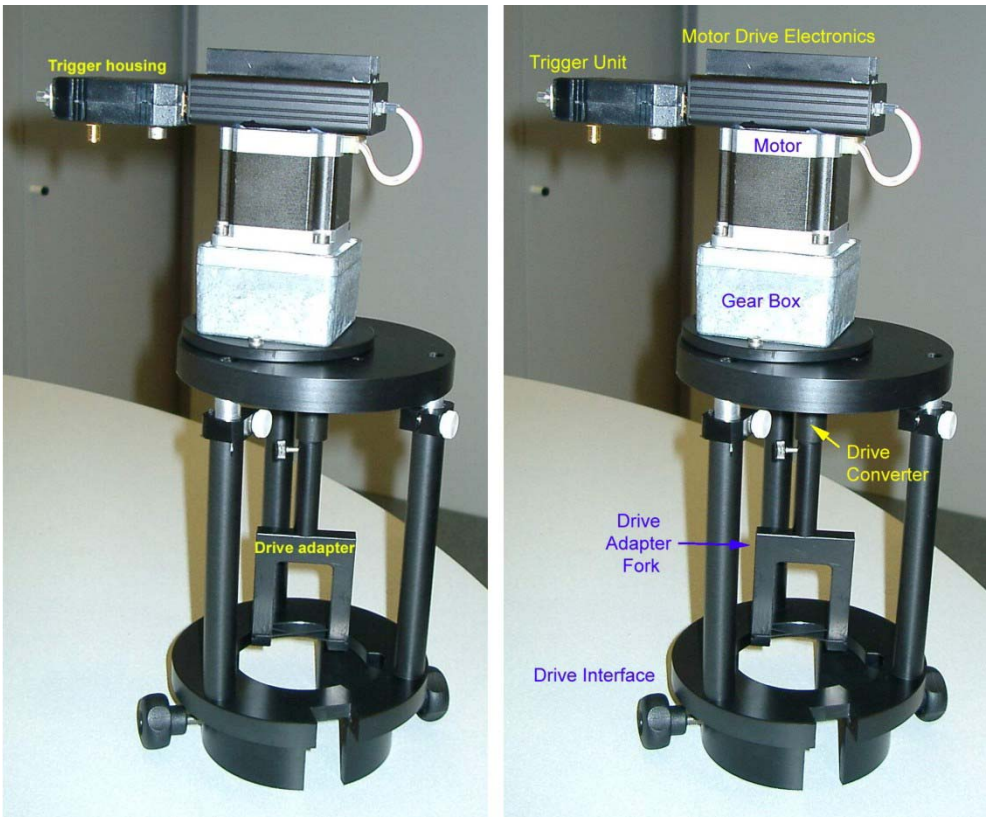


Figure 2.5: Trigger Unit and Drive Adapters.

Slide Pin

The slide pin is used to align the drive interface to the shim system.

2.2.1 Assembling and Mounting the Motor Interface

The motor consists of magnetic parts – use caution when mounting the motor and gear box assembly.

Some of the items shown in the following figure are used to assemble and mount the motor interface:

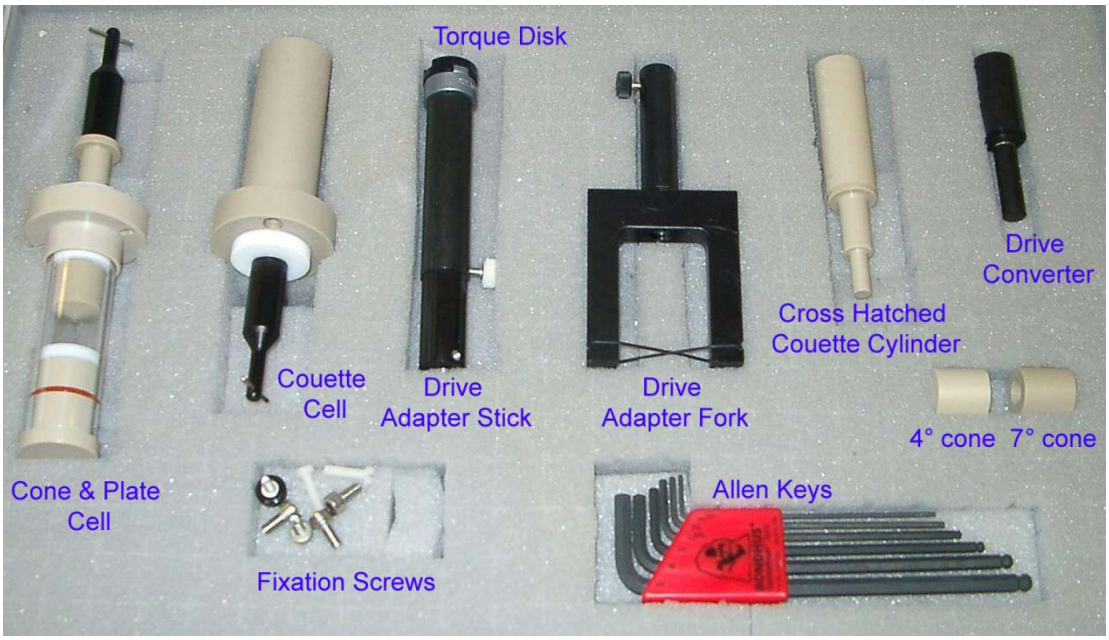


Figure 2.6: Installing Motor Interface – Without Gear Box

Assembly with a Gear Box

1. Fix the ¼" drive converter to the motor.
2. Mount the motor to motor interface using the four M4 x 10 stainless steel screws.
3. Fix the drive adapter stick or the drive adapter fork to the drive converter.
4. Fix the motor interface to upper shim barrel, ensuring it is pushed securely down onto the upper shim barrel.
5. For WB99 shims (red barrel), the drive shaft is aligned with the motor interface using a slide pin. Rotate the drive shaft until the slide pin can be engaged, then lock using the thumb screw.
6. If the drive **adapter stick** is used, adjust the length of the drive adapter stick (rotating the drive shaft if necessary) so that the coupling engages with the drive shaft via the torque disk.
7. If the drive **adapter fork** is used, adjust the length of drive adapter fork (rotating the drive shaft if necessary) so that the coupling engages with the drive shaft via the rubber ring.

Assembly without a Gear Box

Note: The Rheo accessory is shipped with the gear box mounted.

1. If mounted, remove the ¼" drive converter from the motor.
2. Mount the motor to the gear box and ensure the gears are engaged. Fix using the four M5 x 10 mm stainless steel screws.
3. Align the motor/gear box assembly with the locating pin on the motor interface. Fix using the two thumb screws.
4. Fix the drive adapter to the gear box output shaft.
5. Fix the motor interface to the upper shim barrel, ensuring it is pushed securely down onto the upper shim barrel.

6. With WB99 shims (red barrel), the drive shaft is aligned with the motor interface using a slide pin. Rotate the drive shaft until the slide can be engaged, then lock using the thumb screw.
7. Adjust the length of the drive adapter (rotating the drive shaft if necessary) so that the adapter engages with the drive via torque disk.

Assembling the Rheo Accessory on the Wide Bore Shim System

1. Mount the drive adapter at the wide bore shim system and fix it by the screws (blue arrow).

Figure 2.7: Motor Mounted on the Wide Bore Shim System

2. Connect the RS232 cable (1) between the trigger unit and the Rheo controller.
3. Connect the cable (2) between the drive shaft and the trigger unit.
4. Connect the BNC trigger cable (3) between the trigger unit and the spectrometer. The connection at the spectrometer depends on the spectrometer type and is described in the spectrometer hardware manuals.

2.3 Installation of the Rheo Controller

A microprocessor based motor controller communicates with the Rheo motor and the spectrometer to control the rotation of the motor shaft.

Figure 2.8: Rheo Controller

Before operating the controller the controller must be connected and the software installed as described in the following sections.

2.3.1 Controller Setup

To set up the controller for operation:

1. Connect the cable between the Rheo controller and the Rheo motor. This connection allows the motor to be controlled by pushing the buttons on the front panel of the controller.
2. Connect the RS232 connector on the Rheo-NMR unit to the connector on the spectrometer CCU corresponding to the device defined. The supplied cable corresponds to a standard 9 pin null-modem cable, both ends female. This connection allows the motor to be controlled by a menu driven user interface.
3. Connect the BNC cables to the spectrometers RCP pulse inputs as described below. This optional connection allows the motor to be controlled by commands in the pulse program and is only needed if motor control from the pulse program is required:

   D-series (DPX, DRX, DMX, DSX):
   The reset and the clock signal are accessible through pin S and W on the back panel 1.

   AV-series (TCU3):
   The reset and the clock signal are accessible through pins G2 and G1 on the connector T2 on the front panel of the TCU3. A cable is provided to connect these to the Rheo NMR controller.

2.3.2 Installation of the Rheo Controller Software

To install the Rheo controller software:

1. Get the file rheo<version>.tar
2. Enter: `cd $XWINNMRHOME`
3. Enter: `tar xvf rheo<version>.tar`
4. In case you have an AVANCE type instrument, an additional step is necessary. Enter: `cd $XWINNMRHOME/exp/stan/nmr/lists/pp.dimag`
   If you have a DPX, DRX, DMX or DSX: `cp RheoD.incl Rheo.incl`
   If you have an AV type (TCU3): `cp RheoAv.incl Rheo.incl`
5. Run expinstall in XWINNMR and select “Micro Imaging”.
6. Create the file „../conf/instr/spect/rs232_device/rheo“ in using the correct entries for the host and TTY device port where the Rheo controller is connected.

   Example for AV3:

```
unit = Rheo unit
host = 149.236.99.250
device = /dev/tty05
type = RS232
stty = 9600 time 5 cs8 cread clocal istrip
```

   Example for CCU based systems:

```
unit = Rheo unit
host = spect
device = /dev/tty08
type = RS232
stty = 9600 time 5 cs8 cread clocal istrip
```

Note: For correct communication, pins 4, 7, and 8 must be bridged on the back side of the RS232 connector on the Rheo controller. This is usually made before delivery, but should be checked in the case of communication problems.

2.3.3 Operation Modes

The user can operate the controller either within experiments or independently.

Independant Operation of the Controller

Independant operation of the controller can be accomplished through use of the menu-driven user interface or manually by pushing the keys on the front panel of the controller.

The Rheo-NMR unit can be controlled by means of a TclTk script called “rheo”. The rheo script can be started from the XWINNMR or TopSpin command line.

The TclTk User Interface

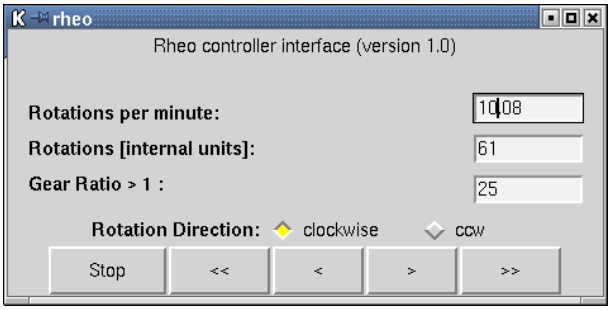


Figure 2.9: A Menu Driven User Interface: The TclTk User Interface

Any positive value can be given for “Rotations per minute”, the program will calculate the next possible rotation frequency in internal units according to the specified gear ratio. The program then accelerates the motor in order to reach the desired value, during which time the interface is blocked. As soon as the motor has reached the desired speed, the interface will be accessible again and will show the finally reached values.

In the example shown in the figure above, 10 rpms and a gear ratio of 25 were specified. The interface calculated 61 internal units, which corresponds to 10.08 rmp.

Rotations [internal units] can be specified between 0 and 159, the interface will calculate the corresponding rotation frequency [rpm].

The gear ratio must be specified as a floating point number >= 1.0, changing the value will only affect the rotations per minute, keeping the frequency in internal units fixed.

The radio buttons “clockwise” and “ccw” select the rotation direction, if applied while the motor is running it will be first stopped and then accelerated again to the same frequency in the opposite rotation direction.

The arrow keys change the value of the internal units by 1 (< >) or 5 (<< >>), downwards or upwards respectively.

Operation of the Controller within Experiments

Commands can be sent, for example, from an automation program via an RS232 port to the controller before and between experiments.

The TTL level can also be set directly in the pulse programs allowing for changes during the execution of a pulse program.

During motor operation the lower line of the controller display shows the current rate and the corresponding motor shaft speed. For example **Rate 10, 0.55** means rate 10 which corresponds to a motor shaft speed of 0.55 revolutions per second.

2.4 Mounting the Rheo Cell in the Probe

The Rheo-NMR Cell Kit contains parts required to mount the cell and adapt the motor and gear box based on user requirements.

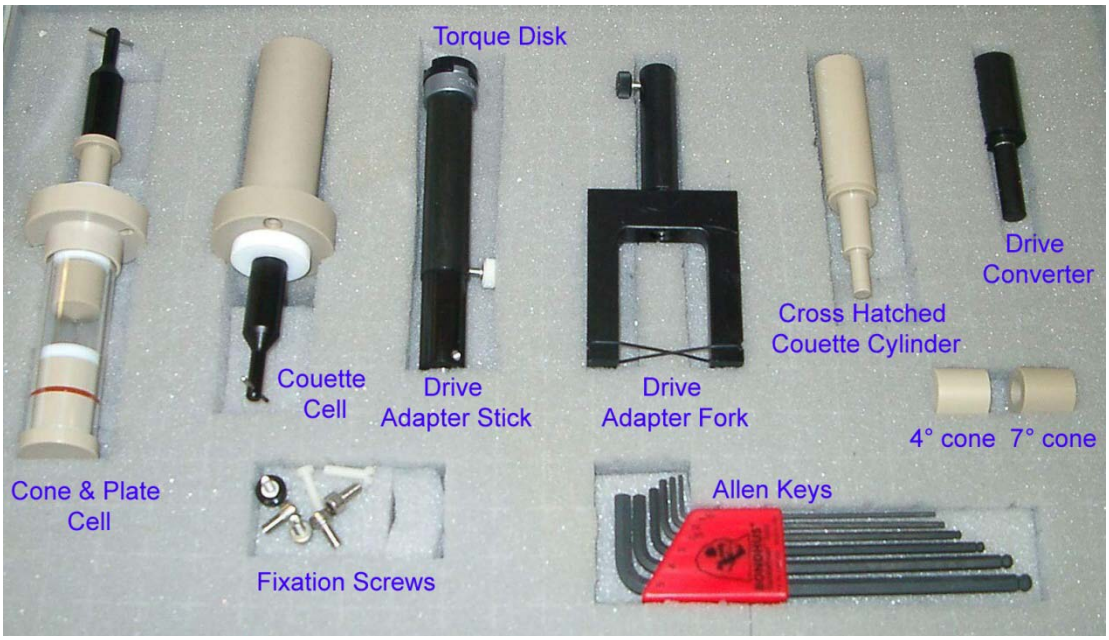


Figure 2.10: Cone & Plate and Couette Rheo Cells, Mechanical Adapters and Tools

The Rheo-NMR Cell Kit Consists of the Following Parts:

1 x Couette cell: 17 mm inner cylinder outer diameter & 19 mm outer cylinder inner diameter (PEEK).

1x Couette cell inner cylinder, smooth surface, (PEEK) shipped fitted to couette cell.

1 x Couette cell inner cylinder, cross hatched surface, (PEEK).

1 x cone & plate assembly (glass/PEEK).

1 x 4º detachable cone (PEEK).

1 x 7º detachable cone (PEEK).

1 x 20º detachable cone (PEEK), shipped fitted to cone & plate cell.

2 x M3 x 15 nylon screws (affixing cells to micro-imaging resonator).

1 x 1.5 mm Allen key (magnetic!).

1 x ¼” drive converter.

1 x aluminum couette cell pin removal tool.

Mounting the Rheo Cells in the Micro 2.5 Probe

Figure 2.11: Cone & Plate Cell and Modified Micro 2.5 Resonator

Figure 2.12: Cell and Resonator Fitted to the Micro 2.5 Probe

1. Select the 25 mm diameter Bruker resonator (25-40T/MI). All resonators supplied after November 2002 are pre-drilled for the Rheo-NMR cell. Resonators supplied prior to this date will require drilling – refer to the chapter Micro 2.5 Resonator Drilling Modifications [▶39].

2. Using the 2 x M3 x 15 nylon screws, to attach the Couette cell to the resonator, assemble the micro-imaging probe and insert as normal into the magnet. Note that the cell has two sets of holes. Those with narrower diameter separation are to be used with the new (CMR) micro-imaging probe. The wider spaced holes are for use with the older (Spectrospin) micro-imaging probe.
3. Ensure that the spinner housing bore tube is set to the correct height within the magnet. The base of the housing should be around 1 mm above the top of the gradient set in order to avoid unwanted forces between the housing and the gradient coils.

Mounting the Rheo Cells in the MicWB40 Probe

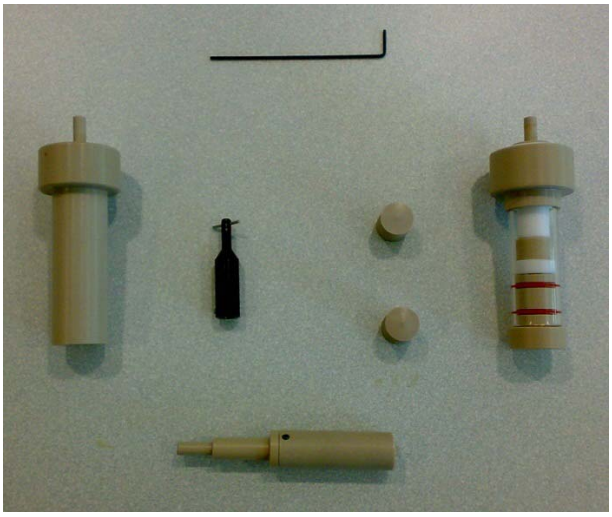


Figure 2.13: Rheo Cells for the MicWB40 Resonator

Figure 2.14: Cell and Resonator Fitted to the MicWB40 Probe

1. Mount the 25 mm MicWB40 resonator on the probe body.
2. Push the rheo cell into the 25 mm MicWB40 resonator from the top.
3. Fix the rheo cell using 3 screws in the horizontal position at the top of the resonator.
4. Ensure that the spinner housing bore tube is set to the correct height within the magnet. The base of the housing should be around 1 mm above the top of the gradient set in order to avoid unwanted forces between the housing and the gradient coils.

Note: For a WB99 shim system, a special shim upper part with a shorter turbine is provided for Rheo-NMR.

Variations in the Rheo Cells

The Couette cell comes with two inner cylinders, one with a smooth surface and one with a roughened (cross hatched) surface. The inner cylinder may also be filled with fluid and used as a marker for the inner cylinder velocity. Note that it is necessary to remove the Couette cell pin in order to gain access to the inner cylinder (see the next Figure).

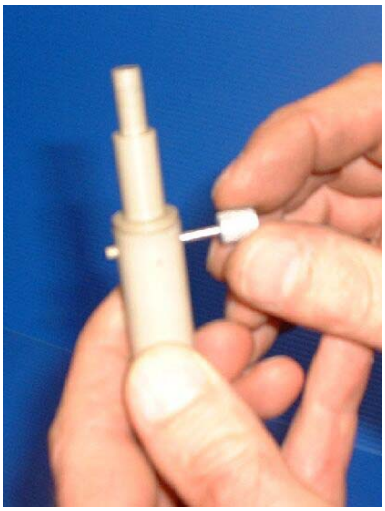


Figure 2.15: Removing the Couette Cell Pin

Notes:

- When using the cone & plate, be careful not to overfill the cell.
- Cones may be easily interchanged by pulling the cone off the shaft.
- Rotation speeds slower than the range covered by the gear boxes and direct drive (0.1 to 14 Hz) can be achieved by purchasing additional gear boxes.
- One method of ensuring that the fluid inside the chosen cell is being sheared is to carry out an imaging velocimetry experiment.

2.5 Mounting the Probe in the Magnet

To mount the probe in the magnet:

1. Push the probe with the Rheo cell carefully into the gradient system in the magnet.
2. Rotate the probe slightly while it is shifted up, until the mechanical connection on the top of the Rheo cell slips into the counterpart at the bottom of the Rheo shaft.
3. Fix the probe in the usual way at the bottom of the gradient system.

2.6 Troubleshooting Guide

Rheospin V3.0 message is not displayed at startup.

Once power has been applied the message **Rheospin V3.0** should be displayed on the top line of the LCD and the display should be backlit.

If the controller fails to display the message, but the display is backlit, consult your Bruker representative for further information.

If the display is completely blank then check the internal fuse. If the fuse is functional contact your Bruker agent. Note that a blown fuse usually indicates that a severe malfunction has occurred. When replacing a fuse, use only a 2A 250 rated fuse.

Motor fails to operate.

With the motor connected, the user should be able to test the motor and controller using the push buttons on the front panel of the controller (see Operation Modes [▶18]).

If the motor fails to operate, check the motor itself using the following procedure:

1. Press the button mounted directly onto the motor.
   ⇨ The motor shaft should turn slowly.
2. If the motor fails to operate contact your Bruker agent for further assistance.

⚠ WARNING

Danger of injury from electrical shock!

A life threatening shock may result when the housing is open during operation.

1. Only qualified personnel should open the housing.
2. Disconnect the device from the electrical power supply before opening the device. Use a voltmeter to verify that the device is not under power!
3. Be sure that the power supply cannot be reconnected without notice.

3 Methods and Triggering

Triggering

Sometimes the data needs to be acquired in a triggered mode. Triggering is supported in most Bruker methods. The trigger events are controlled by macros in the pulse programs. But these macros differ slightly for the in-vivo applications (trigger on level) and for the Rheo-NMR applications (trigger on edge).

Methods

The methods **mic_flowmap** and **mic_seflow** are recommended for velocity measurements in Rheo-NMR applications with AVANCE III spectrometers. These methods already contain the files included for the trigger on edge (TriggerPerPhaseStep1.mod and TriggerPerSlice1.mod).

These files included have to be programmed in pulse programs for Rheo-NMR applications instead of the default TriggerPerPhaseStep.mod and TriggerPerSlice.mod for in-vivo applications.

For In-Vivo, Trigger on Level

```
; TriggerPerPhaseStep.mod - Trigger Module
;
;*************************************************************
;
; PVM_TrigD0 --> PVM_EcgTriggerModuleTime = ACQ_trigger_delay
;
if (PVM_TriggerMode == per_PhaseStep)
{
if (ACQ_trigger_enable == 1)
{
10u ECG_STAMP_LOW
if (CONFIG_instrument_type == Avance_III)
{
10u trignl1
10u GRAD_SYNC
}
else
{
10u trigpl1
}
10u ECG_STAMP_HIGH
TrigD0
}
}
=============================================================
; TriggerPerSlice.mod - Trigger Module
```

```
;
;*****************************************************************
;
; PVM_TrigD0 --> PVM_EcgTriggerModuleTime = ACQ_trigger_delay
;
if (PVM_TriggerMode == per_Slice)
{
if (ACQ_trigger_enable == 1)
{
10u ECG_STAMP_LOW
if (CONFIG_instrument_type == Avance_III)
{
10u trignl1
10u GRAD_SYNC
}
else
{
10u trigpl1
}
10u ECG_STAMP_HIGH
TrigD0
}
}
```

For Rheo-NMR, Trigger on Edge

```
; TriggerPerPhaseStep1.mod - Trigger Module
;
;*****************************************************************
;
; PVM_TrigD0 --> PVM_EcgTriggerModuleTime = ACQ_trigger_delay
;
if (PVM_TriggerMode == per_PhaseStep)
{
if (ACQ_trigger_enable == 1)
{
10u ECG_STAMP_LOW
if (CONFIG_instrument_type == Avance_III)
{
10u trigne1
10u GRAD_SYNC
}
else
```

```
{
10u trigpe1
}
10u ECG_STAMP_HIGH
TrigD0
}
}

============================================================

; TriggerPerSlice1.mod - Trigger Module
;
;*************************************************************
;
; PVM_TrigD0 --> PVM_EcgTriggerModuleTime = ACQ_trigger_delay
;
if (PVM_TriggerMode == per_Slice)
{
if (ACQ_trigger_enable == 1)
{
10u ECG_STAMP_LOW
if (CONFIG_instrument_type == Avance_III)
{
10u trigne1
10u GRAD_SYNC
}
else
{
10u trigpe1
}
10u ECG_STAMP_HIGH
TrigD0
}
}
```

4 Additional Rheo Cell Drive Controls

The Rheo-NMR system can also be used to:

- Set TTL levels in the pulse programs.
- Manually change the desired motor speed using the front panel.
- Send commands from an automation program via an RS232 port.

4.1 Setting TTL Levels in Pulse Programs

Setting TTL level directly in the pulse programs allows for changes during the execution of a pulse program.

The BNC TTL inputs of the controller can be connected to the appropriate TTL outputs of an AMX spectrometer console. A pulse on the “Increment” input will cause the controller to increase the motor rate, and likewise, a pulse on the “Reset” input will cause the controller to stop the motor. Note that a minimum pulse width of 1 ms and a minimum delay of 100 ms between successive pulses should be used.

The real time control is accomplished through the TTL signals **reset** and the **clock signal**. These signals are usually applied for a duration of 1 ms, active high. The use of these commands is explained in the example Pulse Programs [36].

The connections for these signals are different for different spectrometer types. The same is to some extend true for the pulse program syntax.

For DPX, DRX, DSX, DMX Spectrometers

With the D-series the reset and the clock signal are connected to NMR4 bits 6 and 7.

The corresponding pulse program syntax is:

Reset:

...

1m setnmr4|6

10µsetnmr4^6

....

Clock:

...

1m setnmr4|7

10µsetnmr4^7

....

For AVANCE Series Spectrometers

With the AVANCE series the reset and the clock signal are connected to NMR3 bits 17 and 16.

The corresponding pulse program syntax is:

Reset:

...

1m setnmr3|17

10µ setnmr3|17

....

Clock:

...

1m setnmr3|16

10µ setnmr3|16

....

4.2 Manually Changing the Motor Speed from the Front Panel

The desired motor speed can also be selected manually using the keys on the front panel of the motor controller. The “Increment” and “Reset” keys perform the same function as the BNC inputs from the spectrometer. The controller can also run the motor in reverse direction. This is enabled by pressing and holding the “Reset” key and then pressing the “Increment” key. An “R” character will appear in the display to indicate that the motor is reversed for all subsequent operations.

4.3 Sending Commands to the Controller from an Automation Program

Commands can be sent to the controller from an automation program via an RS232 port before and between experiments.

Spectrometer Console Control

Through use of the “Aux” port the controller can communicate directly to an AVANCE spectrometer console using one of the spectrometer’s TTY (RS232) ports. The Aux interface uses a baud rate of 9600, 8 bit data, no parity, and a single stop bit. The use of the Aux interface allows the user to perform a number of more complex motor operations, which are performed using a single command defined as follows:

Preamble	Direction	Wait on TTL	Rate	Angle
“MC”	“F” or “R”	“Y” or “N”	“000”-“159”	“0000”-“9999”

The command is a sequence of 11 upper case characters followed by a carriage return character, for example:

“MCFN0100360<CR>

The example above instructs the controller to immediately operate the motor for 360 degrees (one revolution) in the forward direction at rate 10.

For continuous motor operation the **Angle** should be set to “0000”.

To stop the motor, a **Rate** step of “000” should be selected.

The **Wait on TTL** character is used to delay the start of the motor operation and is useful in synchronizing the start of the motor operation with a pulse program. When “Y” is selected the controller will wait for a pulse on the increment input before activating the motor. The “Aux” connector pinout is for a standard 9 pin RS232 interface where pin 2 is used for data out, pin 3 for data in and pin 5 for ground.

The controller can operate from a range of mains supply voltages and frequencies of 90-240VAC, 50-60 Hz. A 2A 250V fuse is used to provide additional protection should a failure occur. Refer to the Troubleshooting Guide [▸25] for further information.

The communication of this program with the Rheo-NMR unit is accomplished by an AU program, which can also be used interactively or be called by a user AU program or script.

AU Program Control

The Rheo-NMR unit can also be controlled through the RS232 connection using an AU program called “rheoMotor”. The AU program offers several modes of operation:

Interactive Mode

Start rheoMotor without parameters, e.g. using “xau rheoMotor” or “rheoMotor” in the command line of XWINNMR or TopSpin. A dialog will be started asking sequentially to:

- Enter Rotation Frequency [rpm].
- Enter Rotation Direction 0/1.
- Enter Gear Ratio >1.
- Enter Acceleration Ramp Time.

Any rotation frequency may be specified here, the program will report the reached frequency at the end in the XWINNMR or TopSpin status line.

The rotation direction can only be set to 0, clockwise, or 1, counter clockwise, default is 0.

The gear ratio means the reduction factor of the motor revolutions by the gear box connected, it must be larger than 1. It defaults to –1, whereas direct mode will be used.

The parameter “Acceleration Ramp Time” stands for the delay [ms] between the increments of the steps (internal units of the Rheo-NMR unit) during acceleration.

Non-interactive Mode

The non-interactive mode is designed for use within automation sequences and as an interface for a high level user interface. It is currently not available.

Start rheoMotor using parameters, e.g. “xau rheoMotor rpm dir gearRatio rampTime” in the command line of XWINNMR or TopSpin. From XWINNMR 3.5 on “xau” can be omitted. The parameters rpm, dir, gearRatio, and rampTime stand for the parameters “Rotation Frequency”, “Rotation Direction”, “Gear Ratio” and “Ramp Time” as described above.

If parameters are omitted they will be set to their default values. The sequence of parameters cannot be changed.

Direct Mode

Both the interactive and the non-interactive mode can be used in “direct mode” by setting the gear ratio to –1. In this case the numbers given as rpm will be treated as the internal units of the Rheo-NMR controller.

5 Additional Software

5.1 AU Programs

The AU Program ‘rheoMotorStep´

```
/* motorstep */
/* 2/7/01 bm */
/* pulse program name updated 29.06.2004 KLZ */
/* syntax corrections 29.06.2004 KLZ */
/* renamed 29.06.2004 KLZ */

char s25[25];
char save_name[20], save_user[20];
int save_expno,save_procno;
int helpi;

GETCURDATA;
Show_status("AU program rheoMotorStep");
(void)strcpy( save_name, name );
(void)strcpy( save_user, user);
save_expno = expno;
save_procno= procno;
FETCHPAR("L 8", &helpi);

/* Go to the dataset motor */

DATASET( "motor", 1, 1, disk, user );
RPAR("standard1D", "all");
STOREPAR("PULPROG", "rheoMotorStep");
STOREPAR("L 8", helpi);
ZG;
DATASET( save_name, save_expno, save_procno, disk, save_user );
Show_status("motorstep finished");
QUIT
```

The AU Program ‘rheoMotorOff‘

```
/* motoroff */
/* 2/7/01 bm */
/* pulse program name updated 29.06.2004 KLZ */
```

```
/* renamed 29.06.2004 KLZ */

char s25[25];
char save_name[20], save_user[20];
int save_expno,save_procno;

GETCURDATA;
Show_status("AU program rheoMotorOff");
(void)strcpy( save_name, name );
(void)strcpy( save_user, user);
save_expno = expno;
save_procno= procno;

/* Go to the dataset motor */

DATASET( "motor", 1, 1, disk, user );
RPAR("standard1D", "all");
STOREPAR("PULPROG", "rheoMotorOff");

ZG;
DATASET( save_name, save_expno, save_procno, disk, save_user );
Show_status("motor switched off");
QUIT
```

5.2 Pulse Programs

The pulse programs **rheoMotorStep** and **rheoMotorOff** can be used as examples for your own pulse programs. These pulse programs are hardware independent, the individual hardware properties are considered in the different Rheo.incl files. Usually the “expinstall“ command will handle this, at the current state of the software AVANCE users have to decide which version they have and manually copy RheoAv,incl or RheoD.incl to Rheo.incl.

Hardware dependent files included

```
; RheoD.incl
; Rheo NMR controll commands vor DxX
; 29.06.2004 KLZ

#define rheoReset 10m setnmr4|6 \n\
100m setnmr4^6
#define rheoStep 10m setnmr4|7 \n\
100m setnmr4^7

; RheoAv.incl
```

```
; Rheo NMR controll commands vor AV (TCU3)
; 29.06.2004 KLZ

#define rheoReset 10m setnmr3|17 \n\
100m setnmr3^17
#define rheoStep 10m setnmr3|16 \n\
100m setnmr3^16
```

Motor Step

```
; rheoMotorStep
; pulse program for Rheo NMR
; accelerate stepper motor to speed l8
; new version29.06.2004 KLZ

#include <Rheo.incl>

10m
rheoReset
10 rheoStep
lo to 10 times l8
10m
exit

;l8: motor velocity internal units
```

Motor Off

```
; rheoMotorOff
; pulse program for Rheo NMR
; stop stepper motor
; new version29.06.2004 KLZ

#include <Rheo.incl>

10m
rheoReset
exit
```

6 Micro 2.5 Resonator Drilling Modifications

For resonators delivered before November 2002 (with end caps made of white PTFE), it is necessary to drill and tap two 3.0 mm metric holes (refer to the figures below).

This work should only be carried out by an experienced mechanical engineer. Do not drill beyond the air gap (the start of the RF screen).

Figure 6.1: Drilled Resonator

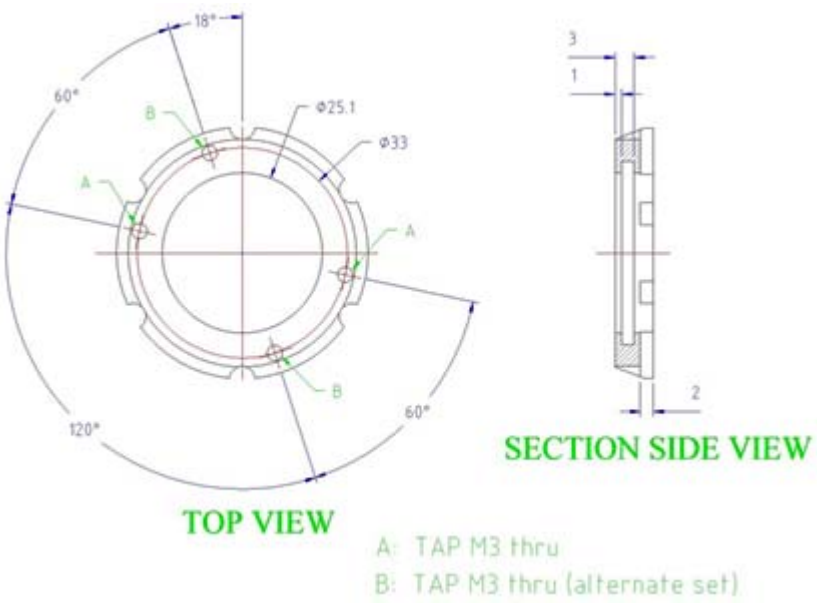


Figure 6.2: Drilling Diagram for Resonator

7 Rheo Shaft Dimensions

The length of the Rheo shaft depends on the length of the upper shim barrel, which varies for the different magnets. The length is specified by the parameter H in the drawing below.

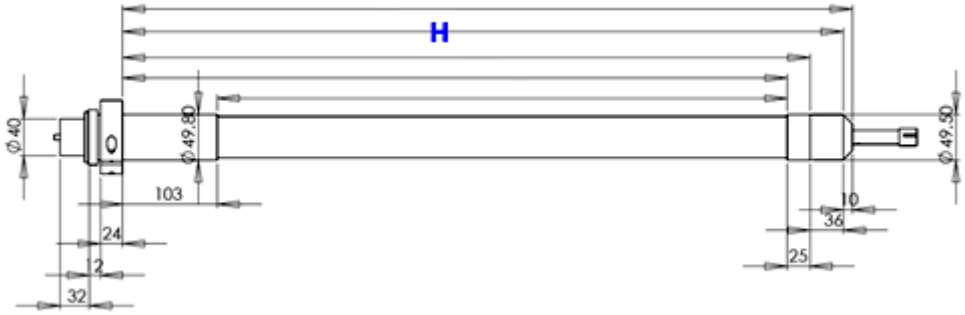


Figure 7.1: Upper Shim Barrel Length

Rheo Shaft Part Number	Rheo Shaft Dimension H (mm)	Shim Upper Part Type	Shim Dimension L (WB) (mm)	**Shim Upper Part Part Number**	Nipple (mm)	Turbine (mm)	Turbine Ring (mm)
	579	A	714	**Z46400.A**	8	68	59
H13643	679	B	814	**Z46400.B**	8	68	59
H13104	779	C	914	**Z46400.C**	8	68	59
	879	D	1014	**Z46400.D**	8	68	59
H13533	979	E	1114	**Z46400.E**	8	68	59

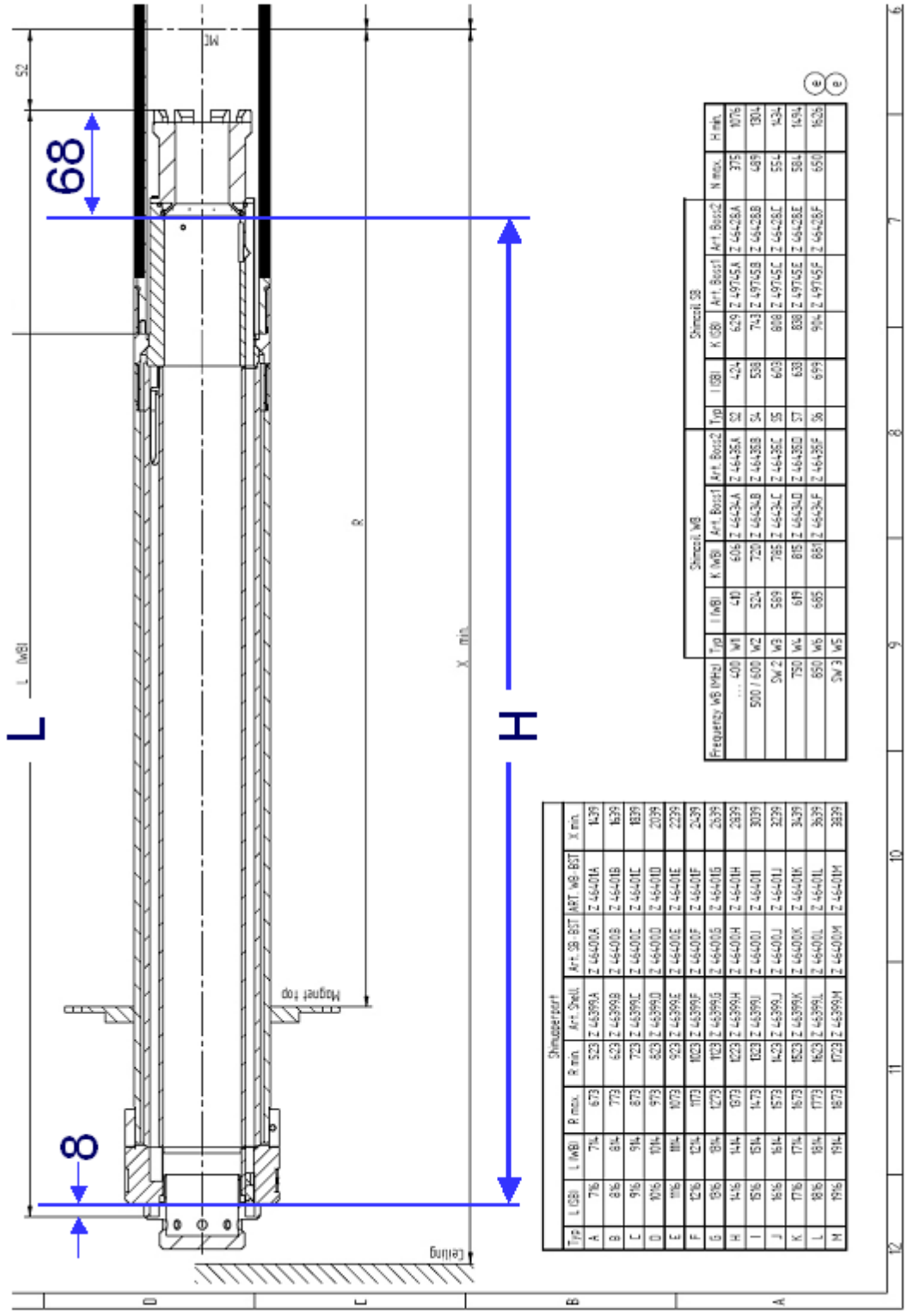
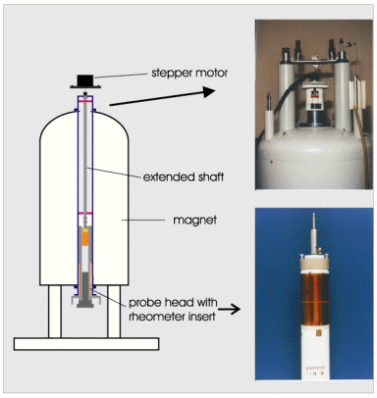
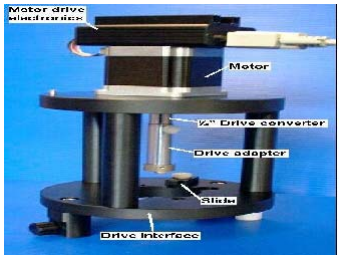
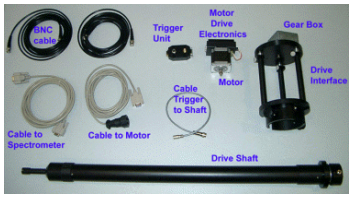
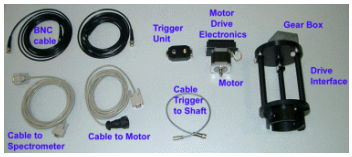
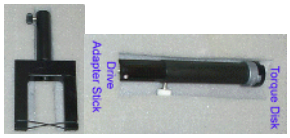
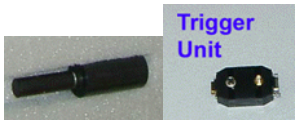


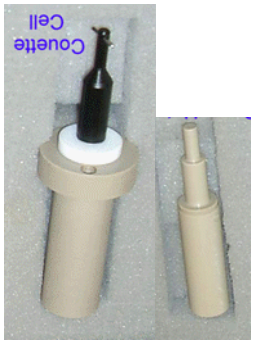
Figure 7.2: Rheo Shaft Dimensions

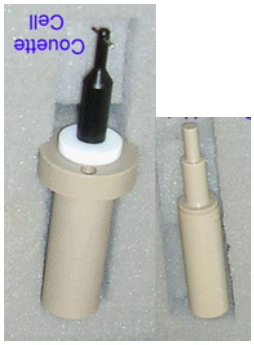
8 Part Numbers

	 		 
Complete Rheo Accessory for BOSS WB Shim Systems	The Rheo-NMR accessories are available only for the following shim upper barrels:		
Rheo Controller Kit (controller, power supply)	Z46400.A		
Rheo Drive Kit (motor, mechanics, fixation and cables)	Z46400.B		
Rheo Shaft Kit (shaft and shim upper barrel)	Z46400.C		
Rheo Cell Kit (Cone & Plate and Couette cell)	Z46400.D		
Rheo Manual	Z46400.E		
	The Rheo cell kits differ for the Micro 2.5 and the MicWB40 probes.		
Rheo Manual		H13331	
Rheo Controller Kit	Rheo Controller H13882 Power Supply H13883	H127786	 

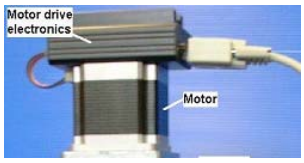
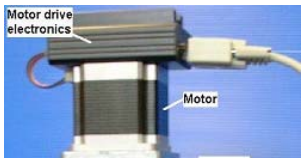
Rheo Drive Kit	Contains the mechanics for driving the Rheo cells.	H126863	  

Part Numbers

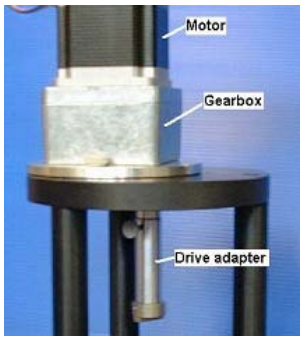
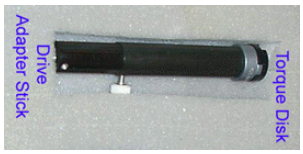
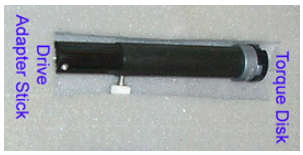
Rheo Shaft Kit	Rheo shaft for: Z46400.A Z46400.B Z46400.C Z46400.D Z46400.E Rheo shim upper part for: Z46400.A Z46400.B Z46400.C Z46400.D Z46400.E	 - H13643 H13104 - H13533 - Z73438.B Z73438.C - Z73438.E	 
Rheo Cell Kit MicWB40 for MicWB40 probe with 25 mm resonator	Contains: H124927 PH RHEO CELL MICWB40 CAP 24/4/G/S/426 H126872 Rheo Cone & Plate Cones H124929 PH RHEO CELL MICWB40 COU 19/17/P/H/253 H126873 Rheo Couette Cross Hatched Cylinder	H126865	 

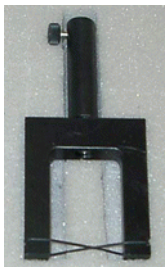
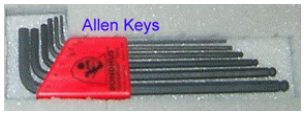
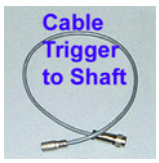
Rheo Cell Kit Micro 2.5 for Micro 2.5 probe with 25 mm resonator	Contains: H13131 PH RHEO CELL CAP 24/4/G/S/426 H126872 Rheo Cone & Plate Cones H13333 PH RHEO CELL COU 19/17/P/H/253 H126873 Rheo Couette Cross Hatched Cylinder	H126866	 

Single Rheo Items

Rheo-NMR Controller 24V	Rheo-NMR Controller with External 24V Power Supply	H13882	
Rheo-NMR Controller Power Supply 24 V	Rheo-NMR Controller 24V Power Supply	H13883	
Rheo Stepper Motor		H13127	
Rheo Motor Drive Electronics		H126867	

Part Numbers

Rheo Gear Box	Ratio 25:2 Ratio 25:1 Ratio 50:1	H13326 H13124 H13125	
Rheo Trigger Unit		H124935	
Rheo Drive Interface		H13327	
Rheo Drive Shaft	Rheo shaft for: Z46400.A Z46400.B Z46400.C Z46400.D Z46400.E	 - H13643 H13104 - H13533	
Rheo Shim Upper Barrel H13117/0 includes an additional BST WB/99 TYPE C shim upper part and Z49764 Turbine ring WB / 99 Rheo	Rheo shim upper part for: Z46400.A Z46400.B Z46400.C Z46400.D Z46400.E	 - Z73438.B Z73438.C - Z73438.E	
Rheo Torque Disk		H126868	
Rheo Drive Adapter Stick		H13329	

Rheo Drive Adapter Fork		H124937	
Rheo Drive Converter		H126869	
Rheo Allen Keys		H126870	
Rheo Fixation Screws		H126871	
Rheo Cable trigger to shaft		H124938	
Rheo Cable controller to motor		H13325	
Rheo Cable controller to spectrometer		H13330	
2 BNC Cables 5 m		H13128	

Rheo Cells Annotation

CAP = Cone and Plate cell, Cone diameter Angle° **G** glass **S** smooth Shear rate (1/s) @ 4.74 rotation rate **COU** = Couette cell, **OD** Outer Diameter of Gap **ID** inner diameter of gap **G** glass **P** peak **S** smooth **H** hatched Shear rate (1/s) @ 4.74 rotation rate **NOTE:** Different types of Rheo cells exist for the Micro 2.5 and MicWB40 probes.	Examples: Rheometric cell Type: Cone-and-plate, cone diameter 24 or 16 mm, angle 4° or 7°, glass material, smooth surface, shear rate 426/s at 4.74 Hz rotation rate (e.g. RHEO CELL CAP 24/4/g/s/426 for a 24 mm diameter, 4° angle, glass material with smooth surface) Rheometric cell Type: Couette, ID of chamber 19 mm, OD of rotor 17 mm, PEEK material, smooth or hatched surface, shear rate 253/s at 4.74 Hz rotation rate (e.g. RHEO CELL COU 19/17/P/h/253 for a 19/17 mm diameter, PEEK material with hatched surface)		 

Rheo Cells for MicWB40 Probe

Cone & Plate Cell for MicWB40 probe with 25 mm resonator	PH RHEO CELL MICWB40 CAP 24/4/G/S/426	H124927	
Couette Cell for MicWB40 probe with 25 mm resonator	PH RHEO CELL MICWB40 COU 19/17/P/H/536	H124930	
Couette Cell for MicWB40 probe with 25 mm resonator	PH RHEO CELL MICWB40 COU 7.5/5/G/S/37	H124934	
Couette Cell for MicWB40 probe with 25 mm resonator	PH RHEO CELL MICWB40 COU 7/4/G/S/40	H124932	

Couette Cell for MicWB40 probe with 25 mm resonator	PH RHEO CELL MICWB40 COU 19/17/P/H/253	H124929
Couette Cell for MicWB40 probe with 25 mm resonator	PH RHEO CELL MICWB40 COU 9/7.5/G/S/149	H124933

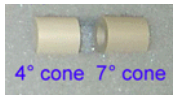
Part Numbers

Rheo Cells for Micro 2.5 Probe

Cone & Plate Cell for Micro 2.5 probe with 25 mm resonator	PH RHEO CELL CAP 24/4/G/S/426	H1313	
Cone & Plate Cell for Micro 2.5 probe with 25 mm resonator	PH RHEO CELL CAP 24/4/G/S/426	H13131	
Cone & Plate Cell for Micro 2.5 probe with 25 mm resonator	PH RHEO CELL CAP 16/7/G/S/426	H13682	
Couette Cell for Micro 2.5 probe with 25 mm resonator	PH RHEO CELL COU 19/17/P/H/536	H13334	
Couette Cell for Micro 2.5 probe with 25 mm resonator	PH RHEO CELL COU 19/17/P/H/536	H13334	
Couette Cell for Micro 2.5 probe with 25 mm resonator	PH RHEO CELL COU 19/17/P/H/253	H13333	
Couette Cell for Micro 2.5 probe with 25 mm resonator	PH RHEO CELL COU 19/17/P/S/253	H13683	

Couette Cell for Micro 2.5 probe with 25 mm resonator	PH RHEO CELL COU 9/7.5/G/S/149	H13336	
Couette Cell for Micro 2.5 probe with 25 mm resonator	PH RHEO CELL COU 9/5/G/S/37	H13684	
Couette Cell for Micro 2.5 probe with 25 mm resonator	PH RHEO CELL COU 7.5/5/G/S/37	H13337	
Couette Cell for Micro 2.5 probe with 25 mm resonator	PH RHEO CELL COU 7/4/G/S/40	H13335	

Rheo Cell Modifications

Rheo Cone & Plate Cones		H126872	
Rheo Couette Cross Hatched Cylinder		H126873	

9 Contact

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D-76287 Rheinstetten
Germany
Phone: +49 721-5161-0
http://www.bruker-biospin.com

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Figures

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