SAFYR7

KAPPABRIDGE CONTROL SOFTWARE

User Manual

Version 1.1
April 2018

AGICO

Contents

User Interface Conventions

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The user interface is optimized as such that the most routine actions can be controlled without using a computer mouse. Use the Tab key to move among multiple text boxes. The buttons corresponding to the most probable action are highlighted in GREEN and can be triggered by pressing Enter .

Status Bar Indicators

Green	Instrument is ready
Orange	Instrument is in action
Blinking Orange	Data are transferred
Red	Error or User stop

Embedded Text Boxes

PROHIBITION BOX is used to prohibit any action which may cause a damage to the instrument.

WARNING BOX is used to draw a special attention to an important information.

INFORMATION / TIP BOX is used to give a useful hint or tip for more comfortable work with the program.

Please note that the appearance of the user interface may vary according to the version of the operating system, language distribution and user settings. All print-screens in this User Manual are based on **Windows 10**, **English Distribution** with **Default Settings**.

1 Introduction

Safyr7 is a *Microsoft Windows* computer program primarily designed to control **AGICO MFK1**, **MFK2**, **KLY5** series of **Kappabridges** (Table 1), optionally coupled with **CS-3/4/L Temperature Control Units** (Table 2). The program is based on a very intuitive graphical user interface. The user interface offers two simultaneous working regimes:

1. **Instrument Control Regime** – Enables an easy control over the whole array of the sophisticated instrument measuring modes:
   - **Anisotropy of Magnetic Susceptibility (AMS)** – Magnetic anisotropy measured using either the 15-position rotatable design or, in the case of the automatic Kappabridge Versions (**FA**, **A**), using 1-Axis or two-axis (3D) Rotator[1]. AMS can be measured in variable fields and, depending upon the Kappabridge Model and Version (Table 1), at one or three operating frequencies; **KLY5** Model simultaneously determines both *In-Phase* and *Out-of-Phase* anisotropy tensors.
   - **Bulk Susceptibility** – *Volume-* or *Mass-Normalized*, *In-Phase* and *Out-of-Phase* magnetic susceptibility measured in variable driving fields and, depending upon the Kappabridge Model and Version (Table 1), at one or three operating frequencies.
   - **Temperature Dependence** – Magnetic susceptibility measured as a function of temperature in the ”low” or ”high” temperature ranges (Table 2).[2] Thermomagnetic curves can be measured in various fields and, depending upon the Kappabridge Model and Version (Table 1), at one or three operating frequencies; **KLY5** Model simultaneously measures both *In-Phase* and *Out-of-Phase* curves.
2. **Data Viewing Regime**[3] – Enables an instant calculation and visualization the results and basic data processing.

The acquired data are stored in binary or text files and can be visualized or further processed using **AGICO** data processing computer programs Anisoft, Cureval, or other programs of user's choice.

[1] The 3D Rotator is an optional accessory to the automatic Kappabridge Versions.
[2] The Kappabridge must be coupled with respective optional Temperature Control Unit(s).
[3] The program can be used solely as a data viewer, i.e., without any instrument connected.

Model \ Version	FA	FB	A	B
MFK1[a]	F1 = 976 Hz F2 = 3904 Hz F3 = 15616 Hz	F1 = 976 Hz F2 = 3904 Hz F3 = 15616 Hz	F1 = 976 Hz	F1 = 976 Hz
MFK2[b]	F1 = 976 Hz F2 = 3904 Hz F3 = 15616 Hz	F1 = 976 Hz F2 = 3904 Hz F3 = 15616 Hz		
KLY5[cd]			F1 = 1220 Hz	F1 = 1220 Hz

[a] Discontinued model, in production 2006-2017.
[b] Current model, in production since 2018.
[c] Current model, in production since 2017.
[d] This model is designed to decompose magnetic susceptibility signal into its *In-Phase* and *Out-of-Phase* components.

Table 1: Models and Versions of **AGICO** **Kappabridges** with respective operating frequencies.

F – Three-frequency Versions

A – Automatic Versions (equipped with the Up/Down Manipulator and Rotator)

B – Manual Versions (without the Up/Down Manipulator and Rotator)

Model \ Temp. Range	Low Temperature	High Temperature
CS-L[a]	–192 °C to Ambient temp.	
CS-3[b]		Ambient temp. to 700 °C
CS-4[c]		Ambient temp. to 700 °C

[a] **CS-L** Unit is an accessory to **CS-3/4** Unit.
[b] Discontinued model, in production 2006-2013.
[c] Current model, in production since 2013.

Table 2: Models of **AGICO** **Temperature Control Units** with respective temperature ranges.

2 Getting Started

2.1 System Requirements

Safyr7 requires a **PC computer** with **Microsoft Windows** operating system (OS). Supported OS are *Windows 10*, *Windows 8*, *Windows 7*, *Windows Vista*, *Windows XP* in both 32 or 64-bit versions. Even though the program is supposed to work well in various language versions, it is recommended that the English version used with a decimal comma (".") set as the system decimal delimiter. For the best functionality of the program, it is recommended that the default setting of the OS is used (i.e., no custom colors, enlarged font sizes, etc…)

2.2 Program Installation

Prior to the installation make sure that no other **AGICO** computer program is currently running. The actual installation procedure is very simple and follows the usual steps of the Microsoft Windows software installation. You can navigate a step forward or backward by clicking on [Next >] or [< Back], respectively.

1. Double-click on `Safyr7-Setup.exe` to start the **Safyr7 Setup Wizard** (Figure 1a).
2. Select the installation directory (Figure 1b). It is recommended to keep the default directory (`C:\Agico\Safyr7`) as pre-set by the installation wizard.
3. Choose the folder name in the Start menu (Figure 1c).
4. Indicate whether you want to create a desktop icon (Figure 1d).
5. Revise your installation settings and start the installation by clicking on [Install] (Figure 1e).
6. Revise the installation report (Figure 1f).
7. Finish the installation by clicking on [Finish] (Figure 1g).

To remove **Safyr7** from your computer, go to the system Start Menu → *(All Programs)* → *Safyr7* → ***Uninstall Safyr7***. When finished, all application files, desktop icons, and shortcuts are deleted from the system.

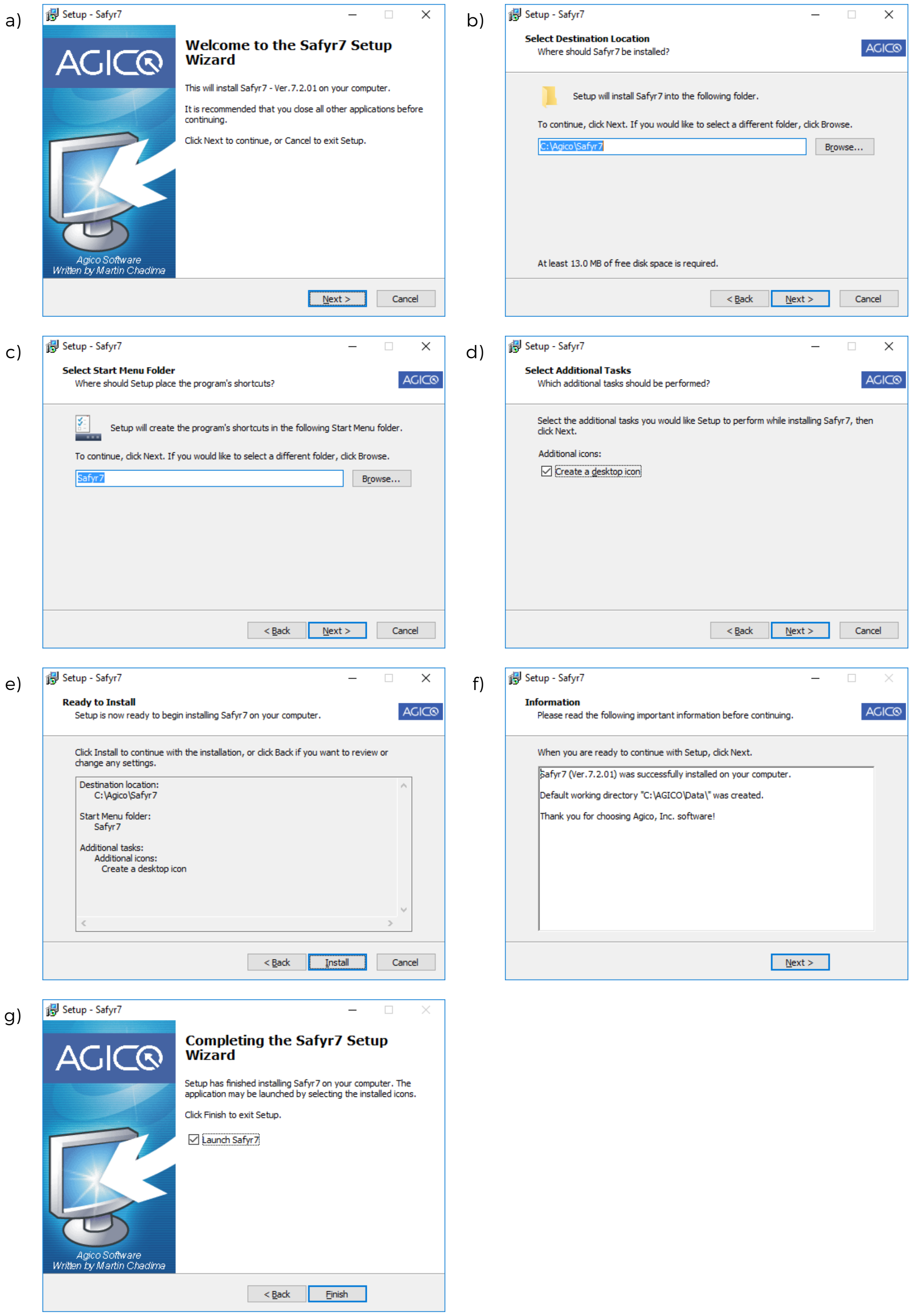


Figure 1: Installation steps of **Safyr7**.

2.3 Program Execution

Safyr7 can be executed by a double-click on the program desktop icon or by going to the OS Start Menu → *(All Programs)* → *Safyr7* → ***Safyr7***. The welcome screen flushes for about 3 s where the program **Version** and **Release** date may be reviewed (Figure 2). The main window of the program user interface is then loaded corresponding to the most recently used measuring mode.

Figure 2: Welcome screen of **Safyr7**.

The program Version and Release date may be also reviewed in the **About** window (Figure 3, About » About , Crtl + A).

Figure 3: The **About** window of **Safyr7** with program **Version** and **Release** date.

2.4 Instrument Activation

2.4.1 Generic Steps

The instrument must be activated in order to establish the connection with the instrument control computer, check various hardware components, and apply the desired user settings[4]. Before the activation sequence starts, perform the following steps:

1. Check whether the instrument is **switched ON** and **connected** to the computer via a serial port (RS232) or a USB/serial adapter.
2. Click on ACTIVATE (Ctrl + Ins).
3. The **Instrument Settings** window is automatically launched (Figure 6).
4. Review/modify the desired instrument settings and hit OK to start the activation routine. Hitting CANCEL aborts the activation.

The activation routine is monitored in the **Instrument Activation** window (Figure 4). The result of each activation step is displayed and successfully completed steps are highlighted in green, errors are in red (Figure 4). Depending upon the desired measuring mode, the activation routine consists of the following steps:

Figure 4: An example of the **Instrument Activation** window.

1. SEARCH FOR PC CONNECTION – Searches for the connection between the instrument and the instrument control computer via a serial port or USB/serial adapter. Please note that only ports number 1 –16 are searched.

[4]Applicable only for the Instrument Control mode.

2. READ FIRMWARE VERSION – Displays the actual firmware version.
3. READ INSTRUMENT TEMP – Displays the instrument service temperature readings (Interior, Water, Coil).
4. READ MAXIMUM FIELD VALUE – Displays the maximum available driving field intensities (for each operating frequency).
5. SET AUTO RANGE – Switches the instrument into the Auto Ranging mode.
6. SET FREQUENCY[5] – Sets the default operating frequency (i.e. F1 – 976 Hz).
7. SET FIELD – Sets the default field intensity (MFK1/2 – 200 A/m, KLY5 – 400 A/m).
8. TEST 25-PIN CABLE[6] – Checks whether the instrument control cable powering the instrument moving parts (Rotator, Up/Down Manipulator), Temperature Sensor and temperature control parts is connected.
9. TEST UP/DOWN MANIPULATOR[7] – Checks whether the **Up/Down Manipulator** works properly. Please note that it requires the full down- and up-movements. If the test is successful, the duration of up-movement is displayed. For the proper functioning of the instrument the movement should be shorter than 3.6 s.
10. ZEROING – Test whether the instrument pick up coils can be zeroed.

2.4.2 Rotator Activation

1. SET ROTATOR SUPPLY – Gradually increases the voltage powering the rotator in order to achieve the predefined speed of rotation. The final voltage displayed in the Action-and-Response line should be 1200–1400 [A/D convertor units]. If the rotator is not connected or it does not work properly the activation routine is aborted.
2. TEST ROTATOR PERIOD – Verifies the rotator speed and displays its rotational period. The common values, depending on the firmware version of the instrument, are close to 2500 ms or 2750 ms.
3. SET ROTATOR INITIAL POSITION – Spins the rotator until its initial position is set.
4. SET 3D INSERT POSITION[8] – Turns the rotator about 10° clockwise in order that the user is able to access the specimen fixing screw.

[5] Applies to the three-frequency versions only; for the single-frequency versions their operating frequency is MFK1, 2 – 976 Hz, KLY5 – 1220 Hz

[6] Applies to the automatic instrument versions only

[7] Applies to the automatic instrument versions only

[8] Applies to the 3D Rotator only.

2.4.3 Temperature Control Unit Activation

The following steps are performed only when **Temperature Dependence Mode** is set and **Temperature Sensor** is connected.

NEVER Connect/Disconnect Temperature Sensor to/from the Pick Up Unit when the instrument is switched **ON**! It may cause a short circuit harmful to the instrument. Always switch the instrument **OFF** when manipulating with Temperature Sensor connection.

1. ACTIVATE CS UNIT – Activates the Temperature Control Unit (CS) and automatically detects the **Low** or **High Temperature Mode** according to whether **Cryostat** is connected or not, respectively.
2. READ SPECIMEN TEMP – Checks whether the temperature sensor works correctly and displays its temperature reading.
3. CHECK WATER FLOW[9] – Checks whether the cooling water close circuit provides enough water necessary to cool down the exterior of the furnace.
4. CHECK HEATING – Checks the heating wiring Current [A] and Voltage [V].

2.4.4 Instrument Stabilization

After a successful activation, the actual instrument setting is reviewed in the **Instrument Configuration** message box. When confirmed, a 10-min countdown starts (Figure 5) designed to stabilize the instrument pick up coils. The stabilization time can be reduced by clicking on **REDUCE WAITING**. Each click reduces waiting time by one minute, not recommended!

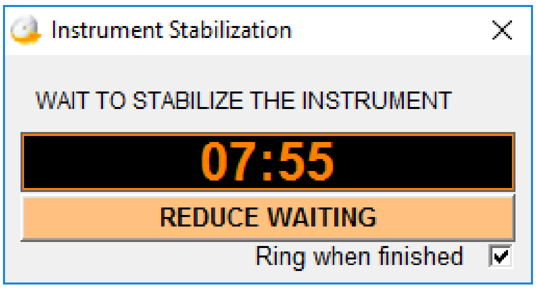


Figure 5: An example of the **Instrument Stabilization** window.

[9] Applies to the High Temperature Mode only.

3 Settings

3.1 Instrument Settings

The instrument settings including measuring mode, field intensity, operating frequency[10], and temperature-related settings[11] are controlled from the **Instrument Settings** window (Figure 6). Access: Settings » Instrument Settings or F12

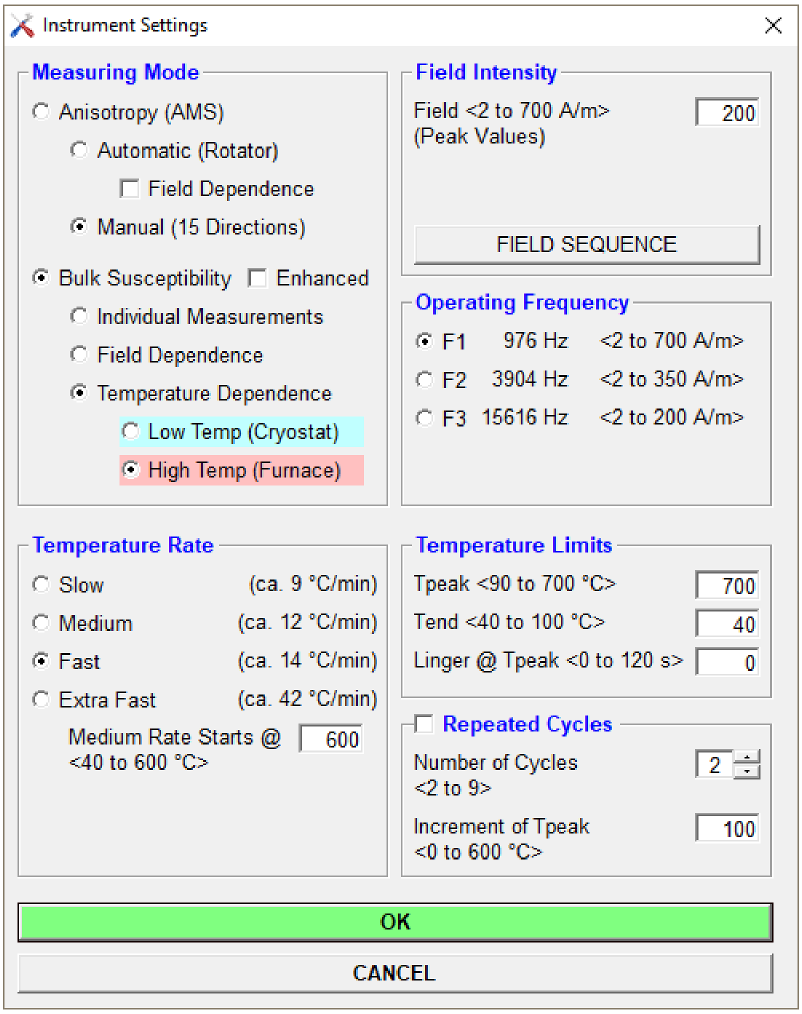


Figure 6: A design-time view of the **Instrument Settings** window, all items enabled. In run-time, the respective items are enabled/disabled according to the actual hardware configuration, phase of program activation, and currently selected measuring mode.

The desired instrument settings can be made by clicking at the respective items.

[10] Available only for the three-frequency versions.
[11] Available only with the optional CS temperature control system.

When done:

- Click **OK** to apply the desired settings. The activation routine is monitored in the **Instrument Activation** window. The actual measuring procedures are described in details in Chapter 5.
- Click **CANCEL** to close the window with the previous settings retained.

3.1.1 Measuring Mode

Depending on the actual hardware configuration, **Safyr7** may work in six different measuring modes:

Anisotropy of Magnetic Susceptibility (AMS)

1. **Automatic Anisotropy Mode**
2. **Manual Anisotropy Mode**

Bulk Susceptibility

3. **Individual Measurements Mode**
4. **Field Dependence Mode**

Temperature Dependence

5. **Low Temperature Mode**
6. **High Temperature Mode**

3.1.1.1 Automatic Anisotropy Mode[12] controls the automatic AMS measurements of the spinning specimen using **1-Axis Rotator** or **3D Rotator**. The measurements can be performed in desired field intensity (see Section 3.1.2.1) and, if applicable, in various operating frequencies (see Section 3.1.3).

To set this mode:

1. Check whether **1-Axis Rotator** or **3D Rotator** is connected to the Pick Up Unit.
2. Select the following items:

Measuring Mode

◉ **Anisotropy (AMS)**

◉ **Automatic (Rotator)**

[12] Available only for the automatic instrument versions. The Rotator (either 1-Axis Rotator or 3D Rotator) must be connected to the instrument Pick Up Unit.

3. Hit **OK** to confirm.

4. The activation routine follows the same steps as described in Section 2.4.2 and automatically recognizes whether **1-Axis Rotator** or **3D Rotator** is connected to the instrument Pick Up Unit and sets the user interface accordingly.

The actual measuring procedure is described in details in Section 5.2, Page 42.

NEVER CONNECT/DISCONNECT ROTATOR to/from the Pick Up Unit when the instrument is switched **ON**! This illegal action may cause a short circuit harmful to the instrument. Before connecting/disconnecting the Rotator, exit **Safyr7** and switch the instrument **OFF**.

3.1.1.1.1 Field Dependence of AMS With **3D Rotator** connected, a special option to automatically measure the field dependence of magnetic anisotropy becomes enabled.

To set this option:

1. Select the following items:

Measuring Mode

- ◉ **Anisotropy (AMS)**
  - ◉ **Automatic (Rotator)**
    - ☑ **Field Dependence**

2. Set the desired Field Dependence settings, see Section 3.1.2.1.

3. Hit **OK** to confirm.

The actual measuring procedure is described in details in Section 5.2, Page 42.

3.1.1.2 Manual Anisotropy Mode provides an option to measure AMS tensors manually based on fifteen directional susceptibility measurements following the rotatable design of Jelinek. The measurements can be performed in desired field intensity (see Section 3.1.2.1) and, if applicable, in various operating frequencies (see Section 3.1.3).

To set this mode:

1. Select the following items:

   Measuring Mode

   ◉ **Anisotropy (AMS)**

   ◉ **Manual (15 Directions)**

2. Hit **OK** to confirm.

The actual measuring procedure is described in Section 5.2.2.3.

UP/DOWN MANIPULATOR can be optionally enabled/disabled in the **Auxiliary Commands** window.

3.1.1.3 Individual Measurements Mode controls a sequence of individual measurements of volume/mass normalized susceptibility in desired field intensity (see Section 3.1.2.1) and, if applicable, in various operating frequencies (see Section 3.1.3).

To set this mode:

1. Select the following items:

   Measuring Mode

   ◉ **Bulk Susceptibility**

   ◉ **Individual Measurements**

2. Hit **OK** to confirm.

The actual measuring procedure is described in Section 5.3.1.

DO NOT USE 3D OR 1-AXIS ROTATOR to hold the specimen. It is highly recommended to use the appropriate **Specimen Holder** or **Vessel for Fragments**.

UP/DOWN MANIPULATOR can be optionally enabled/disabled in the **Auxialiary Commands** window.

3.1.1.3.1 Enhanced Drift Compensation Measurement In order to enhance the drift compensation algorithm, each measurement may be performed in two steps (two subsequent down and up motions):

1. Finds the appropriate measuring range.
2. Measures the specimen in the fixed range in which the finest drift compensation can be achieved.

To select this option:

- Check ☑ **Enhanced**

⚠ **PLEASE NOTE** that each measurement takes **double time** compared to the regular (one-step) algorithm in which the automatic instrument ranging routine is used. For that reason, this option may be applied only for the **Individual Measurements** and **Field Dependence** Modes

3.1.1.4 Field Dependence Mode controls the measurements of volume/mass normalized susceptibility as a function of field intensity. If applicable, the measurements can be performed in various operating frequencies (see Section 3.1.3, Page 24).

To set this mode:

1. Select the following items:

   Measuring Mode

   ◉ **Bulk Susceptibility**

   ◉ **Field Dependence**

2. To set the desired Field Dependence settings, see Section 3.1.2.1.
3. Hit **OK** to confirm.

The actual measuring routine is described in Section 5.3.2.

⚠ **DO NOT USE 3D OR 1-AXIS ROTATOR** to hold the specimen. It is highly recommended to use the appropriate **Specimen Holder** or **Vessel for Fragments**.

ⓘ **UP/DOWN MANIPULATOR** can be optionally enabled/disabled in the **Auxialiary Commands** window.

3.1.1.5 Low Temperature Mode controls the acquisition of thermomagnetic curves (variation of magnetic susceptibility as a function of temperature) in the so-called low temperature range (–192 °C to ambient temperature) using **Cryostat**. Prior to the measurement, the powder specimen is cooled down to the temperature close to that of liquid nitrogen. The specimen is then heated spontaneously up to the desired maximum temperature while magnetic susceptibility is recorded approx. every 20 s.

To set this mode:

1. Check whether **Temperature Sensor** is connected to the Pick Up Unit.
2. Check whether **Cryostat** is installed and connected to the Pick Up Unit.
3. Select the following items:

   Measuring Mode

   - ◉ **Bulk Susceptibility**
     - ◉ **Temperature Dependence**
       - ◉ **Low Temp (Cryostat)**

4. Set desired **Temperature Limits**.
5. Hit **OK** to confirm.
6. The activation routine follows the same steps as described in Section 2.4.2. Please note that the instrument is activated in **Low Temperature Mode** only when **Cryostat** is **connected** to the Pick Up Unit.

NEVER CONNECT/DISCONNECT TEMPERATURE SENSOR to/from the Pick Up Unit when the instrument is switched **ON**! This illegal action may cause a short circuit harmful to the instrument. Before connecting/disconnecting Temperature Sensor, exit **Safyr7** and switch the instrument **OFF**.

DO NOT CONNECT/DISCONNECT CRYOSTAT to/from the Pick Up Unit when the Temperature Control Unit (CS) is **activated**! This illegal action generates firmware error xxx (accompanied by an acoustic warning) and results in instrument deactivation. Prior reactivation, switch the instrument **OFF** and **ON** to clear the error warning.

SWAPPING TEMPERATURE MODES from **High Temperature** into **Low Temperature** can be executed as follows:

1. Select ◉ **Low Temp (Cryostat)**
2. Hit **OK**.
3. The Temperature Control Unit (CS) is deactivated.
4. When prompted, uninstall Furnace and **install** and **connect Cryostat**.
5. Hit **OK**.
6. The Temperature Control Unit (CS) is activated in **Low Temperature Mode**.

3.1.1.5.1 Temperature Limits Set the temperature limits by manual input into the respective text boxes:

1. Set **Tstart** – Temperature at which the user is allowed to start the measurement.
   Input range ⟨–192 °C to 0 °C⟩
2. Set **Tend** – Temperature at which the measurement is terminated.
   Input range ⟨0 to 25 °C⟩

Please refer to Table 3 for approximate duration of low temperature curve acquisition.

TO OBTAIN LOW TEMPERATURE CURVE FASTER set **Tend** lower than the ambient temperature (see Table 3 for approximate duration of measurements).

Tend	Duration
0 °C	1:00 hr.
5 °C	1:10 hr.
10 °C	1:15 hr.
15 °C	1:25 hr.
20 °C	1:45 hr.
25 °C	2:30 hr.

Table 3: Approximate durations of thermomagnetic curve acquisition in Low Temperature Mode according to the maximum desired temperature **Tend**. Ambient temperature was approx. 25 °C., **Tstart** was set as default (–192 °C).

3.1.1.5.2 Temperature Rate As the specimen is heated spontaneously, the heating rate cannot be set manually and the **Temperature Rate** options are disabled. The actual heating rate is proportional to the temperature difference between the specimen temperature and ambient temperature. The heating rate is therefore relatively fast in the beginning, slowing down at the end when the ambient temperature is gradually reached (see Figure 7).

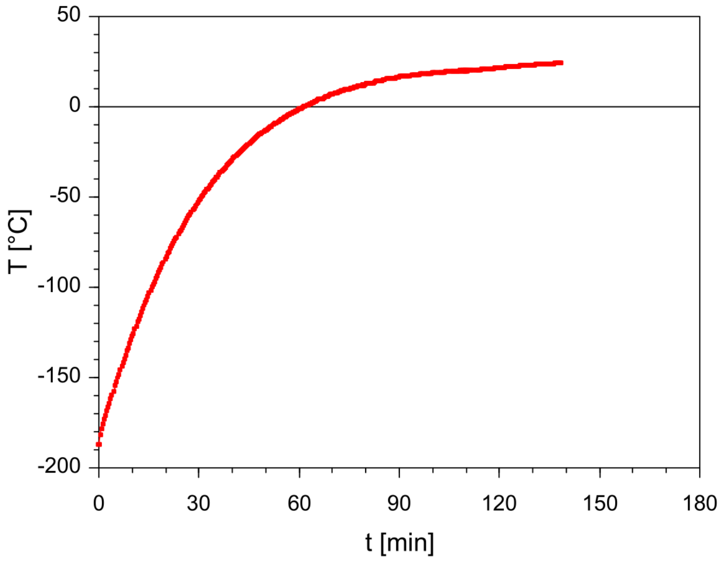


Figure 7: Specimen temperature as a function of time during a spontaneous heating in Low Temperature Mode (ambient temperature was approx. 25 °C).

3.1.1.6 High Temperature Mode controls the acquisition of thermomagnetic curves (variation of magnetic susceptibility as a function of temperature) in the so-called high temperature range (from ambient temperature up to 700 °C and back to ambient temperature) using **Furnace** and its water cooling system. While the specimen is heated (or cooled), magnetic susceptibility is recorded approx. every 20 s.

To set this mode:

1. Check whether **Temperature Sensor** is connected to the Pick Up Unit.
2. Check whether **Furnace** is installed to the Pick Up Unit. (Cryostat must not be connected!)
3. Select the following items:

Measuring Mode

◉ **Bulk Susceptibility**

◉ **Temperature Dependence**

◉ **High Temp (Furnace)**

4. Set desired **Temperature Limits**.
5. Set desired **Temperature Rate**.
6. Optionally, activate and set **Repeated Cycles** options.
7. Hit **OK** to confirm.
8. The activation routine follows the same steps as described in Section 2.4.2. Please note that the instrument is activated in **High Temperature Mode** only when the Temperature Sensor is connected to the Pick Up Unit and **Furnace** is properly installed. Cryostat **must not** be connected!

NEVER CONNECT/DISCONNECT TEMPERATURE SENSOR to/from the Pick Up Unit when the instrument is switched **ON**! This illegal action may cause a short circuit harmful to the instrument. Before connecting/disconnecting Temperature Sensor, exit **Safyr7** and switch the instrument **OFF**.

DO NOT CONNECT/DISCONNECT FURNACE to/from the Pick Up Unit when the Temperature Control Unit (CS) is **activated**! This illegal action generates firmware error xxx (accompanied by an acoustic warning) and results in instrument deactivation. Prior reactivation, switch the instrument **OFF** and **ON** to clear the error warning.

SWAPPING TEMPERATURE MODES from **Low Temperature** into **High Temperature** can be executed as follows:

1. Select ◉ **High Temp (Furnace)**.
2. Hit **OK**.
3. The Temperature Control Unit (CS) is deactivated.
4. When prompted, disconnect and uninstall **Cryostat**, install **Furnace**.
5. Hit **OK**.
6. The Temperature Control Unit (CS) is activated in **High Temperature Mode**.

3.1.1.6.1 Temperature Limits In High Temperature Mode, the specimen is heated from the ambient temperature up to the desired peak temperature (heating half-cycle) and then cooled down to the desired end temperature (cooling half-cycle) while magnetic susceptibility is recorded approx. every 20 s.

Set the temperature limits by manual input into the respective text boxes:

1. Set **Tpeak** – Upper temperature limit to which the specimen is heated in the heating half-cycle.
   Input range ⟨90 to 700 °C⟩
2. Set **Tend** – Temperature below which the cooling half-cycle is terminated.
   Input range ⟨40 to 100 °C⟩
3. Optionally set **Linger @ Tpeak** – Time during which **Tpeak** temperature is maintained in the end of heating half-cycle.
   Input range ⟨0 to 120 s⟩

3.1.1.6.2 Temperature Rate In High Temperature Mode, the specimen is heated at a controlled rate to the maximum temperature **Tpeak** and then cooled down at the same rate to the minimum temperature **Tend**. There are four temperature rates available (Figure 9). Default temperature rate (**Fast**) is suitable for most rocks and environmental materials. For special studies, slower temperature rates (**Slow**, **Medium**) can be used but one must realize that such measurements take correspondingly longer time (see Table 4).

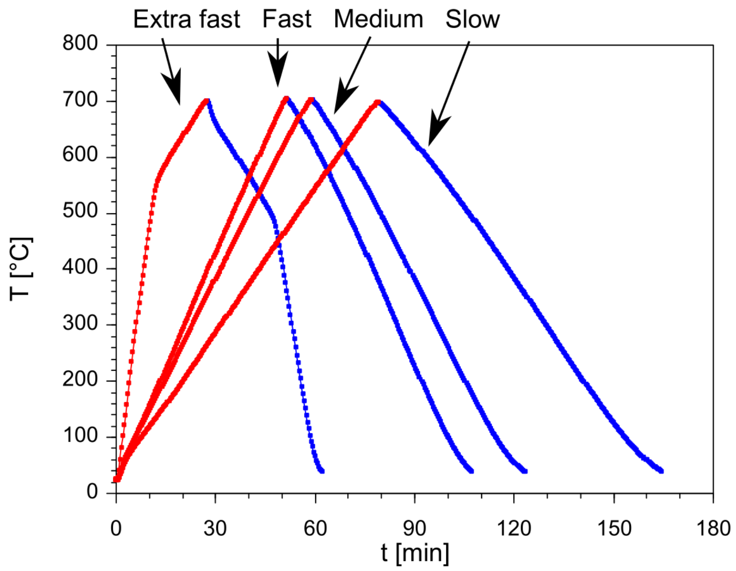


Figure 8: Specimen temperature as a function of time for four available temperature rates in the High Temperature Mode.

TO OBTAIN HIGH TEMPERATURE CURVE FASTER use the **Extra Fast** temperature rate (ca. 42 °C/min). This option may be especially useful when one is not interested in a whole course of thermomagnetic curve but only in a fast way to obtained characteristic temperature(s), e.g., Curie points. In order to have more measurements in the high temperature interval where the characteristic temperature is expected to be, the heating rate is slowed down (roughly corresponding to **Medium Rate**) when the desired **Tpeak** is approached. The temperature above which **Medium Rate Starts** is set automatically or manually; it should be at least 100 °C below the desired **Tpeak** temperature.

Temperature Rate		Duration
Slow	9 °C/min	2:45 hr.
Medium	12 °C/min	2:00 hr.
Fast	**14 °C/min**	**1:45 hr.**
Extra Fast	42 °C/min	1:00 hr.

Table 4: Temperature rates available in the High Tempearature Mode with approximate duration of a standard measurement cycle (from the ambient temperature up to 700 °C and down to 40 °C). Default temperature rate is in **bold**.

3.1.1.6.3 Repeated Cycles In the High Temperature Mode, several subsequent heating/cooling cycles can be automatically measured. For each cycle, the peak temperature (**Tpeak**) is automatically increased by a desired temperature increment.

To apply this option:

1. Set **Temperature Limits** for the first heating/cooling cycle, see Section 3.1.1.6.1
2. Check ☑ **Repeated Cycles**
3. Set **Number of Cycles** – Number of heating/cooling cycles.
   Input range ⟨2 to 9⟩
4. Set **Increment of Tpeak** – Increment by which Tpeak is increased in each heating/cooling cycle.
   Input range ⟨0 to 600 °C⟩

Example of settings:

- **Tpeak** = 100
- **Tend** = 40
- **Linger @ Tpeak** = 60
- **Number of Cycles** = 5
- **Increment of Tpeak** = 100

This setting results in 5 heating/cooling cycles:

1. Heating ⟨Ambient temp. to 100 °C⟩ → Linger 60 s → Cooling ⟨100 to 40 °C⟩
2. Heating ⟨40 to 200 °C⟩ → Linger 60 s → Cooling ⟨200 to 40 °C⟩
3. Heating ⟨40 to 300 °C⟩ → Linger 60 s → Cooling ⟨300 to 40 °C⟩
4. Heating ⟨40 to 400 °C⟩ → Linger 60 s → Cooling ⟨400 to 40 °C⟩
5. Heating ⟨40 to 500 °C⟩ → Linger 60 s → Cooling ⟨500 to 40 °C⟩

3.1.2 Field Intensity

The intensity of driving field can be set in the following text box:

Field Intensity

Field ⟨X to XXX A/m⟩ [ ]

Field intensity is given in its **peak value** (amplitude) in [A/m]. The allowed field range (lower and upper limits) vary according to the instrument model, version, and operating frequency (see Table 5). The default field intensity depends on the instrument model and, if applicable, it corresponds to the maximum allowed field common to all three operating frequencies (see Table 5).

Instrument		**Operating Frequency**		**Field Intensity**	
Model	**Version**	**Name**	**Value**	**Range**	**Default**
MKF1, 2	FA, FB	F1	976 Hz	⟨2 to 700 A/m⟩	200 A/m
		F2	3904 Hz	⟨2 to 350 A/m⟩	200 A/m
		F3	15616 Hz	⟨2 to 200 A/m⟩	200 A/m
MKF1	A, B	F1	976 Hz	⟨2 to 700 A/m⟩	200 A/m
KLY5	A, B	F1	1220 Hz	⟨5 to 750 A/m⟩	400 A/m

Table 5: An instrument overview with available operating frequencies (if applicable), respective guaranteed field ranges and default field values. Note that the upper limits of field ranges vary for individual instruments (piece to piece) and they are usually slightly higher than the upper range limits declared in this table. The actual upper range limits are read during the Instrument Activation (READ MAXIMUM FIELD VALUES) and displayed both in the **Instrument Activation** and **Instrument Settings** windows.

Please note that in the discontinued models of Kappabridges (KLY1–4), the field intensity was given in the **Root Mean Square (rms)** or **effective** values. To recalculate the peak values into effective values, use the following formula:

$$H_{\text{eff}} = \frac{H_{\text{peak}}}{\sqrt{2}}$$

The default field of KLY3,4 Kappabridges is 300 A/m (effective). To achieve a corresponding field intensity for MFK1, 2 and KLY5 Kappabridges, please set ca. 425 A/m (peak).

3.1.2.1 Field Dependence Field dependence settings are applicable for both field dependence of bulk susceptibility and field dependence of magnetic anisotropy.

To edit the Field Dependence setting:

1. Click at the following button:

   Field Intensity

   FIELD SEQUENCE

2. The **Field Dependence Settings** window opens.
3. Set a desired **Field Sequence** by one of the following actions:
   - Use one of the predefined field sequences:

1.	Full	Default > Full	F1
2.	Reduced	Default > Reduced	F2
3.	Basic	Default > Basic	F3

   - Open a field sequence from a file.
     File > Open   Ctrl + O
   - Modify the existing field sequence manually in the text box. Field intensities should be in [A/m, peak values] in increasing order separated by space. When confirmed, the sequence is automatically sorted in increasing order; non-permitted characters and out-of-limit values (see Table 5) are omitted.
   - Optionally, the sequence may be saved into a text file for later use.
     File > Save As   Ctrl + W
4. Set desired **Instrument Ranging** mode:
   - ◉ **Dynamic Range** – The whole sequence is measured using the instrument **Autorange** feature, i.e., the optimum measuring range is set automatically for each field.
   - ◉ **Fixed Range**[13] – Prior to the start of the sequence, the specimen is measured at the strongest desired field in order to find the coarser measuring range to be applied for the whole sequence. **Autorange** is then **disabled** and the whole sequence is measured using the fixed range corresponding to the strongest field intensity.
5. Hit **OK** to confirm.

[13] Applies to Bulk measurement only.

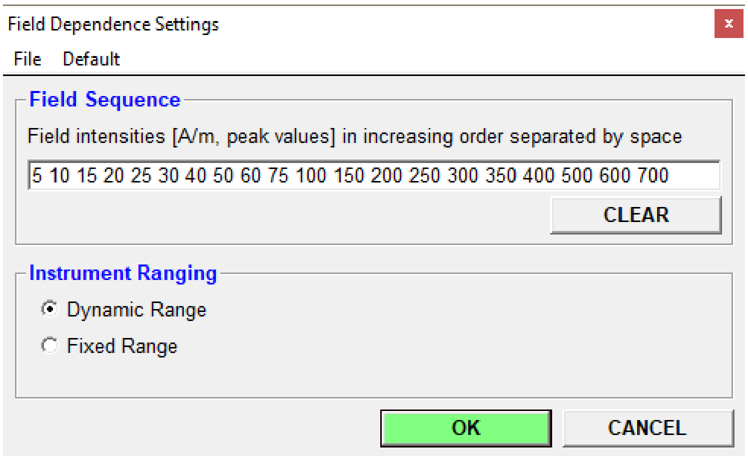


Figure 9: An example of the **Field Dependence Settings** window.

3.1.3 Operating Frequency

Depending on the instrument model and version, the instrument may work in one or three operating frequencies (see Table 1, 5).

To select the desired operating frequency:

1. Check the respective box:

Operating Frequency

◉	F1	976 Hz	⟨2 to 700 A/m⟩	F1
○	F2	3904 Hz	⟨2 to 350 A/m⟩	F2
○	F3	15616 Hz	⟨2 to 200 A/m⟩	F3

2. Hit **OK** to confirm.

3. Let the instrument Pick Up coils to stabilize for at least 10 min.

PLEASE NOTE that the default field intensity is reset any time the operating frequency is changed.

3.2 Volume / Mass Susceptibility

The **Volume / Mass Susceptibility** window controls how the measured susceptibility is normalized and enables to set the default values of the actual specimen volume and/or mass (Figure 10). Access: Settings » Volume / Mass Susceptibility

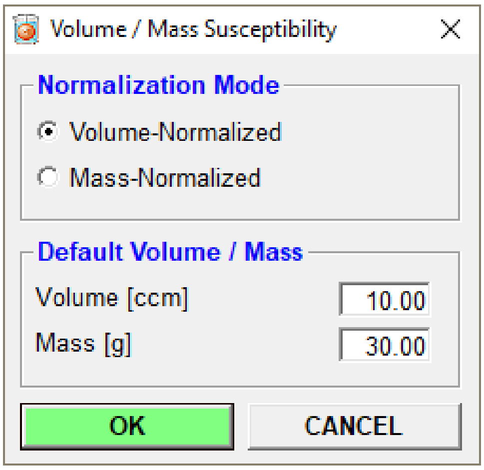


Figure 10: An example of the **Volume / Mass Susceptibility** window.

3.2.1 Susceptibility Normalization

This option defines how the bulk susceptibility data are normalized and presented in the user interface. The raw data are first corrected for the susceptibility of empty holder and then presented as:

- **Volume-normalized** – Also termed as **volume-specific** or simply **bulk susceptibility**
- **Mass-normalized** – Also termed as **mass-specific** or simply **mass susceptibility**

⚠ **PLEASE NOTE** that anisotropy data are always **volume-normalized** using the **actual volume** set for each specimen.

To set the desired normalization mode, click at the respective item:

Normalization Mode

◉ Volume-Normalized

○ Mass-Normalized

The **AGICO** Kappabridges primarily measure the so-called **total susceptibility**, k_{TOT}, that is independent of the specimen volume. The total susceptibility is defined as the induced magnetic moment of the specimen divided by the nominal volume of the instrument (being 10 cm^3 for **AGICO** Kappabridges). The total susceptibility is very convenient in sensitivity and error considerations because it directly corresponds to the "**raw susceptibility signal**" provided by the instrument.

The **volume-normalized susceptibility**, k_{VOL}, is calculated as follows:

$$k_{VOL} = \frac{V_0}{V} k_{TOT}$$

where V is the actual volume of the specimen and V_0 is the nominal volume (V_0= 10 cm^3).

The volume-normalized susceptibility is presented in dimensionless SI unit.

In environmental magnetism, the **mass-normalized susceptibility**, χ, is often used. It is related to the volume-normalized susceptibility as follows:

$$\chi = \frac{k_{VOL}}{\rho} = \frac{V k_{VOL}}{m}$$

where ρ is density, m is specimen mass.

The mass-normalized susceptibility is then related to the total susceptibility as follows:

$$\chi = \frac{V_0}{V}\frac{V}{m} k_{TOT} = \frac{V_0}{m} k_{TOT},$$

The mass-normalized susceptibility is presented in [m^3/kg].

3.2.2 Default Volume / Mass

The **Default** specimen volume or mass value is used each time a new measurement is started and displayed in the **New Specimen** window where the user may overwrite it with the **Actual** volume or mass value.

The default volume and mass is set by direct input in the respective text boxes:

Default Volume / Mass

Volume [ccm]	⟨1 to 20 cm^3⟩
Mass [g]	⟨0.01 to 40 g⟩

3.3 Anisotropy Settings

The following settings are available only when **Magnetic Anisotropy** modes are set.

3.3.1 Demagnetizing Factor

This option indicates whether the correction for demagnetizing factor is considered in the calculation of mean susceptibility.

To enable this option:

1. Click at Settings » Anisotropy Settings » Use Demagnetizing Factor .
2. Go to Settings » Anisotropy Settings and check whether ✓**check mark** appears in front of ✓Use Demagnetizing Factor item.

To disable this option:

1. Click at Settings » Anisotropy Settings » Use Demagnetizing Factor .
2. Go to Settings » Anisotropy Settings and check whether **no check mark** appears in front of Use Demagnetizing Factor item.

3.3.2 Orientation Parameters

In general, there are multiple ways how to sample the oriented specimens. **Safyr7** adapts the general transformation matrix to transform the acquired anisotropy data from the specimen coordinate system into geographic coordinate system (and tectonic coordinate systems) using a set of **Orientation Parameters** (**P1**, **P2**, **P3**, **P4**). The Orientation Parameters quantitatively describe the sampling scheme (see Figure 35 in Appendix).

To set the appropriate Orientation Parameters:

1. Go to: Settings » Anisotropy Settings » Orientation Parameters to launch the **Orientation Parameters** window.
2. Verify the current settings of Orientation Parameters.
3. To enable any changes, hit **CHANGE**.
4. Select the Orientation Parameters.
5. Hit **OK** to confirm.

3.3.3 Quantitative Anisotropy Factors

There is a set of eight **Quantitative Anisotropy Factors** which are calculated and displayed in the user interface. For the definitions of available Anisotropy Factors, go to Section 6.3 in Appendix, Page 79).

To select the desired Anisotropy Factors:

1. Go to: Settings » Anisotropy Settings » Quantitative Anisotropy Factors to launch the **Quantitative Anisotropy Factors** window (Figure 11).
2. Verify the current settings of Anisotropy Factors.
3. To enable any changes, hit **CHANGE**.
4. For each Factor, selected from 38 predefined equations and enter the desired Factor name.
5. Hit **OK** to confirm.

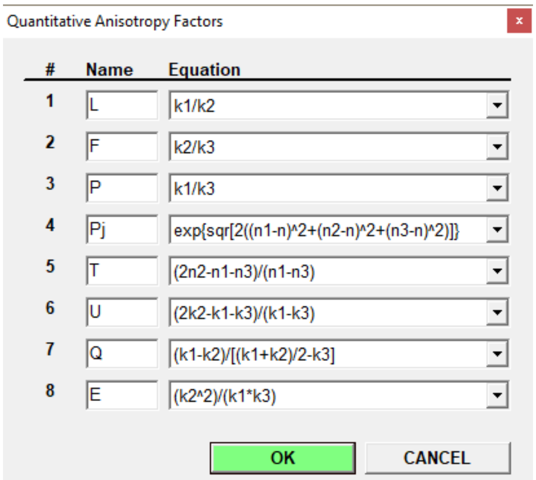


Figure 11: An example of the **Quantitative Anisotropy Factors** window.

⚠ **PLEASE NOTE** that no Quantitative Anisotropy Factors are stored in the anisotropy data files (**.ams, *.ran*). These data files store only the tensor elements and the Anisotropy Factors are calculated during the subsequent data processing according to the setting in the data processing software.

4 Auxiliary Routines

4.1 Calibration

4.1.1 Calibration Standard

Each **AGICO** Kappabridge is provided with a cylindrical **Calibration Standard** of given magnetic susceptibility values. The maximum and minimum values correspond to magnetic susceptibility parallel to the calibration standard cylinder axis and perpendicular to it, respectively. After a fresh installation of **Safyr7**, the calibration standard values must be entered in order to perform the instrument calibration.[14]

If no calibration standard values are set, the user will be prompted to do before starting the actual Calibration Routine.

To enter/modify the calibration standard values follow these steps:

1. Go to: Settings > Calibration Standard to launch the **Calibration Standard Values** window (Figure 12).
2. Verify the current settings of Calibration Standard Values.
3. To enable any changes, hit **CHANGE**.
4. Enter / Modify the maximum and minimum values in the respective text boxes.
5. Hit **OK** to confirm.

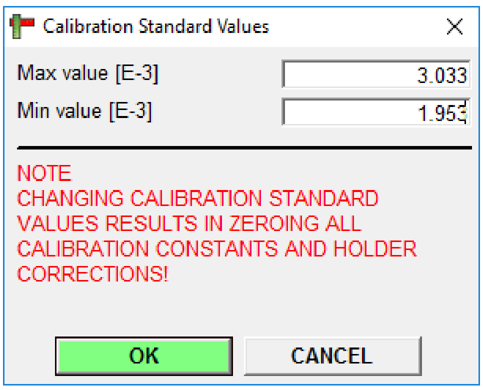


Figure 12: An exaple of the **Calibration Standard Values** window.

[14]With the purchase of new instrument, the calibration standard values are entered by the **AGICO** technician during the instrument installation and training.

4.1.2 Instrument Calibration

In order to obtain the accurate susceptibility readings, the instrument must be calibrated. It is generally recommended to execute the **Instrument Calibration** every day before staring the work. The instrument should be always calibrated when the operating frequency is changed.[15]

ℹ If no calibration has ever been executed (first time use of the instrument or the fresh installation of the software) or the calibration is out of date (30 days or older) the user will be prompted to calibrate when trying to start a new measurement.

To execute **Instrument Calibration** follow these steps:

1. Go to: Execute » Instrument Calibration F3 to launch the **Instrument Calibration** window (Figure 13).
2. Verify whether the displayed **Calibration Standard Values** (Maximum and Minimum) correspond to the actually used Calibration Standard.
3. Fix the Calibration Standard into a manual holder or rotator in the following way:
   - **Manual holder** and **1-Axis Rotator** – Cylinder axis oriented **vertically**.
   - **3D Rotator** – Cylinder axis oriented **horizontally**.
4. Hit **START** to start the calibration routine.
5. In case of emergency, e.g., standard gets loose, holder not aligned with the pick up coil, hit **STOP** Space Bar to abort the routine anytime.
6. The calibration routine consists of one measurement of bulk susceptibility and additionally, in the case of the automatic anisotropy mode, one measurement of anisotropy using the Rotator. The bulk susceptibility measuring routine differs depending on whether the Up/Down Manipulator is enabled or not:
   - **Up/Down Manipulator Enabled** – The measuring routine is performed automatically.
   - **Up/Down Manipulator Disabled** – Wait for a long beep to insert the holder into the coil, and to wait for a short beep to pull it out. The instruction prompts are also displayed in the status bar of the main window.
7. After a successful calibration, new calibration constants are calculated.

[15]Applies to the tree-frequency models only.

8. Hit **SAVE** to save and use the new calibration constants. Please note that all previous holder correction values will be zeroed.

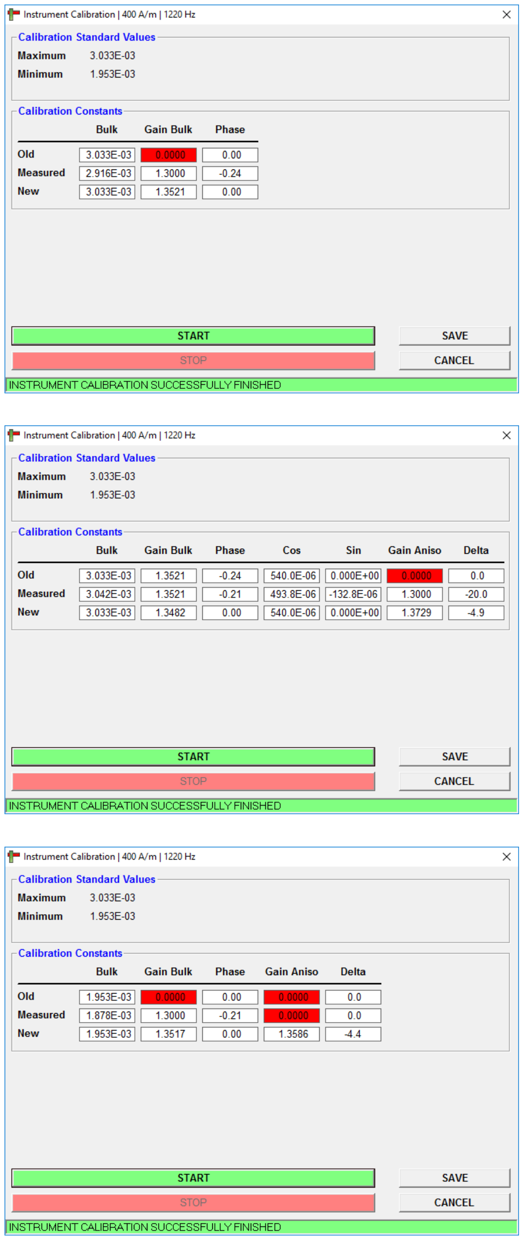


Figure 13: Typical examples of the **Instrument Calibration** windows for a) Manual measuring modes (including Manual Anisotropy Mode), b) 1-Axis Rotator, c) 3D Rotator. (Results for KLY5)

⚠ If Up/Down Manipulator is disabled, make sure that the **plastic cylinder is installed** into the coil.

Please note that for the purpose of the calibration routine, the field intensity is switched to the instrument default value. When finished, the field intensity is reset back to its original value.

4.2 Holder Correction

The **Holder Correction** is intended to correct the measured susceptibility (anisotropy) values for the susceptibility (anisotropy) of an empty holder (rotator).

If no holder correction has ever been executed (first-time use of the instrument or the fresh installation of the software) or the holder correction values are suspicious, the user will be prompted to perform the holder correction routine when trying to start a new measurement.

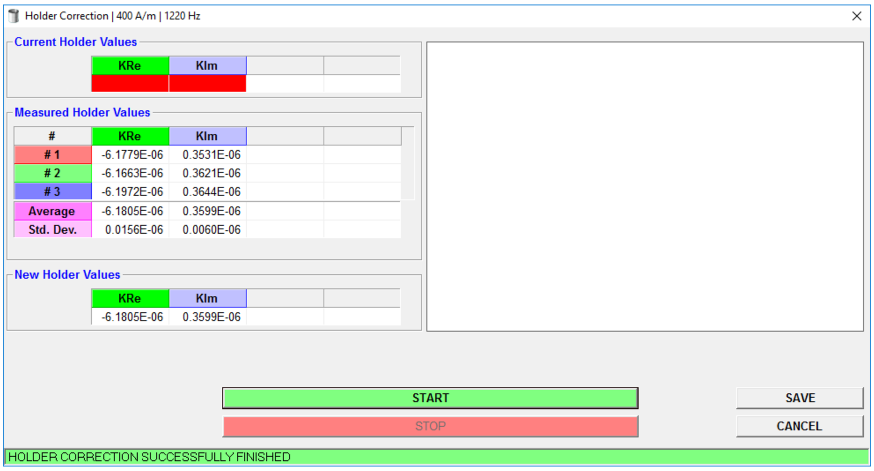
It is recommended to perform the holder correction routine each time after instrument activation, change of operating frequency, change of holder type, or change of measuring mode (which usually implies different holder type to be used)

.

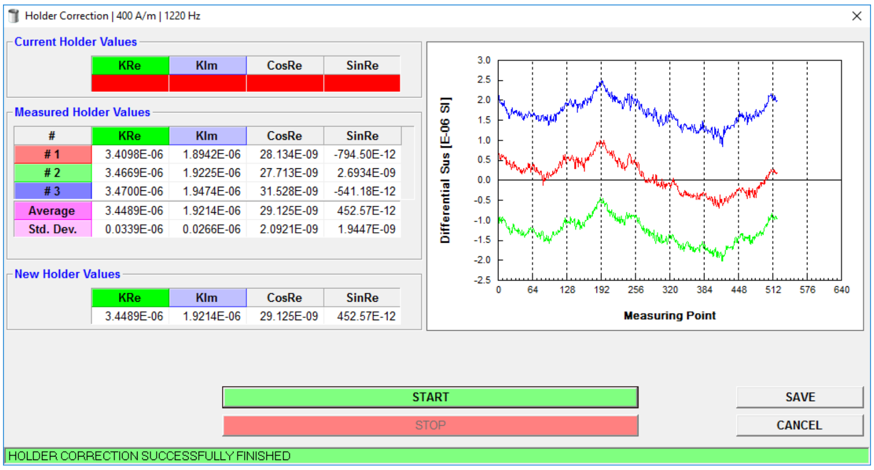
To execute **Holder Correction** follow these steps:

1. Go to: Execute > Holder Correction F4 to launch the **Holder Correction** window (Figure 14).
2. Make sure that the holder or rotator is clean and empty (without any specimen or calibration standard).
3. Hit **START** to start the holder correction routine.
4. In case of emergency, hit **STOP** Space Bar to abort the routine anytime.
5. The holder correction routine consists of three consecutive measurements of bulk susceptibility and additionally, in the case of the automatic anisotropy mode, three consecutive measurements of anisotropy using the Rotator. The bulk susceptibility measuring routine differs depending on whether the U/D Manipulator is enabled or not:
   - **Up/Down Manipulator Enabled** – The measuring routine is performed automatically.
   - **Up/Down Manipulator Disabled** – Wait for a long beep to insert the holder into the coil, and to wait for a short beep to pull it out. The instruction prompts are also displayed in the status bar of the main window.

a)



b)



c)

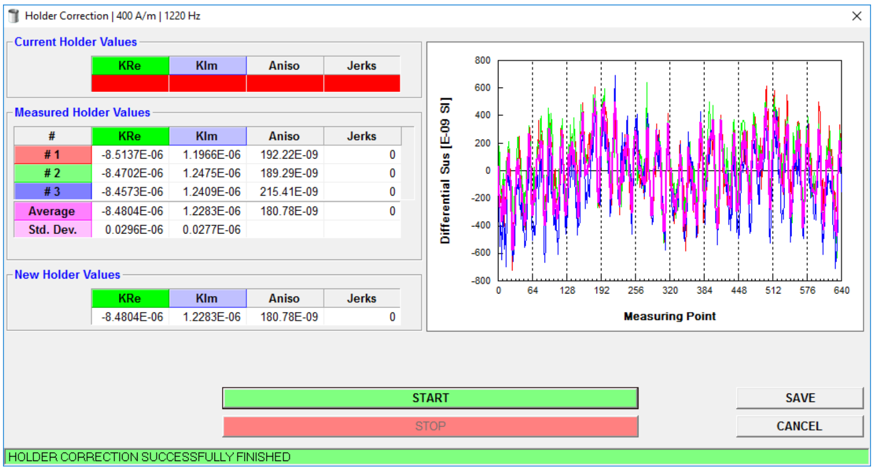


Figure 14: Typical examples of the **Holder Correction** windows for a) Manual measuring modes (including Manual Anisotropy Mode), b) 1-Axis Rotator, c) 3D Rotator.

6. When the routine is successfully terminated, the average holder correction values and their standard errors are calculated.

7. Hit **SAVE** to save and use the new holder correction values.

If bulk susceptibility (anisotropy) of the empty holder (rotator) do not lie within the expected limits or three consecutive measurements are inconsistent, the respective suspicious values are highlighted in red. It is upon the user's judgment whether to save the holder correction values or not (depending also on the strength of the specimens to be measured)

.

Please note that in case of operating frequencies F2 or F3 the holder susceptibility (and its anisotropy) are saved to be used in the current session only.

Please note that the holder correction routine is performed in the current field intensity unless it is not lower than 200 A/m. If this is the case, the field intensity is switched to 200 A/m; when finished the field intensity is reset back to its original value.

Note that the holder correction values are zeroed whenever you perform the calibration routine, change the calibration standard nominal values.

4.3 Auxiliary Commands

The **Auxiliary Commands** directly control the instrument on the elementary level. These commands are intended to enable/disable the certain instrument features, to perform the basic maintenance tasks or to execute the Up/Down Manipulator and/or Rotaror recovery after an immediate halt caused by the user emergency stop.

To execute an Auxiliary Command, follow these steps:

1. Go to: Execute > Auxiliary Commands Alt + Bksp to launch the **Auxiliary Commands** window (Figure 15).

2. Each command is executed immediately after a click on the respective button or check box.

3. The execution of each command is monitored the Action-and-Response table in the lower part of the window. The corresponding command line is highlighted in green or red depending on whether the command execution was successful or not, respectively. Duration of each execution is also displayed.

4. Hit STOP Space Bar for immediate abortion of any currently executed command.

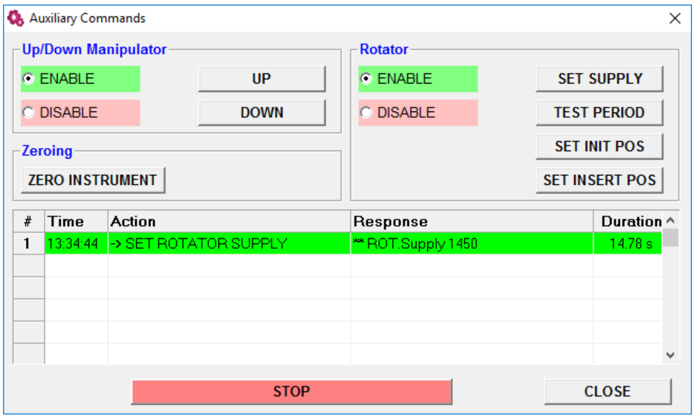


Figure 15: An example of the **Auxiliary Commands** window.

4.3.1 Up/Down Manipulator Commands

4.3.1.1 Enable Up/Down Manipulator ◉ ENABLE – Enables Up/Down Manipulator. This option is applicable to all measuring modes. The lowering and lifting of the specimen holder in/out of the pick coil with the right timing is performed automatically.

When Up/Down Manipulator is enabled, make sure that the **Plastic Cylinder for Manual Measurement** is **not inserted** in the pick up coil.

Please note that in the **Automatic Anisotropy** mode (with Rotator) and **Temperature Dependence** modes, the Up/Down Manipulator must be **always enabled**!

It is highly recommended to use the Up/Down Manipulator whenever the conditions permit as it seems to be more preciser compared with the manual inserting of the specimen holder into the instrument coil.

4.3.1.2 Disable Up/Down Manipulator

◉ DISABLE – Disables Up/Down Manipulator. This option is applicable only to the Individual Measurements, Field Dependence and Manual Anisotropy modes. When the Up/Down Manipulator is disabled, the specimen holder motions must be performed manually. To follow the right timing, the user is guided by two acoustic signals (beeps) and the corresponding [**TEXT PROMPTS**] in the status bar of the main **Safyr7** window:

1. Long Beep [**SPECIMEN IN**] – Insert the specimen into the pick up coil.
2. Short Beep [**SPECIMEN OUT**] – Pull the specimen out from the pick up coil.

⚠ When Up/Down Manipulator is disabled, the **Plastic Cylinder for Manual Measurement** must be **installed** into the pick up coil to ensure the specimen is placed in its homogenous field area (central part).

4.3.1.3 Up / Down Commands

The Up/Down Manipulator motions are executed by pressing the respective buttons:

- **UP** – Moves Up/Down Manipulator to its upper position.
- **DOWN** – Moves Up/Down Manipulator to its lower position.

Duration of each movement is displayed in the Action-and-Response line. The Up movement usually takes longer than the Down movement but it should not exceed 3.6 s.

4.3.2 Rotator Commands

4.3.2.1 Enable / Disable Rotator

Enabling or **Disabling** the Rotator can be perfomed by clicking on the respective check boxes:

- ◉ ENABLE – Enables the Rotator
- ◉ DISABLE – Disables the Rotator

4.3.2.2 Rotator Control Commands

The following commands are related to the spinning motion of the 3D or 1-Axis Rotator:

- **SET SUPPLY** – Gradually increases the voltage powering the rotator in order to achieve the predefined speed of rotation. The final voltage displayed in the Action-and-Response line should be 1200–1400 [A/D convertor units].

- **TEST PERIOD** – Verifies the rotator speed and displays its rotational period. The common values, depending on the firmware version of the instrument, are close to 2500 ms or 2750 ms.
- **SET INIT POS** – Spins the rotator until its initial position is set.
- **SET INSERT POS** – Turns the rotator about 10° clockwise in order that the user is able to access the specimen fixing screw. This option applies to the 3D Rotator only.

4.3.3 Zeroing Command

ZERO INSTRUMENT – Executes the zeroing routine of the pick up coils in order to check the zeroing capability of the instrument. Duration of zeroing is usually between 2–3 s.

4.4 Sigma Test

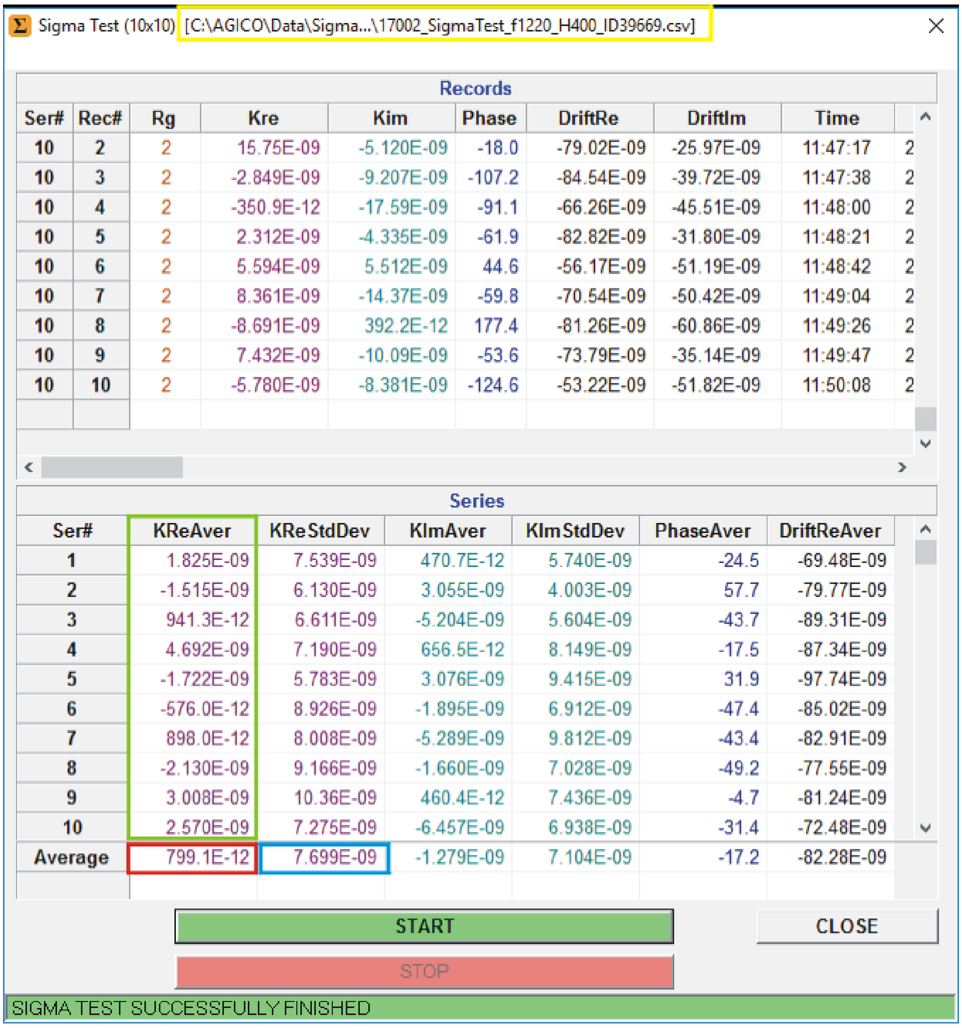
The so-called **Sigma Test** evaluates the instrument sensitivity and magnetic environment in its vicinity. It consists of 10 series of 11 blank measurements (the first measurement is always discarded) of empty coil with field intensity switched to 400 A/m (200 A/m) for frequency F1 (F2, F3) and the Up/Down Manipulator disabled. More details on the Sigma Test can be found in the respective Instrument User Manual.
Do not disturb the test by moving any object in the vicinity of instrument! Make sure that temperature is stable!
To perform the Sigma Test, follow these steps:

1. Switch the instrument to the desired Operating Frequency.
2. Go to: Execute > Sigma Test Shift + Del to launch the **Sigma Test** window (Figure 16).
3. Hit **START** to start the test.
4. Hit **START** to confirm the sigma test instructions.
5. The field Intensity is automatically switched to 400 A/m (200 A/m) for frequency F1 (F2, F3).
6. The Up/Down Manipulator is automatically disabled.
7. Sigma test routine will begin after 10 min. of thermal stabilization.
8. The actual Sigma Test lasts approx. 40 min.

The Sigma Test produces the following results:

- **KReAver** – Represents the average value of In-Phase (Real) susceptibility calculated for each Series of measurements (Figure 16, green rectangle).
- **Average** of **KReAver** – Represents the total average (mean of means) of In-Phase (Real) susceptibility for all measuring Series (Figure 16, red rectangle). This value should be close to the zero.
- **KRe StdErr** – Represents the Standard Deviation of In-Phase (Real) susceptibility estimated for all measuring Series (Figure 16, blue rectangle). To consider the Sigma Test as successful, this value must be lower then 20×10^{-9} SI (for KLY5, MFK1 or MFK2 running on first frequency).

The results of the Sigma Test are automatically stored into the following directory `C:\AGICO\Data\SigmaTest` as the csv-file which name is derived from the actual date and time (Figure 16, yellow strip).



Ser#	Rec#	Rg	Kre	Kim	Phase	DriftRe	DriftIm	Time	
10	2	2	15.75E-09	-5.120E-09	-18.0	-79.02E-09	-25.97E-09	11:47:17	2
10	3	2	-2.849E-09	-9.207E-09	-107.2	-84.54E-09	-39.72E-09	11:47:38	2
10	4	2	-350.9E-12	-17.59E-09	-91.1	-66.26E-09	-45.51E-09	11:48:00	2
10	5	2	2.312E-09	-4.335E-09	-61.9	-82.82E-09	-31.80E-09	11:48:21	2
10	6	2	5.594E-09	5.512E-09	44.6	-56.17E-09	-51.19E-09	11:48:42	2
10	7	2	8.361E-09	-14.37E-09	-59.8	-70.54E-09	-50.42E-09	11:49:04	2
10	8	2	-8.691E-09	392.2E-12	177.4	-81.26E-09	-60.86E-09	11:49:26	2
10	9	2	7.432E-09	-10.09E-09	-53.6	-73.79E-09	-35.14E-09	11:49:47	2
10	10	2	-5.780E-09	-8.381E-09	-124.6	-53.22E-09	-51.82E-09	11:50:08	2

Ser#	KReAver	KReStdDev	KImAver	KImStdDev	PhaseAver	DriftReAver
1	1.825E-09	7.539E-09	470.7E-12	5.740E-09	-24.5	-69.48E-09
2	-1.515E-09	6.130E-09	3.055E-09	4.003E-09	57.7	-79.77E-09
3	941.3E-12	6.611E-09	-5.204E-09	5.604E-09	-43.7	-89.31E-09
4	4.692E-09	7.190E-09	656.5E-12	8.149E-09	-17.5	-87.34E-09
5	-1.722E-09	5.783E-09	3.076E-09	9.415E-09	31.9	-97.74E-09
6	-576.0E-12	8.926E-09	-1.895E-09	6.912E-09	-47.4	-85.02E-09
7	898.0E-12	8.008E-09	-5.289E-09	9.812E-09	-43.4	-82.91E-09
8	-2.130E-09	9.166E-09	-1.660E-09	7.028E-09	-49.2	-77.55E-09
9	3.008E-09	10.36E-09	460.4E-12	7.436E-09	-4.7	-81.24E-09
10	2.570E-09	7.275E-09	-6.457E-09	6.938E-09	-31.4	-72.48E-09
Average	799.1E-12	7.699E-09	-1.279E-09	7.104E-09	-17.2	-82.28E-09

Figure 16: An example of the **Sigma Test** window presenting a complete set of the test results. Green rectangle – **KReAver**

Red rectangle – **Average** of **KReAver**

Blue rectangle – **KRe StdErr**

Yellow strip – Directory and file name storing the current Sigma Test results.

5 Instrument Control

As already described in details in the Settings Chapter (Page 10), **Safyr7** may work in several different measuring modes. The measuring mode can be set in the **Instrument Settings** window (Settings » Instrument Settings F12), see Section 3.1.1, Page 11.

5.1 Data File Handling

Prior to the actual measurement, a data file to store the results may or may not be selected. There are 3 commands to handle the data files:

- **Create** a new data file (File » New Data File Ctrl + N).
- **Open** an existing file (File » Open Data File Ctrl + N).
- **Close** the currently open data file (File » Close Data File Ctrl + X).

The name of the currently open data file with its path (in a shorten form) is shown in the caption of the **Safyr7 Main Window**.

Note that the measurement may be started without having selected any data file. The user will be prompted to select a data file when the measurement is terminated after hitting the **SAVE** button.

5.2 Anisotropy of Magnetic Susceptibility

Regardless of whether the Automatic or Manual Anisotropy Mode is set, the acquisition of anisotropy of magnetic susceptibility (AMS) data follows this sequence:

1. **New Specimen** – Manual inputting the specimen information: Name, Orientation Angles, Orientation of associated mesoscopic structural elements, etc...
2. **Measure** – Execution of a set of measurements necessary to calculate the full anisotropy tensor. Depending on the measuring mode and the type of Rotator, the number of measurements varies:
   - **3D Rotaror** – 1 anisotropy measurement and 1 bulk susceptibility measurement.
   - **1-Axis Rotaror** – 3 anisotropy measurements and 1 bulk susceptibility measurement.

- **Manual Mode** – 15 directional susceptibility measurements.

3. **Calculate** – Calculation of the results and displaying them in the user interface.
4. **Save** – Saving the results into data file(s) or, alternatively, Deleting (Canceling) results.

5.2.1 New Specimen

To start a measuring sequence, follow these steps:

1. Hit NEW SPECIMEN (N or Enter) to launch the **New Specimen** window (Figure 17).

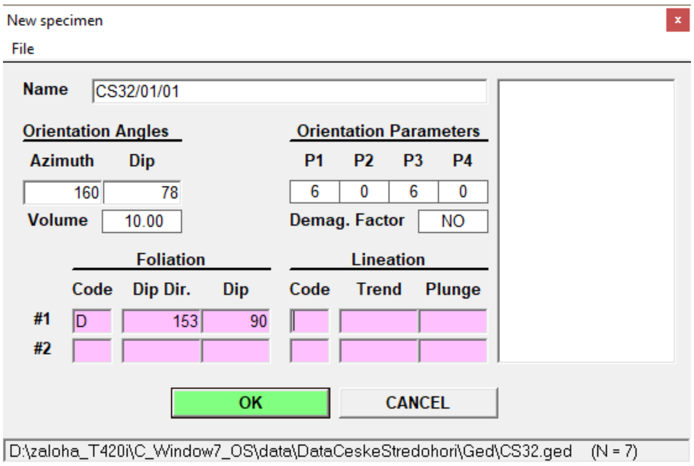


Figure 17: An example the **New Specimen** window for all AMS modes.

2. Enter Specimen **Name** – Specimen name must be up to 12 characters, no spaces, comma or semicolons are allowed.
3. Optionally, enter the **Orientation Data** by manual input into the respective text boxes:
   - **Orientation Angles** – **Azimuth** and **Dip** describing the specimen orientation. The meaning of these two angles is defined by the Orientation Parameters (P1, P2, P3).
   - **Foliation** – **Dip Dir.** or **Strike** and **Dip** of 1 or 2 sets of mesoscopic foliation (bedding, cleavage, dike plane...) adjacent to the specimen together with their one-letter code.
   - **Lineation** – **Trend** and **Plunge** of 1 or 2 sets of mesoscopic lineation (mineral alignment, flow direction, striation...) adjacent to the specimen together with their one-letter code.

4. As an alternative to the manual input of Orientation Data, one may use a **Geological File** (ged-file) where the specimen information is stored:

   (a) Open a desired ged-file: File › Open (Ctrl + G).

   (b) List of sample names stored in this ged-file is displayed on the right-hand site of the **New Specimen** window (Figure 17).

   (c) To copy the specimen information from the ged-file to the respective text boxes, click on the desired sample name or type the specimen name directly into the **Name** text box.
   Note that the specimen name typed in the **Name** text box may be longer (may include suffices or indexes) than that stored in the ged-file. This way, one may use the same orientation data for multiple specimens having originated from the same sample (cubic specimens cut from an oriented hand sample, cylindrical specimens cut from an oriented core sample). For example, *S1* is a sample name stored in the ged-file while *S1-1*, *S1/2*, *S1-A*, *S1B3* are various specimens having originated from that sample and thus having the same orientation.

5. Hit **OK** (Enter) to finish. The **New Specimen** window closes and the specimen information is copied into the Specimen Info Frame of the **Safyr7 Main Window** (Figure 18, 19, 20).

Use the Tab key to move among multiple text boxes.

5.2.2 Anisotropy Measurements

5.2.2.1 3D Rotator The **Safyr7 Main Window** for the Automatic Anisotropy Measurement with 3D Rotator is shown in the Figure 18. The measuring routine is very easy and consists of the following steps:

1. Fix the specimen into the Rotator using the screw on the right hand side of the Rotator (Figure 31).

2. Hit **ANISO** (F1 or Enter) to start the anisotropy measurement. The measuring procedure is fully automatic:

   (a) Rotator moves down into the coil.

   (b) The instrument is zeroed.

   (c) The specimen starts spinning and a set of **Deviatoric susceptibilities** is measured.

   (d) Rotator moves up from the coil.

3. Hit **BULK** (F2 or Enter) to start the bulk susceptibility measurement. With the ☑ **Auto BULK** option being checked (default state), the bulk susceptibility measurement starts automatically when the anisotropy measurement is finished. The measuring procedure is fully automatic:

(a) The instrument is zeroed.

(b) Rotator moves down into the coil.

(c) **Bulk susceptibility** is measured.

(d) Rotator moves up from the coil.

The measured values are presented in the Measurements Frame (Figure 18):

- **Anisotropy**
  - **Rg** – Range of the anisotropy measurement (This reflects the magnitude of deviatoric susceptibility).
- **Bulk Susceptibility** – Bulk susceptibility along the *x*-axis of the specimen
  - **Rg** – Range of the bulk susceptibility measurement.
  - **Kre** – Real (*In-Phase*) susceptibility.
  - **Kim** – Imaginary (*Out-of-Phase*) susceptibility.
  - **Phase** – Phase angle.

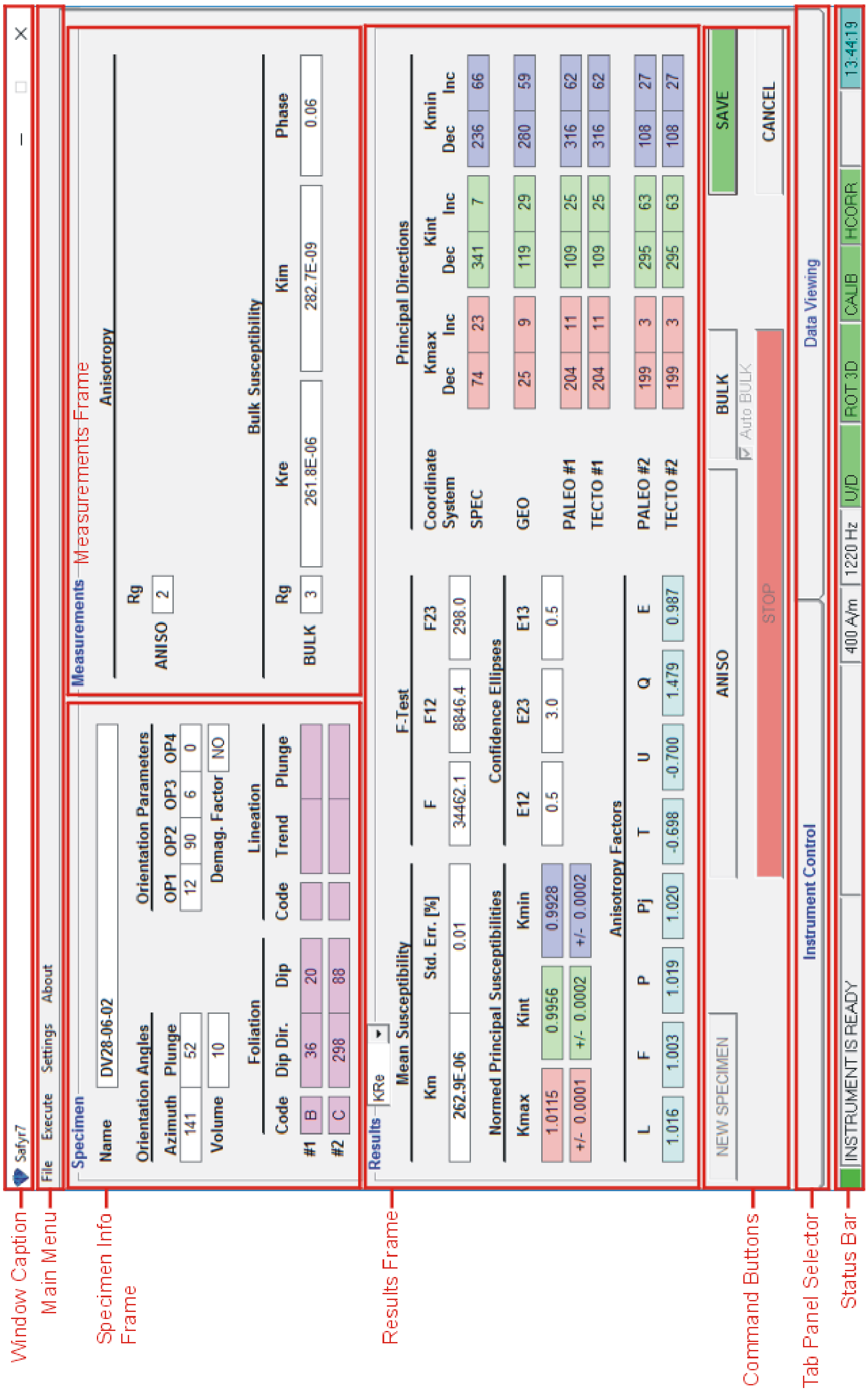


Figure 18: An example of the Safyr7 Main Window controlling the **Automatic Anisotropy Measurement** using **3D Rotator**: The Specimen Info entered, all necessary Measurements terminated, the Results calculated and ready to be saved.

5.2.2.2 1-Axis Rotator The **Safyr7 Main Window** for the Automatic Anisotropy Measurement with 1-Axis Rotator is shown in the Figure 19. The measuring routine is very easy and consists of the following steps:

1. Fix the specimen into the Rotator in the measuring position POS. 1 using the screw on the right hand side of the Rotator (Figure 32).
2. Hit **ANISO1** (F1 or Enter) to start the anisotropy measurement alone the x-axis of the specimen. The measuring procedure is fully automatic:
   (a) Rotator moves down into the coil.
   (b) The instrument is zeroed.
   (c) The specimen starts spinning and a set of **Deviatoric susceptibilities** is measured.
   (d) Rotator moves up from the coil.
3. Fix the specimen into the Rotator in the measuring position POS. 2 (Figure 32).
4. Hit **ANISO2** (F2 or Enter) to start the anisotropy measurement alone the y-axis of the specimen. The actual measurement procedure consists of the same actions as in the Step 2.
5. Fix the specimen into the Rotator in the measuring position POS. 3 (Figure 32).
6. Hit **ANISO3** (F3 or Enter) to start the anisotropy measurement alone the z-axis of the specimen. The actual measurement procedure consists of the same actions as in the Step 2.
7. Hit **BULK** (F4 or Enter) to start the bulk susceptibility measurement. With the ☑ **Auto BULK** option being checked (default state), the bulk susceptibility measurement starts automatically when the anisotropy measurement is finished. The measuring procedure is fully automatic:
   (a) The instrument is zeroed.
   (b) Rotator moves down into the coil.
   (c) **Bulk susceptibility** is measured.
   (d) Rotator moves up from the coil.
8. If necessary, repeat the measurement in any desired position; the anisotropy tensor is automatically recalculated when the measurement is finished.

The measured values are presented in the Measurements Frame (Figure 19):

- **Anisotropy** – Anisotropy curve for each spinning plane.
  - **Rg** – Range of the anisotropy measurement (This reflects the magnitude of deviatoric susceptibility).
  - **Cos** – Cosine component of the average anisotropy curve.
  - **Sin** – Sine component of the average anisotropy curve.
  - **Amp** – Amplitude of the average anisotropy curve.
  - **Error** – Standard deviation of the individual curves from the average curve.
  - **Error [%]** – Standard deviation divided by the amplitude value.

  The error for each of anisotropy curve is standard deviation of the individual curves (there are two sine wave curves for one physical revolution) from the average curve and the error [%] gives this deviation divided by the amplitude value. This error has only informative meaning and reflects the ratio between the noise and 'anisotropy' signal for measurement in one plane only. Thus it depends not only on absolute susceptibility of the specimen measured but mainly on the degree of anisotropy in an individual plane perpendicular to the axis of rotation. In case there is no anisotropy in one of the three planes this error may be over 100 % and has no physical meaning. In case the anisotropy in one plane has 'reasonable' value, the usual value is lower 5 %, but it does not reflect the quality of the measurement, but also the level of anisotropy in one plane.

- **Bulk Susceptibility** – Bulk susceptibility along the *x*-axis of the specimen
  - **Rg** – Range of the bulk susceptibility measurement.
  - **Kre** – Real (*In-Phase*) susceptibility.
  - **Kim** – Imaginary (*Out-of-Phase*) susceptibility.
  - **Phase** – Phase angle.

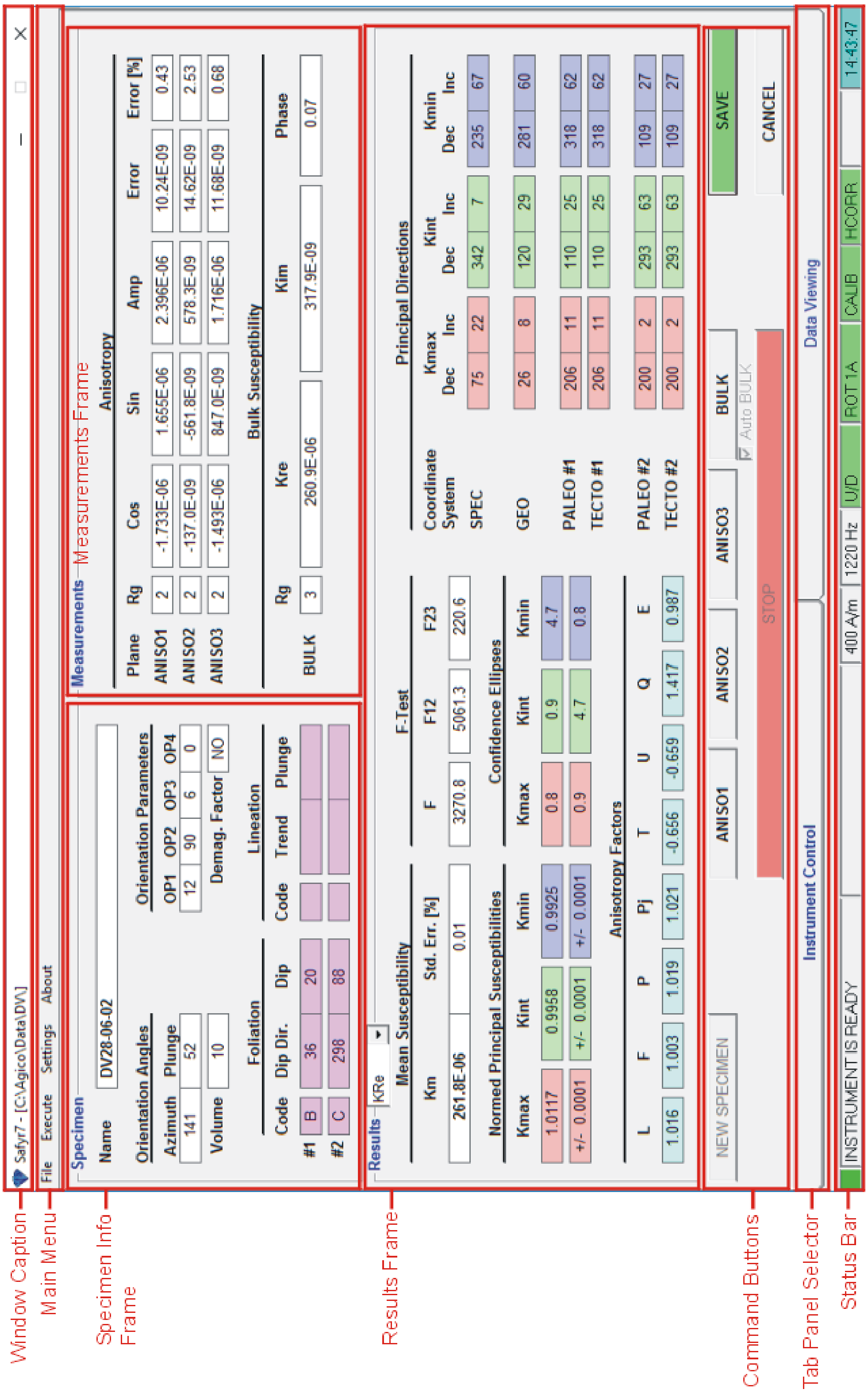


Figure 19: An example of the **Safyr7 Main Window** controlling the **Automatic Anisotropy Measurement** using **1-Axis Rotator**: The Specimen Info entered, all necessary Measurements terminated, the Results calculated and ready to be saved.

5.2.2.3 Manual Mode The **Safyr7 Main Window** for the Manual Anisotropy Measurement is shown in the Figure 20. The measuring routine consists of the following steps:

1. Fix the specimen into the specimen holder in the measuring position POS. 1 (Figure 33, 34).
2. Hit **BULK P1** (Enter) to start the directional susceptibility measurement in Pos. 1. The measuring procedure depends on whether the Up/Down Manipulator (U/D) is Enabled or Disabled:
   (a) The instrument is zeroed.
   (b) • U/D Enabled: Holder moves down into the pick up coil.
       • U/D Disabled: Long Beep (Status Bar Prompt: **SPECIMEN IN**) indicates to insert the holder into the pick up coil.
   (c) **Bulk susceptibility** is measured.
   (d) • U/D Enabled: Holder moves up from the pick up coil.
       • U/D Disabled: Short Beep (**SPECIMEN OUT**) indicates to pull the holder out from the pick up coil.
3. The respective directional susceptibility measurement is displayed in the Measurements Frame.
4. With the ☑ **Auto NEXT** option being checked (default state), the **BULK PX** button is automatically set to measure the next position. Alternatively, click on **PREV POS** or **NEXT POS** to manually set the previous or next position, respectively. These commands are particularly useful when one needs to re-measure some position(s).
5. Fix the specimen into the holder in the measuring position POS. 2 (Figure 33, 34).
6. Hit **BULK P2** (Enter) to start the directional susceptibility measurement in Pos. 2. The measuring procedure follows the same actions as in Step 2.
7. Continue until all 15 directional susceptibilities are measured.
8. If necessary, repeat the measurement in any desired position; the anisotropy tensor is automatically recalculated when the measurement is finished.

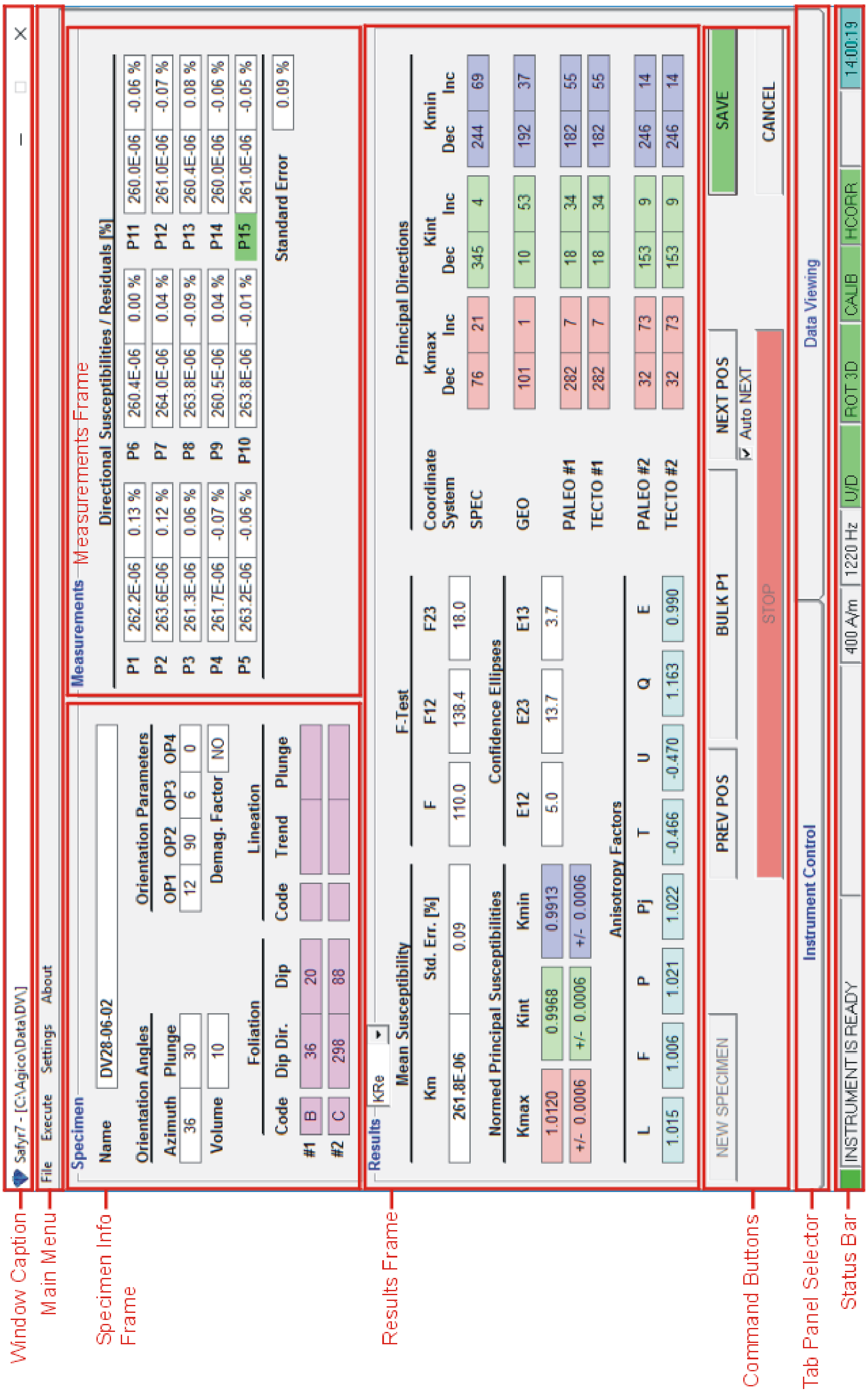


Figure 20: An example of the **Safyr7 Main Window** controlling the **Manual Anisotropy Measurement**: The Specimen Info entered, all necessary Measurements terminated, the Results calculated and ready to be saved.

When all 15 directional susceptibilities are measured, the susceptibility tensor is fitted using the least squares method and the errors are displayed next to each directional susceptibility value in the Measurements Frame (Figure 20). The errors of the fit are calculated as the deviation of the particular directional susceptibility from the calculated anisotropy ellipsoid expressed in [%].

5.2.3 Tensor Calculations

Regardless of whether the Automatic or Manual Anisotropy Mode is used, the calculation of the anisotropy tensor is performed automatically whenever all necessary data are available. Various parameters derived from the anisotropy tensor are displayed in the Results (Figure 18, 19, 20):

- **Mean Susceptibility**
  - **Km** – Mean susceptibility [SI units].
  - **Std. Err** – Standard error [%] of mean susceptibility.
- **F-Test**
  - **F** – Statistics for anisotropy testing.
  - **F12** – Statistics for triaxiality testing.
  - **F23** – Statistics for uniaxiality testing.
- **Normed Principal Susceptibilities** – Principal susceptibilities normed by the norming factor and errors in their determination.
- **Confidence Ellipses** – Confidence ellipses of determination of the principal susceptibility directions; they are expressed in a slightly different way depending on the used measuring mode:
  - 3D Rotator: **E12**, **E23**, **E13** confidence angles (on the 95% probability level)
  - 1-Axis Rotator: Semi-axes of the confidence ellipse for rotation axis **Kmax**, **Kint**, **Kmin** angles
  - Manual measurements: **E12**, **E23**, **E13** confidence angles (on the 95% probability level)
- **Anisotropy Factors** – Values of the selected quantitative anisotropy factors as defined in the anisotropy factor settings (see page 28)
- **Principal Directions** – Orientations of principal susceptibility directions (**Kmax**, **Kint**, **Kmin**) expressed as declinations (**Dec**) and Inclination (**Inc**) in various **Coordinate Systems**:

- **SPEC** – Specimen Coordinate System.
- **GEO** – Geographic Coordinate System. Calculated only when the Orientation Angles were entered.
- **PALEO #1** – Paleogeographic Coordinate System #1. Calculated only when the 1st (#1) mesoscopic fabric elements (Foliation and/or Lineation) were entered.
- **TECTO #1** – Tectonic Coordinate System #1. Calculated only when the 1st (#1) mesoscopic fabric elements (Foliation and/or Lineation) were entered.
- **PALEO #2** – Paleogeographic Coordinate System #2. Calculated only when the 2nd (#2) mesoscopic fabric elements (Foliation and/or Lineation) were entered.
- **TECTO #2** – Tectonic Coordinate System #2. Calculated only when the 2nd (#2) mesoscopic fabric elements (Foliation and/or Lineation) were entered.

To evaluate the quality of anisotropy measurements, use the F-Test values and 95 % confidence ellipses. The general rule is as follows. If the F-Test values are high (> 5), the confidence ellipses are small and the respective principal direction is well defined. The sensitivity of AMS measurement for the field intensity 400 A/m on MFK1 is 2×10^{-8} [SI], the anisotropy of the specimens with mean susceptibility about 5×10^{-6} [SI] can be measured, but the confidence ellipses may be in some cases larger, it depends on type of anisotropy. The sensitivity is approximately linearly decreasing with decreasing field intensity. Due to the influence of Rotator motor on the AMS measurement it may be problematic using it at operating frequencies F2 and F3 in case of specimens weaker than 100×10^{-6} SI units and with degree of anisotropy lower than 5 %. For this case at F3 it is recommended to use manual measurement method in 15 directions to eliminate the influence of motor of the Rotator.

5.2.4 Saving Results

- Hit **SAVE** (Enter or S) to append the results as a new record into the currently open data file.

  OR

- Hit **CANCEL** (Esc) to delete the results without saving.

If no data file is open, the user is prompted to create a new data file or open an existing file after hitting **SAVE**.

To store the results into into other file than that currently open, close the current data file prior hitting **SAVE**.

The anisotropy results are saved together with the mesoscopic fabric elements (foliations and lineations) simultaneously into 3 types of files:

1. **ams-file** (`FileName.ams`) – Enhanced binary data file intended to be further processed using **AGICO Anisoft5** software (Ver. 5).

2. **ran-file** (`FileName.ran`) – Long-time standard binary data file intended to be further processed using **AGICO Anisoft4** software (Ver. 4 and higher).

3. **asc-file** (`FileName.asc`) – ASCII text file which serves as a log-file of each measurement, not intended to be further processed.

The anisotropy results for multiple specimens (those contained in the currently open data file) may be viewed in a graphical form in the **Data Viewing** tab panel of the **Safyr7 Main Window**.

5.3 Bulk Susceptibility

Before starting the bulk susceptibility measurements, the user may set:

- **Susceptibility Normalization** (Volume / Mass-normalized) – See Section 3.2, Page 25
- **Field Intensity** – See Section 3.1.2.1, Page 23
- **Operating Frequency**[16] – See Section 3.1.3, Page 24

⚠ DO NOT USE 3D ROTATOR OR 1-AXIS ROTATOR to hold the specimen. It is highly recommended to use the appropriate **Specimen Holder** or **Vessel for Fragments**.

ℹ UP/DOWN MANIPULATOR can be optionally enabled/disabled in the **Auxialiary Commands** window.

5.3.1 Individual Measurements Mode

The Individual Measurements Mode controls a sequence of individual measurements of volume/mass normalized susceptibility in desired field intensity and, if applicable, in various operating frequencies[17].

The Individual Measurements Mode can be set in the **Instrument Settings** window (Settings > Instrument Settings or F12), see Section 3.1.1.3, Page 13. The **Safyr7 Main Window** for the Individual Measurements Mode is shown in Figure 22.

1. Fix the specimen into the **Specimen Holder** or **Vessel for Fragments**.
2. Hit **NEW SPECIMEN** (N or Enter) to launch the **New Specimen** window (Figure 21).
3. Fill the following text boxes:
   - **Name** – Specimen name must be up to 12 characters, no spaces, comma or semicolons are allowed.
   - **Volume / Mass** – Actual Volume / Mass of the specimen. If no value is entered, the default Volume / Mass will be used.
   - **Note** – Optional note containing a further description of the specimen, measuring conditions or so on.

[16] Applies only to the three-frequency instrument versions
[17] Applies to be three-frequency versions only

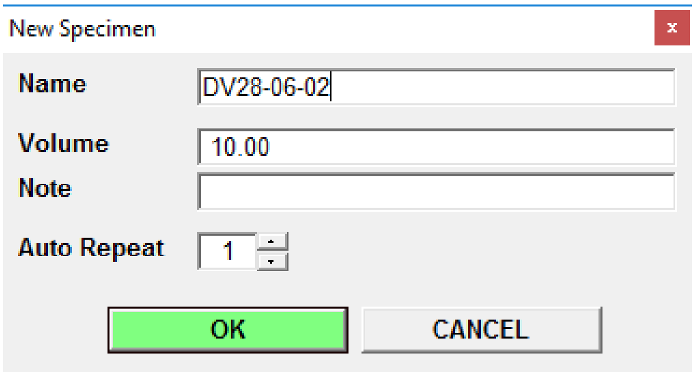


Figure 21: An example of the **New Specimen** window for the Individual Measurements Mode.

- **Auto Repeat** – Optionally, select the number of automatic repetitions of each measurement.

4. Hit **OK** (Enter) to confirm. The **New Specimen** window closes and the specimen information is copied into the Specimen Info Frame of the **Safyr7 Main Window**.
5. Hit **START** (Enter) to start the actual susceptibility measurement. The measuring procedure depends on whether the Up/Down Manipulator (U/D) is Enabled or Disabled:
   (a) The instrument is **zoered**.
   (b)
   - U/D Enabled: Holder moves **down** into the pick up coil.
   - U/D Disabled: Long Beep (Status Bar Prompt: **SPECIMEN IN**) indicates to **insert** the holder into the pick up coil.

   (c) **Bulk susceptibility** is measured.
   (d)
   - U/D Enabled: Holder moves **up** from the pick up coil.
   - U/D Disabled: Short Beep (**SPECIMEN OUT**) indicates to **pull** the holder out from the pick up coil.
6. The measuring results are displayed in the Results Frame of the **Safyr7 Main Window**.
   - Hit **SAVE** (Enter or S) to append the results as a new record into the currently open data file.

     OR
   - Hit **CANCEL** (Esc) to delete the results without saving.
7. The saved results are appended to the Data Table.

The individual susceptibility measurements are saved into a space-delimiter ASCII text file with a fixed format – **bulk-file** (`FileName.bulk`). For a detailed description of bulk-file format, see Section **??** in Appendix.

The individual susceptibility measurements (those contained in the currently open data file) may be viewed and partially processed (e.g., calculation of frequency-dependence parameters) in the **Data Viewing** panel of the **Safyr7 Main Window**.

If no data file is open, the user is prompted to create a new data file or open an existing file after hitting **SAVE**.

To save the results into other file than that currently open, close the current data file prior hitting **SAVE**.

Here are a few tips and recommendations for the measurements of the frequency-dependent susceptibility:

1. After the change of the operating frequency the instrument pick up coils are disbalanced and they require at least 10 min to be stabilized. Thus it is not recommended to change the operating frequency too often. To investigate the frequency-dependent susceptibility of a group of specimens, follow the recommended procedure:
    (a) Set the first desired operating frequency and let the instrument to stabilize
    (b) Perform the holder correction routine
    (c) Measure all specimens of the group
    (d) Set the second desired operating frequency and the instrument to stabilize
    (e) Measure all specimens at the second frequency
2. The frequency-dependent susceptibility is calculated from two (three) independent susceptibility measurements. As the calculation routine must combine these independent measurements, it is essential to use exactly in the same name each time the same specimen is measured at various operating frequencies.
3. To eliminate the possible effect of field dependence, the field intensity must be the same for each operating frequency. For that reason, the default field intensity is automatically set when the operating frequency is changed.
4. To avoid the possible anisotropy effects, the specimens must be orientated in the same way during measurements at each operating frequency. In the case of the cylindrical specimens, it is recommended to measure in vertical orientation so that the cylinder axis is parallel to the axis of the instrument coil (Figure 30, Page 74). That way, magnetic susceptibility parallel to the cylinder axis regardless of the specimen orientation with respect to that axis; this cannot be exactly reached in the perpendicular orientation due to the slight specimen misorientations during each individual measurements.

Figure 22: An example of the Safyr7 Main Window controlling the **Individual Measurements Mode**.

5.3.2 Field Dependence Mode

The Field Dependence Mode controls the automatic acquisition of field-dependent susceptibility curves (magnetic susceptibility as a function of field intensity) in a preset sequence of field intensities. The results are presented as volume/mass normalized *in-phase* and *out-of-phase*[18] susceptibility both in tabular and graphical form. The acquired field dependence data can be saved into the space-delimited data files.

The Field Dependence Mode can be set in the **Instrument Settings** window (Settings > Instrument Settings or F12), see Section 3.1.1.4, Page 14. The **Safyr7 Main Window** for the Field Dependence Mode is shown in Figure 24.

To acquire a field-dependent susceptibility curve, follow these steps:

1. Fix the specimen into the **Specimen Holder** or **Vessel for Fragments**.
2. Open a data file. This step is only optional as the user is prompted to do so each time the acquired curve is to be saved into disk (see Step 14).
3. Review the desired field sequence in the Data Table and hit **FIELD SEQUENCE** to launch the **Field Dependence Settings** window in order to modify the field sequence and/or instrument ranging mode (see Section 3.1.2.1, Page 23).
4. Hit **NEW SPECIMEN** (N or Enter) to launch the **New Specimen** window (Figure 23).

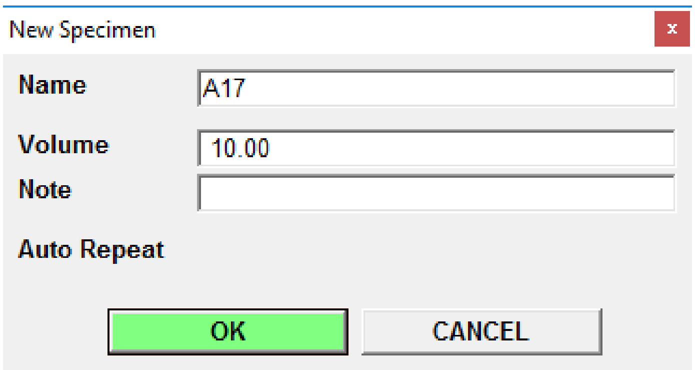


Figure 23: An example of the **New Specimen** window for the Field Dependence Mode.

5. Fill the following text boxes:
   - **Name** – Specimen name must be up to 12 characters, no spaces, comma or semicolons are allowed.

[18] Applies to the KLY5 models only.

- **Volume / Mass** – Actual Volume / Mass of the specimen. If no value is entered, the default Volume / Mass will be used.
- **Note** – Optional note containing a further description of the specimen, measuring conditions or so on.

6. Hit **OK** (Enter) to confirm. The **New Specimen** window is closed and the specimen information is copied into the Specimen Info Frame of the **Safyr7 Main Window**.
7. Hit **START** (Enter) to start the acquisition of field dependence curve. (Hit **STOP** (Space Bar) to abort the curve acquisition in case of emergency, e.g., specimen gets loose, holder not aligned with the pick up coil...etc.)
8. The 1st field intensity in the desired field sequence is automatically set and the instrument is shortly stabilized.
9. Magnetic susceptibility is measured. The actual measuring procedure depends on whether the Up/Down Manipulator is Enabled or Disabled (see Section 4.3.1, Page 36).:
   (a) The instrument is **zeroed**.
   (b)
   - U/D Enabled: Holder automatically moves **down** into the pick up coil.
   - U/D Disabled: Long Beep (Status Bar Prompt: **SPECIMEN IN**) indicates to manually **insert** the holder into the pick up coil.

   (c) **Bulk susceptibility** is measured.
   (d)
   - U/D Enabled: Holder automatically moves **up** from the pick up coil.
   - U/D Disabled: Short Beep (**SPECIMEN OUT**) indicates to manually **pull** the holder out from the pick up coil.
10. The currently measured susceptibility values are appended to the Data Table and the Field-dependence Plot is continuously re-drawn. In addition, several Field-dependence Indexes are calculated and displayed (Figure 24).
11. The steps 8, 9, and 10 are repeated until the susceptibility is measured in all fields in the desired field sequence.
12. The original field intensity is automatically reset.
13. The field dependence curve is terminated and a message box displaying termination time and measurement duration appears. Optionally, when selected, a ring tone sounds.

14. - Hit **SAVE** (Enter or S) to append the measured curve as a set of new records into a data file. In order to enable saving each curve into a separate file, the **Save Data** dialog is automatically launched and the user may select a new files name (the current data file is offered as a default option).

    OR

    - Hit **CANCEL** (Esc) to delete the results without saving.

To save the results into other file than that currently open, close the current data file prior hitting **SAVE**.

The field dependence curves are saved into a space-delimiter ASCII text file with a fixed format – **bulk-file** (`FileName.bulk`). Each curve may be saved into a separate bulk-file or one bulk-file may contain multiple curves.
The field dependence curves for multiple specimens (those contained in the currently open data file) may be viewed in the **Data Viewing** panel of the **Safyr7 Main Window**.

As the curve acquisition is a lasting process, the measured data are automatically appended into a temporary data file: `C:\Agico\Data\TemporaryData\SpecimenName.bulk`. This file may be useful to recover the data in case that the data acquisition is forcefully aborted (software crash, power blackout...etc.).

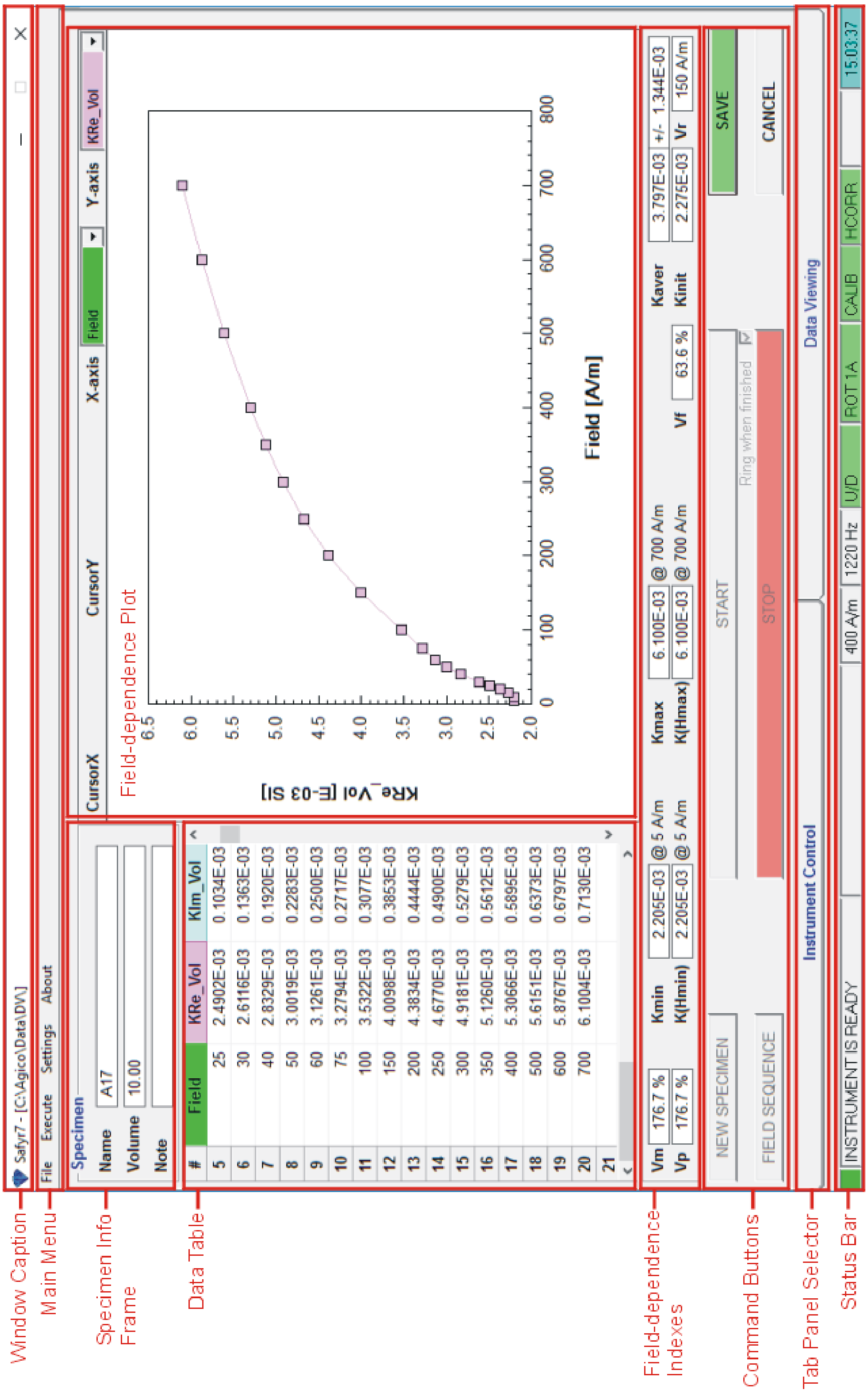


Figure 24: An example of the **Safyr7 Main Window** controlling the **Field Dependence Mode**.

Field variation indexes are defined as follows:

- **Vm** index characterizes the maximum susceptibility variation with field

  $$V_m = 100\frac{k_{max} - k_{min}}{k_{min}}\ [\%]$$

  where k_{max} and k_{min} are the maximum and minimum susceptibilities, respectively, measured during one measuring run. The field intensities in which minimum and maximum susceptibilities were measured are presented in parenthesis.

- **Vp** index characterizes the variation of susceptibility between the weakest and strongest measuring field

  $$V_p = 100\frac{k_{Hmax} - k_{Hmin}}{k_{Hmin}}\ [\%]$$

  where k_{Hmax} and k_{Hmin} are the susceptibilities measured at maximum and minimum field intensities, respectively. Interval of field intensities used for the calculation is presented in parenthesis.

- **Va** index. As the susceptibilities measured at the very low fields may be affected by relatively large errors in weakly magnetic specimens, it is useful to introduce an index which eliminates the effect of the errors at least partially, because the errors are distributed approximately randomly

  $$V_a = 100\frac{k_{Hmax} - k_i}{k_i}\ [\%]$$

  where k_i is the average susceptibility measured at the field intensities $H_{peak} = 15$ A/m and k_{Hmax} is the susceptibility measured at the maximum field. Average susceptibility at the beginning of the k(H) curve, **Ki** is presented. The interval of field intensities used for the calculation in presented in parenthesis.

- **Vf** index. The susceptibility vs. field data usually very well fit the straight line in some range of fields. In this case it is useful to use an index that is calculated from the fit straight line

  $$V_f = 100\frac{k_u - k_l}{k_l}\ [\%]$$

  where k_l and k_u are the susceptibilities calculated from the fit straight line at the beginning and at the end of the field range considered, respectively. The field intensities of the beginning and at the end of the straight line are presented in parenthesis.

- **Vr** index gives the upper limit of the validity of the Rayleigh law. It is calculated as follows. A straight line is fit to the susceptibility vs. field data in the field range between 10 A/m and 80 A/m. The lower limit of this range is high enough to avoid very low fields in which the measuring error may be high for many specimens, and the upper limit is low enough to respect the validity of the Rayleigh law in the most specimens. Using this straight line, theoretical Rayleigh law susceptibilities are calculated successively also for stronger fields. The index Vr equals the maximum field in which the measured susceptibility deviates from the theoretical one less than 5 %.

  In addition the initial susceptibility, **Kint**, is calculated as the intercept of the above straight line with the ordinate.

In addition to the above-described indexes, the minimum, **Kmin**, the maximum, **Kmax**, and the average susceptibilities, **Kaver**, (together with the standard error) are presented.

5.4 Temperature Dependence

5.4.1 Low Temperature Mode

The Low Temperature Mode controls the automatic acquisition of thermomagnetic curves (variation of magnetic susceptibility as a function of temperature) in the so-called low temperature range (–192 °C to ambient temperature) using **Cryostat**. Prior to the curve acquisition, the powder specimen must be cooled down to the temperature close to that of liquid nitrogen. The specimen is then heated spontaneously up to the desired maximum temperature while magnetic susceptibility is recorded approximately every 20 s. The results are presented as *in-phase* and *out-of-phase*[19] susceptibility both in tabular and graphical form. The acquired temperature dependence data are saved into the data files and require further processing, mainly smoothing, correction for empty cryostat curve and volume/mass normalization. The processing is done using Cureval software.

The Low Temperature Mode can be set in the **Instrument Settings** window (Settings > Instrument Settings or F12), see Section 3.1.1.5, Page 15. The **Safyr7 Main Window** for the Low Temperature Mode is shown in Figure 26.

To acquire a low temperature thermomagnetic curve, follow these steps:

1. Prepare the powder specimen into a test tube and insert it to the Cryostat.
2. Review the desired Temperature Limits in the Current State Bar; to modify the limits, go to Section 3.1.1.5.1, Page 16.
3. Hit NEW SPECIMEN (N or Enter) to launch the **New Curve** window (Figure 23).

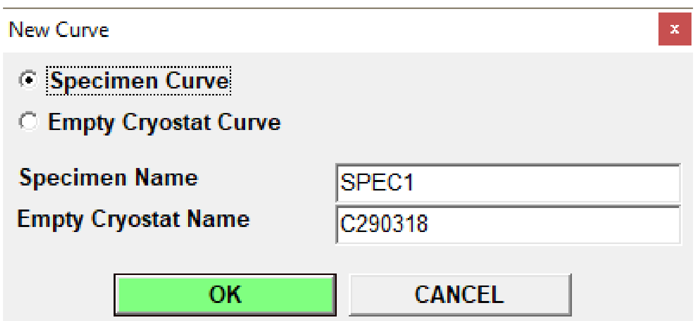


Figure 25: An example of the **New Curve** window for the Low Temperature Mode.

4. Mark the following options:

[19]Applies to the KLY5 models only.

- ◉ **Specimen Curve** – Indicates that the Specimen curve is measured.
- ◉ **Empty Cryostat Curve** – Indicates that the Empty Cryostat curve is measured.

Fill the following text boxes:

- **Specimen Name** – Specimen name must be up to 12 characters, no spaces, comma or semicolons are allowed.
- **Empty Cryostat Name** – Optionally, input the file name containing the respective empty cryostat thermomagnetic curve (it must be in the same directory as the specimen data file). This information serves as a note useful for further data processing. Please note that one empty cryostat thermomagnetic curve may be used for many specimen curves.

5. Hit **OK** (Enter) to confirm. The **New Curve** window is closed and the specimen information is copied into the Specimen Info Frame of the **Safyr7 Main Window**.

6. The specimen must be cooled down. The actual specimen temperature (**Temp**) is displayed in the Current State Bar. Follow the flashing instructions in the Instruction Bar and the associated acoustic signals:

   (a) **Fill SLOWLY liquid nitrogen**

   Temp is higher than the desired minimum temperature (**Tstart**). Slowly fill liquid nitrogen until the Cryostat is half-full. Wait as the specimen cools down.

   (b) **Wait for required temperature**

   Temp is approaching the desired **Tstart**. Wait as the specimen cools down.

   (c) **Be ready to apply argon**

   3 Short Beeps

   Temp drops below **Tstart**. Make the argon blow gun ready to flush out liquid nitrogen.

   (d) **Apply argon and Start measurement**

   5 Short Beeps

   Temp gets approx. 2.4 °C below **Tstart**. Apply argon to flush out liquid nitrogen.

   (e) **Start measurement**

   Long Beep

   Start the curve acquisition, see Step,7

7. Hit **START** (Enter) to start the acquisition of thermomagnetic curve.
   Hit **STOP** (Space Bar) to abort the curve acquisition in the case of emergency.
8. The specimen starts to be spontaneously heated. As the temperature increases, magnetic susceptibility is automatically measured approximately every 20 s. The actual measuring procedure consists of the following actions:
   (a) The instrument is **zeroed**.
   (b) Specimen **temperature** is read and displayed in the Current State Bar.
   (c) Cryostat automatically moves **down** into the pick up coil. pick up coil.
   (d) **Bulk susceptibility** is measured.
   (e) Cryostat automatically moves **up** from the pick up coil.
   (f) Specimen **temperature** is read and displayed in the Current State Bar.
9. The average temperature (from the pre- and post measurement temperature readings) and measured susceptibility values are appended to the Data Table and the Thermomagnetic Plot is continuously re-drawn (Figure 26).
10. The steps 8 and 9 are repeated until the desired maximum temperature (**Tend**) is reached. The thermomagnetic curve is terminated and a message box displaying termination time and measurement duration appears. Optionally, when selected, a ring tone sounds.
11.
   - Hit **SAVE** (Enter or S) to save the measured thermomagnetic curve into a data file. As each curve must be saved into a separate file, the **Save Data** dialog is automatically launched and the user must select the file name (the file name derived from the current specimen name is offered as a default option).

     OR
   - Hit **CANCEL** (Esc) to delete the results without saving.

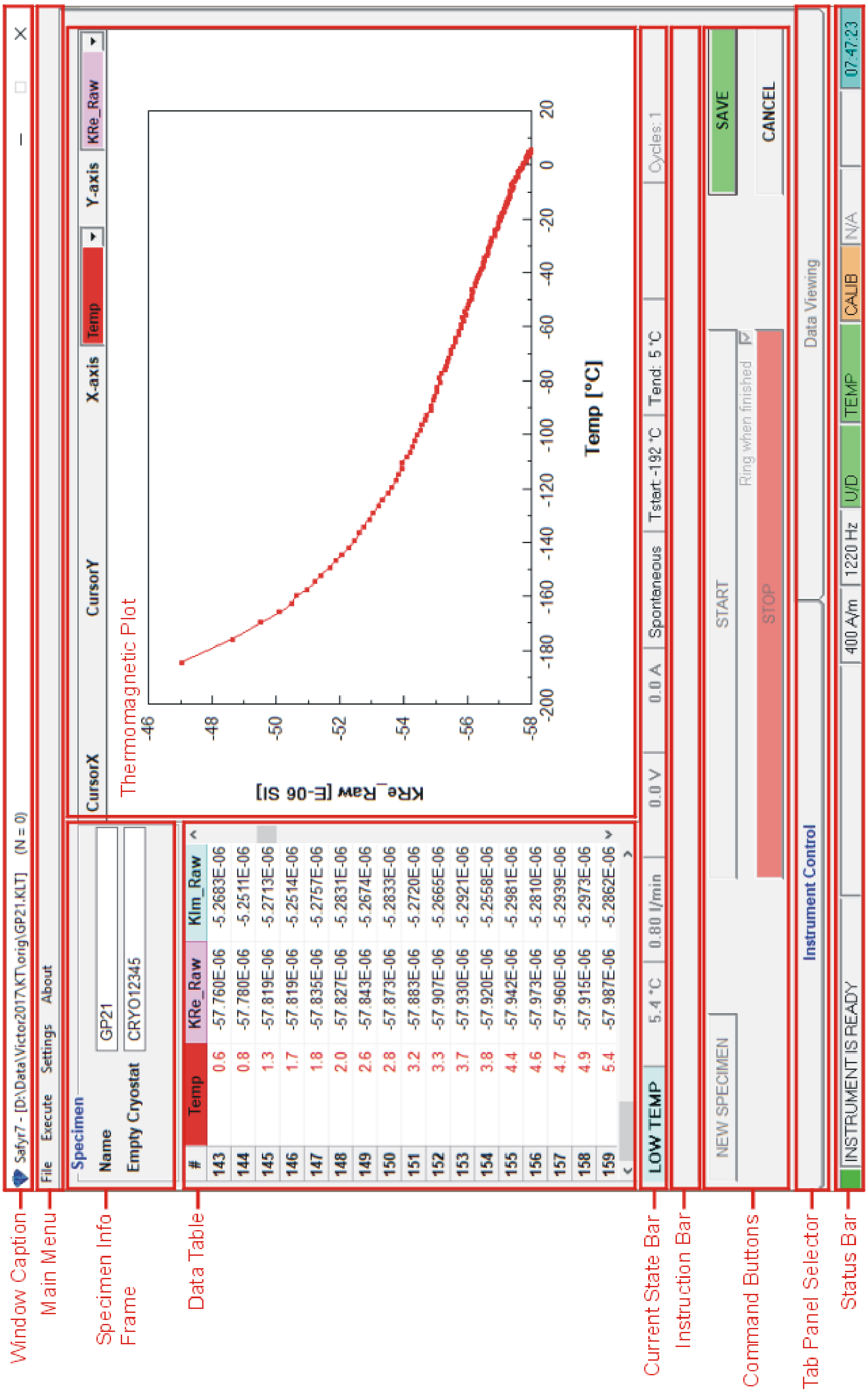


Figure 26: An example of the **Safyr7 Main Window** controlling the **Low Temperature Mode**.

The thermomagnetic curves are saved into a fixed-column-width ASCII text file – **clw-file** (`FileName.clw`). Each curve must be saved into a separate clw-file. When applicable, a separate file (`FileName_Im.clw`) is automatically created to store the out-of-phase susceptibility thermomagnetic curves[20].

As the curve acquisition is a long lasting process, the measured data are automatically appended into a temporary data file: `C:\Agico\Data\TemporaryData\SpecimenName.clw`. This file may be useful to recover the data in case that the data acquisition is forcefully aborted (software crash, power blackout...etc.).

[20] Applies to the KLY5 models only.

5.4.2 High Temperature Mode

The High Temperature Mode controls the automatic acquisition of thermomagnetic curves (variation of magnetic susceptibility as a function of temperature) in the so-called high temperature range (from ambient temperature up to 700 °C and back to ambient temperature) using **Furnace** and its water cooling system. While the specimen is heated (or cooled), magnetic susceptibility is recorded approximately every 20 s. The results are presented as *in-phase* and *out-of-phase*[21] susceptibility both in tabular and graphical form. The acquired temperature dependence data are saved into the data files and require further processing, mainly smoothing, correction for empty furnace curve and volume/mass normalization. The processing is done using Cureval software.

The High Temperature Mode can be set in the **Instrument Settings** window (Settings > Instrument Settings or F12), see Section 3.1.1.6, Page 17. The **Safyr7 Main Window** for the High Temperature Mode is shown in Figure 28.

To acquire a high temperature thermomagnetic curve, follow these steps:

1. Prepare the powder specimen into a test tube and insert it to the Furnace.
2. Review the desired **Temperature Rate**, **Temperature Limits**, and optionally, **Repeated Cycles** option in the Current State Bar; to modify the temperature-related settings, go to Section 3.1.1.6, Page 17.
3. Hit NEW SPECIMEN (N or Enter) to launch the **New Curve** window (Figure 23).

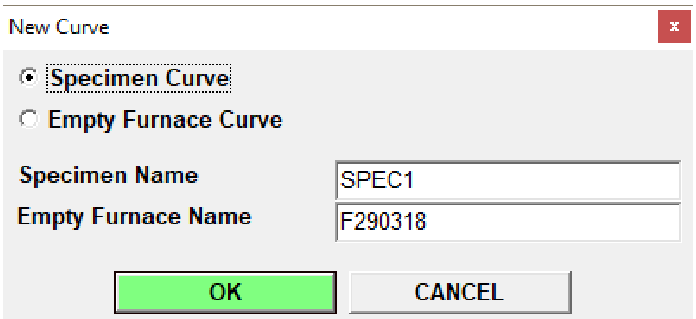


Figure 27: An example of the **New Curve** window for the High Temperature Mode.

4. Mark the following options:

   ◉ **Specimen Curve** – Indicates that the Specimen curve is measured.

[21] Applies to the KLY5 models only.

- ◉ **Empty Furnace Curve** – Indicates that the Empty Furnace curve is measured.

Fill the following text boxes:

- **Specimen Name** – Specimen name must be up to 12 characters, no spaces, comma or semicolons are allowed.
- **Empty Furnace Name** – Optionally, input the file name containing the respective empty furnace thermomagnetic curve (it must be in the same directory as the specimen data file). This information serves as a note useful for further data processing. Please note that one empty furnace thermomagnetic curve may be used for many specimen curves.

5. Hit **OK** (Enter) to confirm. The **New Curve** window is closed and the specimen information is copied into the Specimen Info Frame of the **Safyr7 Main Window**.
6. Hit **START** (Enter) to start the acquisition of thermomagnetic curve. Hit **STOP** (Space Bar) to abort the curve acquisition in the case of emergency.
7. The specimen starts to be heated (cooled) in a controlled way following the preset **Temperature Rate**. As the temperature increases/decreases, magnetic susceptibility is automatically measured approximately every 20 s. The actual measuring procedure consists of the following actions:
   (a) The instrument is **zeroed**.
   (b) Specimen **temperature** is read and displayed in the Current State Bar.
   (c) Cryostat automatically moves **down** into the pick up coil. pick up coil.
   (d) **Bulk susceptibility** is measured.
   (e) Cryostat automatically moves **up** from the pick up coil.
   (f) Specimen **temperature** is read and displayed in the Current State Bar.
8. The average temperature (from the pre- and post measurement temperature readings) and measured susceptibility values are appended to the Data Table and the Thermomagnetic Plot is continuously re-drawn (Figure 28).
9. The steps 7 and 8 are repeated until the desired maximum temperature (**Tpeak**) is reached, and then the controlled cooling starts until the desired minimum temperature (**Tend**) is reached. The thermomagnetic curve is terminated and a message box displaying termination time and measurement duration appears. Optionally, when selected, a ring tone sounds.

10. • Hit **SAVE** (Enter or S) to save the measured thermomagnetic curve into a data file. As each curve must be saved into a separate file, the **Save Data** dialog is automatically launched and the user must select the file name (the file name derived from the current specimen name is offered as a default option).

    OR

    • Hit **CANCEL** (Esc) to delete the results without saving.

Wait – Temperature is too high!

When the curve acquisition is forcefully aborted, the temperature inside the furnace may be very high! The warning starts flashing in the Instruction Bar. The furnace temperature spontaneously decreases towards the ambient temperature and the warning stops when the temperature drops below 100 °C.

The thermomagnetic curves are saved into a fixed-column-width ASCII text file – **cur-file** (`FileName.cur`). Each curve must be saved into a separate cur-file. When applicable, a separate file (`FileName_Im.cur`) is automatically created to store the out-of-phase susceptibility thermomagnetic curves[22].

As the curve acquisition is a long lasting process, the measured data are automatically appended into a temporary data file: `C:\Agico\Data\TemporaryData\SpecimenName.cur`. This file may be useful to recover the data in case that the data acquisition is forcefully aborted (software crash, power blackout...etc.).

[22] Applies to the KLY5 models only.

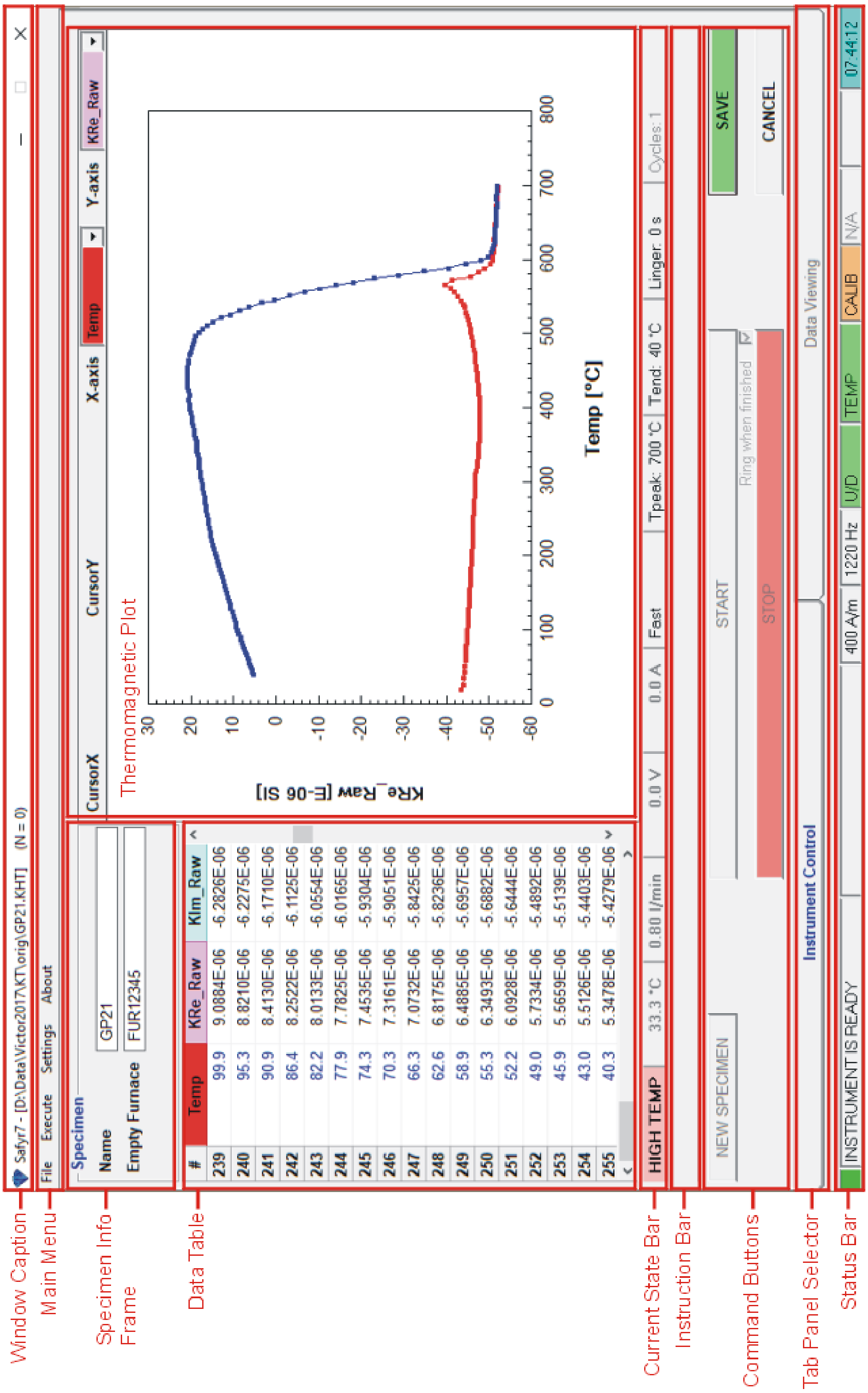


Figure 28: An example of the **Safyr7 Main Window** controlling the **High Temperature Mode**.

6 Appendix

6.1 Specimen Positions

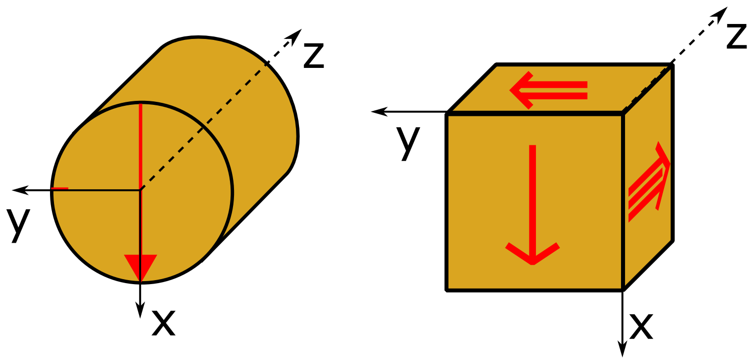


Figure 29: Definition of the Specimen Coordinate System for cylindrical and cubic specimens.

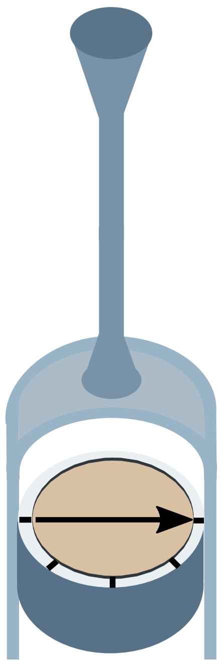


Figure 30: The orientation of the calibration standard in manual specimen holders.

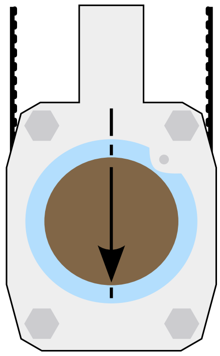


Figure 31: A sketch of 3D Rotator showing the specimen fixing position.

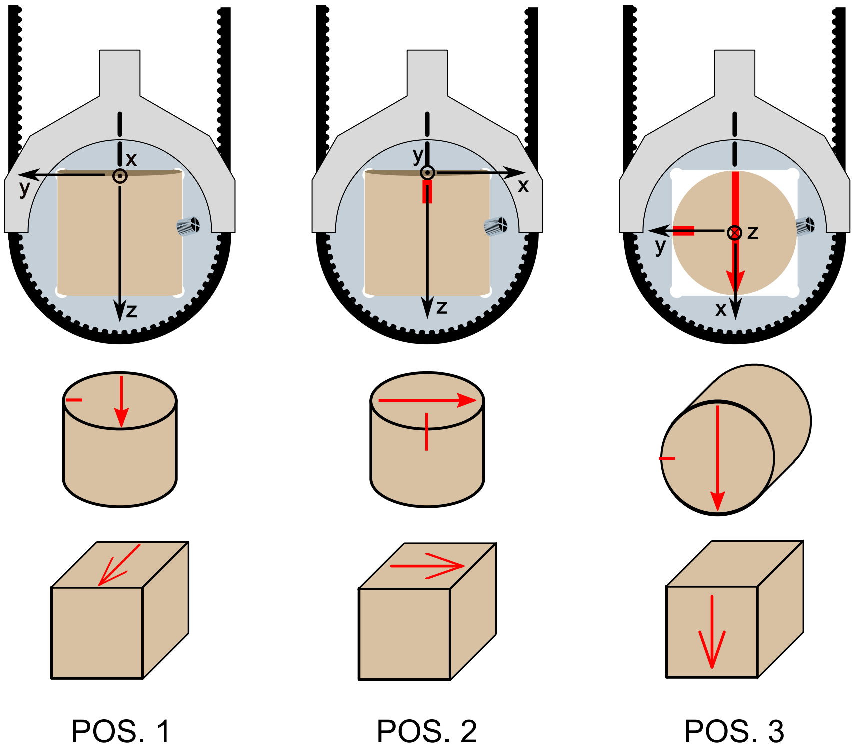


Figure 32: A sketch of 1-Axis Rotator showing the specimen measuring positions.

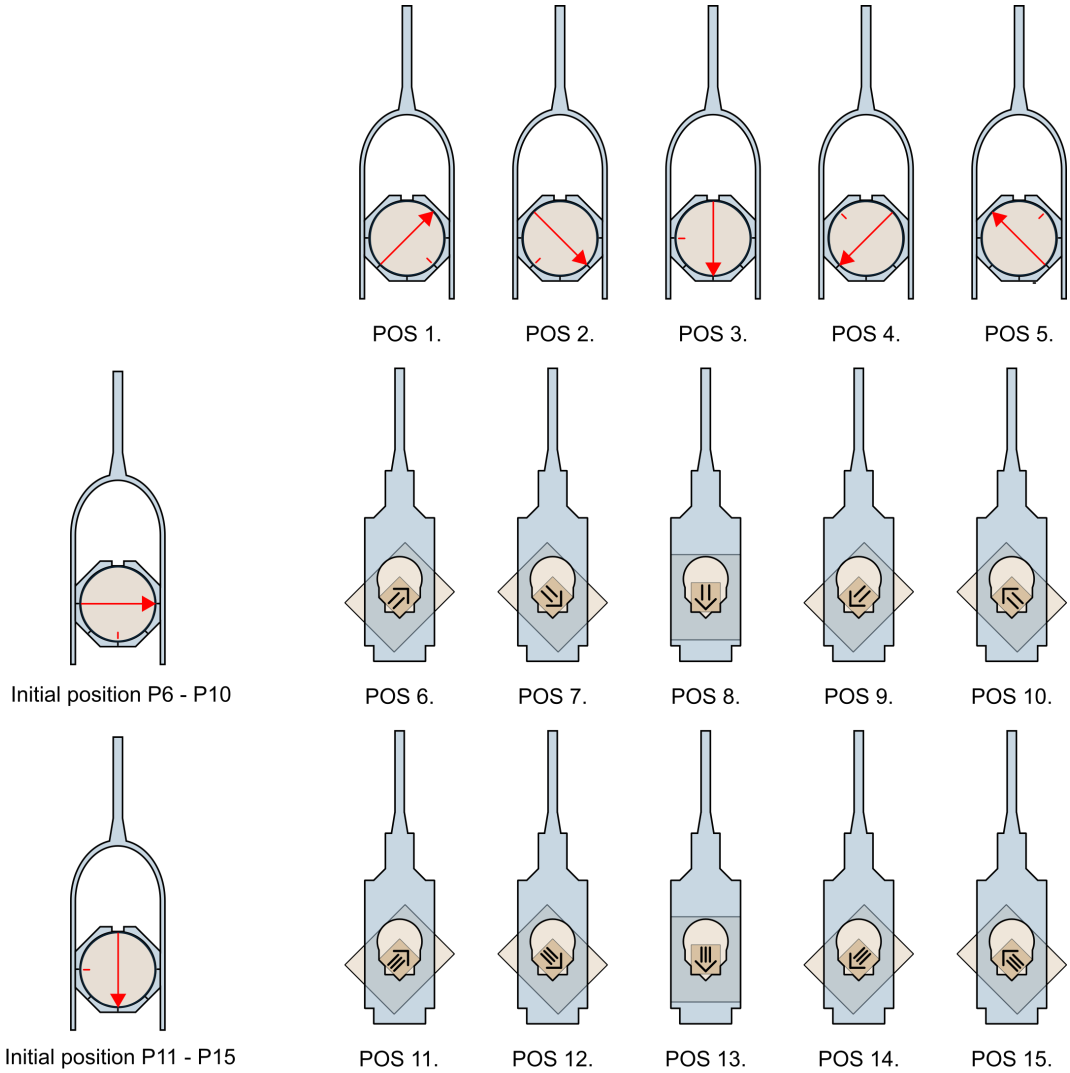


Figure 33: A sketch of the 15-direction measuring design for cylindrical specimens.

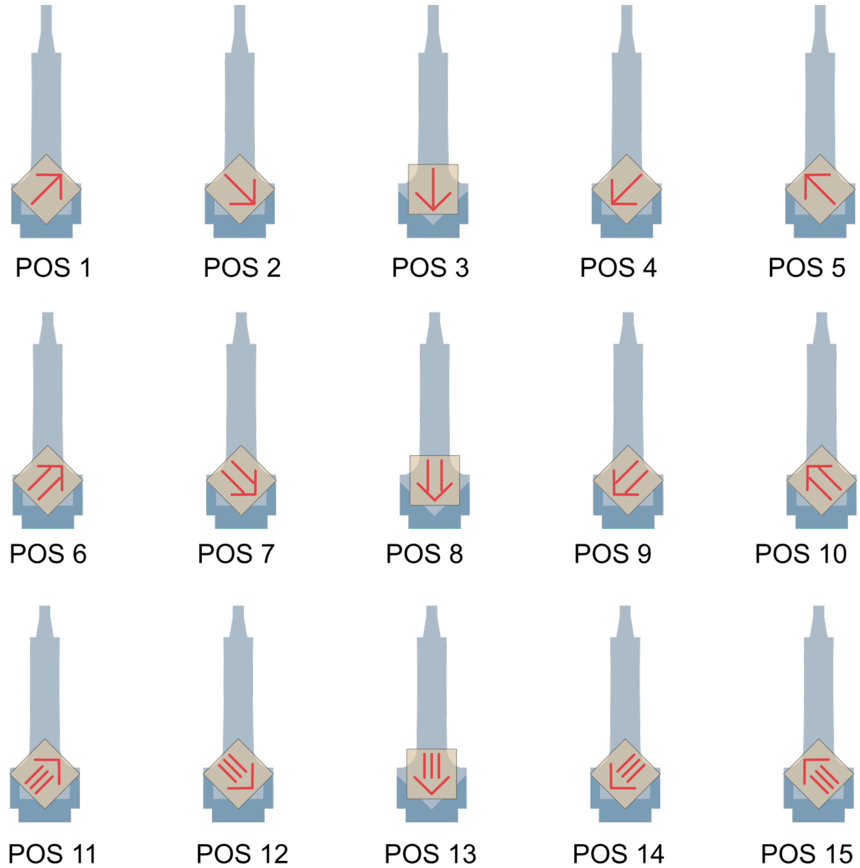


Figure 34: A sketch of the 15-direction measuring design for cubic specimens.

6.2 Orientation Parameters

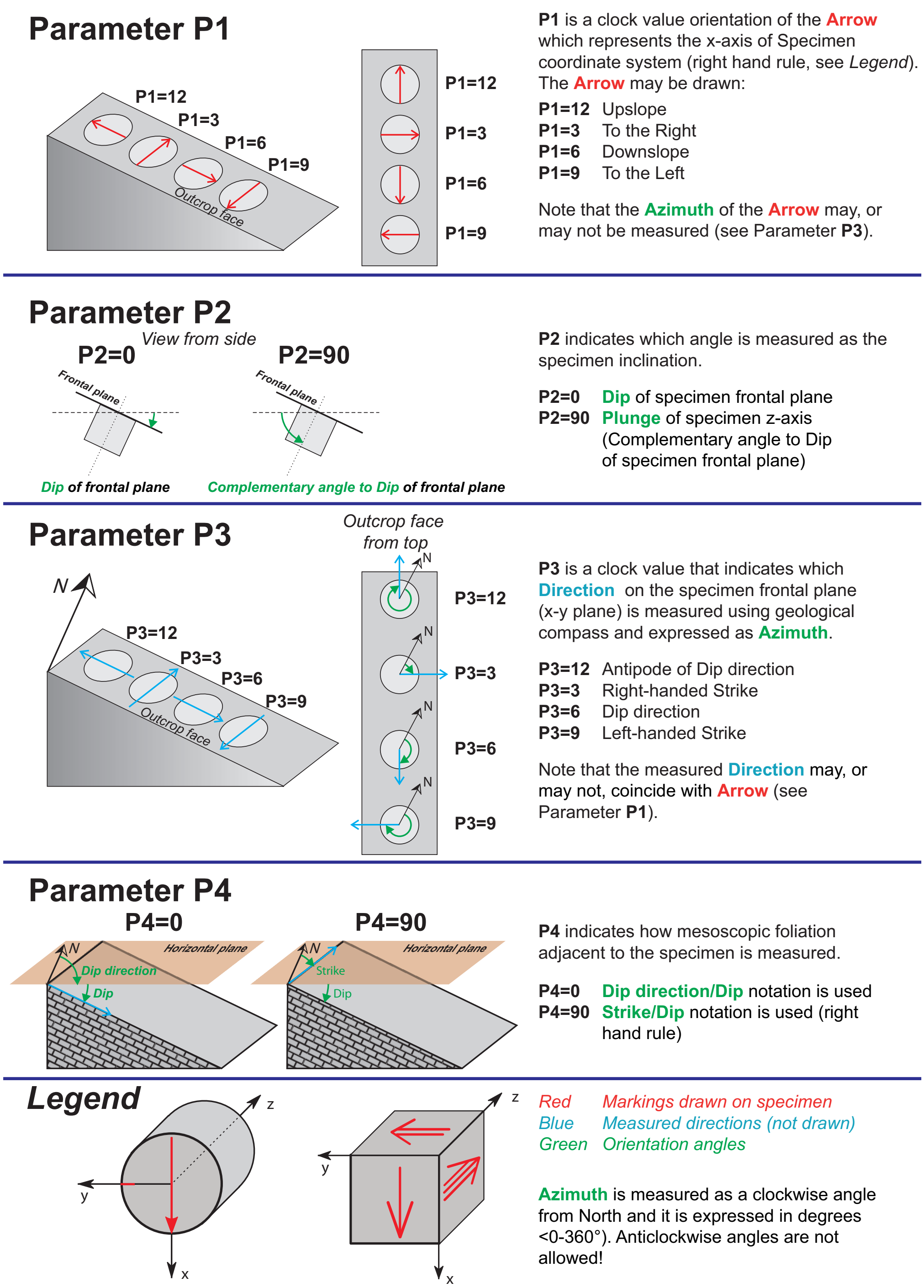


Figure 35: Definition of Orientation Parameters.

6.3 Quantitative Anisotropy Factors

$k_1 > k_2 > k_3$ are principal normed susceptibilities and n_1, n_2, n_3 are their respective natural logarithms. Bold numbers indicate default set of AGICO.

Factor No.	Mathematical expression	Usual Abbreviation
1	$\frac{15}{2}\frac{(k_1-k)^2+(k_2-k)^2+(k_3-k)^2}{(3k)^2}$	
2	$\exp\sqrt{2((n_1-n)^2+(n_2-n)^2+(n_3-n)^2)}$	P'
3	$\sqrt{2[(n_1-n)^2+(n_2-n)^2+(n_3-n)^2]}$	$\ln P'$
4	$\frac{k_1}{k_3}$	P
5	$\ln\frac{k_1}{k_3}$	$\ln P$
6	$100\frac{k_1-k_3}{k_1}$	
7	$\frac{k_1-k_3}{k_2}$	
8	$\frac{k_1-k_3}{k}$	
9	$\frac{k_1}{k_2}$	L
10	$\ln\frac{k_1}{k_2}$	$\ln L$
11	$\frac{k_1-k_2}{k}$	
12	$\frac{2k_1}{k_2+k_3}$	
13	$\frac{k_2}{k_3}$	F
14	$\ln\frac{k_2}{k_3}$	$\ln F$
15	$\frac{k_1+k_2}{2k_3}$	
16	$\frac{k_1+k_3}{2k_2}$	
17	$\frac{2k_2}{k_1+k_3}$	
18	$\frac{1-k_3}{k_2}$	
19	$\frac{2k_1-k_2-k_3}{k_1-k_3}$	
20	$\frac{(k_1+k_2)/2-k_3}{k}$	
21	$\frac{k_2-k_3}{k}$	
22	$\frac{k_1}{\sqrt{k_2k_3}}$	
23	$\frac{k_1k_3}{k_2^2}$	
24	$\frac{k_1-k_2}{(k_1+k_2)/2-k_3}$	Q
25	$\frac{k_1-k_2}{k_2-k_3}$	
26	$\frac{k_2-k_3}{k_1-k_2}$	

27	$\arcsin\sqrt{\frac{k_2-k_3}{k_1-k_3}}$	
28	$\frac{k_2^2}{k_1 k_3}$	E
29	$k_2 \frac{k_1-k_2}{k_1(k_2-k_3)}$	
30	$\frac{k_2/k_3-1}{k_1/k_2-1}$	
31	$\frac{2n_2-n_1-n_3}{n_1-n_3}$	T
32	$\frac{2k_2-k_1-k_3}{k_1-k_3}$	U
33	$\frac{k_1+k_2-2k_3}{k_1-k_2}$	
34	$\frac{\sqrt{((k_1-k)^2+(k_2-k)^2+(k_3-k)^2)/3}}{k}$	R
35	$(k_1 k_2 k_3)^{\frac{1}{3}}$	
36	$\frac{k_3(k_1-k_2)}{k_1(k_2-k_3)}$	
37	$\frac{k_3(k_1-k_2)}{k_2^2-k_1 k_3}$	
38	$\frac{(k_1-k_2)(2k_1-k_2-k_3)}{(k_2-k_3)(k_1+k_2-2k_3)}$	