# APPLICATION NOTE

## Using the 3D-Rotator with Kappabridges MFK2/KLY5

## 1 Introduction

3D-Rotator (Fig. 1) was developed by AGICO company to increase the speed and comfort of anisotropy of magnetic susceptibility (AMS) measurements. The 3D-Rotator rotates the specimen simultaneously about two axes with different velocities. The 2-axis rotation enables to determine 320 directional susceptibilities during a single anisotropy measurement.

These directions are very well distributed on a sphere which makes the measuring design almost rotatable. Calculation of the anisotropy tensor and respective error analysis is based on the principles described by Jelinek (1977)[1].

The actual measurement is fully automated in such a way that, once the specimen is mounted into the rotator, it requires no additional manipulation to measure the full AMS tensor. The approximate duration of one anisotropy measurement including bulk susceptibility is ca. 1.5 min.

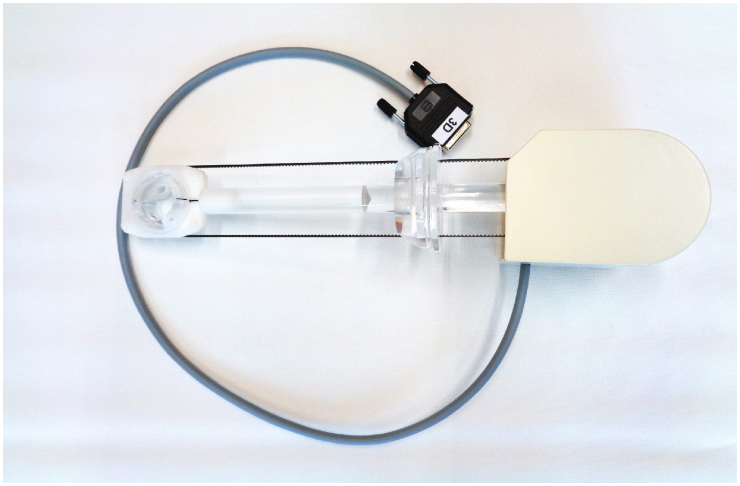

Figure 1: 3D-Rotator

[1] *The Statistical Theory of Measuring Anisotropy of Magnetic Susceptibility of Rocks and Its Interpretation.* This publication can be downloaded from http://www.agico.com pages in the section Customers Support/User manuals and AGICO prints.

# 2 Software

3D-Rotator is compatible with automatic versions of Agico Kappabridges MFK1, MFK2 and KLY5. The measurement with the 3D-Rotator is controlled by the software Safyr.

## 2.1 Instrument settings

The *Instrument settings* in software Safyr allow to set parameters such as Measuring mode, Field intensity and Operating frequency. Once the 3D Rotator is activated, additional selection is enabled where the user can indicate whether Cylindrical or Cubic specimen is measured (see Fig. 2). The *Instrument settings* window is also accessible via *Settings* in the main menu (shortcut `F12`).

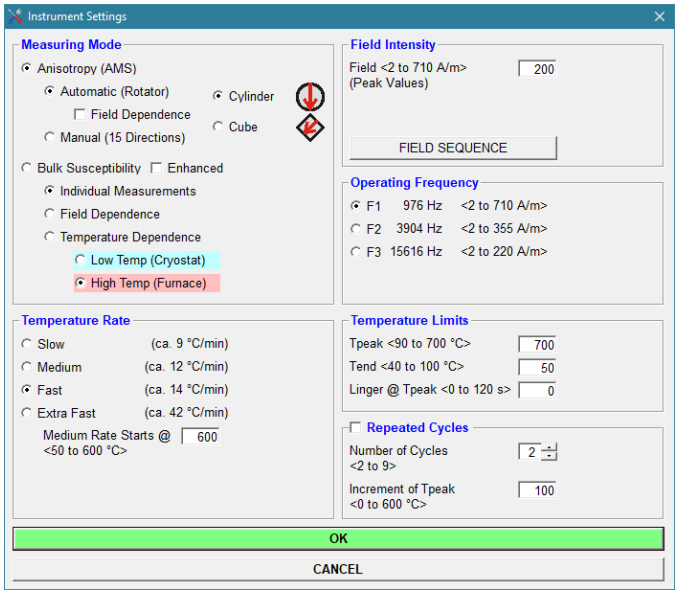


Figure 2: Instrument settings window

## 2.2 Activation routine

Connect the 3D-Rotator to the Pick-Up Unit and switch on the Kappabridge. Start the software Safyr and click on button *Activate* . The *Instrument settings* window is automatically launched. Select *Anisotropy (AMS)* measuring mode with *Automatic Rotator* and hit OK button to start the activation routine.

Results of all steps of activation routine are displayed in the *Instrument Activation* window. The instrument automatically recognizes whether 1-Axis Rotator or 3D-Rotator is connected and sets the user interface accordingly.

The instrument tests proper supply for 3D-Rotator, verifies the rotator speed and displays its rotational period. Then rotator spins until the initial position is set and then it turns about 10° clockwise in order that the user is able to access the specimen fixing screw.

After a successful activation, you are prompted to wait 10 minutes until the instrument is stabilized. The stabilization helps to eliminate the coil drift and it is especially necessary in case of the low-susceptibility specimens with low degree of anisotropy.


Figure 3: Activation window

# 3 Measuring procedure

## 3.1 Specimen to be measured

Design of the 3D-Rotator allows to measure only regularly shaped specimens, cylinder with diameter 25.4 mm and length 22.0 mm or cube with dimensions 20x20x20 mm.

The mounting orientations of cylindrical and cubic specimens is shown on Fig. 4. The red arrow corresponds to the x-axis of the specimen coordinate system. For 3D Rotator design reasons, 8-ccm cubic specimens must be mounted in an oblique orientation with the x-axis pointing down to the left.

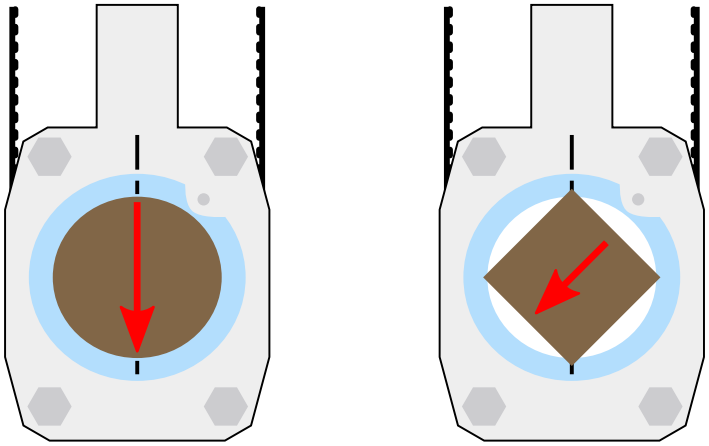

Figure 4: Orientation of cylindrical (left) and cubic (right) specimens

## 3.2 Specimen mounting

The cylindrical and cubic specimens are fixed into the shell using different fixing screws, as shown on Fig. 5. Default fixing screw installed into the shell is for cylindrical specimen.

In case of cubes, it is necessary to remove this fixing screw (marked by green arrow) and install a different screw from bottom right side of the shell (marked by red arrow). Only one type of screw must be installed at the same time.

It should be noted that the fixing screw is accessible only when the inner shell of the 3D-Rotator is turned into the mounting position. The mounting position of the shell is automatically set after the activation routine or whenever the measurement is finished. This screw has to be tightened gently to prevent damage of the shell. Be careful during the loosening of the fixing screw as well.

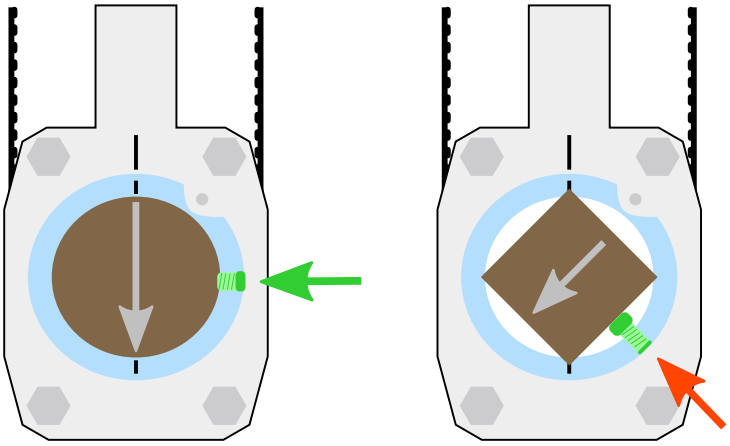

Figure 5: Position of fixing screws for cylindrical (left) and cubic (right) specimens

## 3.3 Calibration with 3D-Rotator

Calibration routine consists of two steps: measurement of bulk susceptibility of the calibration standard for determination of the gain and measurement of anisotropy of susceptibility for obtaining Delta (phase shift) value.

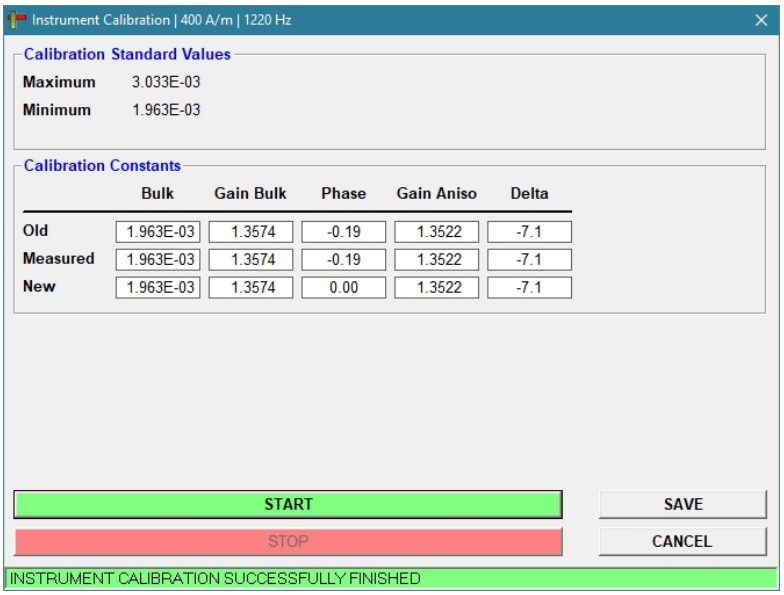


Figure 6: Calibration window

To perform the calibration:

1. Open the *Calibration* window (Fig. 6, main menu *Execution/Calibration*, shortcut F3).
2. Mount calibration standard into the 3D-Rotator. The arrow on the calibration standard points down and it is aligned with arrow drawn on the shell (see Fig. 7). A screw for cylinders must be installed.
3. Compare the Calibration standard values with those written on the calibration standard. If they do not match, close the Calibration window and input the correct calibration standard susceptibility values using the main menu *Settings/Calibration standard values*.
4. Start the calibration by pressing the *Start* button.
5. Instrument sets the shell of the 3D-Rotator to initial position, measures bulk susceptibility and then anistropy of the calibration standard.
6. After a successful calibration, new calibration constants are calculated. Results can be saved by pressing the *Save* button.

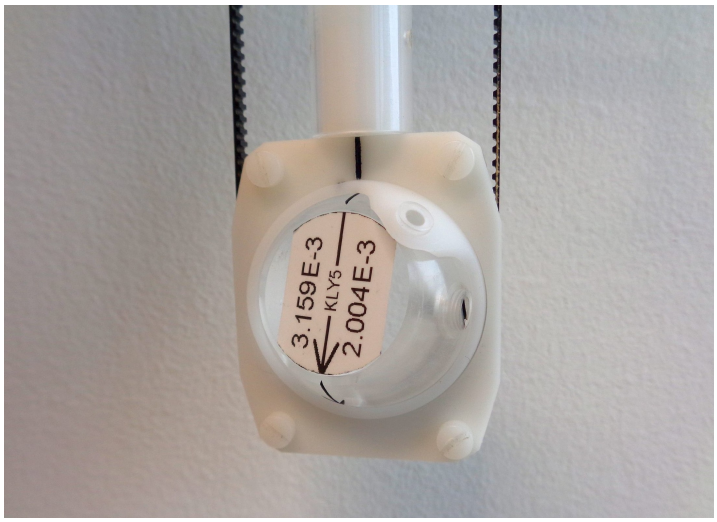


Figure 7: Inserting position of the calibration standard

If the calibration is unsuccessful (due to various reasons), then use the *Cancel* button to retain the old calibration value. Contact Agico for further assistance.

## 3.4 Holder correction

Performing the holder correction routine is crucial for the correct measurement of weak specimens with low degree of anisotropy. It is recommended to perform calibration as well as holder correction everyday to achieve the best measuring results. To perform the holder correction routine:

1. Open the *Holder correction* window ( Fig. 8, main menu, *Execution/Holder correction*, shortcut F4).
2. Make sure that the 3D-Rotator is clean and empty.
3. Start the holder correction by pressing the *Start* button.
4. Three bulk measurements and three anisotropy curves of empty 3D-Rotator are performed. Average values are calculated.
5. Results of holder correction can be saved by pressing the *Save* button (see Fig. 8).

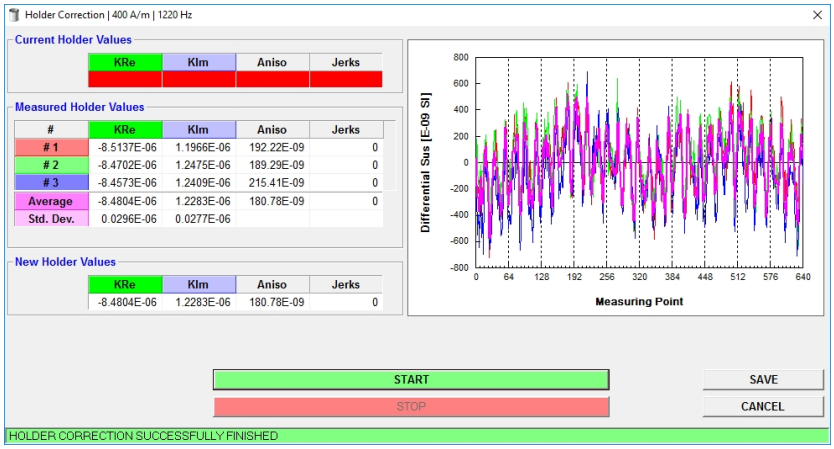


Figure 8: Holder correction window

If bulk susceptibility or anisotropy of the empty 3D-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. If repeated holder correction does not show acceptable results, check environment around the instrument, clean the 3D-Rotator or contact Agico for further assistance.

## 3.5 Specimen measurement

Main screen of software Safyr for the measurements with the 3D-Rotator is shown in Fig. 9. Specimen measurement consists of following steps:

1. Mount the specimen into the rotator as shown on Fig. 5.
2. Press the *New specimen* button to input the specimen name, orientation, foliations and lineations.
3. Press the *Aniso* button to start anisotropy measurement. *Stop* button immediately stops the current operation in case of emergency (hotkey: `Spacebar`).
4. Press the *Bulk* button to start bulk susceptibility measurement. If the *Auto bulk* is checked, the bulk susceptibility is measured automatically right after the anisotropy measurement is finished.
5. Results are automatically calculated whenever all necessary data are available.
6. Press the *Save* button to save current measurement into the file. Press the *Cancel* button if you want to reject current measurement for some reason.
7. Remove the specimen and start to measure another one.

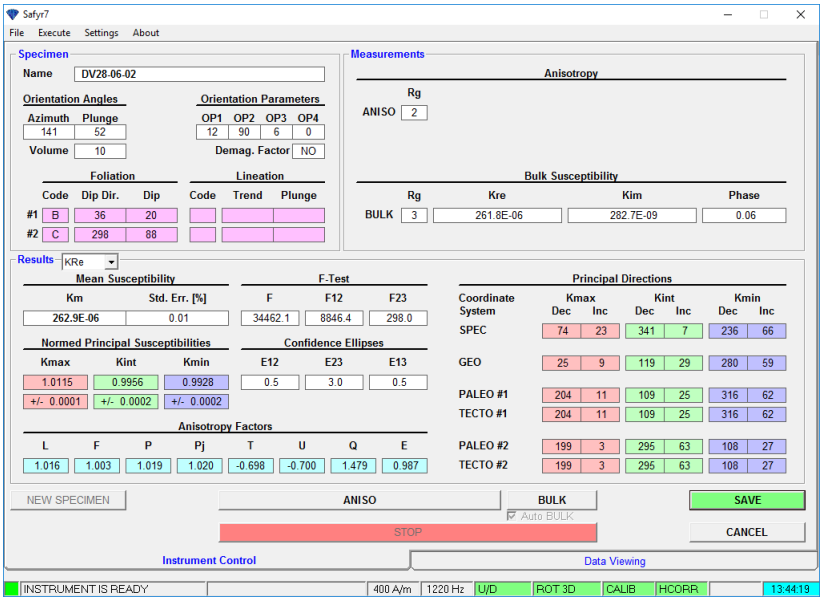


Figure 9: Data acquisition window

# 4 Maintenance and repairs

**Important note:** Please keep your specimens as clean as possible. Any dust particles that fall from your specimens can increase friction in between 3D-Rotator parts, so the voltage for correct speed of 3D-Rotator will increase. Higher voltage dramatically shortens the life-time of the motor and shell of the 3D-Rotator.

## 4.1 3D-rotator disassembling

It is necessary to clean your 3D-Rotator if the values of holder correction are too high or 3D-Rotator makes the suspicious noise during the spinning. Please follow next steps:

1. Switch the Kappabridge OFF and unplug the 3D-Rotator.
2. Unscrew three plastic screws on the lid of the 3D-Rotator, marked by red circles in Fig. 10. Pull the lid gently up to remove it.
3. Check the belt strain to set it later in the same level and remember the belt mark position.
4. Loosen a little bit two screws for belt tension, but do not remove them. Screws are marked by red arrows in Fig. 10 (right side).

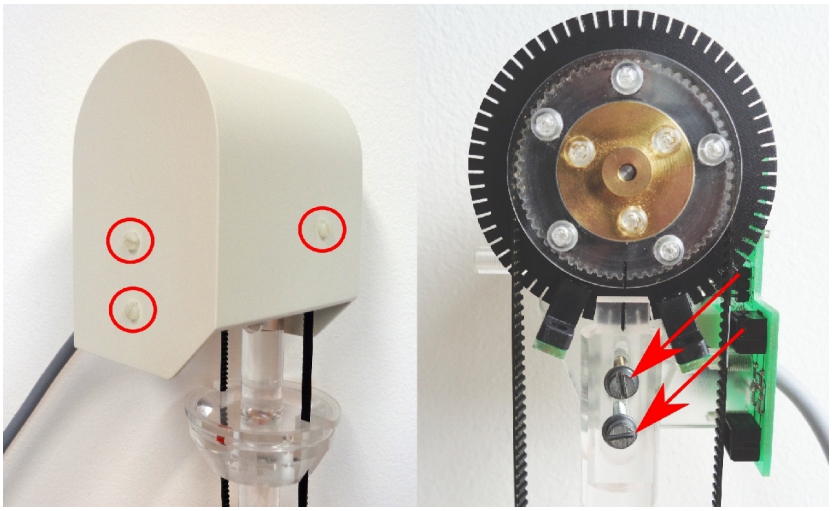

Figure 10: Left - white lid; Right - screws for belt tension

5. Remove four screws with nuts marked by green and red circles in Fig. 11. Two bottom screws have also plastic washers. Set aside white rectangular plate.

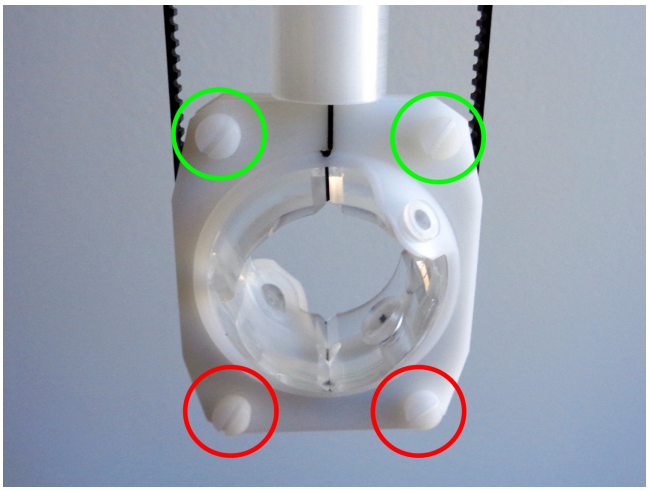

Figure 11: 3D shell

6. Gently release the ring, as you can see in Fig. 12. Pay attention to the position of small rubber washer which works like a spacer. Remove the belt from 3D-Rotator.

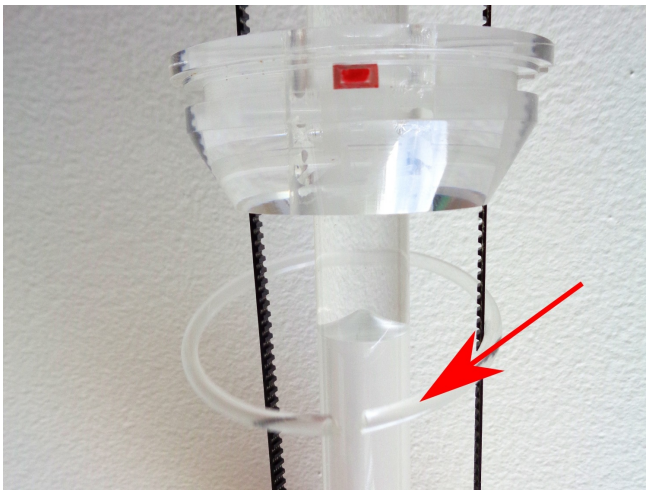

Figure 12: Ring with rubber washer

### 4.2 3D-rotator cleaning

7. To clean the shell, the belt and the bearing use only soft brush and pure water with a small drop of liquid detergent. Check if the belt mark is clear white.
8. Clean also black driving wheel on the motor from dust. Using the magnifying glass to check if all 64 notches are free. Clean also two optocouplers and photosensor using soft dry toothbrush.
9. **Do not use any kind of alcohol for cleaning. Evaporating alcohol can completely damage plastic parts.** Dry all the parts after the cleaning.

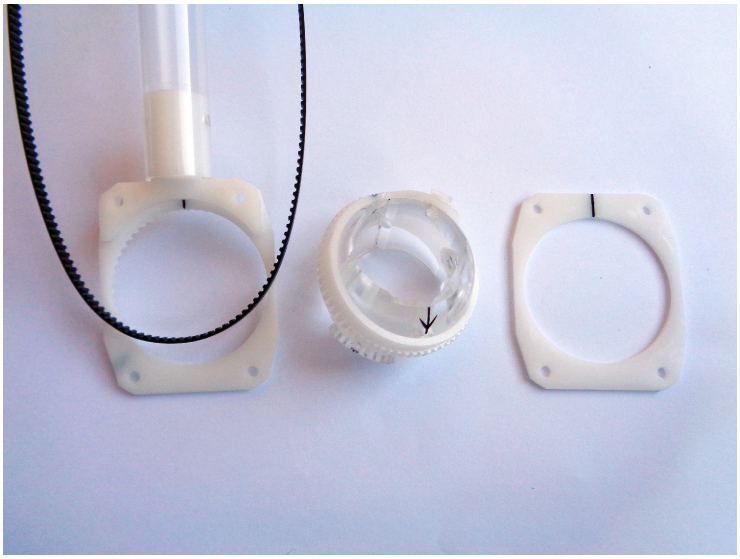

Figure 13: Belt, plastic shell and rectangular plate

## 4.3 3D Rotator assembling

1. Insert the shell into its holder. Position marks on the shell and on the plastic wheel must be simultaneously aligned, as shown in Fig. 14
2. Cover the shell with rectangular plate and carefully screw two upper plastic screws (marked by green circles in Fig. 11).
3. Turn the black driving wheel so that two marks are aligned, as shown in Fig. 14. Then mount the driving belt on the wheel so that the white belt mark is approximately in the center of the top photosensor.
4. Gently screw two bottom plastic screws marked on Fig. 11 by red circles. Do not forget to use washers to keep entire system in correct position.
5. Apply some tension on the belt by picking-up the part with motor and tightening two metal screws. Do not put on top white lid on the 3D-Rotator, yet.

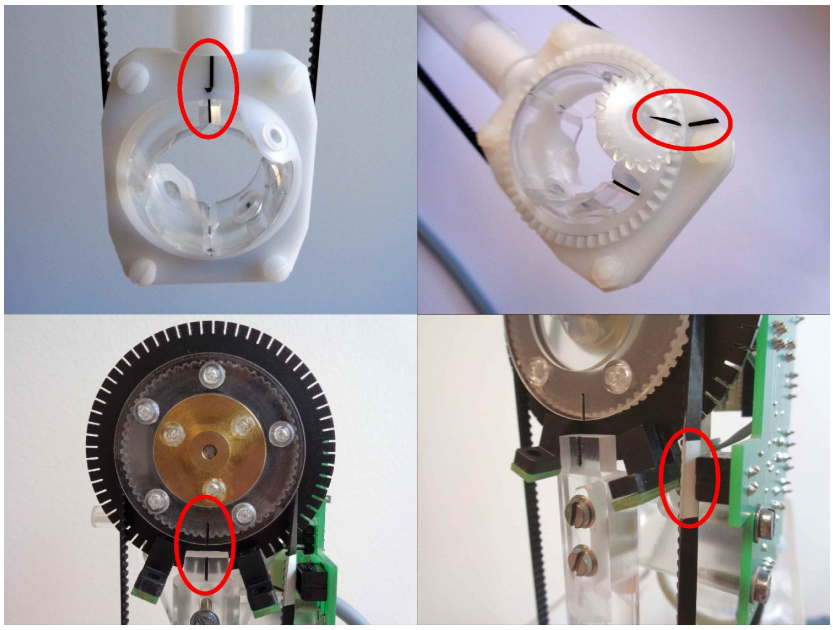

Figure 14: Position marks on the 3D-Rotator

## 4.4 Belt strain value

After a cleaning or replacement of the old belt or when the motor driving voltage is too high, it is necessary to set proper belt strain:

1. Connect the 3D-Rotator to the KLY5/MFK2 unit and switch it on. Then run the SAFYR software and start the initialization routine.
2. From upper menu select *Execute* > *Auxiliary commands* and check the ROTATOR SUPPLY using button *Set supply* in Figure 15.
3. Value of Rotator supply should be between 1200 and 1400, optimal value is around 1300. If necessary, increase this value by increasing strain on the belt or decrease by decreasing the strain on belt. Check also the rotation speed by TEST PERIOD button (duration of one revolution which should be close to the 2750 ms).
4. To set proper belt strain loosen two metal screws marked by red arrows in Fig. 10. After adjustment tighten the screws.
5. If the Rotator supply value is in the desired range, then mount the cover of the 3D-Rotator with three plastic screws and use rotator as usually.
6. It is necessary to perform **calibration** and **holder correction** routines after 3D-Rotator adjustment.

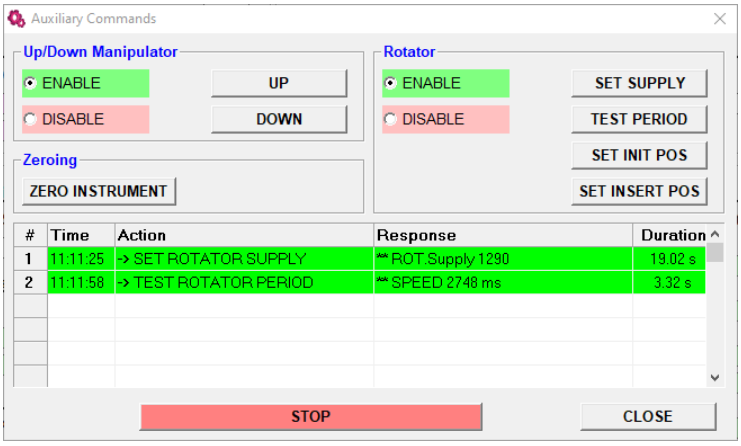


Figure 15: Auxiliary commands